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Florida Citrus Production Guide

2020-2021

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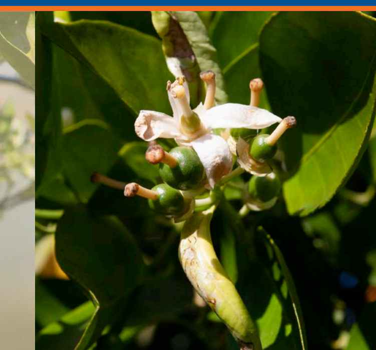
2020- 2021

Florida Citrus

PRODUCTION GUIDE



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2020- 2021

Florida Citrus

PRODUCTION GUIDE

2020–21 Florida Citrus Production Guide

EFFECTIVE AND SAFE CITRUS PRODUCTION STRATEGIES

FOR USE IN COMMERCIAL GROVES ONLY

Before using any pesticide:
Read the complete label and the general
instructions in this guide.

A contribution of the University of Florida Institute of Food and Agricultural Sciences citrus faculty located at the Citrus Research and Education Center–Lake Alfred, Southwest Florida REC–Immokalee, Indian River REC–Ft. Pierce, UF main campus–Gainesville, and researchers from the Florida Department of Citrus–Lake Alfred.

Lauren M. Diepenbrock, Megan M. Dewdney,
and Tripti Vashisth.

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Dear Florida Citrus Growers:

Welcome to the 2020–2021 Florida Citrus Production Guide!

This production guide is a collection of our latest knowledge and recommendations to manage not only HLB but other issues that can affect citrus production here in Florida. Every day UF/IFAS scientists are at work in the lab or field where we learn something new that can be added to our knowledge on how to live with HLB. So, as new information is developed, this guide is updated and provided annually to keep you up to date on the latest science-based information you can use in your groves.

You can also find research and Extension updates at https://citrusresearch.ifas.ufl.edu, which is regularly updated, and you can subscribe to the "All in for Citrus" newsletter (https://citrusresearch.ifas.ufl.edu/newsletter-sign-up/). Faculty also provide regular updates at field days and seminars. UF/IFAS Extension agents are also available to answer your questions and provide important information. Contact information is available in the production guide.

With citrus greening disease here to stay in Florida, we all know that we cannot grow citrus as we did for decades. Experience has taught us that the combination of hard work, commitment to success, and trust in science-backed solutions is the winning formula for Florida citrus production. UF/IFAS has a portfolio of solutions that can assist you in being successful as a Florida citrus grower.

Coupled with the other pests and disease issues growers had to contend with prior to HLB, there is a lot to account for. Every grower's program will be different based on their specific growing conditions and location in the state.

The good news is that the past decade of research on HLB research has paid off. Investments in citrus research from the citrus industry, state legislature, and US Department of Agriculture have resulted in citrus production information that has real impact. We have learned enough about HLB to be able to live with this disease and remain an economically viable industry.

The UF/IFAS Statewide Citrus Team is your partner in finding ways to profitably grow citrus in Florida. Together we will continue to keep citrus Florida's premier agricultural commodity.

Sincerely,

Michael Rogers, Ph.D.
UF/IFAS Statewide Citrus Team
Center Director, UF/IFAS Citrus Research and Education Center

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August 2020

By Scott Angle
jangle@ufl.edu

What does it mean to be #AllInForCitrus? To be "all in" is to be fully committed: all-inclusive, comprehensive, completely involved. The University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) has been all in for decades to help our citrus growers be successful, profitable, and resilient in the fight against HLB and other citrus diseases, but also to offer exciting new varieties and flavors for citrus lovers everywhere.

The fight against HLB is personal for every one of you, and for my family, too. My father-in-law is an 84-year-old citrus grower in California. I love to visit his grove, which he still works in every day, where we bounce down rutted roads in his pickup truck. I can't take that ride without telling him I'm doing everything I can to prevent HLB from taking his trees—and meaning it.

UF/IFAS is the world leader in research for citrus and partnerships and support for growers. I am impressed with the breadth and depth of the commitment to the industry and look forward to supporting future efforts and collaborations to further expand knowledge, solutions, and success.

UF/IFAS's all-in responses to citrus diseases are examples of what happens when a scientific community understands the issues and impacts of an industry. For example, in 2019 a new Citrus Nutrition Box program provided tailored nutrition recommendations four times per year for participating growers via free soil and leaf lab tests. The results were reviewed by UF/IFAS faculty and reported back to the grower. We know that a strong nutrition and irrigation program is key to sustainable, successful grove management, and the program is continuing in 2020.

Our investment and commitment has not wavered, providing our citrus scientists the tools they need to do their best work. The cost of being in the anti-HLB business is high, and the investments to improve our laboratories, greenhouses, and equipment are needed to continue our search for answers.

I look forward to visiting groves and growers across this great state. Citrus is our deepest commitment to Florida agriculture, and I am #AllInForCitrus.

Sincerely,

J. Scott Angle

J. Scott Angle
UF Vice President
Agriculture and Natural Resources

Keep up with our citrus news at http://blogs.ifas.ufl.edu/crec/.

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2020–2021 Florida Citrus Production Guide: Introduction[1]

Lauren M. Diepenbrock, Megan M. Dewdney, and Tripti Vashisth[2]

Over the past decade, Florida citrus production practices have changed dramatically due to the challenges presented by huanglongbing (HLB). As we have learned more about this disease, how it is spread by the Asian citrus psyllid, and the overall effects on citrus tree health, it is increasingly evident that management of this disease requires changes to *all* aspects of citrus production. Several factors must all be considered together when developing a site-specific management plan for citrus production in the presence of HLB. The *Florida Citrus Production Guide* will continue to be updated annually with the latest information to help growers refine their production practices using the latest research-based findings proven to be effective for Florida citrus production.

In addition to changes in production practices needed to manage emerging pest problems in Florida, the regulatory environment is also constantly changing. For example, in 2015 new rules for Worker Protection Standards (WPS) were passed and should have been fully implemented by January 2, 2018. These new rules include important changes to worker training, reporting, and posting of pesticide applications. Likewise, new rules regarding food safety training, reporting, and monitoring are also being implemented. These rules directly affect Florida citrus growers and all agriculture and are explained in the chapters on WPS and food safety. As changes in these rules are likely to occur, the guide will be updated to reflect the latest information growers need to know to ensure compliance, so please continue to review these chapters in the coming years.

Overall, the goal of the *Florida Citrus Production Guide* is to serve as a reference for information needed to guide decision-making in Florida citrus-growing operations. **It is not intended to replace agricultural product labels that 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. Always read and follow label instructions!** Likewise, state and federal regulations on topics such as WPS are constantly changing, and not all the information needed to ensure compliance can be covered in this guide. The WPS chapter in this guide covers some of the important highlights of these rules. **It is imperative that growers obtain copies of and follow the detailed rules outlined in the regulatory documents referenced in this guide. The *Florida Citrus Production Guide* provides general guidance and is NOT the final regulatory document that should be followed!**

For specific information on pest identification, biology, damage, or nonchemical management techniques, refer to Extension Digital Information System (EDIS) and other IFAS, USDA, and Florida Department of Agriculture and Consumer Services (FDACS) publications. In addition to

1. This document is CPMG01, one of a series of the Plant Pathology Department, UF/IFAS Extension. Original publication date December 1999. Revised April 2020. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

2. Lauren M. Diepenbrock, assistant professor, Entomology and Nematology Department; Megan M. Dewdney, associate professor, Plant Pathology Department; and Tripti Vashisth, assistant professor, Horticultural Sciences Department, UF/IFAS Citrus Research and Education Center; UF/IFAS Extension, Gainesville, FL 32611.

the authors listed throughout the *Florida Citrus Production Guide*, the citrus Extension specialists, faculty, and Extension agents listed below can provide assistance with citrus production practices.

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2020–2021 Florida Citrus Production Guide: Useful Telephone Numbers[1]

Frederick M. Fishel[2]

National Pesticide Information Center (NPIC)

1-800-858-7378, 11 am–3 pm Eastern time, Monday–Friday. Provides general information on pesticide products, recognition and management of pesticide poisoning, toxicology, and environmental chemistry.

CHEMTREC®

CHEMTREC® is the Chemical Transportation Emergency Center. It is operated by the Chemical Manufacturers Association to assist in handling chemical emergencies.

Emergency number providing information to persons having large chemical spills or leaks: 1-800-424-9300

UF/IFAS

Pesticide Information Office: 352-392-4721

UF/IFAS Citrus Research and Education Center: 863-956-1151

Florida Department of Agriculture and Consumer Services

Division of Plant Industry: 352-395-4700

Pesticide Certification/Licensing Office: 850-617-7870

Florida's Poison Control Centers

1-800-222-1222

1. This document is PI-15, one of a series of the Agronomy Department, UF/IFAS Extension. Original publication date December 1995. Revised March 2020. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

2. Frederick M. Fishel, professor, Agronomy Department, and director, Pesticide Information Office; UF/IFAS Extension, Gainesville, FL 32611.

2020–2021 Florida Citrus Production Guide: Fresh Fruit Pesticide Residue Limits[1]

Mark A. Ritenour[2]

Current production practices often include the use of various pre- and postharvest chemicals, many of which are pesticides. To be used, these materials must be labeled for use on citrus and used only according to label instructions. Chemical residues on the fruit after harvest are a concern to regulators and the public alike because of their potential negative health effects. Therefore, the United States and other countries set maximum residue limits (MRLs) on fresh produce for various chemicals. It is unlikely for US MRLs to be exceeded when label instructions are followed. However, when importing countries' MRLs are lower than US MRLs, use of these pesticides usually must be modified or discontinued to keep from exceeding the country's tolerances. In addition, individual buyers may set their own, more restrictive standards. Similar to buyer-imposed food safety standards, buyer-imposed MRL standards, especially from large buyers, can significantly impact how pesticides are used in the field and packing facility.

Because MRLs often change frequently, see the UF/IFAS Postharvest Resources Website (https://irrec.ifas.ufl.edu/postharvest/index/pesticides.shtml) for the most current list of MRLs (in parts per million) for various chemicals used on fresh Florida citrus for the United States, CODEX, and important export countries. This website also includes links to a global MRL database (https://bcglobal.bryantchristie.com/) for the most comprehensive list of MRLs for all commodities and markets and specific MRL databases for select countries. The limit of detection for chemical residues on citrus fruit is often around 0.01 ppm, depending on the testing laboratory and chemical of interest. When no tolerance or default tolerances are stated, any detectable residue will constitute a violation. Violations may lead to rejected loads of product, restrictions on future shipments, and even increased requirements for the entire industry to a given market. This information is intended as an initial reference source, and no guarantee is made to its accuracy. Always verify these values with other knowledgeable sources within specific markets of interest.

1. This document is HS1301, one of a series of the Horticultural Sciences Department, UF/IFAS Extension. Original publication date July 2017. Revised March 2020. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

2. Mark A. Ritenour, professor, Horticultural Sciences Department, UF/IFAS Indian River Research and Education Center, Fort Pierce, FL 34945.

2020–2021 Florida Citrus Production Guide: Pesticide Resistance and Resistance Management[1]

Lauren M. Diepenbrock, Megan M. Dewdney, and Ramdas Kanissery[2]

Populations of animals, fungi, bacteria, and plants possess the ability to respond to sustained changes or stresses in their environment in ways that enable the continued survival of the species. Such environmental stresses include physical factors (e.g., temperature or humidity), biological factors (e.g., predators, parasites, or pathogens), and environmental contaminants. In any population, a small percentage of individuals will be better able to respond to new stresses because of unique traits or characteristics that they possess. Consequently, those individuals will survive, reproduce, and become more common in a population. This phenomenon is commonly referred to as "survival of the fittest."

Many pest species, such as the citrus rust mite, are exceptionally well equipped to respond to environmental stresses because of their short generation time and large reproductive potential. The use of chemical sprays to control insect, mite, bacterial and fungal diseases, and weeds of citrus creates a potent environmental stress. There are now many examples of pests, pathogens, and weeds that have responded by developing resistance to one or more pesticides. Pesticide-resistant individuals are those that have developed the ability to tolerate doses of a toxicant that would be lethal to the majority of individuals. The resistance mechanisms can vary according to pest species and/or the class of chemical to which the pest is exposed. Resistance mechanisms include an increased capacity to detoxify the pesticide once it has entered the pest's body, a decreased sensitivity of the target site that the pesticide acts upon, a decreased penetration of the pesticide through the cuticle, or sequestration of the pesticide within the organism. The main resistance mechanism for fungal pathogens is a change in the target site so that the pathogen is less susceptible or fully resistant. With repeated or intense exposure to herbicides, some weeds develop resistance because only individuals that are capable of detoxifying the chemical persist over time. A single resistance mechanism can sometimes provide defense against different classes of chemicals; this is known as *cross-resistance*. When more than one resistance mechanism is expressed in the same individual, this individual is said to show *multiple resistance*.

Of the factors that affect the development of resistance, including the pest's or pathogen's biology, ecology, and genetics, only the operational factors can be manipulated by the grower. The key operational factor that will delay the onset of pesticidal resistance and prolong the effective life of a compound is assuring the survival of some susceptible

1. This document is ENY-624, one of a series of the Entomology and Nematology Department, UF/IFAS Extension. Original publication date December 1995. Revised April 2020. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

2. Lauren M. Diepenbrock, assistant professor, Entomology and Nematology Department; Megan M. Dewdney, associate professor, Plant Pathology Department, UF/IFAS Citrus Research and Education Center; and Ramdas Kanissery, assistant professor, weed science, Agronomy Department, UF/IFAS Southwest Florida REC; UF/IFAS Extension, Gainesville, FL 32611.

individuals to dilute the population of resistant individuals. The following operational procedures should be on a grower's checklist to steward sound pesticidal resistance management for acaricides, insecticides, fungicides, and herbicides:

1. Never rely on a single pesticide class.

2. Integrate chemical control with effective and complementary cultural and biological control practices.

3. Always use pesticides at recommended rates and strive for thorough coverage.

4. When there is more than one generation of pest, alternate different pesticide classes.

5. Do not use tank mixtures of products that have the same mode of action.

6. If control with a pesticide fails, do not re-treat with a chemical that has the same mode of action.

Reports of resistance have been documented for certain acaricides used to control citrus rust mite and fungicides used to combat diseases in Florida. Resistance is also likely to be found in weeds with repeated exposure to certain herbicides. Resistance to Benlate developed in the greasy spot fungus shortly after the product was introduced about 30 years ago and is still widespread. Benlate resistance also occurs in the scab fungus in isolated situations and is stable. In tangerine groves with Alternaria brown spot, resistance has been detected to strobilurin fungicides (Abound, Gem, and Headline, and contained in the mixtures Pristine, Priaxor, and Amistar Top), but no resistance has developed to ferbam. Dicofol resistance in citrus rust mite was detected throughout the citrus industry about 10 years ago, but resistance proved to be unstable and usage of dicofol has continued. Agri-mek tolerance in citrus rust mite is of concern, and growers should follow sound resistance management practices when using this product. Recent studies have shown reduced susceptibility to several insecticides in populations of Asian citrus psyllid after repeated exposure to similar materials, but that susceptibility can be restored by rotating modes of action used in management programs. Resistance management is crucial to the management of this insect. Glyphosate-resistant weeds are becoming commonplace in many production systems with the repeated use of this popular preemergence herbicide, highlighting the need to rotate materials for weed management.

The following tables are provided to aid in the rotation of pesticides with different modes of action within a season or from year to year. There are separate tables for insecticides/acaricides, fungicides, and herbicides. The information in these tables was derived from information produced by the Insecticide Resistance Action Committee (IRAC) (http://www.irac-online.org/), the Fungicide Resistance Action Committee (FRAC) (http://www.frac.info/), and the Herbicide Resistance Action Committee (HRAC) (http://hracglobal.com/pages/classificationofherbicidesiteofaction.aspx). Each table lists the number (or letter in the case of herbicides) of the group code for each pesticide class, the group name or general description of that group of pesticides, the common name of pesticides used in citrus production that belong to each group, and examples of trade names of pesticides for each common name listed. When using the table to rotate between using products with different modes of action, choose products with a different group code than previously used in the grove during the current growing season. In the case of insecticides/acaricides, many of these pesticides are broken into subgroups. It is unclear whether cross-resistance will occur between these subgroups. When possible, it is recommended to rotate with an entirely different group. (Note: The IRAC and FRAC mode of action systems both use a similar numbering system. There is no cross-resistance potential between the insecticides and fungicides.) Products with broad-based activity such as sulfur and oil are not included in this list because the development of resistance to them is not likely.

Table 1. Insecticides and miticides used in Florida citrus grouped by mode of action.

IRAC Group[1]	Subgroup	Group Name	Common Name	Trade Name
1	1A	Carbamates	carbaryl oxamyl	Sevin Vydate
	1B	Organophosphates	acephate chlorpyrifos dimethoate malathion methidathion naled phosmet	Orthene Lorsban Dimethoate Malathion Supracide Dibrom Imidan
3	3A	Pyrethroids	bifenthrin fenpropathrin zeta-cypermethrin	Brigade Danitol Mustang
4	4A	Neonicotinoids	acetamiprid clothianidin imidacloprid thiamethoxam	Actara, Assail, Admire Pro, Advise, Alias, Belay, Couraze, Imida E-Ag, Impulse, Macho, Montana, Nuprid, Pasada, Platinum, Prey, Torrent, Widow
	4D	Butenolides	flupyradifurone	Sivanto
5		Spinosyns	spinosad spinetoram	Spintor Delegate
6		Avermectins	abamectin	Abacus, Abba, Agri-mek, Clinch, Epi-mek, Reaper, Zoro
7	7A	Juvenile Hormone Analogues	methoprene	Extinguish Ant Bait
	7B	Fenoxycarb	fenoxycarb	Precision
	7C	Pyriproxyfen	pyriproxyfen	Knack
10	10A	Hexythiazox	hexythiazox	Savey
11	11A	*Bacillus thuringiensis* (B.t.)	B.t. var. aizawai B.t. var. kurstaki	Various Various
12	12B	Organotin miticides	fenbutatin oxide	Vendex
	12C	Propargite	propargite	Comite
15		Benzoylureas	diflubenzuron	Micromite
16		Buprofezin	buprofezin	Applaud
18		Diacylhydrazines	methoxyfenozide	Intrepid
21	21A	METI acaricides	pyridaben fenpyroximate	Nexter Portal
23		Tetronic/Tetramic acid derivatives	spirodiclofen spirotetramat	Envidor Movento
28		Diamides	chlorantraniliprole	Exirel, Verimark, Voliam Flexi (one component)
UN		Unknown MOA	bifenazate	Acramite
			cryolite	Kryocide
			dicofol	Kelthane

[1] Mode of action based on the Insecticide Resistance Action Committee (IRAC) Mode of Action Classification V8.4 (2018).

Table 2. Fungicides used in Florida citrus grouped by mode of action.

FRAC Group[1]	Group Name	Common Name	Trade Name
1	MBC—fungicides (Methyl benzimidazole carbamates)	thiabendazole	Many (TBZ)
3	DMI—fungicides (Demethylation inhibitors)	difenoconazole fenbuconazole imazalil mefentrifluconazole propiconazole	Amistar Top, Miravis Top Enable Many Provysol Many
4	PA—fungicides (Phenylamides)	Metalaxyl mefenoxam	Ridomil Ultraflourish, Ridomil Gold, Subdue
7	SDHI—fungicides (Succinate-dehydrogenase inhibitors)	boscalid fluopyram fluxapyroxad pydiflumetofen	Pristine Luna Sensation Priaxor Xemium Miravis Top
11	QoI—fungicides (Quinone outside inhibitors)	azoxystrobin trifloxystrobin pyraclostrobin	Abound and others, Graduate A+, Amistar Top Gem Headline, Pristine
12	PP—fungicides (Phenylpyrroles)	fludioxonil	Graduate A+
40	CAA—fungicide (Carboxylic acid amides)	mandipropamid	Revus
43	Benzamides	Fluopicolide	Adorn, Presidio
49	OSBPI—oxysterol binding protein homologue inhibition	Oxathiapiprolin	Orondis
M 03	Dithiocarbamates	ferbam	Ferbam Granuflo
M 01	Inorganic	copper	Many
P 07	Phosphonates	fosetyl-Al phosphorous acid and salts	Aliette Phostrol, ProPhyt

[1] Mode of action based on the 2020 Fungicide Resistance Action Committee (FRAC) Mode of Action Classification.

Table 3. Herbicides used in Florida citrus grouped by mode of action.

HRAC Group[1]	Group Name/Chemical Family	Common Name	Trade Name(s)
A	Aryloxyphenoxy-propionate Cyclohexanedione	fluazifop-p-butyl sethoxydim	Fusilade Poast
C1	Triazine Uracil	simazine bromacil	Caliber, Princep, Simazine Hyvar, Krovar
C2	Urea	diuron	Direx, Karmex, Krovar
D	Bipyridylium	paraquat	Gramoxone
E	N-phenyl-phthalimide Triazolinone Pyrimidinedione	flumioxazin carfentrazone-ethyl saflufenacil	Chateau Aim Treevix
F1	Pyridazinone	norflurazon	Solicam
F2	Triketone	mesotrione	Broadworks
G	Glycine	glyphosate	(Various) e.g., Roundup, Gly Star
K1	Dinitroaniline	oryzalin pendimethalin	Surflan Prowl
L	Alkylazine	indaziflam	Alion

[1] Mode of action based on the 2018 Herbicide Resistance Action Committee (HRAC) Mode of Action Classification.

2020–2021 Florida Citrus Production Guide: Pesticide Application Technology[1]

Masoud Salyani[2]

Spraying Trees

Sprayer Selection

Most Florida citrus applications are made with air-carrier ground sprayers. These sprayers may be truck/tractor-mounted, tractor-drawn (p.t.o./engine-driven), or self-propelled. They may be equipped with a positive or nonpositive displacement pump to pressurize the spray liquid and generate spray droplets by hydraulic nozzles, air-shear nozzles, or rotary atomizers. Spray droplets are normally transported by sprayer airflow, generated with one or more axial-, centrifugal-, or cross-flow fans. The air is directed toward the canopy by a series of fixed, adjustable, or moving deflectors (oscillators). Some sprayers use a short or tall tower attachment to discharge a portion of the spray-laden air close to the upper parts of the tree canopy. Sprayers may use mechanical and/or hydraulic agitation systems.

The differences in size, shape, design features, and construction material of the sprayers could result in substantial variation in the price of the spray equipment. Nevertheless, a higher price does not necessarily mean a better sprayer or guarantee more satisfactory spray coverage. A pesticide can be expected to be effective if the right material is applied, at the right amount, on the right target, at the right time, with the right sprayer, and under the right weather conditions. A cheap sprayer, adjusted and operated properly, may result in better pest control than a sophisticated sprayer used improperly under adverse weather conditions.

Sprayer Air Capacity

Because air-blast applications depend on the sprayer air stream to deposit the spray on the tree, the air volume and velocity must be sufficient for efficient droplet transport, acceptable penetration inside the canopy, and satisfactory spray coverage. However, air-carrier sprayers have a wide range in air capacities (5,000–100,000 cfm). While larger sprayers generate much more air volume than smaller ones, they may not provide any improvement in spray coverage, and in some cases, too much air may adversely affect spray deposition by increasing spray runoff from the leaf surface.

As the fan power requirement changes with the cubic factor of the airflow rate (fan speed), excessive air capacities dramatically increase the needed horsepower for fan operation. A 10%–20% increase in fan speed increases the fan power demand by 33.1%–72.3%, respectively. On the other hand, a 10%–20% decrease of the speed reduces the power requirement by 27.1%–48.8%, respectively. Higher energy

1. This document is ABE-356, one of a series of the Department of Agricultural and Biological Engineering, UF/IFAS Extension. Original publication date December 1995. Revised March 2020. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

2. Masoud Salyani, professor emeritus, Department of Agricultural and Biological Engineering, UF/IFAS Citrus Research and Education Center, Lake Alfred, FL 33850.

demand of the fan requires purchasing a larger sprayer or operating the fan at higher rotational speeds. These practices would increase capital investment, fuel consumption, and operating costs. Therefore, smaller fans or lower rotational speeds should be used as much as possible. Using lower air volumes could offer substantial savings in energy expenditure and cost of spray applications. Certainly, small trees and lightly foliated canopies do not require large sprayers. Reduction of fan speed is a practical method for decreasing pesticide waste and application cost in spraying small and low-density trees. It should be noted that sprayers must be recalibrated if they are used at lower fan speeds.

Nozzle Arrangement

In Florida citrus applications, it has been a common practice to direct 2/3 of the spray volume to the upper half of the tree and 1/3 to the lower half. However, this practice is no longer recommended when spraying small trees or using large airblast sprayers. The 2/3-1/3 nozzle arrangement has shown no significant improvement in overall spray deposition or pest control as compared to 1/2-1/2 (uniform) nozzle arrangement. The latter may also minimize errors in nozzle selection. Sprayer air deflectors, nozzle orientation and number of nozzles should be adjusted to match the size and shape of the canopy and minimize spray wastage (see Figure 1).

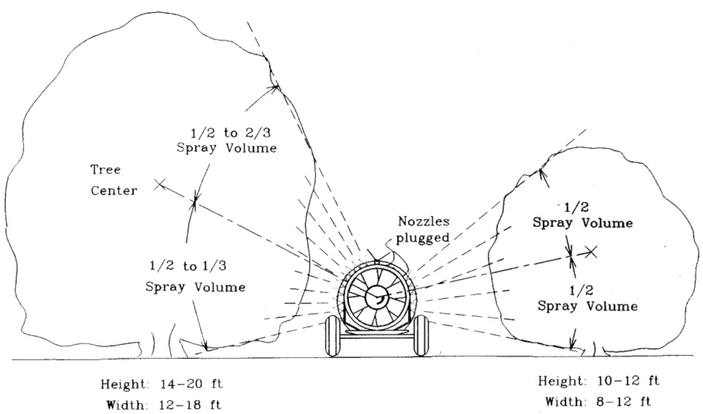

Figure 1. Recommended nozzle arrangement and spray volume distribution.

For low-volume rates (less than 100 gal/acre), reducing the number of nozzles and using smaller disc and core sizes rather than spraying at higher ground speeds may improve spray deposition. For high-volume rates (greater than 250 gal/acre), increasing the number of nozzles and spraying at higher ground speeds, instead of using fewer large disc and core sizes, may give higher deposition efficiency. Deposition efficiency of mid-volume rates (100–250 gal/acre) is less sensitive to these application variables.

Sprayer Calibration

Application errors can originate from either incorrect tank concentration of the pesticides (mixing error) or incorrect sprayer output per unit area (calibration error). The latter may be due to travel speed, nozzle pressure, or the use of improper, defective, and worn nozzles. However, by proper matching of the sprayer discharge rate, swath width, and travel speed, calibration errors can be mitigated. Sprayer calibration can be carried out by: a) determining the amount of the tank mix used to spray a known area; b) operating the sprayer in a fixed place and measuring the amount of discharged liquid (water) for a specified time; or c) collecting the nozzle discharge and determining the output for a time period. Application rate is then determined by calculations. If the rate is not acceptable, then sprayer and/or application parameters need adjustment. See UF/IFAS Circular 1435, *Calibration of Airblast Sprayers* (http://edis.ifas.ufl.edu/ae238), for details. The use of high-capacity nozzles at low pressures to achieve low-volume application rates, one-sided calibration of the sprayer for two-sided operations and vice versa, calibration at closed pressure settings, and intermittent operation of the nozzles can introduce errors in application rates. Sprayers using positive displacement pumps (diaphragm, piston, etc.) have more potential for application error compared to sprayers using centrifugal pumps, particularly at high-volume rates.

Application Rate Adjustment

The maximum per-acre rate of pesticides given in this publication is based on applications to mature citrus trees that have reached containment size (hedgerow status). Smaller trees can be sprayed with the same concentration of agrichemical, but using fewer nozzles (see Figure 1). This should provide spray deposition approximately comparable to that of mature trees, with lower spray volume and active ingredient per acre.

The spray volume rate can be calculated from Equation 1:

$$VR = \frac{(495) \times (SO)}{(GS) \times (RS)}$$

where:
VR = Spray Volume Rate (gal/acre)
SO = Sprayer Output (gal/min)
GS = Ground Speed (mile/hr)
RS = Tree Row Spacing (ft)

Equation 1.

The actual applied rate of pesticides for small trees would be a fraction of the maximum rate per acre, as shown in Equation 2.

$$PRS = \frac{(VRS) \times (PRM)}{(VRM)}$$

where:
PRS = Actual applied rate of pesticides for small trees (pt or lb/acre)
VRS = Spray volume rate for small trees (gal/acre)
VRM = Spray volume rate for mature trees (gal/acre)
PRM = Pesticide rate for mature trees (pt or lb/acre)
Equation 2.

Further reduction in spray usage may be obtained by shutting the nozzles (manually or automatically) when passing by the gaps between adjacent trees. The above adjustments match the sprayer output with the tree size while providing adequate spray coverage and lowered off-target spray movement.

Spray Volume and Ground Speed

Lower spray volumes can deposit as much or more pesticide on the canopy than dilute rates. This is because spray runoff from leaf surface decreases and more material remains on the canopy. Lower volumes involve the use of smaller-orifice nozzles that provide smaller droplet sizes and more uniform spray distribution on the leaf surface. However, variability of spray distribution within the canopy and drift potential increase as spray volume decreases. With existing spray equipment and for average-size trees, a volume rate of about 250 gal/acre may be a good compromise for controlling most pests of economic importance, except some scale insects. The volume rate may be reduced further if higher pesticide concentration is more important than thorough wetting for controlling certain pests (see the label for limitations).

Increasing the ground speed can reduce the runoff from leaf surfaces in locations close to the sprayer. This effect can result in increased spray deposition and may be more pronounced with high-volume rates and large-orifice nozzles. On the other hand, hard-to-reach areas of the canopy may not have enough exposure for adequate spray penetration and deposition. The higher the sprayer air volume, the more potential it may have for high-speed applications. However, because variability of deposition increases at higher speeds, a ground speed of about 2.5 mph may be a reasonable speed for most citrus sprayers operating under average grove conditions.

Weather Conditions

The effectiveness and safety of spray applications largely depend on weather conditions during the application. High wind velocities can decrease spray coverage while increasing the variability of deposition and off-target drift. Pesticides should not be applied when wind velocity exceeds 10 mph or when it blows toward an adjacent residential area or susceptible crop. While calm conditions are desirable for spray deposition, temperature inversion may create severe drift problems. Vertical movement of the air during unstable weather conditions can increase the chance of spray drift, but dilution of the drift cloud makes it less serious than concentrated drift clouds generated under inversion conditions.

The size of the water-based droplets reduces constantly as they move from the sprayer. The evaporation becomes faster under hot and dry conditions and may become critical for low-volume applications. By using larger-orifice nozzles and/or lower spray pressures, droplet size can be increased and spray drift decreased.

LV/ULV Spray Guidance

The US Environmental Protection Agency and the Florida Department of Agriculture and Consumer Services allow the use of a pesticide on an agricultural site in a manner that results in the application of the same or less amount of active ingredient(s) to the site as specified on the product label but with less diluent than is specified on the product label if certain conditions are met:

1. The use of less diluent is not specifically prohibited on the product label; and

2. All other precautionary statements regarding product mixing, loading, and preparation, application methods, rates, frequency, preharvest intervals, tolerances, field reentry intervals, protective clothing or equipment requirements, product packaging and transportation requirements, and storage and disposal practices are complied with.

Typically, pesticide product labels include advisory language encouraging the user to apply the product in a solution of sufficient volume to achieve complete coverage of foliage. Coupled with this language, manufacturers suggest a range of spray volumes necessary to achieve adequate foliage coverage. However, unless the label contains language such as “do not use less than *x* gallons of water volume per acre,” it is acceptable for the grove manager to use less volume than suggested by the range on the label. Growers should be cautious, however, and recognize the fact that crop damage occurring as a result of the use of less diluent than recommended on the label is solely their responsibility. Therefore, it is strongly recommended that this use pattern be tested on a small crop area before implementing widespread application.

Spraying Weeds

Herbicide Applicators

Herbicides are mostly applied with boom sprayers. These sprayers work on the same principles as tree sprayers and consist of a tank, pump, flow (pressure) regulator, agitation system (hydraulic or mechanical), nozzle manifold (boom), and a set of nozzles. However, compared to tree sprayers, herbicide applicators normally are equipped with smaller PTO-driven pumps (centrifugal, roller, or piston) and lower hydraulic pressures (10–50 psi).

The pump should be resistant to wear and corrosion. It must have enough capacity (gal/min) and pressure (psi) for both nozzle output and hydraulic agitation. This requires at least 20% greater capacity beyond the combined nozzle demand. Most pump manufacturers recommend not exceeding 70%–80% of the pump's capacity for continuous operations. Agitation is more critical for wettable powders and water dispersible formulations. Inadequate mixing of these products could result in nonuniform concentration of the herbicide in the tank, nozzle clogging problems, and over- or underdose output from nozzles. Overdosing of blocks with young trees can result in severe stunting and/or phytotoxicity. Tanks without sharp corners minimize the chance for product settlement. Herbicide applicators equipped with mechanical agitation systems perform better than those with hydraulic agitation, but they are more expensive.

Regardless of differences in the design and price of the sprayers, the success of weed control largely depends on the choice of herbicide, timing of the application, and proper maintenance, calibration, and use of the equipment. More information on the selection and timing of herbicide application can be found in HS-107, *Weeds* (chapter 44 of this guide). The following sections provide information on proper nozzle selection and calibration of herbicide applicators.

Nozzle Selection

In Florida, nearly all boom sprayers are equipped with hydraulic pressure nozzles. These nozzles are available in many sizes, shapes, and materials and may be color-coded or identified by a number. A typical nozzle assembly consists of nozzle body, strainer (screen), tip (orifice), and cap (tip holder). Strainers vary in mesh size based on the size of the nozzle orifice (opening). Smaller openings (lower capacities) require finer mesh to minimize nozzle clogging.

Nozzles differ significantly in durability, flow rate, droplet spectrum, and distribution pattern. Brass and nylon nozzle tips are the least expensive but are relatively soft and wear rapidly; therefore, they are not suitable for spraying abrasive tank mixes such as wettable powders. On the other hand, ceramic and hardened stainless steel tips are more expensive but have excellent wear life and are very resistant to abrasive and corrosive chemicals.

For a given nozzle type, flow rate (capacity) depends on the tip orifice size and operating pressure. In nozzle manufacturers' catalogs, nozzle flow rates (GPM) are usually listed for a few selected pressures (PSI). It should be noted that all the tabulations are based on spraying water. When calibrations are based on water, the equivalent GPM of the heavier or lighter solutions should be calculated from Equation 3.

$$GPM_w = GPM_s \times CF$$

where:

GPM_w = Equivalent nozzle capacity for water

$GPMs$ = Desired nozzle capacity of heavier or lighter solution

CF = Correction factor for solution density
= square-root of specific gravity (SG)

Equation 3.

Most nozzles perform satisfactorily around 30 PSI; however, recommended pressure of each specific nozzle should be determined from its manufacturer's catalog. If the desired GPM could not be obtained at the recommended pressure, then the pressure should be adjusted. Because nozzle flow rate varies in proportion to the square-root of the pressure (Equation 4), only minor adjustment could be achieved by changing pressure. Major adjustments require the use of smaller or larger nozzles.

$$PSI_1 = PSI_2 \times \left(\frac{GPM_2}{GPM_1}\right)^2$$

where:

PSI_2 = Correct operating pressure

PSI_1 = Recommended pressure

GPM_2 = Desired flow rate

GPM_1 = Flow rate PSI_1

Equation 4.

$$GPA = \frac{GPM \times 5{,}940}{GS \times NS}$$

or

$$GPM = \frac{GPA \times GS \times NS}{5{,}940}$$

where:
GPA = Application rate (gal/acre)
GPM = Flow rate per nozzle (gal/min)
GS = Sprayer ground speed (mile/h)
NS = Nozzle spacing (in)
Equation 5.

$$GPM = \frac{GPM \times NN \times 495}{GS \times RS}$$

where:
NN = Number of nozzles
RS = Row spacing (ft)
Equation 6.

Droplet size spectra and distribution patterns of nozzles vary substantially and largely depend on nozzle type, flow rate, operating pressure, and spray angle. Flat fan nozzles generate relatively smaller droplets, whereas drift-reducing nozzles produce larger droplets. Extended-range nozzles adjust the droplet size over a wide range of nozzle pressures. Flooding nozzles produce a wide spray angle and flat pattern. Nozzles with solid or hollow cone spray patterns may also be used in some postemergence herbicide applications.

Most of the available nozzles have spray angles ranging from 65° to 140°. The nozzle's designated angle corresponds to the rated pressure. Spray angle increases or decreases at higher or lower pressures, respectively. Nozzle wear not only increases the angle and output, but it also distorts spray distribution pattern to some extent.

Spray Distribution

Unlike tree sprayers, nozzles used on herbicide equipment should be uniform (same type, material, capacity, and spray angle). Using a variety of nozzles on a boom results in uneven distribution patterns. However, herbicide applicators used in citrus may include an off-center nozzle tip (at the end of the boom) to extend the coverage beyond the end of the boom and cover the area around the tree trunk. It is normally mounted on a swivel body, a few inches beyond the last main nozzle.

Nozzles that generate tapered-edge patterns (e.g., flat fan) need some pattern overlap in order to obtain a reasonably uniform distribution across the spray swath. The amount of pattern overlap depends on nozzle spacing, boom height, and spray angle. Nozzles used on citrus herbicide applicators are normally mounted on 10–12 inch centers and operated at a height of 12–14 inches. Smaller spray angles require higher nozzle (boom) height in order to achieve acceptable pattern overlap (usually 30%–50%). Some nozzles may require 50%–100% pattern overlap. Nozzle catalogs normally specify optimum spacing, height, and overlap for each nozzle type. For a given nozzle flow rate, an improper boom height setting or vertical movement of the boom will result in uneven distribution (untreated bands or larger-than-desired treatment areas) across the spray swath.

Herbicide Sprayer Calibration

Application rate depends on nozzle flow rate (function of orifice size and operating pressure), number of nozzles, row spacing, and ground speed. Equations 5 and 6 show the relationships among these factors for broadcast and directed sprays, respectively.

The quality of calibration depends on accuracies of the nozzle flow rate and ground speed measurements. To ensure accurate nozzle flow rate, flow regulator(s) and pressure gauge(s) must be in working order. The latter should have a reasonable range in order to provide accurate reading of the system pressure.

Because nozzle capacity tabulations (in catalogs) are based on pressure at the nozzles, the gauge closer to the nozzles should be used in calibration. In-line strainers and nozzle filters (screens) should be clean in order to avoid any restriction in the nozzle flow. Calibration procedures are similar to those mentioned for tree sprayers. They include: a) determining the amount of the tank mix (gallons) used to spray a known area (acres), b) operating the sprayer in a fixed position and measuring the amount of discharged water (tank refill gallons) for a given time (minutes), or c) determining the nozzle discharge rate (gal/min). If the calculated GPA was not the same as the desired GPA, then ground speed and/or nozzle pressure should be changed. The latter could only be used for minor adjustments. See UF/IFAS Factsheet HS-1012, *Citrus Herbicide Boom Sprayer Calibration* (https://edis.ifas.ufl.edu/hs252), for more information.

Equation 7 determines the ground speed. See UF/IFAS Circular 1435, *Calibration of Airblast Sprayers* (https://edis.ifas.ufl.edu/ae238), for detail of procedures for ground speed measurement.

$$GS = \frac{TD \times 60}{TT \times 88}$$

where:
GS = Sprayer ground speed (mile/h)
TD = Travel distance (ft)
TT = Travel time (sec)
Equation 7.

Best Management Practices (BMPs) for Pesticide Applications

As mentioned earlier, pesticides can be expected to be effective if the right material is applied at the right amount, on the right target, at the right time, with the right sprayer, and under the right weather conditions. Read the product label for specific information, pertinent regulations, and safety recommendations. Follow the federal, state, and local government laws and regulations carefully. The following general BMP guidelines apply to most spraying practices.

1. Identify the nature of the pest that is causing the problem (consult with an Extension agent, plant pathologist, entomologist, etc.).

- Determine whether it is located on the canopy or in the root system, outside or inside the canopy, and on the upper or lower leaf surface.
- In case of weeds, identify their types and whether they are spread under trees or in the row middle.
- Learn about pest biology and its interaction with trees and fruit growth stage.
- Find out if the pest could be controlled by cultural practices and/or nonchemical methods.
- If chemical control is the preferred method, what category of pesticides may provide the desired solution?

2. Find out about the timing of the application.

- Scout the grove/field to establish the pest threshold level.
- Determine the optimum application window for effective control of the pest.
- Try to apply the pesticide when the pest is most vulnerable. It is very important to deal with pests at the most vulnerable biological or growth stages in their life cycles. Pesticide applications beyond the optimum window are likely to result in less efficacious pest control.
- Make sure the application will be completed several hours before a rain shower.

3. Select an appropriate pesticide (insecticide, fungicide, herbicide, etc.).

- Make sure the selected pesticide has been proven effective against the specific pest and registered for the intended use.
- Choose the least persistent and lowest toxicity pesticide.
- Make sure it will not generate phytotoxicity or pest resistance under intended use conditions.
- Check its compatibility with other products that will be included in the tank mixture.
- Learn about proper storage of the material to prevent chemical breakdown and fire hazards (read the label).
- Some pesticides specify the use of specific adjuvants to improve physical and/or chemical properties of the product. Select the right adjuvant and use it at the right rate in order to achieve the desired objective.

4. Determine the right amount (application rate) for the intended application.

- This information could be found on the label. It is usually specified as gallons, pints, pounds, or ounces of the product per grove or treated acre.
- Consider the application time and the target growth stage for suggested dose transfer.
- Adjust the rate according to the tree size, row spacing, pest pressure, and other pertinent factors.

5. Use properly calibrated equipment.

- Make sure the sprayer is in good working condition. Examine the pump, nozzles, manifolds, hoses, regulators, pressure gauges, etc. Clean all nozzle screens and inline strainers.
- Read the label for limitations on spray droplet size (spray classification category) and suggestions for drift mitigation near the sensitive areas. Select the right nozzle type, size, and pressure for the job. Make sure the selected nozzles are consistent with the label's spray quality recommendation (i.e., very fine, fine, medium, coarse, very coarse, or extremely coarse). Use nozzles that generate a minimal percentage of smaller drift-prone droplets at the specified operating pressure. Consider using "low-drift" nozzles when available.

- Check nozzle spacing, nozzle angle, and boom height to make sure there is sufficient pattern overlap for uniform spray coverage.
- In airblast applications, adjust the orientations of nozzles and air deflectors to direct the spray cloud onto the tree canopy only.
- Check the functionality of the sprayer agitation system (mechanical or hydraulic). Some formulations have specific mixing requirements.
- Be careful about the order of material addition into the tank. Usually, adjuvants are added before pesticides. Refer to the product label for recommended mixing order.
- Use only clean water free from dirt, sand, algae, etc. Algae quickly clog the strainers and nozzles. Sand and other abrasive particles expedite pump and nozzle wear. Other contaminants may react with the pesticide and reduce its effectiveness. Water pumped from ditches or ponds should be filtered before filling the tank.
- Examine the uniformity of the tank mixture. This is more critical when using wettable powder or dry formulations, particularly with irregularly shaped tanks featuring sharp corners. Premixing the chemicals in a small container could help uniform mixing in the sprayer tank.
- Follow the label recommendations for avoiding drift from highly volatile formulations.
- Use an appropriate ground speed based on the tractor/sprayer capabilities, terrain conditions, boom stability requirements, etc. Make sure the intended ground speed will be achieved during the application. Check the tire pressure.
- Monitor the operation of the nozzles during the application. Observe the output pattern of nozzles periodically. Nozzle clogging and changes in nozzle pressure and ground speed will affect the actual application rate.
- Carry spare nozzles, screens, washers, etc. for quick adjustments/repairs in the field.

6. Apply pesticide under the right weather conditions.

- If possible, avoid spraying during hot, dry, or windy weather conditions. Nighttime applications could increase spray deposition and reduce drift.
- Avoid spraying during stable (inversion) conditions (early morning and early evening) when there is little or no vertical mixing of the air. These conditions generate concentrated drift clouds and increase the chance of drift fallout.
- Stop spraying a few hours before rain showers. Allow sufficient time for sprays to dry and form reasonably durable deposits.
- Monitor wind direction and do not spray when there are sensitive crops/areas immediately downwind.
- Keep records of air temperature, relative humidity, wind speed, and wind direction. These records as well as equipment and application information may be very helpful in dealing with drift-related litigation.

7. Follow the safety instructions.

- Read the most recent product label. Look at the signal word (Danger, Warning, Caution). It gives an indication of the pesticide toxicity level.
- Learn about the environmental hazards (effects on wildlife, water resources, etc.) associated with using the product.
- Read the label for recommended personal protective equipment (coveralls, boots, gloves, goggles, respirators, etc.). Wear protective clothing during equipment calibration, loading, mixing, spraying, and cleanup.
- Before mixing and applying the pesticide, learn about using the first aid and medical treatment in an accident.
- Minimize the spray mixture leftover and rinsate (mix right amount as needed).
- If possible, use formulations that are packaged in returnable or refillable containers.
- Clean the sprayer shortly after task completion. This practice not only increases equipment life but also reduces the chance of pesticide cross contamination.
- Rinse and dispose the pesticide containers properly as directed by the label.
- Follow all safety guidelines related to the operation of the equipment (tractor, sprayer, nurse tank, etc.).
- If available, use sprayers equipped with a canopy sensing system (UF/IFAS Factsheet HS-872, *Sensor-Controlled Spray Systems for Florida Citrus*, http://ufdc.ufl.edu/IR00002701/00001). The system helps to direct the pesticide to the intended target more precisely, thereby reducing pesticide wastage and environmental contamination.

8. Prevent point-source pollution of pesticides.

- Store your pesticides in a properly constructed and secured storage room. The storage area should have a smooth floor with no connection to a drainage system. It should be equipped with nonabsorbent sturdy shelves, a first aid kit, a fire extinguisher, measuring cups/jugs, and absorbent inert material (to confine spillage). It should display hazard classification symbols, clear instructions for dealing with spillage, and emergency phone numbers. Note that the locker containing personal protective equipment should not be located inside the storage area.

- Store the empty packages/containers of solid/liquid pesticides inside the storage room and dispose of them in a legal way (never burn or bury in the field).
- Use a lockable and securely fixed box to transport the pesticides to the field safely. Do not leave pesticides in a place that is accessible to unauthorized users or children. In case of accident, contact emergency phone numbers.
- Make sure the sprayer tank lid is closed tightly and the tank, pump, strainers, manifolds, and nozzles do not leak. Use antidrip nozzles.
- Fill the tank in a bounded filling station or in the field (away from surface water). If filling in the field, use a tray to collect any accidental spill. Do not overfill the tank and do not insert the water pipe/ hose inside the tank (avoid tank mix contact with water supply). Load powder formulations through induction hopper, if available.
- Rinse empty containers during filling, using the rinsing nozzle or a water hose. Pour the rinsate in the tank.
- Clean the sprayer in a bounded area (with collection system) or in a grassy field (away from surface water). Never drain undiluted spray liquid in the field.
- Do not spray in the buffer zones around lakes, water wells, or along streams and drainage ditches.
- Do not use an airblast sprayer for spraying small trees or bushes. Use a recirculating tunnel sprayer or similar equipment to minimize spray losses to the environment.

2020–2021 Florida Citrus Production Guide: Best Management Practices for Soil-Applied Agricultural Chemicals[1]

Davie M. Kadyampakeni and Larry W. Duncan[2]

During the past few decades, certain pesticides and nitrates have been detected in some shallow groundwater locations on the sandy Ridge soils of central Florida. Federal and state regulatory agency emphasis on the protection of groundwater and all drinking water supplies has already restricted the timing and use of certain widely used agricultural chemicals. As a result of these concerns and development of more stringent regulatory policies and best management practices (BMPs), growers will have to assume increasingly more responsibility for the crop management practices they choose and the environmental fate of the agricultural chemicals they use. In this regard, specific BMPs are currently being implemented to optimize crop production and environmental protection for both Ridge and Flatwoods citrus production. In this state-sponsored, voluntary program, citrus growers are encouraged to develop and adopt site-specific BMP plans for controlling agrichemical contamination of state water resources. Growers who formally adopt BMPs and can produce a documented plan will receive a waiver of liability from the state for any inadvertent environmental contamination events. Many different environmental factors and management components can be involved in the BMP plan.

To prevent or reduce the movement of chemicals to groundwater, users must consider many different site-specific BMPs, including the following: integration of crop and pest management strategies, product selection, application rates, timing, placement in relation to the root system, weed cover, soil properties, and irrigation management strategies.

Application Rates, Frequency, Timing, Placement, and Other Considerations

Integrated pest management (IPM) requires 1) monitoring activities for the presence and abundance of pests within the grove; 2) determining whether pest population densities are high enough to cause economic loss; and 3) selection of a profitable, worker-safe, and environmentally compatible management option. Pesticide application should only be considered after the results of monitoring activities have been completed and other potential causes of tree or grove decline are evaluated and corrected. In addition, a truly integrated strategy requires consideration of pesticide selection, when the choice exists, prior to application.

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2. Davie M. Kadyampakeni, assistant professor, Department of Soil and Water Sciences, and Larry W. Duncan, professor, Entomology and Nematology Department, UF/IFAS Citrus Research and Education Center, Lake Alfred, FL 33850.

Pesticide selection should not be based only on cost-effectiveness, but also on mode of action rotation to avoid resistance buildup, toxicity to nontarget species, product solubility, persistence, leaching potential, irrigation schedule, soil type, and other site characteristics. Various sources of information are available for characterizing specific soil types and irrigation schedules for predicting and minimizing movement and leaching potential of most citrus agrochemicals.

Once a need for pest control has been established and a chemical has been selected, the grower must decide on rate and timing of application. Agricultural chemicals should be applied only at the labeled or recommended rates. Lower rates applied more frequently combined with sound irrigation management practices can significantly reduce chemical movement beyond the root zone. Split applications of pesticides or fertilizers will reduce the amount applied at any one time, thereby reducing the amount that might be leached at a given time.

Controlled release (encapsulated) formulations, when available, also provide the advantage of reduced leachability.

The timing for application of most pest management/crop production chemicals should not be based on the calendar but on pest population biology, abundance, and tree growth periods. Applications during the summer rainy season should be avoided whenever possible. In some instances, pests may require treatment during times when rainfall can be expected, but if heavy rainfall is imminent, application should be delayed and subsequent irrigations adjusted to account for rainfall amounts.

Most soilborne pests are associated with citrus roots. For pesticide applications targeting soilborne pests and diseases, pesticide efficacy occurs primarily within the zone of application, and to a much lesser degree, due to the systemic activity of these pesticides, within and around roots outside of the zone of application. Because a large majority of fibrous roots grow within the top 24–30 inches of soil and decrease in abundance from the tree trunk to the row middle, pesticide placement to maximize undercanopy coverage is of critical importance. Pesticide placement under the tree canopy can significantly improve overall pest control and minimize leaching by targeting applications to areas of highest fibrous root and pest density. Tree skirts may need to be raised by pruning to improve application equipment access under the tree canopy.

Cultural practices that promote excessive vegetative growth, such as overwatering and excessive nitrogen fertilization, can intensify some pest problems and should be avoided in the control of some plant diseases (e.g., Alternaria brown spot). Undercanopy weed growth may reduce pesticide effectiveness by interception or absorption of pesticide residues targeted for citrus roots or pests in the soil. Undercanopy weeds also interfere with microsprinkler operation and prevent uniform coverage of chemigated compounds. At the individual tree level, excessive irrigation coupled with unmanaged weed growth can promote localized deep soil penetration of soil-applied pesticides or fertilizers, resulting in groundwater contamination.

Soil and Chemical Properties

The potential for leaching of agricultural chemicals below the root zone depends on both soil and chemical characteristics. Persistence, sorption, and water solubility are the primary characteristics of chemicals that determine leaching potential. One of the most important soil characteristics in determining leaching potential of many agricultural chemicals is organic matter. Leaching is lower for soils with high organic matter content. Deep Ridge sands are low in organic matter (typically less than 1%) and are particularly vulnerable to leaching. A list of vulnerable soils that allow chemicals to be easily leached may be obtained from the Natural Resources Conservation Service (NRCS, formerly Soil Conservation Service).

Chemical persistence is the length of time required for a material to break down and is often expressed in terms of half-life. Half-life is the amount of time required for one-half of the applied pesticide to be broken down in the soil. Pesticides in the soil are bound to soil particles, particularly organic matter, through a process called sorption. This binding retards their movement through the soil. A useful means of quantifying pesticide sorption on soils is the partition coefficient (K_{oc}), which is defined as the relative affinity or attraction of a pesticide to soil materials. Pesticides with a high K_{oc} are strongly adsorbed and thus less subject to leaching.

Chemicals with shorter half-lives and higher K_{oc} values are less likely to contribute to groundwater contamination. If possible, more leachable products should be used during the drier seasons. Products with short half-lives and high K_{oc} values should be reserved for periods of high rainfall, if needed.

Irrigation

Both rain and irrigation water move agricultural chemicals through the soil. Hence, it is important to consider best management irrigation practices that minimize water movement below the root zone. Failure to irrigate properly may jeopardize the future use of some important soil-applied chemicals. The ability of soils to hold water affects their ability to retain pesticides and nutrients. Many Ridge soils have a low water-holding capacity and a high hydraulic conductivity, which allows water to easily percolate through the soil. These soils require frequent irrigation. If more water is applied than is used by the tree, water will move below the root zone. Repeated irrigation or rainfall events will leach soluble nutrients and pesticides below the root zone where they become both economic losses and potential pollutants of groundwater.

Excessive irrigation and rainfall can also promote population buildup of some pests such as various weeds, *Phytophthora*, and *Alternaria*. Reduced residence time of pesticide compounds in shallow soil horizons contributes to losses in production efficiencies and pest control efficacy. To avoid premature leaching from the root zone, soil-applied fungicides, nematicides, insecticides, herbicides, and fertilizers should be targeted to undercanopy areas of highest fibrous root density and should not be followed by excessive irrigation. Given the sandy, permeable nature of citrus soils and their low soil organic matter content, irrigation schedules based on soil moisture deficits are likely both to improve pest control and grove response to treatment by maximizing retention of toxic concentrations in the citrus tree root zone as well as to prevent problems of environmental contamination.

Best management water-use practices currently rely upon the use of accounting methods or the use of soil water sensors (e.g., tensiometers, capacitance probes, or other sensors) and irrigation apps for determining when and how much irrigation water to apply during any single application. Irrigation based on tensiometers will likely require the instruments to be installed at two depths in the well-drained soils of the Central Ridge. Irrigation will be scheduled when either tensiometer reaches a specified set point of soil water depletion, and the deeper tensiometer can be monitored to ensure that no water moves below the root zone. Irrigation by the budget method requires a computer and daily inputs of rainfall, irrigation, and evapotranspiration data. The set points for irrigation are based on accumulated daily depletion of available soil water throughout the profile and on tree growth stage. The irrigation app provides the guideline for when water content in the root zone reaches a critical point, e.g., below 25% to 33% of available water, thereby prompting an irrigation event to occur.

The diameter and application rate to the wetted under-canopy area and the water-holding capacity of the soil are necessary information to determine the duration of irrigation that will wet to only the appropriate root zone depth. Data on the water-holding capacity of citrus soils can be found in UF/IFAS publications SL 193, *Common Soils Used for Citrus Production in Florida* (available at http://ufdc.ufl.edu/IR00003134/00001); Circular 1127, *Citrus Fertilizer Management on Calcareous Soils* (available at https://edis.ifas.ufl.edu/ch086); Circular 1410, *Fertigation Nutrient Sources and Application Considerations for Citrus* (available at https://edis.ifas.ufl.edu/pdffiles/CH/CH18500.pdf); or in the soil survey report for each county.

It is total volume of irrigation water and not necessarily duration or irrigation run time of the sprinklers that is important in driving the movement of chemicals through the soil profile. Careful planning and management of irrigation can improve pesticide and fertilizer efficacy and reduce the potential for groundwater contamination. For more information on microirrigation management, see UF/IFAS publications Circular 1406, *Understanding Water Quality Parameters for Citrus Irrigation and Drainage Systems* (available at http://edis.ifas.ufl.edu/ch176); Circular 1413, *Control and Automation in Citrus Microirrigation Systems* (available at https://edis.ifas.ufl.edu/ch194); Bulletin 265, *Field Evaluation of Microirrigation Water Application Uniformity* (available at http://edis.ifas.ufl.edu/ae094); and HS958, *Management of Microsprinkler Systems for Florida Citrus* (available at https://edis.ifas.ufl.edu/hs204).

2020–2021 Florida Citrus Production Guide: Interpreting PPE Statements on Pesticide Labels[1]

Frederick M. Fishel[2]

This document helps you understand the revised PPE statements now part of labels on pesticide products used on farms, forests, nurseries, and greenhouses.

Background

Many Personal Protective Equipment (PPE) statements on pesticide labels have been changed as a result of the Worker Protection Standard for Agricultural Pesticides (WPS). These revised statements are more precise on the type of PPE that must be worn by pesticide handlers (mixers, loaders, and applicators). The terminology used to describe the required PPE is now more consistent from label to label. The tables accompanying this document list **LABEL STATEMENTS** used to describe the PPE required for use by mixers, loaders, and applicators.

The column headed **ACCEPTABLE PPE** describes the options the pesticide handler has when the label statement lists a specific item of PPE. The tables are grouped by subject, as follows:

Table 1—Body Protection

Table 2—Hand Protection

Table 3—Eye Protection

Table 4—Foot Protection

Table 5—Respiratory Protection

Table 6—Head Protection

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Use pesticides safely. Read and follow directions on the manufacturer's label.

Table 1. Personal protective equipment (PPE) statements (body protection)

Label Statement	Acceptable PPE
Long-sleeved shirt and long pants	Long-sleeved shirt and long pants, or
	Woven or nonwoven coverall, or
	Plastic- or other barrier-coated coverall, or
	Rubber or plastic suit
Coverall worn over short-sleeved shirt and short pants	Coverall worn over short-sleeved shirt and short pants, or
	Coverall worn over long-sleeved shirt and long pants, or
	Coverall worn over another coverall, or
	Plastic- or other barrier-coated coverall, or
	Rubber or plastic suit
Coverall worn over long-sleeved shirt and long pants	Coverall worn over long-sleeved shirt and long pants, or
	Coverall worn over another coverall, or
	Plastic- or other barrier-coated coverall, or
	Rubber or plastic suit
Chemical-resistant apron worn over coverall or over long-sleeved shirt and long pants	Chemical-resistant apron worn over coverall or long-sleeved shirt and long pants, or barrier-coated coverall, or suit
	Plastic or other barrier-coated coverall, or
	Rubber or plastic
Chemical-resistant protective suit	Plastic- or other barrier-coated coverall, or
	Rubber or plastic suit
Waterproof suit or liquid-proof suit	Plastic- or other barrier-coated coverall, or
	Rubber or plastic suit

Table 2. Personal protective equipment (PPE) statements (hand protection)

Label Statement	Acceptable PPE
Waterproof gloves	Any rubber or plastic gloves sturdy enough to remain intact throughout the task being performed
Chemical-resistant gloves	Barrier-laminate gloves, or
	Other gloves that glove selection charts or guidance documents indicate are chemical-resistant to the pesticide for the period of time required to perform the task
Chemical-resistant gloves such as butyl or nitrile	Butyl gloves, or
	Nitrile gloves, or
	Other gloves that glove selection, charts, or guidance documents indicate are chemical-resistant to the pesticide for the period of time required to perform the task

Table 3. Personal protective equipment (PPE) statements (eye protection)

Label Statement	Acceptable PPE
Protective eyewear	Shielded safety glasses, or
	Face shield, or
	Goggles, or
	Full-face respirator
Goggles	Goggles, or
	Full-face respirator

Table 4. Personal protective equipment (PPE) statements (foot protection)

Label Statement	Acceptable PPE
Shoes	Leather, canvas, or fabric shoes, or
	Chemical-resistant shoes, or
	Chemical-resistant boots, or
	Chemical-resistant shoe coverings (booties)
Chemical-resistant boots	Chemical-resistant boots

Table 5. Personal protective equipment (PPE) statements (respiratory protection)

Label Statement	Acceptable PPE
Cartridge respirator	Respirator with organic vapor-removing cartridge and pesticide prefilter, or
	Respirator with canister approved for pesticides, or
	Air-supplying respirator
Air-supplying respirator or self-contained breathing apparatus (SCBA)	Air-supplying respirator, or
	Self-contained breathing apparatus
Dust/mist filtering respirator	Dust/mist filtering respirator, or
	Respirator with dust/mist filtering cartridge, or
	Respirator with organic vapor-removing cartridge and pesticide prefilter, or
	Air-supplying respirator
Canister respirator (gas mask)	Respirator with canister approved for pesticides, or
	Air-supplying respirator

Table 6. Personal protective equipment (PPE) statements (head protection)

Label Statement	Acceptable PPE
Chemical-resistant hood or wide-brimmed hat	Rubber or plastic-coated safari-style hat, or
	Rubber or plastic-coated firefighter-style hat or
	Plastic- or other barrier-coated hood, or
	Rubber or plastic hood, or
	Full hood or helmet that is part of some respirators

2020–2021 Florida Citrus Production Guide: Quick Reference Guide to the Worker Protection Standard (WPS)[1]

Frederick M. Fishel[2]

For the complete details of the WPS, refer to *How to Comply with the 2015 Revised Worker Protection Standard For Agricultural Pesticides: What Owners and Employers Need To Know* (https://www.epa.gov/pesticide-worker-safety/pesticide-worker-protection-standard-how-comply-manual).

Introduction

The Worker Protection Standard (WPS) is a regulation originally issued by the US Environmental Protection Agency (EPA) in 1992 and most recently revised in 2015. This regulation is primarily intended to reduce the risks of illness or injury to workers and pesticide handlers resulting from occupational exposures to pesticides used in the production of agricultural plants on agricultural establishments (i.e., farms, forests, nurseries, and enclosed space production facilities such as greenhouses). Workers are generally those who perform hand-labor tasks in pesticide-treated crops, such as harvesting, thinning, and pruning. Handlers are usually those that are in direct contact with pesticides through activities such as mixing, loading, or applying pesticides.

The WPS requires agricultural employers and commercial pesticide handler employers to provide specific information and protections to workers, handlers and other persons when WPS-labeled pesticide products are used on agricultural establishments in the production of agricultural plants. It also requires owners of agricultural establishments to provide certain protections for themselves and their immediate family, requires handlers to wear label-specified clothing and personal protective equipment when performing handler activities, and requires owners to take measures to protect workers and other persons during pesticide applications.

Overview of the 2015 Revisions

The 2015 revisions to the Worker Protection Standard cover many different topic areas. The major revisions include:

- Annual mandatory training to inform workers and handlers about the required protections afforded to them.
- Expanded training that includes instructions to reduce take-home exposure from pesticides on work clothing, as well as other safety topics.
- Prohibition on anyone under 18 years old from being a pesticide handler or doing early-entry work during a restricted-entry interval (REI).
- Expanded mandatory posting of no-entry signs for outdoor production (e.g., farms, forests, and nurseries) if the REI is greater than 48 hours.

1. This document is CPMG-07, one of a series of the Agronomy Department, UF/IFAS Extension. Original publication date December 1995. Revised March 2020. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

2. Frederick M. Fishel, professor, Agronomy Department, and director, Pesticide Information Office, UF/IFAS Extension, Gainesville, FL 32611.

- New application exclusion zones (AEZ) up to 100 feet surrounding pesticide application equipment intended to protect workers and others from pesticide exposure during pesticide applications.
- Providing more than one way for workers and handlers to gain access to pesticide application information and safety data sheets: the sheets must be centrally posted and available on request by the workers themselves, through medical personnel, or through a designated representative.
- If a respirator is required by the labeling, the employer must provide the handler with a medical evaluation, fit testing, and respirator training in compliance with the Occupational Safety and Health Administration's (OSHA's) Respiratory Protection Standard.
- Mandatory record-keeping to improve states' ability to follow up on pesticide violations and enforce compliance. Records of application-specific pesticide information, safety data sheets (SDS), worker/handler pesticide safety training and respirator medical evaluations, fit testing, and respirator training must be kept for 2 years.
- Antiretaliation provisions that are comparable to those of the US Department of Labor.
- If protective eyewear is required by the labeling, the employer must provide water for emergency eye flushing for handlers at pesticide mixing/loading sites.
- Expanded definition of immediate family and criteria for agricultural establishments that are eligible for the exemption for owners and their immediate families.
- Replaced the term "greenhouse" with "enclosed space production," which includes greenhouses, mushroom houses, hoop houses, high tunnels, and grow houses.

Implementation Dates of the New WPS Requirements

Effective January 2, 2017

- Annual mandatory training for workers and handlers.
- No grace period to train workers (there has never been a grace period to train handlers).
- Recordkeeping of handler and worker training.
- Minimum age requirement of 18 years old for pesticide handlers or early-entry workers entering into a treated site before the REI has expired.
- Expanded mandatory posting of no-entry signs for outdoor production (e.g., farms, forests, and nurseries) if the REI is greater than 48 hours.
- Recordkeeping and posting of pesticide application information and hazard information (i.e., SDS).
- Antiretaliation protections strengthened.
- Requirements for medical evaluation, fit testing, and specific training for use of respirators and the associated recordkeeping.
- Provide specific amounts of water to be used for routine decontamination.
- Provide water for emergency eye flushing for handlers at mixing/loading sites if protective eyewear is required by the pesticide product labeling.
- Continued exemption for owners and their immediate family with an expanded definition of immediate family.
- During pesticide applications, agricultural employers must keep workers and other persons out of the AEZ surrounding the pesticide application equipment within the establishment's property boundary.

Effective January 2, 2018

- Expanded training content for workers and handlers (January 2, 2018, or within 6 months of EPA making training materials available but not before January 2, 2018).
- The expanded content that must be included in the pesticide safety information display (safety posters).
- Suspending applications. The requirement for handlers to suspend applications if anyone, other than a trained and equipped handler involved with the application, is in the AEZ, which can extend beyond the establishment's property boundary.

Duties for all Employees

These requirements apply to agricultural employers and commercial pesticide handler employers, except for the pesticide safety, application, and hazard information requirements that apply only to agricultural employers.

Antiretaliation

Employers must not retaliate against a worker or handler who attempts to comply with the WPS, files a complaint, or provides information in an investigation of alleged WPS noncompliance.

Minimum Age Requirements

Ensure that early-entry workers and all handlers are at least 18 years old.

Pesticide Safety, Application, and Hazard Information

An agricultural employer must display or make certain information available on the establishment. Commercial pesticide handler employers do not have to comply with information display requirements.

1. Display or make available all of the information listed in #2 together in an easily accessible ("central") location on the agricultural establishment.

2. The information includes:

    - EPA WPS safety poster or equivalent information, which must include some additional information by January 2, 2018, and must be kept current.
    - Application information that includes:
        - Product name, EPA registration number, and active ingredient
        - Crop or site treated, location, and description of the treated area
        - Date, start and end times of the application, and duration of restricted-entry interval (REI).
    - A copy of the safety data sheet (SDS) for the formulated product for each WPS-labeled pesticide applied.

3. In addition, display the EPA WPS safety poster (or equivalent) where decontamination supplies are located at permanent sites and where decontamination supplies are provided for 11 or more workers.

4. Allow workers and handlers unrestricted access to all of the information and keep all of the displayed information current and legible.

5. Display the EPA WPS safety poster or equivalent information before an application takes place and for 30 days after the REI expires.

6. Display the SDS and application information within 24 hours of the application and before workers enter treated areas. This information must be displayed for 30 days after the REI expires and kept in records on the agricultural establishment until 2 years after the REI expires.

7. Provide the SDS and application information upon request of a worker, handler, designated representative, or medical personnel within 15 days.

Pesticide Safety Training

Ensure that workers are trained before performing tasks in a pesticide-treated area (REI in effect within the last 30 days). Ensure that handlers are trained before performing any handler activity. There is no grace period for worker or handler training.

1. Train workers and handlers annually.

2. Present training using EPA-approved materials either orally from written materials or audiovisually. After January 2, 2018, the training must cover additional topics.

3. Trainers must be certified applicators or have completed an EPA-approved train-the-trainer program or be designated by the state or tribal pesticide enforcement agency.

4. Training must be delivered in a manner the employees can understand, and the trainer must be present and respond to questions.

5. Maintain training records on the establishment for 2 years from the training date for each worker and handler required to be trained on the agricultural establishment.

Pesticide Safety Training Content (Workers)

The pesticide safety training for workers under the revised WPS must include all of the following after January 2, 2018:

- The responsibility of agricultural employers to provide workers and handlers with information and protections designed to reduce work-related pesticide exposures and illnesses. This includes ensuring workers and handlers have been trained on pesticide safety, providing pesticide safety and application and hazard information, decontamination supplies and emergency medical assistance, and notifying workers of restrictions during applications and on entering pesticide-treated areas. A worker or handler may designate in writing a representative to request access to pesticide application and hazard information.
- How to recognize and understand the meaning of the posted warning signs used for notifying workers of restrictions on entering pesticide-treated areas on the establishment.
- How to follow directions and/or signs about keeping out of pesticide-treated areas subject to a restricted-entry interval and application exclusion zones.

- Where and in what forms pesticides may be encountered during work activities, and potential sources of pesticide exposure on the agricultural establishment. This includes exposure to pesticide residues that may be on or in plants, soil, tractors, application and chemigation equipment, or used personal protective equipment, and that pesticides may drift through the air from nearby applications or be in irrigation water.
- Potential hazards from toxicity and exposure that pesticides present to workers and their families, including acute and chronic effects, delayed effects, and sensitization.
- Routes through which pesticides can enter the body.
- Signs and symptoms of common types of pesticide poisoning.
- Emergency first aid for pesticide injuries or poisonings.
- Routine and emergency decontamination procedures, including emergency eye-flushing techniques; how if pesticides are spilled or sprayed on the body to use decontamination supplies to wash immediately or rinse off in the nearest clean water, including springs, streams, lakes or other sources if more readily available than decontamination supplies; and as soon as possible, to wash or shower with soap and water, shampoo hair, and change into clean clothes.
- How and when to obtain emergency medical care.
- When working in pesticide-treated areas, wear work clothing that protects the body from pesticide residues and wash hands before eating, drinking, using chewing gum or tobacco, or using the toilet.
- Wash or shower with soap and water, shampoo hair, and change into clean clothes as soon as possible after working in pesticide-treated areas.
- Potential hazards from pesticide residues on clothing.
- Wash work clothes before wearing them again and wash them separately from other clothes.
- Do not take pesticides or pesticide containers used at work to your home.
- Safety data sheets providing hazard, emergency medical treatment and other information about the pesticides used on the establishment workers and handlers may come in contact with. Agricultural employers have a responsibility to do all of the following:
  - Display safety data sheets for all pesticides used on the establishment.
  - Provide workers and handlers information about the location of the safety data sheets on the establishment.
  - Provide workers and handlers unimpeded access to safety data sheets during normal work hours.
- The rule prohibits agricultural employers from allowing or directing any worker to mix, load or apply pesticides or assist in the application of pesticides unless the worker has been trained as a handler.
- The responsibility of agricultural employers to provide specific information to workers before directing them to perform early-entry activities. Workers must be 18 years old to perform early-entry activities.
- Potential hazards to children and pregnant women from pesticide exposure.
- Keep children and nonworking family members away from pesticide-treated areas.
- After working in pesticide-treated areas, remove work boots or shoes before entering your home, and remove work clothes and wash or shower before having physical contact with children or family members.
- How to report suspected pesticide-use violations to the state or tribal agency responsible for pesticide enforcement.
- The rule prohibits agricultural employers from intimidating, threatening, coercing, or discriminating against any worker or handler for complying with or attempting to comply with the requirements of this rule, or because the worker or handler provided, caused to be provided, or is about to provide information to the employer or the EPA or its agents regarding conduct that the employee reasonably believes violates this part, and/or made a complaint, testified, assisted, or participated in any manner in an investigation, proceeding, or hearing concerning compliance with this rule.

Pesticide Safety Training Content (Handlers)

The pesticide safety training for handlers under the revised WPS must include all of the training points/topics for workers *plus* the following after January 2, 2018:

- Information on proper application and use of pesticides.
- Handlers must follow the portions of the labeling applicable to the safe use of the pesticide.
- Format and meaning of information contained on pesticide labels and in labeling applicable to the safe use of the pesticide.

- Need for and appropriate use and removal of all personal protective equipment.
- How to recognize, prevent, and provide first-aid treatment for heat-related illness.
- Safety requirements for handling, transporting, storing, and disposing of pesticides, including general procedures for spill cleanup.
- Environmental concerns, such as drift, runoff, and wildlife hazards.
- Handlers must not apply pesticides in a manner that results in contact with workers or other persons.
- The responsibility of handler employers to provide handlers with information and protections designed to reduce work-related pesticide exposures and illnesses. This includes providing, cleaning, maintaining, storing, and ensuring proper use of all required personal protective equipment; providing decontamination supplies; and providing specific information about pesticide use and labeling information.
- Handlers must suspend a pesticide application if workers or other persons are in the application exclusion zone.
- Handlers must be at least 18 years old.
- The responsibility of handler employers to ensure handlers have received respirator fit testing, training, and medical evaluation if they are required to wear a respirator by the product labeling.
- The responsibility of agricultural employers to post treated areas as required by this rule.

Separate from the pesticide safety training, employers must tell workers and handlers where to find the following on the worksite: EPA WPS safety poster (or equivalent), application information, SDSs, and decontamination supplies.

Decontamination Supplies

1. Establish accessible decontamination supplies located together within ¼ mile of all workers (when required) and handlers.

    - 1 gallon of water per worker and 3 gallons of water per handler at the beginning of each work period for routine and emergency decontamination;
    - Plenty of soap and single-use towels. Note: hand sanitizers and wet towelettes are insufficient; and,
    - A clean coverall (or other clean change of clothes) for handlers.

2. Provide water that is safe and cool enough for washing, eye-flushing, and drinking. Do not use water that is also used for mixing pesticides unless steps are taken to ensure safety.

3. Provide handlers with decontamination supplies where personal protective equipment (PPE) is removed at the end of a task.

4. Provide handlers with decontamination supplies at each mixing and loading site.

5. When a product requires protective eyewear for handlers, and/or when using a closed system under pressure, provide the following in mixing and loading areas: a system that can deliver gently running water at 0.4 gallons per minute for at least 15 minutes or 6 gallons of water in containers suitable for providing a gentle eye-flush for about 15 minutes.

6. When applying a product that requires protective eyewear, provide 1 pint of water per handler in portable containers that are immediately available to each handler.

7. Do not put worker decontamination supplies in areas being treated or under an REI.

8. For handlers, decontamination supplies must be kept outside the treated area, or any area under an REI, unless they are protected from contamination in closed containers.

Employer Information Exchange

1. Before any application, commercial pesticide handler employers must make sure the owner/operator of an agricultural establishment where a pesticide will be applied is aware of:

    - Location and description of area to be treated;
    - Date of application, estimated start time and estimated end time of the application;
    - Product name, EPA registration number, active ingredient(s), and REI;
    - Whether the product label requires both oral warnings and treated area posting; and
    - All other safety requirements on labeling for workers or other people.

2. Owners/operators of agricultural establishments must make sure any commercial pesticide handler employer they hire is aware of:

- Specific location and description of any treated areas where an REI is in effect that the commercial handler may be in or walk within ¼ mile of; and
- Restrictions on entering those areas.

The commercial pesticide employer must pass this information along to the handler doing the work.

Emergency Assistance

If there is reason to believe a worker or handler has been exposed to pesticides, during or within 72 hours, and needs emergency medical treatment, employers must do the following:

1. Promptly make transportation available to an appropriate emergency medical facility.

2. Promptly provide to the treating medical personnel the following information related to each pesticide product to which the person may have been exposed:

   - Safety Data Sheet
   - Product name, EPA registration number, and active ingredient(s).
   - Description of how the pesticide was used on the agricultural establishment.
   - Circumstances that could have resulted in exposure to the pesticide.

Additional Duties for Worker Employers

These restrictions apply to agricultural employers who employ workers.

Restrictions during Applications

During pesticide applications, keep workers and everyone other than appropriately trained and equipped handlers out of the treated area (for all types of applications) and out of:

1. The application exclusion zone (AEZ) for outdoor production; or

2. A specified area that varies by the type of application until the ventilation criteria are met for enclosed space production.

Restricted-Entry Intervals (REIs)

Do not direct or allow any worker to enter or remain in the treated area until the REI has expired and all posted warning signs are removed or covered. Read the exceptions in the full reference: http://www.pesticideresources.org/wps/htc/htcmanual.pdf.

Notice about Applications

1. Orally warn workers and post treated areas if required by the pesticide labeling.

2. If not, post warning signs if the REI is greater than:

   - 48 hours for outdoor production; or
   - 4 hours for enclosed space production.

3. For all other applications, either orally warn workers or post warning signs.

Posted Warning Signs

1. Post legible 14″ × 16″ WPS-design warning signs no more than 24 hours prior to an application; keep posted during REI; remove or cover before workers enter and within 3 days after the end of the REI.

2. Post signs so they can be seen at all reasonably expected entrances to treated areas.

3. Warning signs can be smaller than 14″ × 16″ under certain conditions. All warning signs must meet specific requirements.

Oral Warnings

1. Before each application, tell workers who are on the establishment (in a manner they can understand):

   - Location and description of treated area;
   - Date and times entry is restricted; and
   - AEZ, REI, and not to enter during REI.

2. Workers who enter the establishment after application starts must receive the same warning at the start of their work period.

Additional Duties for Handler Employers

These requirements apply to commercial pesticide handler employers and agricultural employers who employ handlers.

Application Restrictions and Monitoring

1. Do not allow handlers to apply a pesticide so that it contacts, directly or through drift, anyone other than appropriately trained and equipped handlers.

2. Handlers must suspend applications when anyone other than appropriately trained and equipped handlers enters the AEZ. This goes into effect on January 2, 2018.

3. When anyone is handling a highly toxic pesticide with a skull-and-crossbones, maintain sight or voice contact every 2 hours.

4. Make sure a trained handler equipped with labeling-specific PPE maintains constant voice or visual contact with any handler in an enclosed space production site (e.g., greenhouses, high tunnels, indoor grow houses) while applying a fumigant.

Specific Instructions for Handlers

1. Before handlers do any handling task, inform them, in a manner they can understand, of all pesticide labeling instructions for safe use.

2. Ensure that the handler has access to product labeling during the entire handling task.

Equipment Safety

1. Inspect pesticide handling equipment before each day of use, and repair or replace as needed.

2. Allow only appropriately trained and equipped handlers to repair, clean, or adjust pesticide equipment that contains pesticides or residues, unless they are not employed on the establishment. See Additional Agricultural Employer Duties for information regarding nonemployed persons.

Personal Protective Equipment (PPE) Handlers Must Use

1. Provide handlers with the PPE required by the pesticide labeling, and be sure it is:

    - Clean and in operating condition;
    - Worn and used according to the manufacturer's instructions;
    - Inspected before each day of use; and
    - Repaired or replaced as needed.

2. When a respirator is required by product labeling, provide handlers with:

    - A medical evaluation to ensure the handler is physically able to safely wear the respirator;
    - Training in respirator use; and
    - A fit test to ensure the respirator fits correctly.
    - Keep records on the establishment of these items for 2 years.

3. Take steps to avoid heat-related illness when labeling requires the use of PPE for a handler activity.

4. Provide handlers a pesticide-free area for:

    - Storing personal clothing not in use;
    - Putting on PPE at start of task; and
    - Taking off PPE at end of task.

5. Do not allow used PPE to be taken home.

Care of PPE

1. Store and wash used PPE separately from other clothing and laundry.

2. If PPE will be reused, clean it before each day of reuse, according to the instructions from the PPE manufacturer, unless the pesticide labeling specifies other requirements. If there are no other instructions, wash in detergent and hot water.

3. Dry the clean PPE before storing.

4. Store clean PPE away from personal clothing and apart from pesticide-contaminated areas.

Replacing Respirator Purifying Elements

1. Replace particulate filters or filtering facepiece respirators when any of the following conditions is met:

    - When breathing becomes difficult;
    - When the filter is damaged or torn;
    - When the respirator label or pesticide label requires it;
    - After 8 total hours of use, in the absence of any other instructions or indications of service life.
    - Replace vapor-removing cartridges/canisters when any following condition is met:
    - When odor/taste/irritation is noticed;

- When the respirator label or pesticide label requires it (whichever is shorter);
- When breathing resistance becomes excessive; or
- After 8 total hours of use, in the absence of any other instructions or indications of service life.

Disposal of PPE

1. Discard, do not clean, coveralls and other absorbent materials that are heavily contaminated with pesticide having a signal word "DANGER" or "WARNING." When discarding PPE, ensure that it is unusable as apparel or made unavailable for further use.

2. Follow federal, state, and local laws when disposing of PPE that cannot be cleaned correctly.

Instructions for People Who Clean PPE

The handler employer must inform people who clean or launder PPE:

1. That PPE may be contaminated with pesticides;

2. Of the potential for harmful effects of exposure to pesticides;

3. How to protect themselves when handling PPE;

4. How to clean PPE correctly; and

5. Decontamination procedures to follow after handling contaminated PPE.

Additional Agricultural Employer Duties

Before allowing persons not directly employed by the establishment to clean, repair, or adjust pesticide application equipment, provide the following information:

1. The equipment may be contaminated with pesticides;

2. The potentially harmful effects of pesticide exposure;

3. How to handle equipment to limit exposure to pesticides; and

4. How to wash themselves and/or their clothes to remove and prevent exposure to pesticide residues.

Employer Responsibilities for Supervisors and Labor Contractors

Employers must provide sufficient information to supervisors and/or labor contractors to ensure compliance with the revised WPS. Specify:

- The tasks supervisors/labor contractors must do; and
- The information they must provide to workers/handlers.

Employers are liable for a penalty under FIFRA if a supervisor or labor contractor acting for them fails to comply with the revised WPS requirements.

Additional Information

Fishel, Fred M., and Tatiana Sanchez. 2016. *Worker Protection Standard: Application Exclusion Zone (AEZ)*. PI263. Gainesville: University of Florida Institute of Food and Agricultural Sciences. https://edis.ifas.ufl.edu/pi263

US EPA. 2016. *How to Comply with the 2015 Revised Worker Protection Standard for Agricultural Pesticides: What Owners and Employers Need to Know. EPA 735-B-16-001. United States Environmental Protection Agency*. https://www.epa.gov/pesticide-worker-safety/pesticide-worker-protection-standard-how-comply-manual

2020–2021 Florida Citrus Production Guide: Food Safety Requirements and Considerations for the Florida Citrus Grower[1]

Travis K. Chapin, Michelle D. Danyluk, Renée M. Goodrich-Schneider, Keith R. Schneider, Matt Krug, Mark A. Ritenour, and Tripti Vashisth[2]

Introduction and Objective

Florida citrus growers have long implemented *Good Agricultural Practices (GAPs)*, preharvest practices (e.g., in the field or before the farm gate) established to prevent, minimize, or eliminate contamination and hazards to human health. Essential components of the GAPs process include careful planning, implementation, and documentation of required steps and procedures that together analyze and minimize risks from biological, chemical, and physical hazards.

The development of GAPs is based on sound science, including peer-reviewed scientific literature as well as outbreak investigations related to various fresh produce commodities. The Produce Safety Rule (PSR) of the Food Safety Modernization Act (FSMA) formalized and codified many of the previously voluntary GAPs that growers have practiced for many years. GAPs related to citrus will continue to evolve as new information evolves. Growers represent the first step in the farm-to-table food chain. Growers with a strong GAPs program will be well-positioned to meet the evolving market-driven demands and regulatory requirements.

The objective of this document is to present general GAPs principles and PSR requirements needed to plan, execute, and document production practices that will prevent, minimize, or eliminate the possibility of fruit contamination. The materials contained in this document are a combination of recommendations based on the best available science and minimum standards outlined in the PSR. The distinction between voluntary GAPs recommendations and PSR requirements is made in this document by the deliberate use of the words "must" and "should," where "must" is used to denote PSR requirements and "should" is used to denote voluntary GAPs. This document will be reviewed and updated as new risk data emerges; it is not a comprehensive list of all PSR requirements.

Background

While the consumption of whole fresh citrus fruit has not been associated with foodborne illness, GAPs represent important procedures that Florida citrus growers should follow to minimize the potential for fruit contamination and meet certain requirements of the PSR. Florida's citrus growers, processors, and fresh-fruit packers have invested considerable resources developing and implementing food

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safety protocols and participating in third-party audit programs. Many growers are documenting production, harvest, and transportation practices before the farm gate as part of their normal operations to mitigate the potential for foodborne illnesses, and packers also adhere to their own food safety requirements. Citrus juice processors implement the *Hazard Analysis and Critical Control Point Program (HACCP),* which is required by the FDA (21 CFR Part 120). Farm owners and managers who produce citrus intended for fresh-squeezed juice should be aware of and follow the Juice HACCP regulation in that rule.

GAPs are a prerequisite of these fresh-citrus packing and juicing food safety requirements. Although a full HACCP or Preventive Controls for Human Food program with carefully controlled processes is not possible in an outdoor grove environment, the principles of hazard analysis and preventive measures can and need to be applied. A GAPs program that has been developed, supervised, and properly implemented protects the health of consumers and the producer's investment in the product.

In general, GAPs programs (https://edis.ifas.ufl.edu/topic_series_food_safety_on_the_farm) address the potential risk of three types of contamination or hazard:

1. Biological

2. Chemical

3. Physical

Biological hazards, including *pathogens* such as bacteria, viruses, and parasites, can lead to widespread foodborne illness if practices are not in place to minimize or eliminate product contact with such contamination. There are many routes biological hazards may take to contaminate produce. Biological contamination can occur by contact of fruit with feces. Direct contact may occur from untreated or improperly treated manure used as soil amendments or from animal feces contacting fruit in the grove. Indirect contact can include transfer from contaminated soil, water, bins, gloves, equipment, and hands or clothes of field workers onto produce during production, harvesting, or handling.

Chemical hazards can include residues of agrochemicals, sanitizers, and pathogen toxins that may be present in or on fruit. While agrochemicals can enhance production of horticultural commodities and are valuable tools for growers, practices must document that materials were applied only according to label instructions, because *the label is the law*.

Physical hazards can include hard or sharp objects in food that may result in personal injuries. Such objects, if present, are removed during sorting and culling of citrus fruit.

While acknowledging the potential for chemical and physical hazards to exist, the FSMA PSR focuses exclusively on biological hazards and relies on proper implementation of GAPs programs to prevent the introduction of chemical or physical hazards into the food supply.

GAPs Topics

Management and Personnel Responsibility

Food safety is a shared responsibility; the collective efforts of growers, processors, packers, shippers, and regulators of fresh and processed citrus products are essential to ensure a safe and wholesome product. Each company must specifically designate an individual or team that is responsible for implementing food safety programs and ensuring compliance with the requirements of the PSR. For absentee landowners not directly involved with citrus production, grove caretaking companies or independent consultants may serve in this role through contractual agreement.

Worker Training, Health, and Hygiene

Proper worker hygiene is critical for implementation of GAPs. Without it, employees who work with citrus fruit may increase the risk of transmitting foodborne illness. A review highlighting information and requirements of field sanitation (OSHA Standard 1928.110) is available from OSHA (https://www.osha.gov/laws-regs/regulations/standardnumber/1928/1928.110) and expands on many of the subjects discussed below.

TRAIN WORKERS IN GOOD HYGIENE PROCEDURES AND DOCUMENT THEIR TRAINING

Begin with a written employee training program, and document the dates training was conducted, the personnel trained, and the content of the training. All personnel must receive food safety training appropriate to their specific job duties at least annually.

At least one supervisor or representative must have received food safety training at least equivalent to the standardized curriculum recognized as adequate by the FDA. Successfully completing a Produce Safety Alliance Grower Training course is a way to fulfill this requirement (https://producesafetyalliance.cornell.edu/training/grower-training-courses). Day-to-day duties and many other key food safety responsibilities can be and are delegated to qualified staff or other third parties but should be overseen by a responsible supervisor or representative.

Training for Employees Must Include

- Principles of food safety
- Health and personal hygiene (e.g., general cleanliness, proper handwashing and use of toilet, trash disposal, approved areas for food consumption)
- Identification of and policies regarding sick employees
- Recognizing contaminated fruit (i.e., visible fecal matter) that must not be harvested
- Inspecting harvest containers and equipment for contamination
- Procedures for correcting problems with harvest containers or equipment
- Cleaning, sanitizing, and storage of tools and equipment (when relevant to job duties)

HANDWASHING AND SANITARY FACILITIES

Poor management of wastes in the field can significantly increase the risk of contaminating produce. A minimum of one toilet and one handwashing facility must be maintained for every 20 employees. For both regulatory compliance and workers' convenience, handwashing and toilet facilities must be located within a one-quarter-mile walk or five-minute drive. Such facilities are not required for employees who do field work for three hours or less each day. For details, see:

- OSHA 29 CFR part 1928.110—Field Sanitation (https://www.osha.gov/laws-regs/regulations/standardnumber/1928/1928.110), and
- Florida Administrative Code, Rule 64E-14.016—Field Sanitation (https://www.flrules.org/Gateway/View_notice.asp?id=6181051).

Requirements and Best Practices

- All employees who handle produce or food-contact surfaces must receive proper hygiene and food safety training upon hiring and again at least annually. Any responsible supervisor or representative may train employees.
- Toilet and handwashing facilities must be provided during harvesting activities.
- Handwashing facilities must be furnished with running water. Water should be potable (best practice) but at a minimum must not contain detectable generic *E. coli* in 100 milliliters.
- Handwashing facilities must also be furnished with soap and hand-drying devices, which may be single-use towels (best practice) or electric dryers.
- Post signs indicating that water is only for handwashing purposes (best practice).
- Wash- and rinse-water and garbage must be contained for proper disposal after use.
- Place portable toilets outside the immediate crop production area (best practice) but within ¼ mile of where workers will be working. At a minimum, toilets must be placed in a manner that prevents contamination of fruit with human waste.
- Toilet facilities must be maintained in clean condition. Keep on file any documentation for maintenance and servicing of toilet and handwashing facilities. Keep facilities well supplied with toilet paper, water, soap, and paper towels. Provide a trash container for used hand towels.
- Toilets must be serviced and cleaned to ensure proper use (i.e., employees don't avoid proper use of toilet due to smell or filth). When toilets must be cleaned or serviced near the field, use appropriate barriers to prevent contamination in case of an accidental leak or spill.
- Have a mitigation plan in place so that pickers and supervisors know the company response policy in the event of accidental or malicious sewage spill.
- Workers who display symptoms of infectious disease must either be assigned tasks that prevent them from coming in direct contact with fruit or sent home.
- If used for harvest, gloves must be kept as clean as possible and free from contamination during the workday. Wash or replace gloves as needed.
- Hands must be washed before putting on gloves to reduce the risk of contaminating the gloves.
- Store harvest gloves properly (off the ground in a designated, clean area) when using the bathroom or on breaks. Do not carry gloves into toilet facility.
- Eating, drinking, and tobacco use must be limited to non-fruit-production areas.
- Workers with visible open wounds or sores should cover them sufficiently (for example, hand wounds must be bandaged and gloved) to prevent bodily fluids from contacting fruit.

Water

Citrus production relies on water supplies for several field operations including irrigation, freeze protection, and the application of agrochemicals. Water is used in cleaning hands and equipment. Water can be a direct or indirect source of contamination, so policies and procedures must be in place to minimize the risk that may be imposed. Water that is intended or likely to contact fruit or fruit-contact surfaces is called *agricultural water* and presents a higher level of risk than water that does not contact fruit or fruit-contact surfaces. Different sources of *agricultural water* can also present different levels of risk, with untreated surface water representing a higher level of risk than groundwater or treated water. These risk factors should be weighed when considering best uses of different water supplies (e.g., using higher-risk water sources for lower-risk applications and vice versa). For example, untreated surface water could be used for seepage or undercanopy irrigation while groundwater, municipal water, or properly treated surface water must be used for handwashing of harvest workers. For more information regarding water GAPs, refer to https://edis.ifas.ufl.edu/fs136.

Water for Field Use

Agricultural water quality must be safe and adequate for its intended use and meet all applicable federal, state, and local laws and regulations.

Note that *agricultural water* will need to meet specific PSR provisions; however, the FDA is currently reviewing the agricultural water criteria in the PSR, and we anticipate FDA clarification around *agricultural water* requirements (all of subpart E of the PSR).

REQUIREMENTS AND BEST PRACTICES

- *Agricultural water* distribution systems must be assessed for potential food safety hazards at least annually, with consideration given to the type of water source (e.g., surface, ground), control and protection of each source (e.g., deep well, shared canal), adjacent land use, and maintenance issues, including keeping the source free of debris, trash, and domestic animals.
- Water used in foliar applications can be obtained from 1) municipal, treated water sources, 2) groundwater obtained from a properly constructed well (https://edis.ifas.ufl.edu/fe603) in good condition, or 3) surface water that is suitable for its intended use (e.g., as shown through microbial testing and visual inspection).
- Water sources used for foliar applications must be tested routinely as needed and records of water quality maintained. Treated water and municipal water do not require testing. Water treatments must be monitored and recorded to demonstrate effectiveness. The FDA is currently readdressing the microbial water-quality criteria.
- Well water used for foliar applications should be drawn from properly engineered and protected sources. Wells should be properly cased and above grade. Wells must be inspected for cracks, leaks, etc. and records of repairs kept.
- If available, results of a microbial analysis of a water source from a public entity, such as the local water authority, may serve as acceptable documentation in lieu of testing by the grower and should be kept on file.
- Domestic animals must be excluded from surface water used for foliar application to the extent possible.
- Extend the amount of time between the last foliar application of agricultural water and harvest as much as possible to allow time for microbial die-off.

Water Contamination Risk from Adjacent Land

Farmland or other uses and activities on adjacent land may pose a risk for runoff or leaching of microbiological or chemical contaminants. Producers should work with local watershed authorities to understand watershed issues and consider mitigation strategies such as berms or ditches where necessary to minimize runoff.

REQUIREMENTS AND BEST PRACTICES

- Risks from adjacent land and water must be identified and documented as part of the annual inspection of your agricultural water source(s). Such risks can include landfill sites, sewage treatment facilities, and septic tanks and leach fields, or surrounding farm operations such as dairy farms or compost producers.
- Preventive or corrective actions must be taken and documented if water contamination sources are identified. Such actions can include construction of physical barriers (berms, ditches, or fencing) or use of a catch basin. You must inspect your water sources on an annual basis to ensure mitigation steps are still functioning as intended.

Land Use and Soil Amendments

Land use prior to grove establishment and patterns of adjacent land use can have food safety implications. The grower has no control over historic uses, but awareness of potential problems may help determine if mitigation is needed and what control options are feasible.

Biological soil amendments of animal origin are identified in the PSR as the soil amendments most vulnerable to microbial contamination. Manure or biosolids can serve as effective and safe fertilizer if proper treatment and application procedures are in place. Such treatment procedures can include composting to reduce microbial pathogens in number, thereby reducing the risks associated with their presence in soil amendments. The PSR outlines criteria to determine whether a biological soil amendment of animal origin is considered treated or untreated, and such designation determines the allowable application methods and minimum application-to-harvest intervals. Only specific composting methods can be used to produce treated amendments, and certain treatment conditions must be monitored and documented. Currently, the FDA does not intend to take exception to growers using (raw) manure in compliance with National Organic Program standards. Additional research and risk assessments are being conducted to determine an appropriate time interval between application of raw manure and crop harvest. The PSR does not restrict use of Class A biosolids. Detailed GAPs related to manure and biosolids are available at https://edis.ifas.ufl.edu/fs150. Preventing fruit from touching the ground will greatly reduce the potential for contamination. In cases where fruit may fall to the ground, they must never be harvested for use in the fresh market.

Recommendations and Best Practices

- Avoid planting citrus on land previously used for any operations engaged in risk-accumulation practices—that is, avoid areas previously spread with contaminated wastes or those of an unknown industrial use (best practice).
- If needed, conduct a title search or environmental assessment, or question state/local officials to establish whether previous land use involved disposal of chemical or biological wastes (best practice).
- Document the source of the soil amendment, compost producer, amount used, and when and how it was applied (best practice).
- Record the type of application and time interval between application and harvest (best practice). The interval between application and harvest should be as wide as feasible, with adequate consideration to other crops nearby.
- Obtain certificate of conformance annually from compost suppliers to demonstrate the compost treatment process met PSR requirements for treated compost (required if using purchased compost in a way that it may contact fruit during or after application).
- Apply treated compost in a way that prevents contact with fruit (best practice).
- Untreated compost must never be applied in a way that it contacts fruit during application.
- Compost must be handled and stored in a location and manner to minimize potential for contamination of citrus fruit and surface waters.

Animal Control

Wildlife and domestic animals, including but not limited to dogs, cattle, rodents, hogs, deer, reptiles, amphibians, and birds, may serve as sources of contamination. While minimizing animal contact with fresh produce also minimizes the risk of product contamination, it is understood that wildlife is difficult to control in grove settings. Growers must balance these management efforts with their responsibility for environmental stewardship; this is commonly referred to as co-managing food safety and ecological health (https://producesafetyalliance.cornell.edu/sites/producesafetyalliance.cornell.edu/files/shared/documents/MillsCo-Management.pdf).

Domestic Animals

The activities of domestic animals are the easiest to manage and their access into production, packing, and equipment storage areas should be prevented. If not totally excluded (e.g., in the case of guide or guard dogs), reasonable precautions should be taken to prevent contamination.

BEST PRACTICES

- Maintain fencing or other barriers to prevent intrusion by neighboring cattle or other domestic livestock, as appropriate.
- Have a policy in place to mitigate fecal material deposited by domestic animals in the grove to the extent possible.

Wild Animals

Growers are not expected to take extraordinary measures to exclude all animals from outdoor growing areas or to destroy wildlife habitat. However, if there is a reasonable possibility that animals will contaminate crops, the grove areas must be monitored for evidence of animal intrusion immediately prior to harvest and as needed throughout the year. Fruit visibly contaminated with feces must not be harvested.

REQUIREMENTS AND BEST PRACTICES

- To the extent possible, minimize animal attractants by discarding old equipment and containers and removing excess water from the field.

- Inspect storage areas for rodents, birds, and insects and use pest control procedures (e.g., traps, screens, etc.) to minimize pests.
- Keep cull and debris piles away from crop production areas.
- Have a policy in place to look for and mitigate risks from fecal material deposited by wild animals in the grove to the extent possible.
- Fruit with visible fecal contamination should be from the grove and must never be harvested for the fresh market.

Agrochemical Use

This GAPs document is not intended to provide guidance for pest management practices (for this guidance, please see the *2020–2021 Florida Citrus Production Guide* [https://edis.ifas.ufl.edu/topic_book_florida_citrus_pest_management_guide]).

Agrochemicals such as sanitizers, disinfectants, fungicides, insecticides, and herbicides can enhance production, quality, and the safety of horticultural commodities when used according to their product labels. Pesticides are closely regulated by the EPA, and EPA approval of each pesticide formulation includes specific limitations regarding the means by which the agrochemical may be applied, conditions of application, labeled rates, target organisms against which the chemical may be employed, use restrictions, and requirements for pesticide disposal and its containers.

The EPA also has the responsibility to determine tolerances or exemptions from tolerances for pesticide residues on raw agricultural commodities in the United States. Residue tolerances for export markets are regulated and enforced by their respective countries. Proper pesticide use involves close working relationships among citrus growers, packers, shippers, and processors.

Pesticides

- As part of GAPs documentation, labels and safety data sheets (SDS) of pesticides used must be kept on file, and a detailed written procedure for the application of all pesticides must be recorded. Pesticide labels clearly state the maximum allowable rate, methods of application, and the target organism. Using a pesticide in a manner inconsistent with its label, including for a purpose not specifically identified on the label, constitutes a violation of federal and state law. Florida law requires maintaining specific records for Restricted Use Products (i.e., products for which use and application is restricted to certified applicators or under the direct supervision of such) that include the EPA registration number, the date each pesticide was applied, the quantity used, and where and how the application was made. For additional information and requirements, see the Florida Department of Agriculture and Consumer Services, Pesticide Applicator Licenses website (https://www.fdacs.gov/Business-Services/Pesticide-Licensing/Pesticide-Applicator-Licenses/Pesticide-Applicator-Certification-and-Licensing). Meet all federal, state, and local pesticide application, field posting, preharvest intervals, and documentation requirements.
- Verify proper licensing and registration of subcontractors, custom applicators, crop advisors, etc.
- Document compliance with the EPA's Worker Protection Standard (https://www.epa.gov/pesticide-worker-safety/agricultural-worker-protection-standard-wps).

Field Sanitation, Harvest, and Transport

Fresh produce can become contaminated when contacted by soil, fertilizers, water, workers, and harvesting equipment during growing and harvest activities. General sanitation of the grove, bins, and equipment is necessary to prevent contamination of fruit with biological hazards.

Harvest Equipment and Bins

Requirements and Best Practices

- Harvesting equipment such as gloves, hand tools, and picking sacks must be routinely cleaned and sanitized as appropriate.
- Document procedures and schedules for cleaning and sanitizing equipment used in the field. At a minimum, a cleaning record is required for fruit-contact tools and equipment.
- Picking bins must be maintained free from debris and contaminants. A pressurized sprayer with a labeled cleaning agent can be an effective means to remove field dirt.
- Bins should be used only for the purpose of holding and transporting fruit. Any out-of-service bins used for storage need to be clearly marked and never returned to service.
- Inspect bins regularly for evidence of animal intrusion. Clean and sanitize as needed and document.
- Separate, segregate, and dispose of fruit if exposed to hydraulic oils or other chemical contaminants from harvesting equipment.
- Exclude from the fresh market all fruit that touch the ground or are visibly contaminated with fecal matter.

Transportation

Proper transport of fresh produce will help reduce the potential for biological hazards.

REQUIREMENTS AND BEST PRACTICES

- Good hygienic and sanitation practices should be used when loading, unloading, and inspecting produce.
- Inspect transportation vehicles for obvious dirt and debris before loading. The vehicle must be cleaned and sanitized if evidence of debris, animal manure, or other raw animal by-product exists.
- Load produce carefully to minimize physical damage.

Traceability and Record Keeping

A written food safety plan is central to successfully implementing any GAPs program, although a full food safety plan is not required by the PSR. Having records to document these practices, and the resulting traceability benefits, are vital to the GAPs process. Documentation, including records of all corrective actions, is required to prove to regulatory agencies, handlers, and retailers that you are following GAPs. Such documentation is important to demonstrate that proper procedures (e.g., cleaning and sanitation) were followed.

Traceability is an important part of GAPs documentation. *Traceback* is the ability to track food back to its source. *Traceforward* is the ability to identify all receivers of your citrus fruit from a given grove or source. It is critical that growers establish tracking systems from the earliest stages that follow their fruit within the distribution system. This system includes supply-chain partners involved in processing, packing, storing, shipping, and transporting Florida citrus fruit. Both traceback and traceforward actions are necessary to identify the potential source of any safety problems that might occur and for supply-chain partners to implement targeted recalls efficiently and effectively. GAPs forms should be readily available or collected together in a single location for ease of rapid access in the event that fruit is associated with an alleged contamination issue. For more information about preparing for and conducting a recall, see EDIS publication FSHN0410, *The Food Recall Manual* (https://edis.ifas.ufl.edu/fs108).

Basic sample recordkeeping forms are available online (https://producesafetyalliance.cornell.edu/sites/producesafetyalliance.cornell.edu/files/shared/documents/Records-Required-by-the-FSMA-PSR.pdf), but these are not intended to replace other required state report forms or forms prescribed by your packer or processor as part of their quality management systems. While they represent excellent examples, forms should be adapted to fit individual operation needs.

In addition to the documentation and recordkeeping indicated in this document, each load of harvested product should include the source of the product, the date of harvest, farm identification, and a record of who handled the product. These may include properly completed Trip Tickets (https://www.flrules.org/gateway/ChapterHome.asp?Chapter=20-2).

Best Practices

- Ensure a food safety plan and traceability plan are in place.
- Organize all documentation so that records can be accessed quickly.
- Demonstrate that product can be traced one step forward and one step back.
- Include tracking information with each citrus load (e.g., fruit source, harvest date, harvest crew, etc.). This can usually be satisfied with a properly completed Trip Ticket.

Summary

It is important to ensure the food safety of all citrus commodities in order to minimize food safety risk and maintain consumer trust. As with other commodities, producers of Florida citrus should follow the guidelines and requirements outlined above. Audit tools generally follow these guidelines quite closely, although individual customers often impose requirements of their own that must be addressed.

CG096

2020–2021 Florida Citrus Production Guide: Crop Insurance Policies Available to Citrus Growers[1]

Ariel Singerman[2]

Production risk is one of the main risks that growers are subject to. A grower can combine the same inputs every year and yet obtain different yields each time. The main source of risk and therefore the extent to which yields may differ from year to year in crop production stems from the unpredictable nature of weather, pests, diseases, and more.

Another source of risk for growers is market or price risk. Because growers are typically price takers, they are exposed to the supply-and-demand market forces for inputs and outputs. Thus, commodity prices vary each year and even within a given season. In addition, growers seldom know for certain the prices of farm inputs and outputs at the time they must make decisions about how much of which inputs to use or what and how much of various outputs to produce. Therefore, market risk includes risks derived from cyclical and seasonal price fluctuations of agricultural products, trade restrictions (i.e., market access), subsidies, and currency exchange rates. Contracts with buyers and suppliers can mitigate market risk, but when selling a commodity, contracts can also limit a price increase that would benefit the grower.

In this article, I describe the main crop insurance policies available to citrus growers and provide examples that illustrate the calculations involved. Some policies offer coverage for trees, others for production, and others for farm revenue. However, the commonality among all policies is that by purchasing crop insurance, the grower transfers part of the risk in exchange for a premium (the cost of purchasing insurance).

Crop Insurance as a Tool for Managing Risk

Federal crop insurance is provided through a partnership between public institutions and private companies. The Risk Management Agency (RMA) acts on behalf of the Federal Crop Insurance Corporation (FCIC) to administer all federal crop insurance programs. The RMA designates private insurance companies, who are in charge of marketing, underwriting, and adjusting claims for crop insurance policies. It is important to realize that premium rates and insurance terms and conditions are established by the FCIC. Therefore, the premium for a specific policy and coverage level is the same across companies; insurance companies compete only with their knowledge, customer service, and related insurance products. In addition, to increase participation in the program, the federal government subsidizes crop insurance premiums.

The Basics

At the time of enrollment, the grower chooses a certain coverage level, which determines two components of the policy. First, it determines the guarantee or liability (the amount at which the grower is insuring for). Second, the coverage level chosen also determines the deductible (the amount of loss for which the grower will not receive

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an indemnity). In the event of a loss, any level below the guarantee will trigger an indemnity. Figure 1 illustrates the basics of how crop insurance works with a one-acre example. Assume a grower expects revenue to be $2,325 and chooses a 60% coverage level. His choice of coverage level sets the guarantee at $1,395 and also establishes the premium the grower will pay for insuring at such level. If, for example, the grower experiences a 50% loss, the actual farm revenue will be $1,163. The indemnity will then be equal to $232, which is the difference between the guarantee and the actual farm revenue.

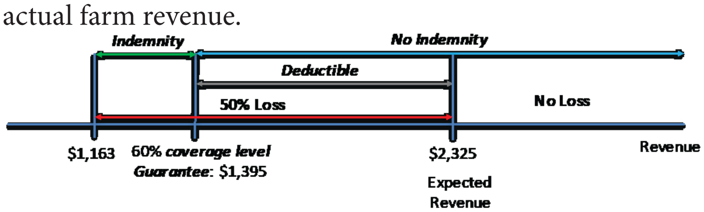

Figure 1. Illustration of the basic concepts involved in crop insurance for a one-acre farm.

Crop Insurance Policies for Citrus

There are two insurance policies specifically available for Florida citrus growers based on maximum reference dollar amounts set by the RMA: tree insurance and fruit/crop insurance. Catastrophic Risk Protection (CAT) is available for both policies and is set at 50% coverage and 55% of the reference dollar amount. Thus, the coverage is very limited because payments are only triggered for losses that are greater than 73% (=50% × 55%) of the maximum reference dollar amount. The advantage, however, is that it is less expensive; it costs $300 per crop per county regardless of acreage. The majority of citrus growers in Florida chooses CAT coverage for their trees and fruit. This is likely due to its low cost together with either the need to fulfill a lender's requirement or to make themselves eligible for ad hoc hurricane relief.

Tree insurance is based on reference prices established by the RMA that differ according to tree age. For example, orange trees older than 6 years have a reference price of $87 per tree. Causes of insurable loss under this policy are excess moisture, flooding, freeze, and wind. Coverage levels range from 50% to 75% in 5% increments. For example, the premium subsidy for 60% coverage is 64%, so the grower has to pay the remaining 36%.

Citrus fruit/crop insurance is based on a reference maximum dollar amount per acre. This policy offers coverage for fruit from trees that are at least 5 years old. Insurable causes of loss under this policy are excess wind, fire, freeze, hurricane, hail, and tornado. Growers can choose coverage levels ranging from 50% to 85% in 5% increments. Table 1 illustrates how the fruit dollar-amount policy works using one acre of late-season oranges from 9-year-old trees located in Polk County. The reference maximum dollar amount established by the RMA for 2019 is $2,325 per acre. Assuming the grower chooses 60% coverage level, the guarantee is set at $1,395 and the deductible at $930. The calculations in table 1 also show the total premium is $52, but the grower only needs to pay $19 per acre. In case of a 50% loss, the amount lost would equal $1,163, triggering an indemnity of $232 so as to provide the guarantee of $1,395.

Whole Farm Revenue Protection (WFRP) is a newer policy available nationwide that provides coverage against losses in farm revenue for the entire farm. In other words, all farm revenue is insured together under one policy. Thus, individual commodity losses are not considered. The approved revenue amount under this policy is the lower of (1) historic farm revenue (5-year average based on tax records), or (2) expected revenue. Coverage level ranges from 50% to 85% in 5% increments. Eligibility criteria include having no more than $1 million expected revenue from animals and animal products; having no more than $1 million from greenhouse and nursery products; and having no more than $8.5 million in insured (i.e., approved) revenue.

The federal premium subsidy for WFRP depends on how many commodities are grown on the farm. As illustrated in Table 2, if only one commodity is grown on the farm, the basic premium subsidy applies. But if two or more commodities are grown, the premium subsidy increases to 80%. However, each commodity needs to make a minimum contribution to revenue (in percentage terms) for the additional premium subsidy to apply. When two commodities are grown on the farm, each needs to contribute at least 16.67% to the farm's revenue. When three, four, or five commodities are grown on the farm, that percentage is at least 11.11%, 8.33%, and 6.67%, respectively. Farm diversification affects not only the premium subsidy but also the premium rate; growing more commodities (up to seven) lowers the premium rate.

Table 3 illustrates how WFRP works for a one-acre farm located in Polk County. For comparison purposes, the values chosen are similar to those in the previous example. Assuming the farm generated $2,500 in revenue each of the past 5 years and is expected to generate $2,325 next year, the approved revenue is $2,325. Assuming the grower chooses 60% coverage level, the guarantee is set at $1,395 and the deductible at $930. However, the premium calculations in Table 3 show how the number of commodities grown on the farm influences the premium the grower has to pay. Importantly, starting this year, early and late juice oranges are not considered to be different commodities for insurance purposes. Thus, for example, if each contributes 50% towards farm revenue, the diversity factor is still equal to 1, and the premium subsidy is 64%. Hence, in this example, the grower premium is $37 per acre.

If the one-acre farm was devoted to growing early oranges and mandarins that contributed 50% each towards farm revenue, then the RMA considers those two to be different commodities, and the grower premium decreases to $9 per acre. In an example in which a farm grows grapefruit, mandarins, and early oranges for juice (which the RMA considers as three different commodities) with each contributing 33% toward farm revenue, the grower premium also turns out to be $9 per acre. In case of a 50% loss (as in the example for the fruit dollar-amount policy above), the amount lost would equal $1,163, triggering an indemnity of $232.

Even though the numbers used for the examples in the fruit dollar-amount policy and WFRP were purposely made to be the same, it is important to realize the significant differences between the policies and the type of coverage they offer. One of the main differences is that WFRP is based on the insured farm's records, not on an amount the RMA establishes. In addition, the dollar-amount policy covers production risk (decrease in yield), whereas WFRP covers production and market risk (decrease in both yield and price). In terms of premium, WFRP is more expensive for a single commodity but becomes significantly cheaper once two or more commodities are grown on the farm.

Conclusion

Dollar-amount policies for insuring citrus trees and fruit are based on reference prices established by the RMA, not on farm's records as with WFRP. In addition, the coverage dollar-amount policies provide are for specific perils. WFRP allows eligible growers to insure their entire farm revenue under one policy. Dollar-amount policy covers production risk (decrease in yield), whereas WFRP covers production and market risk (decrease in both yield and price). WFRP can be expensive for a single commodity but becomes significantly cheaper once two or more commodities are grown on the farm; the subsidy and premium rate depend on the number of commodities grown on the farm. For a diversified farm that meets the eligibility criteria, WFRP can provide better coverage relative to a dollar-amount policy.

Table 1. Fruit dollar-amount policy example for one acre in Polk County

Line #	**RMA Terminology**	
(1)	Age class	9-year-old
(2)	Commodity	Oranges
(3)	Commodity type	Late season
(4)	Intended use	Juice
(5)	Ref. maximum dollar amount	$2,325
(6)	Coverage Level	60%
(7)	Guarantee [(5)×(6)]	$1,395
(8)	Deductible [(5)–(7)]	$930
	Base Premium Calculation	
(9)	Basic rate	0.041
(10)	Rate differential factor	0.901
(11)	Base premium rate[(9)×(10)]	0.037
(12)	Total premium [(7)×(11)]	$52
(13)	Subsidy percent	64%
(14)	Subsidized amount [(12)×(13)]	$33
(15)	Grower premium [(12)–(14)]	$19
	Indemnity Calculation	
(16)	Assumed production damage	50%
(17)	Loss value [(5)×(16)]	$1,163
(18)	Indemnity [(7)–(17)]	$232

Table 2. Premium subsidy for each level of Whole Farm Revenue Protection (WFRP) coverage and number of commodities grown on the farm

	Coverage Level							
	50%	**55%**	**60%**	**65%**	**70%**	**75%**	**80%**	**85%**
Minimum # Commodities Required	1	1	1	1	1	1	3	3
Basic Subsidy for 1 Commodity	67%	64%	64%	59%	59%	55%	N/A	N/A
Subsidy for 2 Commodities	80%	80%	80%	80%	80%	80%	N/A	N/A
Subsidy for 3+ Commodities	80%	80%	80%	80%	80%	80%	71%	56%

Table 3. Whole Farm Revenue Protection (WFRP) example for one acre in Polk County

Line #	RMA Terminology			
(1)	**Allowable revenue***	**Amount**		
	Year 1	$2500		
	Year 2	$2500		
	Year 3	$2500		
	Year 4	$2500		
	Year 5	$2500		
(2)	Average	$2500		
(3)	Expected revenue	$2325		
(4)	Approved revenue [min((2),(3))]	$2325		
(5)	Coverage level	60%		
(6)	Guarantee [(4)×(5)]	$1,395		
(7)	Deductible	$930		
	Base Premium Calculation			
		Example I	**Example II**	**Example III**
		50% Early 50% Late	50% Early 50% Mandarins	33% Early 33% Mandarins 33% Grapefruit
(8)	Weighted commodity rate	0.073	0.046	0.059
(9)	Commodity factor	1.00	0.5	0.333
(10)	Diversity factor	1.00	0.668	0.523
(11)	Premium rate [(8)×(10)]	0.073	0.031	0.031
(12)	Total premium [(6)×(11)]	$102	$43	$43
(13)	Subsidy percent	64%	80%	80%
(14)	Subsidized amount [(12)×(13)]	$65	$35	$35
(15)	Grower premium [(12)–(14)]	$37	$9	$9
	Indemnity calculation			
(16)	Assumed production damage	50%		
(17)	Loss value [(4)×(16)]	$1,163		
(18)	Indemnity [(6)–(17)]	$232		
* subject to Revenue Index factor: 0.8 cup and 1.2 cap				

2020–2021 Florida Citrus Production Guide: Useful Websites and Mobile Apps[1]

Jamie D. Burrow, Laurie Hurner, Chris Oswalt, Juanita Popenoe, Mongi Zekri, Ajia M. Paolillo, and Stephen H. Futch[2]

Over the last decade, technology has changed rapidly, and today carrying a mobile device puts a computer in your hands. With the ever-evolving changes in technology, the agriculture industry is implementing tools to help growers make better management decisions for their crops. GPS equipment in tractors, computer programs to predict disease progression, and mobile phone apps to monitor weather are a few of the most common advances in technology being used.

Several web-based programs and mobile apps are available for free or at a cost. These programs can be used to assist in the decision-making process of maintaining Florida citrus groves. A variety of programs are available through UF/IFAS, along with others from government and private entities. The listing here does not indicate general or specific endorsement or exclusion of a product or service, nor does it indicate approval by UF/IFAS Extension.

Websites

Citrus Copper Application Scheduler

http://agroclimate.org/tools/citrus-copper-application-scheduler/

The Citrus Copper Application Scheduler is designed to assist in determining the best time to make copper applications for citrus canker (see chapter 31 of this guide, PP-182, *Citrus Canker*, https://edis.ifas.ufl.edu/cg040). By submitting rainfall data (your own records or selecting the nearest weather station), bloom date, and last copper application, a graph will be produced to show you the copper residue still on the fruit. Based on the graph, it will provide an estimate of the next best time to apply copper. The program uses several years of collected data to estimate fruit size based on rainfall and bloom date; therefore, the graph shows the amount of copper still on the fruit based on the fruit growth.

Florida Automated Weather Network (FAWN)

https://fawn.ifas.ufl.edu/

FAWN provides weather data for the entire state from weather stations maintained by UF/IFAS and local farm weather stations. For each weather station, the website provides current and historical readings of temperature, wind, rainfall, soil temperature at 10 cm, sunlight (in Rads), heat index, and dew point that you can view in table or graphical format. In addition, there are tools to assist the

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2. Jamie D. Burrow, Extension program manager, UF/IFAS Citrus Research and Education Center; Laurie Hurner, citrus Extension agent, UF/IFAS Extension Highlands County; Chris Oswalt, citrus Extension agent, UF/IFAS Extension Polk County; Juanita Popenoe, citrus Extension agent, UF/IFAS Extension Lake County; Mongi Zekri, citrus Extension agent, UF/IFAS Extension Hendry County; Ajia M. Paolillo, citrus Extension agent, UF/IFAS Extension DeSoto County; and Stephen H. Futch, multicounty Extension agent emeritus, UF/IFAS Citrus REC; UF/IFAS Extension, Gainesville, FL 32611.

grower, including a cold-protection toolkit, forecast tracker, chill-hour accumulation, evapotranspiration, and irrigation scheduling. The FAWN Freeze Alert system is a new feature with a mobile phone alert of when to start and stop cold-protection irrigation. The Citrus Pesticide Application tool provides information for your site on the weather conditions for pesticide application to help you schedule a time for safe application. Click on the weather station closest to your site from the map on the home page, and access the tools on the left side of the page or from the tabs at the top of the page.

Weather Underground

https://www.wunderground.com/

Weather Underground, founded in 1995, supplies weather data to many of the leading media companies and millions of users across the globe. They have over 270,000 weather stations worldwide and provide weather data in real time. This website provides information ranging from current conditions to an interactive map including weather stations, radar, satellite, heat map, and rain accumulation. The website and app provide severe weather alerts, weather radio, and full customization of options on your desktop.

Citrus Microsprinkler Irrigation Scheduler

https://fawn.ifas.ufl.edu/tools/irrigation/citrus/scheduler/

The microsprinkler irrigation scheduler is part of the irrigation toolkit provided by FAWN. Users enter the tree spacing, details about emitters, soil type, irrigation depth, irrigation trigger depth, and the local FAWN station. The tool will then calculate a two-week irrigation schedule to maximize irrigation efficiency. Having a Mobile Irrigation Lab provide details on irrigation system efficiency will establish some of the information needed for calculations.

Flower Bud Induction Advisory and Decision Information System for Citrus

https://crec.ifas.ufl.edu/flower-bud-induction

http://disc.ifas.ufl.edu/bloom/

Citrus flower bud growth and development is determined by winter temperatures that may fluctuate. Predicting the bloom date is key to managing production. The Flower Bud Induction Advisory takes the temperatures, updated every two weeks, and calculates the intensity and time of bloom as part of the Decision Information System for Citrus. Early warm periods after cool may stimulate a weak bloom, and later cool/warm conditions may stimulate additional blooms. The Citrus Flowering Monitor uses observed and predicted weather patterns and other cultural metrics (such as cultivar, tree age, and soil type) to predict bloom. Users enter parameters specific to their grove to get a prediction. The Citrus Flowering Monitor also gives specific recommendations on how to manage bloom.

Citrus Advisory System

http://agroclimate.org/tools/cas/

Colletotrichum acutatum is a fungus that infects flowers on all species of citrus and causes postbloom fruit drop (PFD). Severity on a given cultivar varies according to the time of bloom in relation to rainfall because spores produced on the blooms, leaves, buttons, and twigs splash onto other flowers to spread the disease. Preventative fungicides must be applied during bloom, but the number of fungicides available and the number of applications for each fungicide are limited, so timing of sprays is critical, especially with prolonged bloom periods. The Citrus Advisory System uses real-time weather data from FAWN to determine if risk conditions for PFD are low, moderate, or high and gives specific fungicide spray recommendations according to the disease risk conditions. The user may set up an e-mail alert to be sent when an infection event has occurred to alert the user to check the model for the risk at their site.

Electronic Data Information Source (EDIS)

https://edis.ifas.ufl.edu/

The University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) has an extensive collection of informative documents available to print or view online. All documents are free to view and print. The site is called Electronic Data Information Source, or EDIS for short. The documents available cover a wide range of topics, including commercial agriculture, urban horticulture, consumer sciences, and youth programs, and they are written for a general audience.

Once at the site, you can use the search box in the upper right-hand corner for general topic searches. If you are looking for a specific document by title, author, or publication number, click the advanced search tab at the top of the home page and enter the requested information to take you directly to the desired publication.

For EDIS inquiries, you can contact any UF/IFAS Extension Office for assistance, or see the EDIS FAQ page for contact information for the EDIS production and editing staff: http://edis.ifas.ufl.edu/faq/index.html.

UF/IFAS Extension Citrus Agents

http://citrusagents.ifas.ufl.edu

This site is designed to disseminate knowledge and information to growers and the citrus community in the state of Florida. The information is intended to enhance the productivity, profitability, and environmental stewardship of Florida citrus growers through practice implementation, adoption, and education using applied citrus research.

Once at the site you will find access to current newsletters from each of the county agents that specialize in citrus as well as helpful links including upcoming events, continuing education unit (CEU) article series, citrus publications, Worker Protection Standards (WPS) resources, postbloom fruit drop presentations, and archived presentations. Additionally, a photo series is available that has monthly photos of the same trees from October 2010 to the present time to show the progression of citrus greening over time.

USDA Citrus Statistics

https://www.nass.usda.gov/Statistics_by_State/Florida/Publications/Citrus/

This website provides citrus production forecast monthly reports, forecasting methodology and development, citrus statistics, citrus abandoned acres, maturity yield and test results, citrus summaries, commercial citrus inventories, and historical reports dating back over 50 years.

Citrus Variety Collection, University of California Riverside

https://citrusvariety.ucr.edu/varieties.html

This website provides descriptions, characteristics, photos, sources, parentage/origins, rootstocks of accession, and season of maturity of selected citrus varieties by alphabetical order, category, or type. It also provides fruit quality evaluation data, and related articles, references, and other information for the selected citrus varieties.

Key to Diaprepes IPM in Florida Groves

https://crec.ifas.ufl.edu/extension/diaprepes/key.shtml

This website has three main sections: 1) Meeting Reports related to the Diaprepes Task Force for 2004–06; 2) Bibliography from 1970 to the present; and 3) Management Key for both pre- and postplant decisions. The website highlights the extensive work that has been conducted to study the Diaprepes root weevil, the damage it causes, and various control options that have been recommended.

The Ultimate Citrus Page

http://www.ultimatecitrus.com/

UltimateCitrus.com is a comprehensive website on citrus news, benefits of the citrus industry to the environment, citrus growing regions, grower tools, fresh fruit, and processed juice. This website tells the story of Florida orange juice from the grove to your glass (how orange juice is made). It also provides lists of citrus organizations, information on citrus health, weather, freeze forecasting, recipes, citrus growers, and international citrus links.

Citrus ID

http://idtools.org/id/citrus/citrusid/

The Citrus ID website was created in 2011 and led by the USDA and North Carolina State University. Various people from the industry, extension, and government affiliations contributed to the content of the website. The website contains information on citrus pests and diseases with written information and photos. It contains fact sheets, a glossary, a photo gallery, and more.

Mobile Apps

Radar Now!

This app puts a weather radar in your pocket. Users can quickly see an animated radar image and current conditions. Radar Now! provides National Weather Service (NWS) Enhanced Radar images from NOAA Radar sites located around the United States. This app is free with an optional paid upgrade to remove ads.

WUnderground

This app is the free companion for cell phones from Weather Underground. This app will provide current conditions at local weather stations, or you can drop a pin in your neighborhood for conditions there. You can follow things such as "feels like" temperatures, wind speed/direction, rain accumulation, and forecasts ranging from hourly to 10-day.

Hi-Def Radar

This simple yet powerful app lets you view real-time animated weather radar images in color on an interactive map. With this app you can view radar, clouds, wind speed, temperatures, water temperatures, and more. A great feature of this app is a Severe Weather Overlay that can be placed over the map and watched as the weather moves toward the user's location.

Google Earth

The Google Earth app allows users to access directions and digital satellite maps. It includes a map ruler to determine length or distance and acreage. It is developed by Google LLC and is free of cost.

Fox 13 Sky Tower

This phone app has many features, including tracking hazardous weather with interactive maps and future weather movement. It also includes a lightning detector feature. Users can opt to receive alerts based on predefined settings and their location.

SoilWeb

The SoilWeb app was created by the California Soil Resource Lab (CSRL) at the University of California, Davis. They partnered with the USDA–Natural Resources Conservation Service to use information from the SSURGO (Soil Survey Geographic Database) dataset to generate specific soil details. SoilWeb uses GPS to access the user's current location and gives the characteristics and composition of the soil in that area. The app provides the soil name(s) along with a simulation image of the soil profile, which includes horizons and corresponding depths in the soil. The user can select an individual soil type to access a large amount of detailed information that can be very beneficial in the field. The app lists soil taxonomy, characteristics of soil horizons, geographic settings the soil is typically found in, water-holding capacity, and much more. The "Details" tab for each soil lists "Soil Suitability Ratings," which gives a description for uses in areas such as Agriculture, Forestry, Urban/Recreational, and Wildlife. The Agriculture rating lists the leaching and surface runoff potential of the soils to aid in decisions about pesticide applications. The app also offers a feature to allow for more or less location accuracy based on the amount of battery power it uses. Web links are provided for CSRL applications, the USDA–NRCS homepage, and the SSURGO database. SoilWeb is available in both the App Store and Google Play.

Citrus Diseases Key

The Citrus Diseases Key application is designed to help you diagnose diseases based on the symptoms you see. The app is an interactive Lucid Key, updated in 2018 and available on the App Store, Google Play, and http://idtools.org/id/citrus/diseases. It covers citrus diseases in the United States and of concern elsewhere. When you open the app, you choose where the symptoms are seen: on the entire tree, the leaf, or the fruit. The key will lead you through selections where you choose yes or no based on observations. You may enter as many symptoms as you see. When you have made all your selections, press "Remaining" at the bottom, and the diagnosis is presented with information about the disease, its symptoms, distribution, host range, disease cycle, whether there is any regulatory information, similar diseases that it may be confused with, and further identifying photos. If you wish to review which selections you made, press "Selections." If you wish to look over the options again and select or deselect some, press "Features." If your described symptoms match more than one disease, the ones that match are presented with further details to help you decide which it could be.

2020–2021 Florida Citrus Production Guide: Rootstock and Scion Selection[1]

Ute Albrecht, Fernando Alferez, and Mongi Zekri[2]

When preparing for new planting or replanting, an important factor to consider is the choice of rootstock. Choosing the right rootstock and scion combination can result in higher economic returns without any additional cost. The rootstock affects scion vigor, yield, fruit size and quality, and pest tolerance. However, tree growth, yield, and fruit quality interact strongly with climate, soil type, tree spacing, and other abiotic and biotic factors, often producing inconsistent reports on rootstock performance in different areas.

Rootstock selection should be based on soil type, soil pH, pest and disease pressure, desired tree spacing and size control, and other horticultural traits. Several new rootstock selections were recently released; therefore, not much information exists on their long-term performance under different environmental conditions and different commercial management. Also important is the choice of scion to be used in combination with the selected rootstock. Several novel scion varieties have been released by the breeding programs at UF/IFAS and the USDA. These novel varieties are expected to have better field performance, disease tolerance, and better fruit quality, making some of them suitable for the fresh-fruit market. Many of the newest scion and rootstock combinations are currently evaluated under the Fast Track program managed by the New Varieties Development & Management Corporation (NVDMC). This program makes advanced citrus selections available to growers and nurseries for trial and potential early commercialization. Check http://nvdmc.org/fast-track/ for the newest information on rootstocks and scions released under the Fast Track program.

Soil Characteristics

Choosing the right rootstock for your soil type is critical. Rootstocks performing satisfactorily on the well-drained sandy soils of the central Florida ridge may not be suitable for the wet “flatwoods” soils of the southwest and eastern Florida citrus production areas. Equally important is the ability to better tolerate conditions of high pH and salinity. Unfortunately, few rootstocks have shown to be as adaptable to suboptimal soil conditions as sour orange. Although Cleopatra mandarin can tolerate conditions of higher salinity and alkalinity better than most rootstocks, it is not well suited for poorly drained soils. Also suitable for high pH or calcareous soils is Volkamer lemon. C-22, a Californian cultivar also known as ‘Bitters’, is considered tolerant of calcareous soils. Rootstocks such as C-35, Carrizo, and Swingle are among the rootstocks that perform most poorly in the presence of high pH and salinity. Thus far, little is known regarding the impact of soil type on the performance of the newer rootstock cultivars.

1. This document is HS1308, one of a series of the Horticultural Sciences Department, UF/IFAS Extension. Original publication date September 2017. Revised March 2020. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication. For more detailed information on citrus rootstocks, please refer to SP 42, *Rootstocks for Florida Citrus,* and HS1260, *Florida Citrus Rootstock Selection Guide* (which was developed through a collaborative effort of citrus researchers from UF/IFAS and USDA). The interactive guide assisting in the selection of rootstocks best suited for the individual needs of a citrus operation can be found at https://crec.ifas.ufl.edu/extension/citrus_rootstock/.

2. Ute Albrecht, assistant professor; Fernando Alferez, assistant professor, Horticultural Sciences Department, UF/IFAS Southwest Florida Research and Education Center; and Mongi Zekri, citrus Extension agent, UF/IFAS Extension Hendry County; UF/IFAS Extension, Gainesville, FL 32611.

Rootstock Effects on Pests and Diseases

Many of the newer rootstock cultivars are of partially trifoliate origin, thereby inheriting some degree of tolerance to phytophthora. In respect to the phytophthora/Diaprepes root weevil complex, US-802, US-897, US-942, UFR-4, and UFR-5 are more tolerant in comparison with other rootstocks. Unfortunately, damage from phytophthora is exacerbated in roots already compromised by HLB. Although thus far no rootstock has shown to induce the desired levels of tolerance to HLB, trees grown on some rootstock cultivars produce good yields under high HLB pressure and exhibit lower-than-average rates of fruit drop. These rootstocks include US-942, US-812, 'UFR-4', 'UFR-5', and the Californian cultivars C-54 ('Carpenter') and C-57 ('Furr'). X-639, developed in South Africa in the 1950s, produces very healthy and vigorous trees despite HLB, but fruit production may be low during the early production years. Whereas most of the newer available rootstocks are tolerant to citrus tristeza virus, little is known regarding tolerance to blight, except for US-896, US-812 and US-942, which are considered tolerant to this disease.

In 2015, five rootstocks with improved tolerance to HLB were released by USDA: US-1279, US-1281, US-1282, US-1283, and US-1284. All five are hybrids of mandarin and trifoliate orange, produce medium-sized trees, and appear adapted to Florida's flatwood soils. In 2018, USDA released three new SuperSour rootstocks, US SuperSour 1 (SS1), US SuperSour 2 (SS2), and US SuperSour 3 (SS3). SS1 performs well with sweet orange on the ridge and east coast flatwoods, whereas SS2 and SS3 perform well on the ridge and the east coast flatwoods, respectively. All three SuperSour rootstocks induced higher yield than standard sour orange in the presence of HLB under the tested conditions.

The UF/IFAS rootstocks UFR-1, UFR-2, UFR-3, UFR-4, UFR-5, UFR-6, UFR-15, UDR-16, and UFR-17 are released under the Citrus Fast Track Release Option managed by Florida Foundation Seed Producers, Inc. (FFSP). Replicated field trials across different commercial production areas in Florida are under way to evaluate these and other experimental rootstocks. More information can be found at http://www.ffsp.net/varieties/citrus/citrus-rootstocks/.

Tree Spacing and Size

Trees should be spaced based on the expected size of the tree and lifespan of the grove. A more densely planted grove may provide earlier economic returns despite an initially higher investment. C-22, US-897, and UFR-6 rootstocks produce relatively small trees, which should be spaced at 6–8 feet within the row and 15 feet between rows. The only rootstock producing an even smaller tree is Flying Dragon, allowing for an in-row spacing of 5–7 feet as well as closer between-row spacing, if feasible. Yield efficiency and quality of fruit on these small-tree-size-inducing rootstocks is usually high compared with some of the more vigorous rootstocks. Most of the other available rootstocks will induce trees of average size with a recommended spacing of 8–12 feet and that produce fruit of intermediate to high quality. If the desired grove architecture is for a larger in-row spacing of trees (12–15 feet), rootstocks such as US-802, Volkamer lemon, Rough lemon, and Cleopatra mandarin are appropriate. The high vigor of these rootstocks may be advantageous in that they allow a tree to better cope with the damaging effects of HLB compared with less vigorous trees. Although yield will be high on these rootstocks, fruit quality will generally be lower, which may be disadvantageous when used in combination with some scion varieties.

Check https://crec.ifas.ufl.edu/extension/citrus_rootstock/ for more information on rootstocks.

Rootstock/Scion Combination

Choice of rootstock will also depend on the scion variety selected for the new planting. An excellent example is sour orange, which is susceptible to tristeza virus when used in combination with sweet orange and most other scion varieties. Although sour orange was the fifth most propagated rootstock in the 2018–19 season (DPI Citrus Budwood Annual Report, https://www.fdacs.gov/Divisions-Offices/Plant-Industry/Bureaus-and-Services/Citrus-Budwood-Registration), it is not recommended for extensive use in Florida because of the endemic presence of the tristeza virus. Most of the more recently released rootstocks have been evaluated in combination with few scion varieties, mainly sweet oranges, and it is recommended to be cautious when choosing new combinations. Recently, US-1283 was discovered to exhibit incompatibility with several fresh-fruit cultivars (Bearss lemon, Star Ruby grapefruit, and Tango mandarin), although it appears to perform well with Hamlin and Valencia scions.

Field trials of different scion/rootstock combinations that include new releases are under way, and it is expected that new information on compatibility and other horticultural traits will be available soon.

One trend increasingly followed by the industry and researchers is to develop high-quality sweet orange varieties that reach commercial maturity in early and mid-season with reduced production costs. Higher fruit quality and maturation standards achieved earlier would also reduce the need for juice blending with late varieties. Moreover, developing varieties with an early maturation window and improved internal fruit quality would allow replacement of Hamlin, which is particularly sensitive to citrus canker and HLB.

New varieties have been developed through irradiation and other techniques by UF/IFAS and the USDA. Among the newer UF varieties are the early Valencia somaclone Valquarius and the Florida EV1 and EV2, which reach commercial maturity about two months earlier than standard Valencia selections. Yield, juice quality, and maturity dates (February/March) for Vernia, a mid-season sweet orange somaclone, are also quite desirable when compared with standard Valencia. An attractive feature of Vernia is that fruit have the highest color score of any orange at time of harvest. Other interesting varieties are the OLL series, which are late-maturing varieties with high pound solids and yields. Among the late-season varieties, Valencia UF B9-65 has superior quality in terms of yield and pound solids.

In general, to hit the juice market earlier, there is a need to advance the harvesting window for Valencia selections. Although not new, there are noteworthy choices such as the introduced Midknight and Delta. These are South African selections that reach commercial maturity several weeks before traditional Valencia oranges grown in Florida. Midknight trees are less vigorous than other Valencia selections and grow well on Carrizo and Swingle rootstocks. Delta trees are more vigorous, and because fruit has lower Brix than other Valencia selections, rootstocks recommended for this scion are Swingle and Carrizo. So far, there is no information available about the performance of these two varieties on newly released rootstocks from UF/IFAS or USDA.

Newer scion releases with potential for the fresh-fruit industry include LB8-9 (SugarBelle®) as the most promising variety. These trees are vigorous and relatively tolerant to HLB and Alternaria. Mature trees can reach 20 feet in height depending on the rootstock. This makes regular pruning, hedging, and topping imperative to maximize light exposure and achieve good yield. Fruit matures from late November to early January and may be seedy depending on cross-pollination incidence. Fruit is easy peeling, and retention is good and well past normal market maturity. Bingo, an easy-peeling seedless mandarin with a deep orange color, is suitable for the fresh-fruit market. It matures early in the season and can be harvested between early October and early November. It provides all attributes to compete with California clementines. Several UF/IFAS-USDA collaborative field trials are under way to identify rootstocks most suitable to combine with both SugarBelle® and Bingo.

An interesting variety obtained by irradiation and released by the USDA is US Early Pride, a very low-seeded tangerine and mutant of Fallglo that matures early (early October) in the season. Also low-seeded and with excellent internal color is Tango. Whereas Early Pride is average for tangerines in terms of HLB tolerance, Tango performs better than average. Fruit mature in December but do not degreen well, and the response to postharvest ethylene is poor if not enough chilling hours accumulate during the season, especially in central and south Florida. One of the newest varieties in the UF/IFAS arsenal of fresh fruit varieties is Marathon mandarin, which is seedless and easy to peel. Marathon obtained its name from its exceptional ability to hold long on the tree.

Another commercial variety managed by the NVDMC with interest for the fresh market is Roe tangerine, which like Bingo is low-seeded and easy peeling. Roe resembles a traditional Florida tangerine, which matures around Thanksgiving, and has good tree retention (holding through January), but requires clipping. The variety US Sun Dragon was recently released by the USDA. It is orange-like, HLB-tolerant, and may have potential for the juice market.

2020–2021 Florida Citrus Production Guide: Planting New Citrus Groves in Florida in the Era of Citrus Greening[1]

Ariel Singerman, Marina Burani-Arouca, and Stephen H. Futch[2]

In this article, we summarize the results of an analysis to examine the profitability of three tree densities under different production and market conditions. We found that establishing a new grove with a tree density similar to that of the state's average is not profitable under current market conditions. In addition, such density only attains a modest return under potentially higher prices. Despite the higher level of investment required for planting higher-density groves, such investments are profitable under the assumptions and scenarios analyzed. Our results should prove useful to citrus growers looking to invest in alternatives that have the potential to improve their profitability.

Assumptions

Our analysis is for Valencia oranges, which are the predominant late variety produced in Florida, accounting for approximately 55% of the bearing acreage of oranges grown in the state during the last few years. The choice of this variety determines the values for yields and prices used in our model. Our cost estimates, however, are also applicable to early varieties. The basis for our annual estimates on cost of production is the survey data collected in southwest Florida in 2016/17 for growing processed oranges (Singerman 2018). As is typical for developing Extension budgets, our computations and analysis are for one representative acre. However, for the purposes of calculating the necessary investment in machinery and associated fixed costs, we assume the operation has 250 net acres; smaller operations would likely find it more cost-effective to hire caretakers to perform the cultural practices.

The tree-density baseline for our analysis is 145 trees per acre, which is the average tree density reported by growers participating in the survey, and which is also similar to the state average for a citrus grove in Florida (USDA-NASS 2017). The between-rows and between-trees spacing associated with 145 trees per acre is 25 by 12 feet, respectively. We also analyzed two higher tree densities, namely 220 trees per acre (with 22 by 9 feet spacing between rows and trees, respectively) and 303 trees per acre (with 18 by 8 feet spacing between rows and trees, respectively). These two higher densities are based on the feedback we obtained from growers who have already planted high-density groves.

Irrigation and frost protection are a key component of the investment in a new grove. Thus, to estimate such an investment, the first step was to determine the quantity of water needed for each tree density. The per-tree water needs for a grove with 140 trees per acre are 14 and 39 gallons per day for winter and summer months, respectively, whereas a grove with 218 trees per acre will need 9 and 25 gallons per tree per day for winter and summer months, respectively (Parsons and Morgan 2017). To compute the water required

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to irrigate a grove with 303 trees per acre, we extrapolated the water requirements based on the percentage of additional trees with respect to 220 trees per acre, taking into account a reduction in per-tree water needs; we found the per-tree water needs for a grove planted at 303 trees per acre to be 7 and 19 gallons per day for winter and summer, respectively. We then established the volume of annual irrigation needed by taking into account the amount of water that trees receive from rainfall. We estimated the historical average rainfall in three representative citrus-growing cities in Florida from 2010 to 2016 using data from the Florida Automated Weather Network (FAWN). Then, based on the gallons of water needed per day per tree for each tree density, we calculated the average amount of irrigated water needed each month to supplement rainfall.

To account for frost protection, we assumed four radiation frost events per year based on Jackson, Morgan, and Lusher (2015). During each event, the irrigation system was assumed to be run for 12 continuous hours. We assumed a 50-acre irrigation zone based on feedback from irrigation supply companies. We also made assumptions regarding the use of microsprinklers, which in turn affected the decision of the capacity of the water-well and pump needed, which is different for each tree density. Then we gathered appropriate quotes for the equipment and computed the variable costs associated with the irrigation system (such as pumping hours and diesel consumption, repairs, and maintenance using feedback from suppliers).

We assume that the average expected lifespan of a grove in Florida has decreased from 30 to 20 years as a consequence of the impact of HLB. The disease has also affected tree mortality, which we assume to be 3% in years 2 through 6 and 5% from years 7 through 20. These figures are based on growers' feedback. However, the tree-replacement strategy for removed trees is based on a sensitivity analysis that maximizes profit. In our model, we also assume that the following cultural activities are contracted: land preparation and bedding, fertilization, hedging and topping, tree removal, and tree replacement. Regarding the land, we assume it is already owned.

Within cultural cost of production, foliar sprays are the largest expense in the caretaking of groves, accounting for 34% of the total (Singerman 2018). Because we assume the use of tree-sensing technology for the application of foliar sprays, we wanted to obtain the cost of materials per tree by age. To calculate such cost per tree, we divided the cost per acre of the foliar sprays program by the total number of trees in the year in which trees reach maturity. Taking into account the HLB-stunting effect on citrus trees, we assumed it would take 12 years for them to reach full growth (height). Thus, the material application rate for trees between 1 and 11 years old was computed taking into account a percent reduction relative to mature trees based on their age (and height). Once we obtained the cost per tree by tree age, we computed the foliar sprays costs per acre for each year by simply multiplying the number of trees in each age cohort by the associated foliar spray cost per tree.

Fertilizer is the second-largest expense in the caretaking of groves, which accounted for 21% of the cultural cost of production in 2016/17 (Singerman 2018). To compute the cost of the annual fertilizer program, we also wanted to obtain fertilization rates per tree. To calculate such rates per tree, we divided the cost per acre of the program by the total number of trees 4 years old and older in year 12. Mature trees receive 100% of the rate that is associated with the survey cost data. However, to compute the cost of fertilizing younger trees we did the following. For trees 1, 2, and 3 years old, we based fertilizer applications on UF/IFAS recommendations (Morgan et al. 2017) that specify using three dry fertilizer applications and eight liquid fertilizer applications. For trees between 4 and 11 years old, we computed a reduction in their material application rate relative to a mature tree based on their height.

To compute the cost of the fertilizing program for tree densities 220 and 303, we calculated the cost per tree in a similar fashion to that described above. However, because fertilizer recommendations are on a per-acre basis, we applied a cap equal to the cost of the mature trees' program in the 145-tree density. Regarding the annual application cost per acre for dry fertilizer, we included an application cost upcharge of 11% and 44% for 220 and 303 trees per acre, respectively. Such upcharges are based on the extra cost of fuel and labor involved in the applications due to the additional number of rows per acre in higher-density groves relative to the 145-trees-per-acre density.

Scenario Analysis

To allow for the possibility of different types of growers planting a new grove, we also made assumptions regarding the level of investment needed in terms of machinery and irrigation. We assume such investment could be either full or partial so as to represent the cases of a new grower and that of a current grower, respectively. The difference between the two scenarios is that in the full-investment scenario, the grower needs to purchase all machinery and irrigation equipment required to manage the grove, whereas in the partial-investment scenario, the grower only needs to make some investment in irrigation (the well and pumping station are assumed to be in place already). However, in both scenarios we assume that the grower needs to purchase a new tractor, ATV, and pickup truck in year 11. The rest of the machinery is assumed to be used beyond its accounting lifespan of 10 years.

Yield is a key parameter in the model, and we assume two possible scenarios for it. In both scenarios, trees start to fruit 26 months after planting. In the first scenario, which we refer to as low, we assume that the boxes per tree for each of the different age cohorts are given by the USDA-NASS average for southwest Florida during seasons 2013/14 through 2015/16. Such estimates represent approximately a 40% yield reduction compared to pre-HLB yield levels, which is in agreement with the average loss reported by growers (Singerman and Useche 2017). In the second scenario, which we refer to as high, we assume trees yield more boxes relative to scenario 1 based on the feedback from growers we visited with, who attain yields higher than the state's average. Regarding yield quality, we assume that in both scenarios each box yields 6.24 pound solids (ps) (FDOC 2017a).

Price is another key parameter in the model. The average delivered-in price for Valencia (late-season) oranges in 2016/17 was $2.85/ps (FDOC 2017b). To obtain the on-tree price (which is the price the grower receives) from the delivered-in price, we subtract $3.27/box (Singerman et al. 2017) for harvesting and $0.07/box for FDOC assessment from delivered-in prices and obtain $2.31/ps. We model three scenarios to represent possible market conditions: low, medium, and high prices. Thus, we use the on-tree price estimate as the medium price scenario and assume a 15% decrease (10% increase) with respect to such price to establish the low (high) scenario of $1.97/ps ($2.55/ps); these translate into delivered-in estimates of $2.50/ps and $3.08/ps, respectively. These prices were chosen so as to represent a range of conservative current and future potential market conditions. For simplicity, we assume that prices are constant throughout the investment period. We assume that the annual cash flows are expressed in real terms, so we do not need to adjust them for inflation. Thus, the resulting rates of return are to be interpreted in real terms as well.

Results

By combining the investment requirement (full or partial), cost of production, yields, and prices described in the previous section, we obtained a set of different scenarios for each tree density. Thus, we computed a financial budget for each scenario, which is the basis for the investment analysis—the typical methodology for establishing the profitability of an investment.

Interestingly, annual expenses for higher tree densities do not increase proportionally with the number of trees planted. Figure 1 shows the cash expenses for each of the three tree densities throughout the 20-year investment period. Panel A of that figure denotes the expenses for the partial-investment scenario and panel B for the full-investment scenario. In the partial-investment scenario, expenses in year 1 are $6,908, $8,253, and $10,265 per acre for 145, 220, and 303 trees per acre, respectively. The latter two are 19% and 49% higher relative to the 145-trees-per-acre baseline. In years 2 and 3, expenses for the 220- and 303-tree densities decrease but are still approximately 20% and 50% higher with respect to those of a grove planted at 145 trees per acre. However, in years 4 through 11, expenses are approximately between 7% to 10% higher for the 220-trees-per-acre density, and 16% to 28% higher for the 303-trees-per-acre density compared to the baseline. Starting in year 12, expenses are only up to 6% and 15% higher for the 220- and 303-trees-per-acre density, respectively, compared to the 145-density baseline. As shown in Figure 1 panel B, results for the full investment scenario show a similar trend.

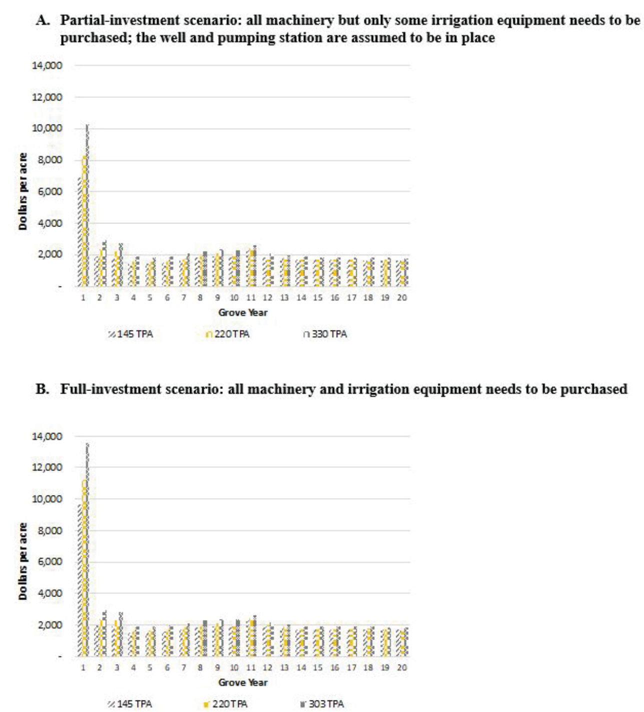
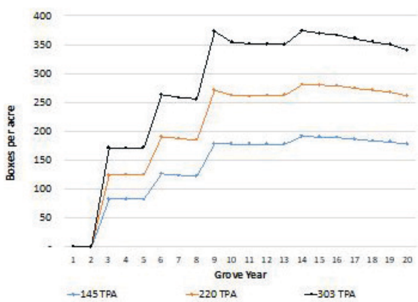


Figure 1. Cash expenses by grove year for 145, 220, and 330 trees per acre (TPA).

Yield per acre increases proportionally to the higher number of trees planted. Such proportional increase is imposed by assumption because, as described above, we used data on yield per tree from USDA-NASS (2017) for our calculations. However, starting in year 10, the proportional change decreases due to the effect of the penalty we impose for canopy closure (3.5% and 5% for the 220 and 303 densities, respectively) and resetting strategy for the higher densities. Figure 2 shows yield per acre by grove year for each of the three tree densities under the low and high scenarios and illustrates the proportional increase in yield for tree densities 220 and 303 relative to the 145-tree-density baseline.

A. Low Yield



B. High Yield

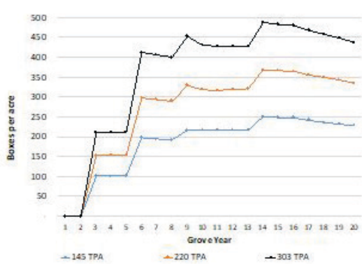


Figure 2. Yield per acre by grove year for 145, 220, and 303 trees per acre (TPA).

We use investment analysis to evaluate the profitability of the long-term investment in an orange grove. The Net Present Value (NPV) can be used as a methodology for such evaluation, which consists in summing all the discounted cash flows. As a rule of thumb, investments with a positive NPV should be accepted and those with a negative NPV rejected. The rationale for accepting investments with positive NPVs is that they yield higher returns than the discount rate (i.e., cost of capital). However, it is impossible to estimate a discount rate that would represent the cost of capital for all growers; each individual grower has a different opportunity cost of capital. Therefore, we show the results of the investment analysis using the internal rate of return (IRR) methodology. The IRR is the actual rate of return on the investment; it is the discount rate that makes the NPV be zero.

Table 1 shows the results of the investment analysis for the different scenarios and tree densities. Table 1 panel A shows that in a grove with 145 trees per acre, under a scenario with low yield and low prices, the investment is not profitable; with medium prices, the partial-investment scenario yields an IRR of 1%. Table 1 panel A also shows that, when prices are high, there is a modest return between 1% and 3% depending on the level of investment in machinery and irrigation. Under a high-yield scenario, the IRR of a grove with 145 trees per acre varies from 1% up to 10% depending on the combination of prices and investment requirement. The payback period is 12 years in the best-case scenario.

Despite the higher initial investment relative to the 145 baseline, Table 1 panel B shows that in a grove with 220 trees per acre, the IRR are positive. Under a low-yield scenario, the IRR ranges between 2% to 10%, depending on market conditions and the level of investment required. The payback period is at least 12 years. Under a high-yield scenario, depending on the level of prices and investment, the IRR ranges from 8% to 17%, and the payback period can be as low as 8 years in the best-case scenario.

Table 1 panel C shows the IRR for a grove with 303 trees per acre improved beyond those obtained for 220 trees per acre even further (despite the even higher level of initial investment relative to the baseline). Under a low-yield scenario, the rate of return ranges between 5% to 13%, depending on market conditions and the level of investment needed. In a high-yield scenario, depending on prices and the investment required, the IRR ranges from 11% to 20%, and the payback period can be as low as 8 years in some cases.

The main driver for the results discussed above is that while the costs of higher-density groves do not increase proportionally with the number of trees, yield per acre does. More specifically, while in a higher-density grove each tree produces somewhat less yield compared to a tree in a lower-density grove, the higher number of trees contributes to obtain a higher yield per acre. Therefore, planting higher-density groves could help offset some of the impact of HLB by decreasing the cost of production per box due to costs being allocated to a higher number of boxes (Figure 3), ultimately resulting in an increase in profitability per acre.

Conclusions and Limitations of the Analysis

We found that a grove with a tree density similar to that of the state's average is not profitable under current market conditions. Moreover, such tree density only attains a modest return under potential higher prices. However, despite the higher level of investment required for planting 220 and 303 trees per acre, our analysis shows that under the assumptions and scenarios we analyzed, those investments yield positive returns.

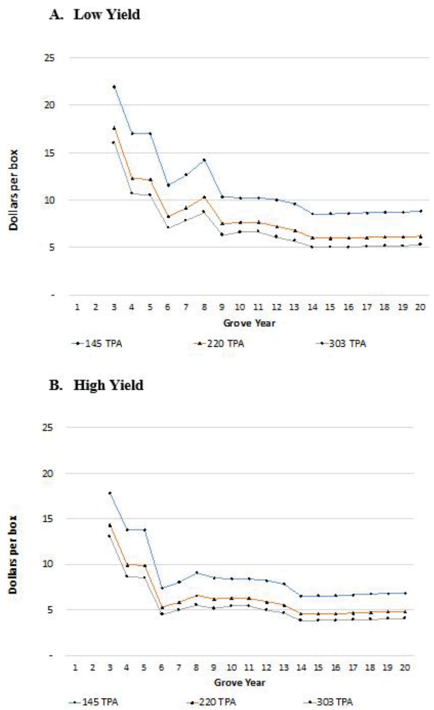


Figure 3. Average cost per box by grove year for 145, 220, and 330 trees per acre (TPA).

The limitations of this analysis are the following. First, because HLB was first found in Florida in 2005, it is not yet clear how trees will be affected by the disease in the future. Therefore, in our model, the impact of HLB on yield of trees that are 13 years old and older is a projection based on current data. Second, we did not include any potential impact of weather events such as freezes or hurricanes (and their effect on prices and yield) in our analysis. Third, potential future management strategies or solutions to HLB could involve planting (new) trees with resistant or tolerant traits to the disease, which could make an existing grove with trees that do not have such traits obsolete.

Excel spreadsheets containing the analysis presented in this article can be downloaded at the website listed below. In addition, once downloaded, the user can customize some of the estimates to make the analysis applicable to their own operation. https://www.crec.ifas.ufl.edu/extension/economics/economic_tools.shtml

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Table 1. Internal rate of return from investing in a new citrus grove.

Tree Density	Yield Scenario	Price ($)		Capital Investment	IRR	Payback Period (Year)
145-Trees-Per-Acre Scenario						
145	Low	Low	15.62/box	Full	-7%	Not in 20 years
			2.50/ps	Partial	-5%	Not in 20 years
		Medium	17.78/box	Full	-2%	Not in 20 years
			2.85/ps	Partial	1%	20
		High	19.23/box	Full	1%	20
			3.08/ps	Partial	3%	17
	High	Low	15.62/box	Full	1%	19
			2.50/ps	Partial	4%	16
		Medium	17.78/box	Full	5%	15
			2.85/ps	Partial	8%	13
		High	19.23/box	Full	7%	14
			3.08/ps	Partial	10%	12
220-Trees-Per-Acre Scenario						
220	Low	Low	15.62/box	Full	2%	18
			2.50/ps	Partial	4%	16
		Medium	17.78/box	Full	5%	15
			2.85/ps	Partial	8%	13
		High	19.23/box	Full	7%	13
			3.08/ps	Partial	10%	12
	High	Low	15.62/box	Full	8%	13
			2.50/ps	Partial	11%	11
		Medium	17.78/box	Full	11%	11
			2.85/ps	Partial	15%	9
		High	19.23/box	Full	13%	10
			3.08/ps	Partial	17%	8
303-Trees-Per-Acre Scenario						
303	Low	Low	15.62/box	Full	5%	15
			2.50/ps	Partial	8%	13
		Medium	17.78/box	Full	8%	12
			2.85/ps	Partial	11%	11
		High	19.23/box	Full	10%	11
			3.08/ps	Partial	13%	10
	High	Low	15.62/box	Full	11%	11
			2.50/ps	Partial	14%	9
		Medium	17.78/box	Full	14%	9
			2.85/ps	Partial	18%	8
		High	19.23/box	Full	16%	9
			3.08/ps	Partial	20%	8

2020–2021 Florida Citrus Production Guide: Grove Planning and Establishment[1]

Christopher Vincent, Tripti Vashisth, Mongi Zekri, and Ute Albrecht[2]

Main points:

- Plan all aspects of a new planting in coordination with your management program.
- Prepare soil and irrigation/fertigation infrastructure before planting.
- Use only good-quality plant material for planting.
- Careful planning prior to grove establishment will result in higher productivity and profitability.

"It's complicated."

Every choice in grove management affects other aspects of management, and many of these decisions must be made even before the grove is planted. For instance, decisions on planting density will have to consider the rootstock and the scion variety, because plant vigor will determine how quickly the space between plants will be filled. Because these choices are irreversible for the lifetime of the planting, each of them should be considered together, fitting each piece while considering the whole puzzle. This chapter addresses the most important decisions that should be made before and immediately after planting, and it refers to other chapters with more detailed information on specific management topics. The most important factors before planting fall into 1) site selection and 2) grove planning and preparation. Planting and early tree care are also essential to long-term grove success. Coordinated planning of all aspects of grove establishment and careful planting establishment can set you up for success and reduced frustrations in the future.

Site Selection

Every potential site has some challenges when establishing a new grove. In this section we will discuss the most important factors to consider when selecting a site, including pest and disease history, soil type, and quality of available water for irrigation.

Pest and Disease History

Soilborne pests tend to persist over many years. Make sure you know whether the site has a history of phytophthora or Diaprepes root weevil. Poorly drained soils are more likely to have phytophthora, even if there are no records for the site. When sites are available that do not have histories of these problems, it is better to choose those sites. If you cannot choose another site, we will discuss measures to manage sites with a history of soilborne pests or diseases in the site preparation section.

Management of neighboring groves must also be considered because it can greatly affect disease pressure, especially from HLB. If neighboring groves are managed poorly, high psyllid populations will likely be present in your grove at most times during the year. Having no citrus nearby or

1. This document is HS1302, one of a series of the Horticultural Sciences Department, UF/IFAS Extension. Original publication date July 2017. Revised April 2020. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

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having well-managed groves with active psyllid management is better.

Soil Fertility

Several soil characteristics affect soil fertility. These include pH, organic matter, and cation exchange capacity. Although most native Florida soils used for citrus plantings historically had a low pH in the upper 6 inches, at present most have a high pH. This is because most irrigation water is alkaline and raises the pH over time, leading to high pH in soils that have been in irrigated crop production. The optimum pH of soil and irrigation water is between 6.0 and 6.5.

Cation exchange capacity (CEC) is a measure of how well the soil holds most mineral nutrients. Most soils used for citrus production in Florida are sandy and have a very low CEC, usually between 0 and 2 (meq per 100 g soil). Below we will discuss approaches to managing low-CEC soils. Soil organic matter affects both nutrient- and moisture-holding properties of the soil. Most soils in Florida's citrus production areas have low organic matter (between 0% and 1%). A higher content of soil organic matter is generally preferred, because in most cases it will lead to higher CEC and water-holding capacity.

Soil Moisture

It can be difficult to achieve a happy medium of soil moisture in Florida soils. Upper layers of sand drain rapidly after rain or irrigation, leading to water deficits. However, high water tables or clay pans with poor drainage may result in waterlogging in the deeper layers of the soil. Waterlogging reduces the amount of oxygen that is available for root respiration and therefore inhibits root growth. In addition, growth of harmful microbes may occur in this oxygen-limited environment. If these conditions last for longer than 72 hours, root death is likely to occur. Root injury and death also open up infection sites for soilborne pathogens, such as phytophthora, which can further reduce root growth. Information on the history of flooding in the selected site will help assess whether waterlogging is likely to occur. In flood-prone regions, it is imperative to raise beds and establish a drainage system consisting of furrows, ditches, or tile drains.

Water Access and Quality

Access to water for irrigation is essential for citrus production in Florida. The site must have permits for well or surface-water pumps. Additionally, pump volume capacity must meet the maximum volume needed for the planting. The irrigation management chapter of this guide provides more information on determining the volume of water needed to irrigate the area supplied by the available pumps. Irrigation output capacity is especially important in areas where irrigation is used for freeze protection. If sufficient water volumes cannot be delivered during the freeze, then the system will fail. Consider the available infrastructure when choosing the site.

The quality of the water available for irrigation is as important as the available quantity. The best-quality water should not be alkaline nor contain high levels of bicarbonates. The specific concentration at which bicarbonates begin to affect citrus root growth is not known, but lower concentrations should be preferred over higher concentrations. Some evidence suggests that concentrations higher than 100 ppm of bicarbonates will negatively affect root growth. Any grower using nonsurface irrigation water should consider approaches to remediate bicarbonate levels.

Weather—Freeze Risk

Although freezes do not occur often in Florida, if they do, they can result in great economic losses and set a grove back by years in terms of production. The risk of freezing temperatures is the major reason for the expansion of citrus production areas southward since their initial establishment in northern Florida. The history of freezes is a good way of understanding the relative future risk of a freeze event a particular location. Most freezes in Florida are advective, meaning they result from cold air that moves in fronts from the north. These freezes pose regional risks, though the risk is higher further north. Sites close to a large body of water may have some relief from an advective freeze if they are on the leeward side, because the water will warm the cold air as it crosses. However, some freeze events are convective, which means that they result from warm air dissipating upward as colder air settles. In a convective freeze topography makes all the difference. Lower-lying areas between hills are more likely to accumulate cold air in frost pockets and are therefore more prone to freezes than sites that are elevated above their surroundings. Especially in northern production areas, frost pockets should be anticipated and adequately prepared for to avoid major crop losses. The risk of freezing should be considered when choosing the planting site, as well as when choosing rootstock and scion varieties and irrigation systems.

Grove Planning and Preparation

No site is perfect. In this section we discuss how to overcome challenges presented by a selected site and approaches to reduce risks and improve productivity.

Grove Design

Before the site is prepared and the irrigation system is installed, you should consider tree spacing and orientation, because they can greatly affect profitability of a planting. Sunlight is the source of energy for tree and fruit growth; therefore, a grove should be designed so that the tree canopies capture sunlight most efficiently. Tree spacing should be based on the expected vigor of the scion/rootstock combination and the expected lifespan of the grove. Tree rows oriented north to south will maximize sunlight interception. However, row orientation may also depend on the row length and the direction of water drainage. A good grove design results in healthier, more productive trees with only minor pruning required.

Spacing between rows is a question of infrastructure. Rows need to allow enough space for a tractor to pass through without harming the trees when they are mature. Typically, row spacing is 18–22 feet. This allows enough space for an 8-foot wide tractor to pass between trees with 10–14 foot canopy widths. The between-row spacing should be as narrow as your equipment allows. Anything wider than necessary will result in fewer plants per acre and thus fewer boxes of fruit per acre. Within rows, growers typically plant 8–12 feet apart, though there are no studies comparing planting densities with currently planted varieties in Florida. A spacing of 18 feet between rows and 8 feet within rows allows for 302 trees per acre, whereas a spacing of 22 feet between rows and 12 feet within rows only allows for 165 trees per acre. Within this range, climate, soil, scion variety, influence of rootstock on tree vigor, and expected disease pressure should be considered. In general, groves planted at higher density provide earlier returns than groves planted at lower densities, though they do not produce higher yields at maturity. Because the expected life span of a tree is considerably shorter under the present endemic conditions of HLB in combination with reduced yields of infected trees over time, maximizing yield during the early production years is essential. For a detailed assessment of the economics of planting density, see chapter 12 of this guide, *Planting New Citrus Groves in Florida in the Era of Citrus Greening*.

Pest History

It is best to avoid sites that have a history of Diaprepes root weevil or phytophthora. If this is not possible, measures can be taken to minimize the effects of this pest-disease complex. Generally, phytophthora problems are intensified in poorly drained soils. Therefore, improving drainage will reduce disease pressure (see "Soil Moisture," below). If the selected site has a history of phytophthora or Diaprepes root weevil, choosing the proper rootstock is essential. Several rootstock options are available; see the Rootstock Selection Guide (https://crec.ifas.ufl.edu/extension/citrus_rootstock/templates/guide/explore.html) for more information.

Soil Fertility

One of the major fertility challenges in Florida citrus soils is high pH. Adjustment of the pH to the optimal range of 6.0–6.5 is recommended, because at a higher pH, availability of some nutrients is limited. However, soils that have high pH will tend to be high for a long time. Therefore, if the pH of the planting begins high, you should consider planting with one of the few rootstocks that tolerate high pH.

Florida citrus soils often require adjustment prior to planting. Our soils often have high pH accompanied by low nutrient-holding capacity. Preplanting applications of acidifying fertilizers, such as ammonium sulfate, can help lower the soil pH. Additionally, acid injection systems to acidify irrigation water should be considered. For more information, see chapters 15 and 16 of this guide on irrigation and nutrition management.

In addition to pH adjustment, preplant practices that increase or preserve soil organic matter can improve soil fertility during establishment. These practices include the planting of cover crops and using minimal tillage to prepare the ground for planting, if additional shaping, such as bedding is not required. Although costly, additions of composted materials increase soil fertility and therefore tree growth and productivity of newly planted trees, because they help maintain a balanced pH and improve nutrient-holding capacity. For further information about cover crops, SARE offers a well-documented cover crop manual for free download (https://www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition).

Soil Moisture

Excessive soil moisture can be more damaging to citrus trees than drought. More than 3 days of rootzone flooding will cause severe damage to the roots followed by tree decline and possible death of trees. Sites in the southern and coastal areas of the state referred to as flatwoods are poorly drained and therefore are more prone to flooding than other parts of the state. To improve drainage in poorly drained areas, trees are usually planted on double-row raised beds. The crown of raised beds should be 3–4 feet above the bottom of the furrow. Drainage systems consist of water furrows, ditches, tile drains if needed, and a perimeter ditch to remove excess water. The drainage system in the flatwoods should be designed to remove 4 inches of water per day. Drainage is usually adequate in the sandy soils of the central Florida ridge, and these groves usually do not require bedding or additional drainage measures.

Because of seasonal prolonged periods without adequate rainfall, in combination with the predominantly sandy soils in Florida's citrus production areas, installation of an irrigation system is required prior to planting. Microirrigation, including low-volume emitters such as drippers or microsprinklers, is preferred over other systems because it is more cost-effective and water-use efficient than traditional sprinkler systems. Microirrigation systems are easily automated and operate at lower pressures and hence use less energy. Microsprinkler systems can be engineered to offer some degree of cold protection by installing one emitter per tree and using additional "spaghetti" tubing to hang the emitter in the lower canopy when there is threat of a freeze. Compared to overhead irrigation, microirrigation also reduces incidence of diseases that thrive in a moist environment by not wetting the canopy.

The goal of designing an irrigation system is to apply the water uniformly across the grove, improve water-use efficiency, and minimize water losses to evaporation, runoff, or drainage below the root zone. Uniform application means that each tree receives the same amount of water. Water-use efficiency means that the plants receive just enough water to grow optimally. This will also minimize nutrient leaching. When designing an irrigation system to optimize water-use efficiency, emitter type and strategies to schedule and monitor irrigation need to be considered. For details of irrigation management, please see chapter 15 of this guide, *Irrigation Management of Citrus Trees*.

Nutrient management should also be considered when selecting an irrigation system. Injection systems can allow you to acidify the soil through acid injection or to fertilize through the irrigation system ("fertigation"). There are other options to reduce soil pH, including acid-forming fertilizers and elemental sulfur. However, for sites with high soil and water pH, an injection system may be the most effective. Injection systems should be installed preplanting.

Water Supply

When planning for adequate supply of water, well capacity and permits for any additional wells need to be considered. Well capacity should be calculated for the maximum volume needed, whether for cold protection or for irrigation. In the dry season, calculations need to include the estimated volume of water lost to total daily evapotranspiration of the crop per acre. For cold protection, calculations need to include the maximum volume needed to ensure the crop remains above freezing temperature. See chapter 15 on irrigation management and chapter 21 on cold protection for how to calculate these values. It is important to conduct these calculations before designing the irrigation system to avoid a situation where the system is not capable of delivering the amount of water needed to keep trees alive and productive.

Variety Selection

Both scion and rootstock selection should consider soil type, expected disease pressure, and desired planting density. Choosing the rootstock that is best adapted to the conditions of the soil in the selected site is essential for maximum productivity. In addition, rootstock will influence tree size, fruit quality, and yield. If you intend to have a high-density planting, small-to-mid-size-inducing rootstocks should be preferred over more vigorous rootstocks. Small-to-mid-size-inducing rootstocks should also be preferred if fruit quality is of concern. Similarly, vigorous scion varieties such as Sugar Belle are also not well-suited to high-density planting. Vigorous varieties will generally require more pruning, especially when planted at a higher density. For more information on rootstock and scion selection, see chapter 12 of this guide.

Planting

Sourcing High-Quality Trees

High-quality nursery trees are essential for maximum productivity. Citrus growers should purchase only from certified nurseries to obtain healthy, uniform, and true-to-type trees. Healthy trees should have retained the majority of their foliage and have a well-developed root system. Roots should not be pot-bound. Trees should be of good vigor with a mature woody stem (larger than ⅜" in diameter) to ensure survival and rapid growth after planting. Trees with mature flush are preferred over trees with tender new flush, because the new flush may compete with roots for available resources after growth. A good sign of tree health is how long the leaves have remained on the tree; the lower in the canopy the leaves have been held, the more likely the plant has not had a debilitating stress while in the nursery.

Planting Day

Young citrus trees can be planted during most times of the year. However, in regions where there is potential for freezing temperatures, planting should be delayed until the spring. Ideally, trees should be planted on the same day they are received. Under no circumstances should the roots be allowed to dry out. To minimize root desiccation and damage, trees should be kept shaded and moist until they are planted. Trees should be removed from the container and roots should be inspected. If roots that are tangled are not removed, they will remain tangled and will restrict growth and therefore productivity of the tree. Therefore, pot-bound roots should be removed or untangled prior to planting. If roots are moderately pot-bound, use a clean and sharp knife to make several vertical slashes about one-inch deep through the root ball to encourage new root growth. These slashes will also allow the roots to interface more closely with the soil in the planting hole. If planting severely pot-bound plants cannot be avoided, it is advisable to cut off the outer ½" of the root ball. Alternatively, some of the outer roots may be exposed by pulling them so they protrude from the root ball and extend into the soil in which the tree is planted. If roots are left in a pot-bound state, trees will not grow quickly, and growth may be hampered for the life of the tree. Trees with irregular root systems should not be planted, because this indicates other problems, such as phytophthora. For more information on root health, refer to chapter 18 of this guide, *Root Health Management*.

Other Details to Consider at Planting

Plastic tree tags from nurseries may girdle a tree if they remain on the trunk and become buried in the soil during planting. Remove tree tags or ensure they remain aboveground, where they will usually deteriorate over time and not girdle the tree. Tree damage can also occur from metal tree stakes. Close contact of stakes with the tree trunk can lead to injury and pathogen infection and therefore restrict tree growth.

Caring for Young Trees

Because of Florida's sandy soils, high temperatures, and frequent rainfall, young tree care requires regular fertilization, insect and disease management, and weed control. The primary objective during the first few years is rapid development of the tree canopy. Young trees are more sensitive and more attractive to pests than mature trees due to high levels of vegetative growth. Monitoring for insect pests and diseases in new plantings is essential, and adequate control is imperative. Weed management is especially important in newly established groves to reduce competition and ensure rapid tree growth. Application rates of crop protection chemicals need to be adjusted based on the size of the trees. Proper irrigation and nutrition are also critical factors to ensure rapid growth of young trees. Minor selective pruning (especially of water sprouts) can be beneficial during the first two years to develop good canopy architecture. The goal of such pruning should be to develop a canopy that allows light penetration into the center of the canopy.

Weed Control

Weeds compete with young citrus trees for water, nutrients, soil-applied pesticides, and sunlight, and they should be controlled both before planting and during the early years of growth. If herbicides with residual activity are used prior to planting, they should be applied at least 30 days in advance of planting to avoid negative impacts on the young trees. Herbicides should always be applied at recommended rates, which are lower for young trees. Not all herbicides are suitable for young trees; be sure to read labels carefully for restrictions. To minimize herbicide contact to young trees, using tree wraps is advisable. When using wraps, be sure to monitor the space between trunk and wrap for ants or other pests that may damage the tree. For more information, refer to chapter 44 of this guide, *Weeds*.

Suckering

Rootstock sprouts, called "suckers," should be removed during the growing season before the sprouts become large and compete with the scion shoots. Young trees require regular sprout removal. Tree wraps usually reduce the need for removal.

Irrigation and Drainage

Because of their smaller root systems, young citrus trees require frequent but moderate irrigation for survival and proper growth. Irrigation systems should be in place before planting. Trees should be monitored frequently to be certain they are receiving sufficient but not excessive amounts of water. For more information, refer to chapter 15 in this guide, *Irrigation Management of Citrus Trees*.

Fertilization

Regular fertilization of young trees is imperative to promote vigorous vegetative growth that rapidly produces a canopy with high fruit-bearing capacity. Applying fertilizer in several small doses is more efficient than applying fertilizer in few large doses because it ensures constant nutrient availability and reduces losses due to leaching. Frequent application of water-soluble fertilizers with irrigation water (fertigation) or use of controlled-release fertilizers can greatly increase nutrient-use efficiency. The needed quantities of water and fertilizers increase each year as the trees grow and should be based on tree size and canopy density. Great care must be taken to ensure that proper rates of fertilizer materials are dispensed to prevent nutritional deficiencies or toxicities. For more information, refer to chapter 16 of this guide, *Nutrition Management of Citrus Trees*.

Pest Control

Because young trees flush more frequently than mature trees, they are more attractive and sensitive to pests. Therefore, special care is needed to control Asian citrus psyllids and leafminers to reduce leaf damage, severity of citrus canker, and incidence of HLB. Maintaining young trees free of citrus canker and HLB is of utmost importance, because the trees that become infected during the early years will never become productive. Relying solely on foliar-applied contact insecticides for young trees is not a good strategy. Recently, noninsecticidal approaches, such as the use of kaolin particle films or individual-tree pest-exclusion nets have been developed. For more information on management of citrus psyllids and leafminers, refer to the pest management sections in this guide. Under the current HLB-endemic conditions in Florida, trees are very likely to become infected, but any practice that prevents or delays infection will improve productivity and higher economic returns in the long term.

2020–2021 Florida Citrus Production Guide: Irrigation Management of Citrus Trees[1]

Davie M. Kadyampakeni, Kelly T. Morgan, Mongi Zekri, Rhuanito S. Ferrarezi, Arnold W. Schumann, and Thomas A. Obreza[2]

The chapter on irrigation management of citrus is largely taken from guidelines provided in SL463, *Nutrition of Florida Citrus Trees*, Chapter 9 on trees prior to citrus greening, available here: https://edis.ifas.ufl.edu/ss676. A section has been added to cover recent findings on water use of trees affected by citrus greening and the impact this would have on irrigation management considerations.

Water Supply

Water is a limiting factor in Florida citrus production during the majority of the year because of the low water-holding capacity of our sandy soils and the nonuniform distribution of rainfall. In Florida, the major portion of rainfall occurs from June through September, but rainfall is usually scarce from February to May. The latter period coincides with the critical stages of leaf expansion, bloom, fruit set, and fruit enlargement, and additional irrigation is necessary to reduce the negative effects of water stress. Adequate irrigation management is key to optimize water use and increase crop yield. Several weather-, soil-, and plant-based methods are available for irrigation management. The most-used methods rely on weather stations to calculate evapotranspiration (ET), which is the combination of water lost by plant transpiration and removal of water from soils and wet surfaces by evaporation. Therefore, ET plays a critical role in agricultural irrigation management.

Allowable Soil Water Depletion

As soil dries out, water becomes increasingly difficult for trees to remove, which can eventually cause water stress. Tree health and yield will suffer if the soil is allowed to get too dry. To provide adequate water for flowering, fruit set, and vegetative growth, maximum soil water depletion should not exceed 25% to 33% of available water from February to June. Once the rainy season starts, the maximum depletion can be increased to 50% to 66%. This additional allowable depletion increases the capacity of the soil to hold rainfall without leaching nutrients or any applied chemicals. The same depletion in the fall and winter months will save water without reduction in yield. The soil water depletion of the available soil water is calculated as the difference between moisture contents at field capacity and permanent wilting point. Field capacity is the water content at which the initial rapid gravity drainage ceases or becomes negligible, considered as 10 cb for sandy soils. The permanent wilting point is considered the soil water content at 15 bar.

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Irrigation Scheduling

Improved irrigation strategies must be practiced to allow growers to maintain or increase crop production without depletion of water resources. Increase in water-use efficiency is achieved by selecting a proper irrigation scheduling method and application timing. Proper irrigation scheduling applies an appropriate volume of water to a citrus grove at the appropriate time based on tree need, soil properties, and weather conditions. Successful irrigation management maintains sufficient water and nutrients in the root zone to maximize plant growth and health.

Growers who focus on improving water- and nutrient-use efficiency simultaneously will reduce nutrient losses and decrease negative environmental impacts. While some nutrient loss is unavoidable due to excess rainfall, loss due to management decisions can be minimized.

Current UF/IFAS citrus irrigation recommendations estimate citrus tree water requirements for mature trees based on data collected prior to the introduction of HLB into Florida. Citrus trees affected by HLB are known to lose substantial foliage and root mass depending on disease severity, thus negatively influencing water and nutrient uptake.

The commonly used methods of irrigation management include soil water measurement, water budgeting, and smartphone apps.

Soil Water Measurement

Experience or the calendar method can provide a reasonably good irrigation schedule but are not accurate enough to maximize water-use efficiency and prevent nutrient leaching. Using soil moisture sensors (Figure 1) improves accuracy because they quantitatively measure changes in soil water status. These devices may be fixed in one location, portable, or handheld. They may measure soil water at one depth or at multiple depths. General categories include time-domain refractometry (TDR) probes and capacitance probes.

Considerations when using soil moisture sensors to schedule irrigation include:

- Knowing the soil water-holding capacity and tree root zone depth.
- Placing sensors where the majority of roots are located (typically in the top 12 inches), such as at the dripline of the tree.

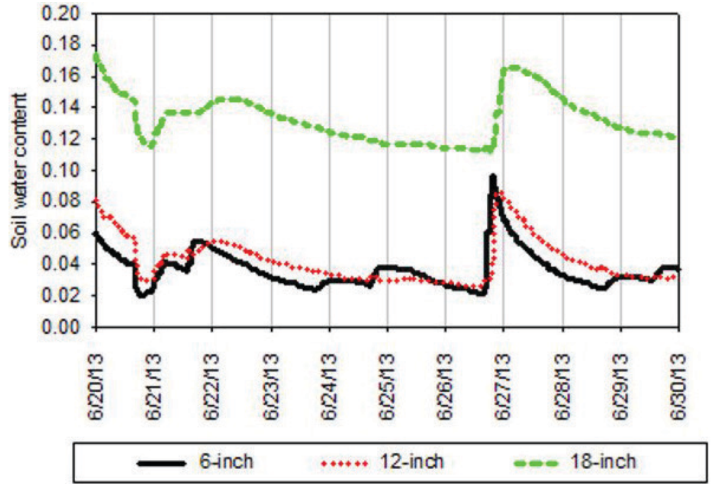

Figure 1. Continuous monitoring of soil moisture at 6-, 12-, and 18-inch depths in the soil by a multilevel capacitance probe installed in the root zone of a mature citrus tree.

- Using multiple sensors, both across the grove and with depth, to fully characterize the tree root zone.
- Moving sensors to follow root growth as the tree canopy expands in developing groves.
- Basing irrigation on the soil depth containing the greatest root density.
- Managing root zone soil moisture between field capacity and the maximum allowable water depletion (one-fourth to two-thirds depletion, depending on the time of year).

Water Budgeting

An alternative method to schedule irrigation uses a computer program that estimates tree water consumption (ET) from weather data. Reference ET and convenient irrigation scheduling management tools for all Florida citrus production regions can be found on the Florida Automated Weather Network (FAWN) website at https://fawn.ifas.ufl.edu and http://www.crec.ifas.ufl.edu/extension/trade_journals/2015/2015_March_grower_tools.pdf.

Smartphone Apps

Mobile smart devices (e.g., smartphones, tablets) have become popular because of their convenience and ease of use, making them ideal for disseminating information on a regular basis with real-time data. Tools developed for use on mobile smart devices are typically called “apps” and are available for a variety of functions. Due to the increasing popularity of smartphones and apps, FAWN developed an app for the iPhone and Android platforms, provided as a cost share from the Florida Department of Agriculture and Consumer Services, that allows users to view data from grower-owned weather stations on their smartphones in much the same way that the data can be viewed on the FAWN webpage. UF/IFAS has also developed smartphone apps for crop irrigation scheduling using FAWN weather data. The Citrus SmartIrrigation apps are available to download in the App Store and Play Store at no cost. A simple description of how to use the app is available at https://crec.ifas.ufl.edu/extension/trade_journals/2016/2016_July_app.pdf. The goal is to provide users with an easy-to-use mobile app to access information to improve irrigation scheduling for a wide range of crops, including citrus. By using the app instead of a set time-based schedule for irrigation, accurate irrigation is achieved. The irrigation scheduling app has the potential to reduce water and fertilizer use, resulting in reduced irrigation and fertilizer costs and the possibility of reducing nutrient leaching

Irrigation Strategies to Improve Nutrient Uptake and Reduce Leaching

Developing an irrigation strategy to reduce nutrient leaching has the objective of not applying more water than the root zone can hold. Considering the low water-holding capacity of citrus grove soils, this objective is very challenging even for the most experienced and diligent irrigation managers. The major questions to be answered in this procedure are:

- How much water can the root zone hold?
- What is the maximum irrigation system run time before leaching occurs?

Example

We have a central ridge citrus grove with the following characteristics:

- Tree spacing—12½ ft in-row × 25 ft between rows.
- Tree canopy diameter—17½ ft.
- Root zone depth—3 ft.
- One 16 gal/hr microsprinkler per tree with a 16-ft diameter wetted pattern.
- The citrus root zone is continuous from tree to tree, existing both inside and outside of the wetted pattern.
- The irrigated system wets approximately 60% of the total root zone (Figure 2a).
- Nutrient leaching risk in this grove is higher within the wetted pattern due to potential overirrigation, plus the fact that most fertilizers are applied to that zone (Figure 2b). A good irrigation manager will control this risk with careful water management.

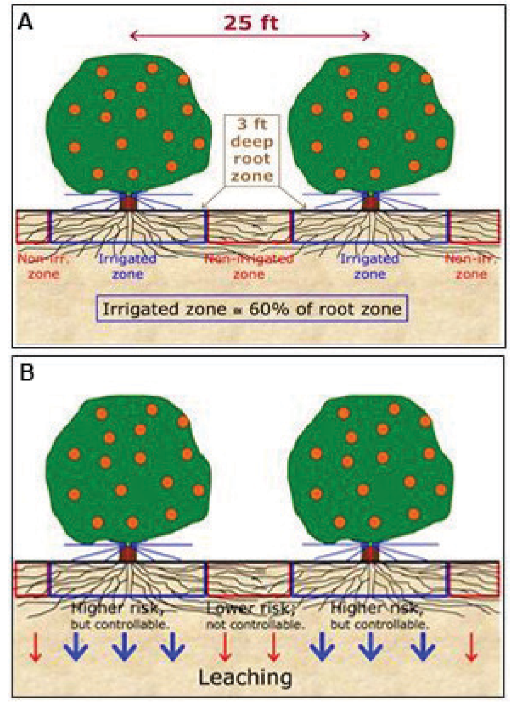

Figure 2. A) Scaled diagram of example citrus grove described above (top); B) Irrigated and nonirrigated zones in a citrus grove have different leaching potentials that depend on irrigation scheduling and fertilizer placement (bottom).

This example starts with the entire grove at field capacity moisture content following a heavy rain (Figure 2b). The citrus trees begin to remove water from the soil in response to the atmospheric ET demand. After several days have passed (depending on time of year), the water content in the root zone decreases to 50% of available water capacity (Figure 3a).

At this point, the grove manager turns on the irrigation system and operates it long enough to return the soil in the wetted pattern back to field capacity (Figure 3b). From this point until the next significant rainfall, the manager can only influence the soil water content in the irrigated zone. The water content in the nonirrigated zone rapidly decreases to the point where little to no soil water can be extracted by the trees.

If the grove manager operates the irrigation system too long and applies more water than the soil can hold, water will move beneath citrus tree roots. If water soluble nutrients like nitrate or potassium are present in the irrigated zone during the irrigation period, a portion will leach (Figure 4a).

How much water can the root zone hold?

- Central ridge soils—0.3 to 0.7 inches/ft
- Flatwoods soils—0.3 to 1.2 inches/ft

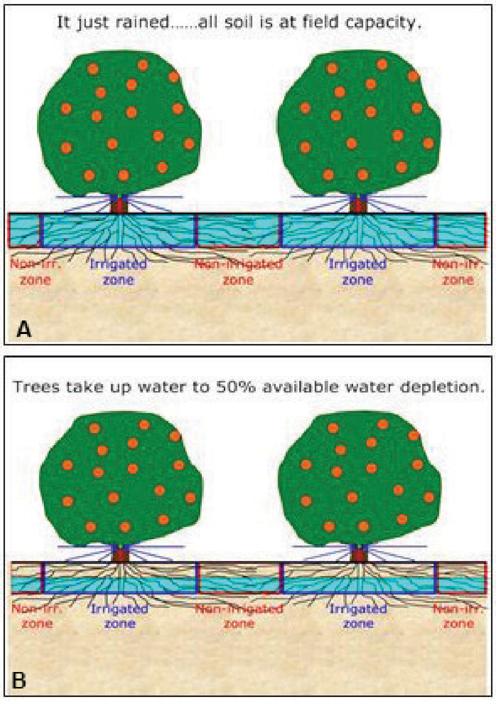

Figure 3. A) The citrus grove at field capacity soil water content (time = 0) (top); B) The citrus grove several days later, after half of the available water has been removed from the root zone. Note that water extraction has occurred from both the irrigated and nonirrigated zones (bottom).

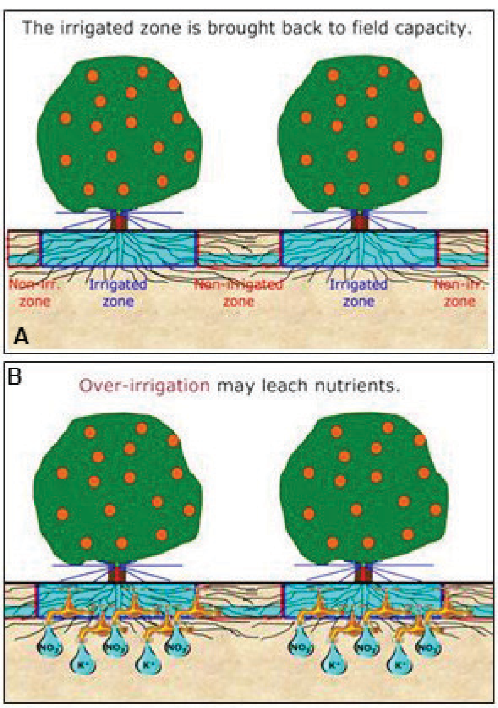

Figure 4. A) The citrus grove after irrigation returns the wetted zone to field capacity. Note that the nonirrigated zone contains very little available water (top); B) Excessive irrigation leaches mobile nutrients like nitrate or potassium (bottom).

What is the maximum system run time before leaching occurs?

Information needed:	In this example:
Soil water-holding capacity	0.6 inches/ft
Maximum allowable depletion	50%
Root zone depth	3 ft
Surface area wetted by microsprinklers	60%
Microsprinkler flow rate	16 gal/hr
Tree spacing	12½ ft × 25 ft

CALCULATIONS

1. Volume of water the root zone can hold: 0.6 inches/ft × 3 ft deep root zone = 1.8 inches

2. Volume of water to refill at maximum depletion: 1.8 inches × 50% = 0.9 inches

3. Volume of water this represents per tree space: 0. 9 inches/tree × 1 ft/12 in × (25 ft × 12½ ft) × 7.5 gal/ft^3 × 60% coverage = 105 gal/tree

4. Maximum system run time: 10.5 gal ÷ 16 gal/hr emitter flow rate = 6.6 hr

5. Adjust for system irrigation efficiency of 90%:

6. 6 hr ÷ 0.9 = 7.3 hr

Therefore, the irrigation system should never be run longer than about 7 hours for any single cycle provided that the available soil water is at least 50% depleted when the irrigation begins.

Irrigation Management Considerations for HLB-Affected Trees

With HLB, irrigation scheduling is becoming more important than ever, because water stress can negatively affect tree growth and crop production.

Other benefits of proper irrigation scheduling include reduced loss of nutrients through leaching due to excess water applications and reduced pollution of groundwater or surface waters. Three studies were conducted in Florida from 2011 to 2015 with the objective of determining 1) the effectiveness of ET-based irrigation scheduling on reduced water use in citrus, 2) irrigation requirements of HLB-affected citrus trees compared with healthy trees, and

3) effect of irrigation scheduling on productivity of citrus trees affected with HLB.

Results from the first field study indicate water use with soil moisture sensors and ET-based models reduced average monthly water use by approximately 14% of the conventional irrigation practice without reducing yields (see Notes section). Results from a second study under greenhouse conditions indicated that healthy trees consumed approximately 25% more water than HLB-affected trees (Figure 5). Reduced water uptake by HLB-affected trees resulted in significantly greater soil water content. The relationship between leaf area and water uptake indicated that diseased trees with lower canopy density and corresponding lower leaf area index take up less water and consequently less nutrients from the soil. The elevated soil water content may partially explain higher rates of root infection with *Phytophthora* spp. observed in some HLB-affected trees. The third experiment was conducted in three commercial groves on ridge and flatwoods soils. Irrigation schedules consisted of current UF/IFAS ET-based recommendations, daily irrigation, and an intermediate schedule, all using the same amount of water on an annual basis. The UF/IFAS schedule was determined weekly using the Citrus Irrigation Scheduler found at the Florida Automated Weather Network (FAWN) website (https://fawn.ifas.ufl.edu/tools/irrigation/citrus/scheduler/) and resulted in irrigation schedules ranging from daily in May to every 10–14 days in the winter months from November to February. Daily irrigation schedules were determined by dividing the UF/IFAS irrigation duration by the number of days between irrigations. "Intermediate" irrigation was half the UF/IFAS interval for half the time. Daily irrigation increased tree water uptake and soil water content compared with Intermediate and UF/IFAS schedules. Daily and Intermediate irrigation increased canopy density as measured by leaf area index compared with the UF/IFAS schedule. Fruit drop per square foot under canopy area was lower for daily irrigation schedules in the second year of the study, but yields were similar among all irrigation schedules.

This shows that for HLB-affected trees, **irrigation frequency needs to be increased and amounts of irrigation water decreased to minimize water stress from drought or excess water**, while ensuring optimal water availability in the root zone at all times. Growers should seek to maintain soil moisture in the root zone (top 3 feet for ridge and 18 inches for flatwoods soils) using soil moisture sensors or irrigation apps. The SmartIrrigation app provides the option of daily irrigation schedules. As noted above, HLB-affected trees with lower canopies use less water than do healthy trees. Therefore, if the irrigation scheduling app is used, the irrigation time should be reduced by 10% to 20%. For example, if the app suggests an irrigation time of 1 hour, this time could be reduced by 6 to 12 minutes for HLB-affected trees.

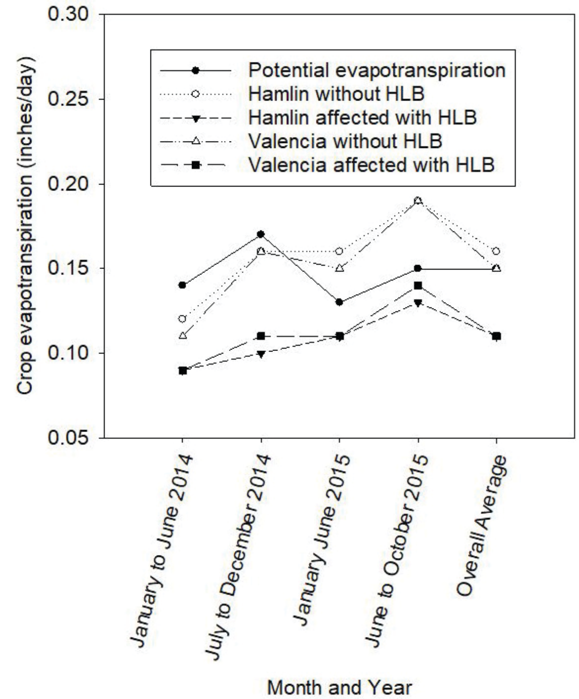

Figure 5. Water use of HLB-affected trees in southwest Florida under greenhouse conditions.

Notes

[1] Figures 2 to 4 were illustrations included in SL253 chapter 9. The illustrations of water content changes in the citrus tree root zone (Figs. 3 to 4) do not represent the actual water extraction pattern. The blue shading shows 1) approximately where water extraction occurs beneath the canopy, and 2) the relative soil water content with respect to available soil water-holding capacity.

[2] Conventional irrigation practice for Florida citrus refers to use of microsprinkler irrigation based on replacing the citrus seasonal tree water requirements using Florida Automated Weather Network data.

2020–2021 Florida Citrus Production Guide: Nutrition Management for Citrus Trees[1]

Kelly T. Morgan, Davie M. Kadyampakeni, Mongi Zekri, Arnold W. Schumann, Tripti Vashisth, and Thomas A. Obreza[2]

The following description of citrus fertilizer uptake, soil and leaf testing, and nutrient recommendations was taken from EDIS publication SL253* and reflects citrus nutrient management for healthy trees prior to citrus greening, or HLB, entering Florida. Additional information on nutrients obtained since the publication was released appear in this document as "the effect of HLB" on various aspects of citrus nutrient management and are noted as such with published papers cited.

*__*Nutrition of Florida Citrus Trees*, 3rd Edition__ by Kelly T. Morgan and Davie Kadyampakeni (eds.) (2020)

Fertilizer, Nutrition Uptake, and Yield Response

This section describes the typical citrus yield increase with added fertilizers. The increase in yield with increased fertilizer rates is called the yield response curve. The shape of this curve is similar for a range of crops and conditions (Figure 1).

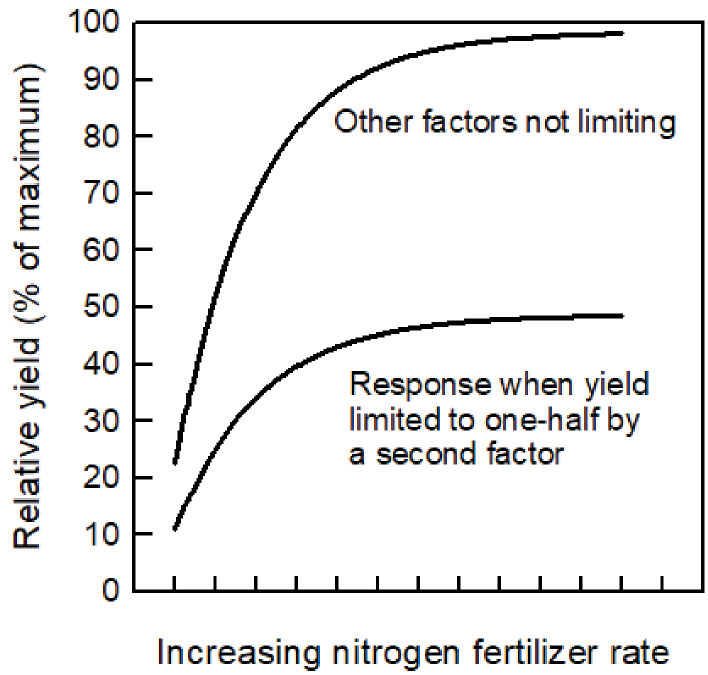

Figure 1. Generic response of healthy citrus yield to N fertilizer rate.

Fertilizer nitrogen (N) is used in this example, but the nature of the response curve is similar for other nutrients. At very low N rates, there is a large increase in yield with each added unit of N. As yield increases, each additional unit of N results in a smaller increase in yield. This smaller

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response to increasing the fertilizer amount is also referred to as the law of diminishing returns. The two response curves in Figure 1 compare the effect of N rate for two situations: one where the amount of fertilizer nutrients in the soil limits or reduces yield, and another where the yield is limited to one-half by low concentrations of a second fertilizer nutrient. The shapes of the curves are similar, and the rate of N where the slope levels off is only slightly higher for the more productive grove.

The amount of nutrient the crop removes varies from a fraction of a lb/acre for some of the micronutrients to as much as 100 lb/acre of N or K from a high-producing grove. For oranges, approximately 0.12 lb N/box is removed with the harvest. Therefore, crop removal ranges from 12 lb N/acre for a 100 box/acre yield to around 100 lb N/acre for a grove producing 800 boxes/acre.

Nutrient uptake from applied fertilizers is not 100% efficient—that is, not all the fertilizer applied is taken up by the tree, so more nutrients must be applied than the minimum required by the tree. N use efficiency, expressed as lb N removed by the crop divided by lb N applied, ranges from 0.2 to 0.4 in groves with low to moderate yield. For healthy citrus trees, N efficiencies around 0.5 have been observed in groves with a good production record. Application of 200 lb N/acre supplies sufficient N for an 800 box/acre orange yield when N use efficiency is 0.5.

Effect of HLB on Nutrient Uptake

Nutrient uptake efficiency of HLB-affected trees may be at the low range of N use efficiency because of root loss (up to 80% depending on HLB severity). Therefore, an HLB-affected citrus grove picking 300 boxes per acre and requiring 12 pounds of N per 100 boxes would need only 36 pounds of N. However, assuming an N use efficiency of 0.2, the amount of fertilizer N required for the year would be 36 divided by 0.2 or 180 pounds.

Leaf Nutrient Analysis

Leaf analysis is a useful tool to detect problems and adjust fertilizer programs for citrus trees because leaf nutrient concentrations are the most accurate indicators of sufficient nutrition of fruit crops. Leaves reflect nutrients taken up from the soil and redistributed throughout the plant, so the deficiency or excess of an element in the soil is often reflected in the leaf analysis. Nutrient deficiency or excess will cause citrus trees to grow poorly and produce lower yields and/or fruit quality. Determining potential nutritional problems should be a routine citrus-growing practice. Quantifying nutrients in trees or soils with leaf and soil analysis eliminates guesswork in adjusting a fertilizer program.

Leaf analysis should include N, phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), manganese (Mn), zinc (Zn), copper (Cu), iron (Fe), and boron (B). Chlorine (Cl) concentration is sufficient under most field conditions, but Cl may become excessive where soil or irrigation water is saline. Similarly, molybdenum (Mo) deficiency or toxicity is rare. The goal in tissue analysis is to adjust fertilization programs such that nutritional problems and their costly consequences from higher costs and lower yields are prevented.

Leaf analysis integrates all the factors that might influence nutrient availability and uptake. It shows the relationship of nutrients to each other. For example, potassium deficiency may result from a lack of K in the soil or from excessive Ca, Mg, or sodium (Na). Similarly, adding N when K is low may result in K deficiency because the increased growth requires more K.

Tissue analysis:

- Determines if the soil is sufficiently supplying the essential nutrients.
- Confirms nutritional deficiencies, toxicities, or imbalances.
- Identifies “hidden” toxicities and deficiencies when visible symptoms do not appear.
- Evaluates the effectiveness of fertilizer programs.
- Provides a way to compare several fertilizer treatments.
- Determines the availability of elements not tested for by other methods.
- Helps in determining interactions between nutrients.

Steps in Leaf Analysis

Citrus trees affected by HLB are typically low to optimum for many nutrients, but sampling guidelines should be followed precisely to ensure that analytical results are meaningful.

Procedures for proper sampling, preparation, and analysis of leaves have been standardized to achieve meaningful comparisons and interpretations. If done correctly, the reliability of the chemical analysis, data interpretation, fertilization recommendations, and adjustment of fertilizer programs will be sound. Therefore, considerable care should be taken from the time leaves are selected for sampling to the time they are received at the laboratory for analysis.

LEAF SAMPLE TIMING

- Leaf samples must be taken at the correct time of year because nutrient concentrations within leaves continuously change. As leaves age from spring through fall, N, P, and K concentrations decrease, while Ca and Mg increase. However, leaf mineral concentrations are relatively stable from 4 to 6 months after emergence in the spring.
- The best time to collect spring flush leaves of this age is July and August. If leaves are sampled later in the season, summer leaf growth can easily be confused with spring growth.

LEAF SAMPLING TECHNIQUE

- A sampled citrus grove block or management unit should be no larger than 20 acres. The sampler should make sure that the leaves taken represent the block being sampled.
- Each leaf sample should consist of about 100 leaves taken from nonfruiting twigs of 15 to 20 uniform trees of the same variety and rootstock and under the same fertilizer program.
- Use clean paper bags to store the sample. Label them with an identification number that can be referenced when the analytical results are received.
- Avoid immature leaves due to their rapidly changing composition.
- Do not sample abnormal-appearing trees, trees at the edge of the block, or trees at the end of rows because they may be coated with soil particles and dust or have other problems.
- Do not include diseased, insect-damaged, or dead leaves in a sample.
- Select only one leaf from a shoot and remove it with its petiole (leaf stem).
- Leaves should be washed with soapy water and rinsed with distilled water within 24 hours of sampling.

ANALYSIS AND INTERPRETATION

- The laboratory determines the total concentration of each nutrient in the leaf sample. Because total concentration is determined, there should be no difference in leaf analysis results between different laboratories.
- The laboratory usually interprets each result as deficient, low, optimum, high, or excess, but the citrus grower can also interpret the results using UF/IFAS leaf analysis standards (Table 1). These standards are based on long-term field observations and experiments conducted in different countries with different citrus varieties, rootstocks, and management practices and are used to gauge citrus tree nutrition throughout the world.
- The goal in nutrition management is to maintain leaf nutrient concentrations within the optimum range every year. If the interpretation for a particular nutrient is not optimum, various strategies can be used to address the situation (Table 2).

Soil Nutrient Analysis

Soil analysis measures organic matter content, pH, and extractable nutrients, which are useful in formulating and improving a fertilization program. Soil analysis is particularly useful when conducted for several consecutive years so that trends can be observed.

Similar to leaf analysis, methods to determine organic matter and soil pH are universal, so results should not differ between laboratories. However, soil nutrient extraction procedures vary from lab to lab. Several accepted chemical procedures exist that remove different amounts of nutrients from the soil because they vary in strength. To draw useful information from soil tests, consistency in use of a single extraction procedure from year to year is important to avoid confusion when interpreting the amount of nutrients extracted.

A soil extraction procedure does not measure the total amount of nutrients present, nor does it measure the quantity actually available to citrus trees. A perfect extractant would remove nutrients from the soil in amounts that are exactly correlated with the amount available to the plant. Therefore, the utility of a soil testing procedure is how well the extractable values correlate with the amount of nutrient a plant can take up. The process of relating these two quantities is called calibration.

A soil test is only useful if it is calibrated with plant response. Calibration means that as a soil-test value increases, nutrient availability to plants increases in a predictable way (Figure 2). Low soil-test values imply that a crop will respond to fertilization with the particular nutrient. High soil-test values indicate the soil can supply all the plant needs, so no fertilization is required (Figure 3). Caution should be taken on some high soil-test values, such as Ca and P, where all extractable nutrient might not necessarily be available for plant uptake, and supplemental fertilizer might be required.

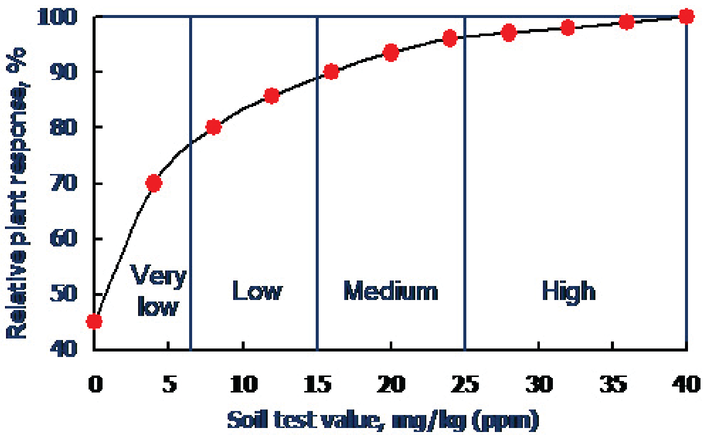

Figure 2. Ideal soil test calibration curve.

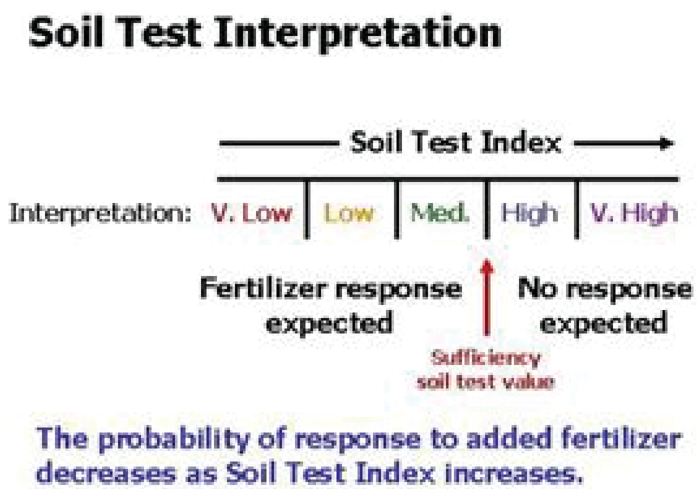

Figure 3. Soil test interpretation categories and their relationship to expected fertilizer response.

In Florida, soil testing for mobile, readily leached elements like N and K has no value. In addition to organic matter and pH, soil testing is important for P, Mg, Ca, and Cu. The UF/IFAS soil-test interpretations for P, K, and Mg using Mehlich 3 extraction were established from experiments conducted for many years (Table 3).

The single most useful soil test in a citrus grove is for pH. Soil pH greatly influences nutrient availability. Some nutrient deficiencies can be avoided by maintaining soil pH between 5.5 and 6.5. Deficiencies or excesses (toxicities) are more likely when the pH is outside this range.

In some cases, soil tests can determine the best way to correcting a deficiency identified by leaf analysis. For example, Mg deficiency may result from low soil pH or excessively high soil Ca. Dolomitic lime applications are advised if the pH is too low, but magnesium sulfate is preferred if soil Ca is very high and the soil pH is in the desirable range. If soil Ca is excessive and soil pH is relatively high, then foliar application of magnesium nitrate is recommended.

Steps in Soil Sampling

Standard procedures for sampling, preparing, and analyzing soil should be followed for meaningful interpretations of the test results and accurate recommendations.

Soil Sample Timing

- In Florida, if soil samples are collected once per year, the best time is at the end of the summer rainy season and prior to fall fertilization (September and October).
- Annual soil samples should be taken at the same time as leaf samples to save time and reduce cost.

Soil Sampling Technique

- The accuracy of soil-test interpretations depends on how well the soil sample represents the grove block or management unit sampled.
- Each soil sample should consist of one soil core taken about 8 inches deep at the dripline of 15 to 20 trees within the area wetted by the irrigation system in the zone of maximum root activity.
- Areas sampled should correspond to the grove blocks where leaf samples were taken. They should contain similar soil types with trees of roughly uniform size and vigor.
- Thoroughly mix the cores in a nonmetal bucket to form a composite sample. Take a subsample from this mixture and place it into a labeled paper bag.

Preparation for Analysis

- Soil samples should be dried in the oven before shipping to the laboratory for analysis.

Analysis and Interpretation

- The basic soil analysis package run by most agricultural laboratories includes soil pH and extractable P, K, Ca, and Mg. Organic matter is sometimes also part of the package, or it may be a separate analysis. Extractable Cu is normally determined upon request.
- The laboratory interprets each soil test result as very low, low, medium, high, or very high and may also provide fertilizer recommendations accordingly. A citrus grower should independently interpret the numerical results according to UF/IFAS guidelines based on the Mehlich 3 extractant used (Table 3).
- The interpretations should be used to make decisions regarding soil pH control or fertilizer application (Table 4).

Recommended Fertilizer Rates and Timing

Young Tree (1 to 3 Years after Planting)

NITROGEN

Recommended rates of N for the first three years a citrus tree is in a grove can be found in Table 5. A constant supply of N is essential to achieve maximum tree growth and early fruit yield. It is recommended that controlled-release fertilizer or fertigation be applied frequently (Table 5).

PHOSPHORUS

If soil testing justifies P fertilizer application, test the soil again the following year and compare with Table 3 to determine if P fertilization can be decreased or omitted. A leaf tissue-testing program for P should begin at this time, comparing the results with the standards in Table 1.

POTASSIUM

Apply K fertilizer at a K_2O rate equal to the 1.25 times the N rate.

CALCIUM

If the soil pH is in the optimum range of 5.5 to 6.5, there is no need to apply Ca. If soil pH is below 5.5, the soil should be limed to pH 6.5, which will supply needed Ca. If soil pH is above 6.5, the soil will contain abundant Ca. At pH close to 8, Ca will form precipitates.

NUTRIENT MANAGEMENT

Applying fertilizer in several small doses increases fertilizer efficiency by maintaining more constant nutrient availability and by reducing leaching if unexpected rain occurs (Table 4). A minimum of 4 to 6 applications of dry fertilizer is recommended. Splitting fertigation into 10 to 30 applications per year is common and desirable. The cost of liquid injection during irrigation is relatively small, particularly if the injection can be automated. Two or three applications of controlled-release fertilizer is satisfactory for HLB-affected trees because nutrients are protected from leaching rains. Controlled-release formulations may be applied preplant, incorporated after planting, or broadcast to ensure uniform distribution of nutrients throughout the enlarging root zone of young trees.

Bearing Trees (4+ Years in Grove)

Nutrient management for bearing trees requires many of the same considerations important for nonbearing trees. Nitrogen continues to be the most important element for tree growth, fruit yield, and fruit quality, but others also have substantial effects on production and fruit quality. Removal of elements by harvesting the crop becomes significant but accounts for only part of the fertilizer requirement.

NITROGEN

Recommended N fertilizer rates (Table 6) provide enough N for canopy expansion towards containment size while producing maximum economic yields of high quality fruit. The chosen N rate will depend on soil characteristics, yield potential, and tree needs as indicated by leaf analysis interpretation (Table 1).

- For grapefruit, the recommended annual N rate is 120 to 160 lb/acre.
- For oranges and other varieties, the recommended annual N rate is 120 to 200 lb/acre.

Mature Bearing Trees (8+ Years in Grove)

Once trees reach containment size, further canopy growth is not desired, so nutrition inputs can be stabilized and possibly reduced. Nitrogen fertilizer management should focus on replacing N exported with the harvested crop plus that needed to maintain tree biomass. The guidelines for annual N fertilizer rates accounts for the needs of both vegetative growth and crop removal (Table 6).

- For grapefruit, the recommended annual N rate is 120 to 160 lb/acre. The chosen N rate will depend on soil characteristics, desired fresh-fruit quality characteristics, yield potential, and tree needs as indicated by leaf analysis interpretation (Table 1).
- For oranges, the annual N rate should fall within the range of 125 to 245 lb/acre. The recommended rate for a specific grove depends on either expected yield potential (for 8-to-11-year-old trees) or 4-year running average production history (for trees 12 years and older) expressed as either fruit yield or soluble solids production. When basing N fertilization on expected yield potential, the rate should be chosen considering 1) how well the young, bearing trees have produced, and 2) leaf tissue analysis. If leaf N is maintained in the optimum range, additional fertilizer likely will not produce additional fruit and may reduce quality.

Leaching Rain Rule. If more than 3 inches of rainfall accumulates within a 72-hour period after an N fertilizer application, "replacement" fertilizer may be applied within 1 week up to one-half of the N rate used in the preceding application (not to exceed 30 lb/acre).

PHOSPHORUS

Determine the need for P fertilization using leaf tissue and soil test results.

- Sample leaves and soil.
- Compare the analytical results with the interpretations provided in Tables 1 and 2.
- Follow the P fertilization guidelines in Table 7.

POTASSIUM

Apply K fertilizer at a K_2O rate equal to 1.25 the N rate. If leaf K is consistently below optimum, increase the K_2O rate by 25%, especially if the grove soil is calcareous.

CALCIUM

If the soil pH is in the optimum range of 5.5 to 6.5, there is no need to apply Ca. If soil pH is below 5.5, the soil should be limed to pH 6.5, which will supply needed Ca. If soil pH is above 6.5, the soil will contain abundant Ca.

Effect of Huanglongbing on Micronutrient Requirements

Leaf chlorosis develops as a result of infection with *Candidatus* Liberibacter asiaticus (*C*Las), including interveinal chlorosis of young leaves, similar in symptomology to Mn and Zn deficiencies that develop early in the growing season. Leaf chlorosis is followed by blotchy mottling of older leaves, which develops later in the growing season. Symptoms similar to those of nutrient deficiency develop in HLB-affected trees, including K, P, Mg, Ca, Mn, Zn, and Fe. HLB causes fibrous roots to decline within a few months after infection and before foliar symptoms develop. Fibrous roots are responsible for the bulk of nutrient uptake, and their decline likely explains the deficiency symptoms that develop in the canopy. Research has demonstrated that HLB symptoms can be reduced by foliar applications of micronutrients, especially Ca, Mg, Mn, and Zn. These responses have promoted development and use of enhanced foliar nutritional programs in Florida. The efficacy of these programs has been a topic of considerable discussion and debate. Fertilization programs have varied considerably among growers and have consisted of various rates and application schedules of essential macro- and micronutrients.

Foliar nutrition applications are not likely to lead to past production levels in the short term. Research* has found that maintaining leaf concentration of essential nutrients increased canopy volume and occasionally yield. Application of the current UF/IFAS foliar recommendations (Table 8) three times per year following flushes in March, May, and September was found to maintain leaf concentrations in the optimum range with improved canopy density and yield. For example, the UF/IFAS recommendation for Mn and Zn is five pounds metallic per acre per year; thus, trees receiving three times UF/IFAS recommendation would receive three applications for a total of 15 pounds metallic per acre per year.

*Kelly T. Morgan, Robert E. Rouse, and Robert C. Ebel. 2016. "Foliar Applications of Essential Nutrients on Growth and Yield of 'Valencia' Sweet Orange Infected with Huanglongbing." *HortScience* 51 (12): 1482–1493.

Table 1. Guidelines for interpretation of leaf analysis based on 4-to-6-month-old spring-flush leaves from nonfruiting twigs of healthy trees.

Element	Unit of Measure	Deficient	Low	Optimum	High	Excess
N	%	< 2.2	2.2–2.4	2.5–2.7	2.8–3.0	> 3.0
P	%	< 0.09	0.09–0.11	0.12–0.16	0.17–0.30	> 0.30
K	%	< 0.7	0.7–1.1	1.2–1.7	1.8–2.4	> 2.4
Ca	%	< 1.5	1.5–2.9	3.0–4.9	5.0–7.0	> 7.0
Mg	%	< 0.20	0.20–0.29	0.30–0.49	0.50–0.70	> 0.70
Cl	%	---	---	< 0.2	0.20–0.70	> 0.70[1]
Na	%	---	---	---	0.15–0.25	> 0.25
Mn	mg/kg or ppm[2]	< 18	18–24	25–100	101–300	> 300
Zn	mg/kg or ppm	< 18	18–24	25–100	101–300	> 300
Cu	mg/kg or ppm	< 3	3–4	5–16	17–20	> 20
Fe	mg/kg or ppm	< 35	35–59	60–120	121–200	> 200
B	mg/kg or ppm	< 20	20–35	36–100	101–200	> 200
Mo	mg/kg or ppm	< 0.05	0.06–0.09	0.10–2.0	2.0–5.0	> 5.0

[1] Leaf burn and defoliation can occur at Cl concentration >1.0%.
[2] ppm = parts per million.

Table 2. Adjusting a citrus fertilization program based on leaf tissue analysis.

Nutrient	What if it is less than optimum in the leaf? Options:	What if it is greater than optimum in the leaf? Options:
N	Check yield. Check tree health. Review water management. Review N fertilizer rate.	Check soil organic matter. Review N fertilizer rate.
P	Apply P fertilizer (see Chapter 8 of SL253).	Do nothing.
K	Increase K fertilizer rate (see Chapter 8 of SL253). Apply foliar K fertilizer.	Decrease K fertilizer rate.
Ca	Check soil pH.	Do nothing.
Mg	Check soil pH. Apply dolomite or Mg fertilizer.	Do nothing.
Micronutrients	Check soil pH. Apply foliar micronutrients for immediate uptake. Include micronutrients in soil-applied fertilizer.	Check for spray residue on tested leaves. Do nothing.

Table 3. Interpretation of soil analysis data for citrus using the Mehlich 3 extractant.

Element	Soil Test Interpretation				
	Very Low	Low	Medium	High	Very High
	mg/kg (ppm)[1]				
P	< 10	10–15	16–30	31–60	> 60
Mg[2]	---	< 15	15–30	> 30	---
Ca[2]			250[3]	> 250	
Cu			< 25[4]	25–50[5]	> 50[6]

[1] parts per million (ppm) × 2 = lb/acre.
[2] A Ca-to-Mg ratio greater than 10 may induce Mg deficiency.
[3] The UF/IFAS Extension Soil Testing Laboratory does not interpret extractable Ca. Work with Florida citrus trees suggests that a Mehlich 1 soil test Ca of 250 mg/kg or greater is sufficient.
[4] Cu toxicity is unlikely even if soil pH is less than 5.5.
[5] Cu toxicity is possible if soil pH is less than 5.5.
[6] Cu toxicity is likely unless soil pH is raised to 6.5.

Table 4. Adjusting a citrus fertilization program based on soil analysis.

Property or Nutrient	What if it is below the sufficiency value in the soil? Options:	What if it is above the sufficiency value in the soil? Options:
Soil pH[1]	Lime to pH 5.5–6.5; pH in this range can avoid nutrient deficiencies.	Do nothing. Use acid-forming N fertilizer. Apply elemental sulfur. Change rootstocks.
Organic matter[2]	Do nothing (live with it). Apply organic material.	Do nothing.
P	Check leaf P status. Apply P fertilizer if leaf P is below optimum (see Chapter 8 of SL253 for further details).	Do nothing.
K	Apply K fertilizer.	Lower K fertilizer rate.
Ca	If soil pH is < 5.3, apply lime. Apply gypsum.	Do nothing. Check leaf K and Mg status.
Mg	If soil pH is < 5.3, apply dolomite. Check leaf Mg status.	Do nothing.
Cu	Do nothing.	Lime to pH 6.5.

[1] The sufficiency value for soil pH is 6.0.
[2] There is no established sufficiency value for soil organic matter.

Table 5. Recommended N rates and minimum number of applications for nonbearing citrus trees (1–3 years old).

Year in Grove	lb N/tree/year	Lower Limit of Annual Application Frequency	
	(range)	Controlled-Release Fertilizer	Fertigation
1	0.15–0.30	1–4	10–20
2	0.30–0.60	1–4	10–20
3	0.45–0.90	1–4	10–20

Table 6. Recommended N rates and minimum number of applications for bearing citrus trees.

Year in Grove	Oranges	Grapefruit	Other Varieties	Lower Limit of Annual Application Frequency		
	lb N/acre/year (range)			Controlled-Release Fertilizer	Dry Soluble Fertilizer	Fertigation
4–7	125–200	120–160	120–200	1	3–4	10
8+	125–245 Yield-based	120–160	120–300	1	3–4	10

Table 7. Recommendations for P fertilization of bearing citrus trees based on leaf tissue and soil tests.

If leaf tissue P is…	…and soil test P is…	…the recommendation for P fertilization is:
Excessive High	Very High High Medium Low Very Low	Do not apply P fertilizer to the soil for 12 months following leaf and soil sampling, then sample again and reevaluate.
Optimum	Very High High Medium	Do not apply P fertilizer to the soil for 12 months following leaf and soil sampling, then sample again and reevaluate.
Optimum	Low Very Low	Apply 8 lb P_2O_5/acre for every 100 boxes/acre of fruit produced during the current year. Sample leaves and soil again in 12 months and reevaluate.
Low	Low Very Low	Apply 12 lb P_2O_5/acre for every 100 boxes/acre of fruit produced during the current year. Sample leaves and soil again in 12 months and reevaluate.
Deficient	Low Very Low	Apply 16 lb P_2O_5/acre for every 100 boxes/acre of fruit produced during the current year. Sample leaves and soil again in 12 months and reevaluate.

Table 8. Recommended methods, timing, and rates for micronutrient application to citrus groves.

		Mn	Zn	Cu	B	Fe
Method	Foliar	Yes	Yes	Yes	Yes	No
	Soil	Yes[1]	No	Yes	Yes	Yes
Timing	Foliar	When spring flush leaves reach full expansion				
	Soil	Any time as needed				
	lb metallic equivalent/500 gallons of water					
Rates	Foliar	3.75	5.0	3.75	0.25	---
	lb metallic equivalent/acre					
	Soil	9	---	5	1	See below[2]

[1] Soil applications of Mn are not recommended on calcareous soils.
[2] Acid soil: Fe-EDTA, 20 grams/tree; Calcareous soil: Fe-EDDHA, 50 grams/tree.

2020–2021 Florida Citrus Production Guide: Fertilizer Application Methods[1]

Mongi Zekri, Arnold W. Schumann, Tripti Vashisth, Davie M. Kadyampakeni, Kelly T. Morgan, Brian Boman, and Thomas A. Obreza[2]

Fertilization is an important aspect of growing citrus commercially. Citrus tree growth, health, fruit production, and fruit quality are closely affected by plant nutrition. As important as it is to include all the mineral nutrients in proper balance in a fertilizer program, choosing the right method of delivery is equally important. Many fertilizer sources and formulations are available for commercial citrus production. There are also different methods of applying fertilizers. Applying the right fertilizer type, at the right rate, at the right time, at the right location (within the root zone) is very important to improving nutrient uptake efficiency. Some fertilization methods are better suited for a particular setting; therefore, it is suggested to consider all the fertilization options before deciding to invest in one program. Often a combination of delivery methods in fertilization programs works best for commercial citrus groves to ensure a tree receives all the nutrients in the right form and at the right time.

Granular and 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

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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 have 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.

Fertigation

Microirrigation is an important component of citrus production systems. For citrus trees, microirrigation is more desirable than other irrigation methods for three main reasons: water conservation, fertilizer management efficiency, and freeze protection. Microirrigation combined with fertigation (applying of small amounts of soluble fertilizer directly to the root zone through irrigation systems) provides precise timing and application of water and fertilizer nutrients in citrus production. Fertilizer can be prescription-applied in small doses and at particular times when those nutrients are needed. This capability helps growers increase fertilizer efficiency and reduce nutrient leaching by excess rainfall or overirrigation, and it should result in reduced fertilizer rates for citrus production. The two most common nutrients applied to citrus through fertigation are nitrogen and potassium.

Florida state law requires that backflow prevention equipment be installed and maintained on irrigation systems that have fertilizer injection capability. The function of the backflow prevention device is to prevent contamination of ground or surface water by the applied chemicals. Therefore, before injecting fertilizer into any irrigation system, make sure all required backflow prevention devices are in place and working properly.

The time required for water to travel from the injection point to the farthest emitter is generally 20 to 30 minutes for most microirrigation systems. Therefore, a minimum injection time of 30 minutes is recommended. After fertigation, continue to run water for 30 minutes to completely flush the fertilizer from irrigation system lines and emitters to minimize clogging potential. Keep in mind that excessive flushing time beyond 30 minutes can leach the recently applied plant nutrients below the root zone.

Fertilizer Solubility

Before injecting fertilizer solutions, a "jar test" should be conducted to determine compatibility of liquids and clogging potential of the solution within irrigation system components. A sample of the fertilizer solution should be mixed with irrigation water in a jar (at the same dilution rate used in the irrigation system) to determine if any precipitate or milkiness occurs within 1 to 2 hours. If cloudiness does occur, there is a chance that injection of the chemical will cause line or emitter plugging.

When urea, ammonium nitrate, calcium nitrate, or potassium nitrate is dissolved, heat is absorbed from the water and a very cold solution results. Consequently, it may not be possible to dissolve as much fertilizer as needed to achieve the desired concentration. It is often necessary to let the mixture stand for several hours and warm to a temperature that will allow all the mixture to dissolve.

FERTIGATION—SUMMARY

- Fertilizer is precisely placed in the wetted zone area where feeder roots are extensive due to water availability.
- Increased fertilizer application frequency can improve plant nutrient-uptake efficiency and reduce leaching.
- Application cost is much lower than that of dry or foliar fertilizer application.
- Through fertigation, comparable or better yields and quality can be produced with less fertilizer.
- Microirrigation systems must be properly maintained to apply water and fertilizer uniformly.

Foliar Fertilization

Foliar fertilizer application is certainly not a new concept to the citrus industry. For over five decades, foliar fertilization of citrus has been recommended to correct zinc, manganese, boron, copper, and magnesium deficiencies. It is now common knowledge in agriculture that properly nourished crops may better tolerate insect pests and diseases.

Field research has shown that supplemental foliar feeding can increase yield by 10%–25% compared with conventional soil fertilization. However, foliar fertilization should not be considered a substitute for a sound soil-applied nutritional program, but a supplement to that soil program. Foliar applications are often used in situations to help trees through short but critical periods of nutrient demand, such as vegetative growth, bud differentiation, fruit set, and fruit growth. Foliar application of nutrients is of great importance when the root system is unable to keep up with crop demand or when the soil has a history of problems that inhibit normal nutrient uptake. Foliar nutrition is proven to be useful under prolonged periods of wet conditions, drought conditions, calcareous soil, cold weather, or any other condition that decreases the tree's ability to take up nutrients when there is a demand. Foliar feeding may be effectively utilized when a nutritional deficiency is diagnosed. Foliar application is absolutely the quickest method of getting the most nutrients into plants. However, if the deficiency can be observed on the tree, the crop has already lost some potential yield.

While foliar feeding has many advantages, it can burn leaves when applied at high rates under certain environmental conditions. It is therefore important to foliar feed within established guidelines. A number of plant, soil, and environmental conditions can increase the chances of causing foliar burn to foliar fertilizer application. Applications when the weather is hot (above 80°F) should be avoided. This means that during warm seasons, applications should be made in the morning or evening when the temperature is right, wind is minimal, and the stomates on citrus leaves are open, allowing leaves to efficiently exchange water and air. Highly concentrated sprays have the potential to cause leaf burn or drop.

Nutrient absorption is increased when spray coverage reaches the undersides of the leaves where the stomates are located. Favorable results from foliar feeding are most likely to occur when the total leaf area is large. Foliar applications of micronutrients, with the exception of iron, are more effective and efficient when the spring, summer, and fall new-flush leaves are almost fully expanded. Another important factor when applying nutrients foliarly is to ensure that the pH of the spray solution is between 5.5 and 6.5. This is particularly important in areas where water quality is poor. To enhance uptake and thus the effectiveness of any foliar application, nitrogen should be added to the solution. Urea may be the most suitable nitrogen source for foliar applications due to its low salt index and high solubility in comparison with other nitrogen sources. However, the urea utilized in foliar sprays should be low in biuret content (0.2% or less) to avoid leaf burn. Be careful about possible chemical interactions among foliar fertilizers. Some materials are incompatible and should not be mixed together. They may create precipitates that tie up and make some nutrients unavailable or clog spray nozzles. Many product labels warn of such incompatibilities.

Overall, foliar nutrition is a very important and effective way of addressing diagnosed problems with specific deficiencies observed within the grove, as well as a best management strategy for supplying micronutrients, with the exception of iron. The concept that foliar sprays should be applied only after the appearance of a deficiency is not advisable because reductions in yield and quality usually precede the appearance of visual symptoms. In addition to soil-applied fertilizers, foliar sprays of nutrients should be used with the objective of maintaining citrus trees' health at an optimal level.

2020–2021 Florida Citrus Production Guide: Root Health Management[1]

Evan G. Johnson, James H. Graham, and Kelly T. Morgan[2]

Developing and maintaining a healthy root system is important for establishment and long-term productivity of trees. Roots take up nutrients and water from the soil to transport them to the tree canopy (the leaves and fruit). The root system also acts as an anchor for the tree, which is important during high wind conditions, such as thunderstorms and tropical systems. At the same time, the leaves provide carbohydrates to grow and maintain a functional root system. In a healthy tree, the carbohydrate supply is balanced between new leaves, fruit, and roots. When root health is compromised, the root system has reduced nutrient and water uptake capacity, which can subsequently affect growth of new leaves and fruit.

Root health can be compromised by pests, pathogens, and environmental (abiotic) factors. Citrus root pests include Diaprepes root weevil, burrowing nematode, sting nematode, and others. Historically, the most damaging root pathogens in citrus have been *Phytophthora* spp. that cause root, crown, and foot rot. The most common detrimental environmental factors for roots in Florida citrus are soil pH, salinity, and flooding. An increase in soil pH above 7.0 results in precipitation of phosphorus, calcium, magnesium, and other plant nutrients, reducing the concentration of nutrients in solution available for uptake by the roots. Extended waterlogging (oxygen deprivation) and salinity can cause root decline and death. Site-specific decisions made while preparing to plant will reduce the risk and impact of these biotic and abiotic causes of root health decline. Management of root health problems depends on cultural and, when necessary, chemical management tools.

The root system has two main types of roots, structural and fibrous (feeder), which serve different essential functions for the tree. The structural roots provide the anchoring scaffold of the root system and act as the major transport corridors for nutrients, water, and carbohydrates. The fibrous roots form the interface with the soil where water and nutrients are absorbed. Both kinds of roots are important for root and tree health and are affected differently by pests, pathogens, environmental factors, and any interactions of the three. Structural roots often extend outward to the edge of the wetted zone or canopy and then continue down and outward beyond the canopy. Fibrous roots only grow in high-density clusters from structural roots where water and nutrients are most abundant. In irrigated trees, the fibrous roots are concentrated in the wetted zone of the irrigation system. For example, microsprinkler irrigation concentrates 80% of the fibrous roots in the top 10 inches of the wetted zone under the canopy. Root systems are important to understand because root health management should be focused on these areas of high fibrous-root density.

Introduction of *Candidatus* Liberibacter asiaticus (*C*Las), the cause of huanglongbing (HLB), into Florida greatly complicates citrus root health management. *C*Las infection

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causes severe damage to fibrous roots that exacerbates the effects of the other root pests and pathogens and can reduce the efficacy of treatments. Root health management has become more challenging and more important because most citrus trees in Florida are now affected by HLB.

Huanglongbing and Root Health

HLB severely affects root health, causing 30%–50% root loss early in disease development and greater than 70% root loss once canopy decline begins (sectored leaf drop and dieback). This root loss results from a shortened lifespan of 1.5–4 months for fibrous roots compared to 9–12 months for healthy roots. The shortened lifespan is accompanied by increased root growth, leading to an imbalance in carbohydrate demand in the tree and reducing the total uptake capacity of the root system. Structural roots also die back from HLB, with ~20% dieback within the wetted zone as canopy decline begins, continuing inward toward the trunk. Currently, there is no proven management option for prevention of HLB-associated root loss. Treatments that stimulate root growth are **not** recommended, because they may increase the root-canopy imbalance. Instead, growers should focus on altering soil applications to adapt to the limited uptake capacity and, when economically feasible, attempt to prevent further damage to the existing roots to maintain or improve root longevity. This includes irrigation and fertilization in small and frequent doses to balance the water and nutrient supply with uptake capacity and adjustment of soil pH below 6.5 to avoid additional stress on the root system.

Managing Root Health

A healthy root system improves productivity of trees and improves their tolerance of major stresses, such as freezes, drought, and high winds. Starting a grove with a healthy root system allows for rapid tree establishment and growth. Maintaining a healthy root system in existing groves lengthens the productive life of the trees.

Root Health in New Plantings

The best way to manage root health is to prevent problems from starting. This requires careful consideration and planning before ordering trees and planting a new grove. The largest contributor to root health that will affect pests, pathogens, and the tree itself is the soil and water at the site. The most cost-effective way to manage root health is proper field preparation for planting and choosing rootstocks based on site-specific knowledge of the soil and irrigation water. Flooding and water table problems that affect root health can be managed with land preparation, including drainage and bedding (see chapter 14, *Grove Planning and Establishment*). Many of the soil, pest, and pathogen problems can be addressed by choosing the best-adapted rootstock. To select a rootstock, you need to know the site history, such as existing nematode problems or previous infestations of Diaprepes. It may also be important to know what has been done in the past to modify soil pH. If recent efforts were made to change the soil pH with liming or sulfur, it is likely that the soil will slowly shift back to its native pH. To avoid the perennial expense of adjusting the pH in your grove, select a rootstock with an appropriate pH tolerance. Rootstock selection can be difficult because there is limited knowledge about soil preference and pest and pathogen resistance for some rootstocks (especially newly released rootstocks). To help in the selection process, a summary of what is known for commercially available rootstocks can be found in the rootstock selection chapter of this guide and the Citrus Rootstock Selection Guide (https://crec.ifas.ufl.edu/extension/citrus_rootstock/). Some locations may have multiple pest, pathogen, and environmental problems. In these cases, a rootstock that addresses all the problems may not be available. It is important to consider which problems are the most severe at the site, and which can be most easily and economically managed by land preparation or on a regular long-term basis. In situations where multiple problems cannot be addressed by proper rootstock selection, alternative crops should be investigated.

Starting with healthy root establishment is also important. When planting trees, it is important to give them the best chance to establish a healthy root system. This requires inspecting the root balls for signs of phytophthora damage, pot-bound root system, or dry potting medium. Phytophthora damage will slow or prevent root establishment, immediately stunting trees. Dry potting media will inhibit water penetration after planting, leading to tree stunting or death. Pot-bound root systems can lead to intertwined structural roots that can cause tree stunting and decline a few years after planting as the structural roots begin to girdle each other. For more details, see *Grove Planning and Establishment*, chapter 14 of this guide.

Root Health for Existing Groves

Unlike new plantings, root health problems in existing groves have to be managed instead of avoided. However, like new plantings, root health in existing groves requires site-specific management. The first step is to identify the problems present in the grove. Take soil samples for pH and nutrient analysis as well as phytophthora and nematode counts. Determine the pH, salinity, and bicarbonate content of irrigation water. Bicarbonates are leached from limestone in the aquifer and act as a buffer raising the pH of the water and irrigated soil. Groves should be scouted for the presence of Diaprepes root weevil, and if they are known to be a problem, see chapter 28, *Citrus Root Weevils*. Once the root health problems are identified, develop a decision-making process to determine which problems are the most severe and should be managed first. For example, if *Phytophthora* spp. are at damaging levels on roots, but there are also problems with soil pH and Diaprepes, addressing soil pH or Diaprepes may effectively reduce phytophthora populations in a grove soil because these factors interact with phytophthora to make it worse than it would otherwise be. Therefore, pH or Diaprepes should be treated first, and phytophthora counts should be reassessed to determine if chemical applications for *Phytophthora* spp. are still needed. HLB-induced root damage also interacts with *Phytophthora* spp. by increasing the exudation of sugars from roots. This sugar exudation attracts *Phytophthora* zoospores, increasing infection. HLB also reduces the efficacy of fungicides (phosphite, focetyl-Al, fluopicolide, and mefenoxam) for control of *Phytophthora* spp. Timing is essential to maintain efficacy of phytophthora management applications. Propagule counts should be monitored carefully for developing problems, so late summer or fall root flushes (root flushes follow leaf flushes) can be protected. For more information, see chapter 32, *Phytophthora Foot Rot, Crown Rot, and Root Rot*.

Soil pH and bicarbonates in irrigation water have gained attention because HLB has reduced the tolerance for pH incompatibilities on rootstocks mismatched with grove soil, such as Swingle on high-pH soils. In many cases, especially in the flatwoods, management of pH and bicarbonates resulted in increased root density of trees with HLB. For reasons yet to be determined, groves on ridge soils do not respond as well to pH and bicarbonate management. Soil pH or high-bicarbonate irrigation water can be treated with ground-applied sulfur or by acidifying irrigation water with injections of sulfuric or N-phuric acid. For Swingle rootstock, the ideal pH range is 5.5 to 6.5. Recent field experiments have determined that maintaining soil pH in the 5.5 to 6.5 range increases nutrient uptake and root density. Test the pH before and after treatment, because overacidification could lead to the release of toxic amounts of copper and other metals and depletion of essential nutrients, such as calcium and magnesium, from the soil. Extra care needs to be taken to avoid overacidification when using sulfur. Sulfur acidification is dependent on microbial breakdown of elemental sulfur and can take a year or more before soil pH drops. The soil pH is very likely to drop below the optimum range if other acidification methods are used before the sulfur takes effect.

Depending on the results of soil tests for nutrients such as calcium, supplemental application may be necessary to replenish those lost from leaching and to prevent copper toxicity to roots. When pH management is necessary, sources of calcium that don't counteract pH management should be chosen; for example, gypsum ($CaSO_4 \cdot 2H_2O$) instead of lime can add calcium without increasing the soil pH.

2020–2021 Florida Citrus Production Guide: Canopy Management[1]

Tripti Vashisth, Mongi Zekri, and Fernando Alferez[2]

Tree canopy and bearing volume are two important factors in fruit production and fruit quality. Generally, trees with larger canopy and bearing volumes produce more fruit than smaller-canopy trees. Canopy management is an important aspect of citrus production in Florida to avoid problems associated with overcrowding and excessively tall trees, to improve light interception, and to improve pesticide distribution into the canopy, as well as to facilitate equipment operation within the grove. Proper control of vegetative growth is essential for the maintenance of healthy, productive citrus trees. The effect of insufficient light is frequently observed in mature citrus groves that are not managed regularly. Shading reduces yield and foliage on the lower parts of the trees. Sunlight not only influences flowering and fruit set but also enhances fruit quality and color development. Increased sunlight penetration within the tree canopy might also allow foliage to dry more quickly after a rain shower and could help reduce establishment of fungal pathogens. Therefore, adjustments must be made to the tree canopy to maximize sunlight interception.

Pruning is one of the oldest horticultural practices that changes the form and growth of a tree. The pruning process 1) adjusts tree shape and the ratio of the framework to the fruit-bearing shell of the canopy, 2) alters the shoot/root ratio, and 3) changes the carbohydrate (food storage) status of the tree. Pruning healthy, mature citrus trees can reduce yields in proportion to the amount of foliage removed and can delay fruiting of young, nonbearing trees. Pruning should therefore be limited to that required for future canopy bearing-surface development and to conduct efficient cultural and harvesting operations (Figure 1). Under Florida weather conditions, citrus trees often produce vigorous vegetative growth, which can result in overcrowding and shading. Therefore, canopy management is very important. In general, tree response to pruning depends on several factors, including variety, rootstock, tree age, growing conditions, time of pruning, and production practices. There is no fixed set of rules, and therefore each situation should be critically analyzed before any severe canopy management decisions. Growers are encouraged to gain a clear understanding of the basic principles regarding pruning and to take advantage of research results as well as to consult knowledgeable colleagues and custom operators for their observations and recommendations.

Basic Pruning Cuts

Thinning out and heading back are the main types of pruning cuts (Figure 2). Thinning out is a selective pruning method that involves the removal of complete branches down to the main trunk and is often done with handheld equipment. It encourages longer growth of the remaining terminals and can result in a more open tree, which allows more sunlight to penetrate deeper into the tree canopy. Thinning out is commonly seen in peaches and plums to

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maximize light penetration into the inner canopy for better fruit set and growth. This type of pruning is generally considered too labor intensive and costly, and therefore it is not commonly practiced in the Florida citrus industry. Heading back removes the terminal portion of a shoot or branch, removing apical dominance and stimulating lateral bud breaks (Figure 2). As a result of heading back, trees are more branched and compact. Mechanical hedging and topping are the main forms of mass heading back used in Florida for mature trees.

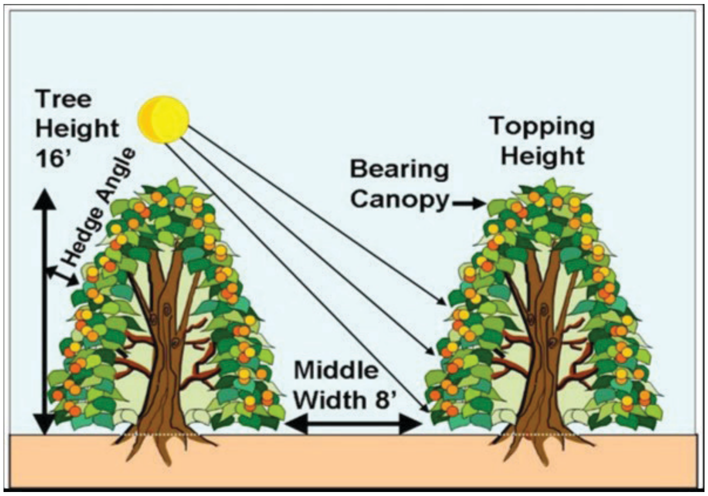

Figure 1. Topping height, middle width, and solar angle influence the amount of sunlight that gets to the lower canopy.
Credits: UF/IFAS (adapted from EDIS HS1026)

Canopy Management for Young Trees

Severe pruning and training of young, nonbearing trees tends to delay fruit production and should be avoided. Most trees usually need no pruning for the first few years in the grove except for removal of sprouts on the trunk. Larger sprouts should be cut off flush with the trunk to avoid dominance over a weaker tree. Sprouting on the trunks of young, nonbearing trees can be greatly reduced by using a commercial sprout inhibitor containing naphthaleneacetic acid (NAA; refer to *Plant Growth Regulators*, chapter 20 of this guide). While protective wraps around the trunk will reduce sprouting, careful monitoring and observation is required to avoid insect and disease problems under the wraps.

Canopy Management for Mature Trees

When mature trees begin to overcrowd, growing tall and into the row middles, canopy management becomes essential to maintain tree size and improve light penetration. Hedging and topping are very common cultural grove-management practices in Florida.

Hedging and Topping

Hedging consists of cutting back the sides of trees to prevent or alleviate crowding. Hedging produces numerous cut wood surfaces along the side of the tree canopy from which new sprouts arise, eventually developing into a wall of new foliage. Middles (alleys) between tree rows should be sufficiently wide to accommodate grove equipment and provide adequate light access to the sides of the trees. Middles are usually hedged to a width of 7 to 8 ft but will vary depending on original grove design, scion variety, rootstock, and equipment used in all production practices.

Hedging should be completed before canopy crowding becomes a problem. As a general rule of thumb, pruning of branches greater than 0.13"–0.25" (1/8"–1/4") in diameter should be avoided. Developing a proactive pruning program should assist managers in removing the right-sized branches. Removal of a significant portion of the tree will result in excessive vegetative growth and a drastic reduction in subsequent yield. Hedging is usually done at an angle, with the boom tilted inward toward the treetops so that the hedged row middles are wider at the top than at the bottom. This angled hedging allows more light to reach the lower skirts of the tree. Commonly used hedging angles vary from 10 to 15 degrees from vertical.

Topping should be done before trees have become excessively tall and should be an integral part of a tree-size maintenance program. Long intervals between toppings increase the cost of the operation due to heavy cutting and more brush disposal.

Furthermore, excessively tall trees are more difficult and expensive to harvest and spray. Topping trees will improve fruit quality and increase fruit size while reducing management and harvesting costs. Some common topping heights are 12 to 14 ft at the shoulder and 16 to 17 ft at the peak. Generally, topping heights should be two times the row-middle width.

Lower heights are sometimes used for training trees, increasing fruit size, or rejuvenating declining trees, or after flooding events that damaged the root system. Taller trees are sometimes maintained when they are vigorous and widely spaced. Trees in the flatwoods areas are generally topped lower than those on the ridge because the more limited root systems will usually not support as much top growth. Topping should be started before extensive cutting is required. If heavy cutting is required, the initial cuts should be low enough to avoid cutting excess wood in subsequent topping operations. Retopping is generally done just above the old cut.

After severe hedging or topping, heavy nitrogen applications will produce vigorous vegetative regrowth at the expense of fruit production. Therefore, nitrogen applications should be adjusted to the severity of hedging or topping. Reducing or omitting a nitrogen application before and possibly after heavy hedging will reduce both costs and excessive vegetative regrowth. Light maintenance hedging should not affect fertilizer requirements or application.

Large crops tend to deplete carbohydrates and result in a reduced fruit yield and increased vegetative growth the following year. Pruning after a heavy crop additionally stimulates vegetative growth and reduces fruit yield the following year. Pruning after a light crop and before an expected heavy crop is recommended because it can help reduce alternate bearing, which can be a significant problem in Pineapple orange and Murcott production.

Severe hedging may create problems of brush disposal and stimulates vigorous new vegetative growth, especially when done before a major growth flush. This happens because an undisturbed root system is providing water and nutrients to a reduced canopy area. The larger the wood that is cut, the larger the subsequent shoot growth. Severe pruning reduces fruiting and increases fruit size.

Canopy Management Program

The best time of year to hedge or top depends on scion variety, grove location, severity of pruning, and availability of equipment. Because pruning is usually done after removal of the crop, early-maturing varieties are generally hedged before late-maturing varieties. Most growers prefer to hedge before bloom, but trees will get more vegetative regrowth, which may not be desirable. Pruning could begin as early as November prior to harvesting in warmer areas. During this period, pruning operations should only cut minimal foliage and fruit from the trees.

Valencia trees may be hedged in late fall with only minimal crop reduction when the hedging process removes only a small amount of vegetative growth. In cases where excessive growth is to be removed, the trees are usually harvested before hedging is conducted. Light maintenance pruning can be done throughout the summer and until early fall with little or no loss in fruit yield. Moderate to severe pruning should not continue into the winter in freeze-prone areas, because trees with tender regrowth are susceptible to cold injury.

Tree Skirting

Skirting is a pruning practice to raise tree skirts. Without skirting, the movement of herbicide booms, fertilization (in wetted zones), and mechanical harvesting equipment is impeded. Fruit and limbs near the ground are often damaged by the passage of such equipment and by herbicide spray and fertilizer contact. Skirting allows uniform distribution of granular fertilizers and improved water coverage of microsprinkler irrigation systems under tree canopies. Skirting facilitates the inspection of microirrigation systems and reduces the incidence of phytophthora foot rot and brown rot because it allows good air circulation.

Canopy Management and Huanglongbing

Because Florida groves have become heavily affected with huanglongbing (HLB) and the psyllid population has been on continuous increase, selecting the best time for hedging and topping is becoming more complicated. New growth flushes promoted by hedging and topping in late spring, the summer, and the early fall can increase the population of leafminers and psyllids and aggravate the spread of HLB. HLB-affected trees often undergo severe root loss; therefore, these trees can be hedged and topped to help balance the shoot-to-root ratio to improve tree performance and extend tree longevity. However, buckhorn pruning or severe pruning of HLB-affected trees is not recommended, because such practices have been found to be not economically viable; also, a significant reduction in yield should be expected in year one and two following severe/buckhorn pruning. Moreover, severe pruning can result in reduction in root density for up to 3 years following the pruning.

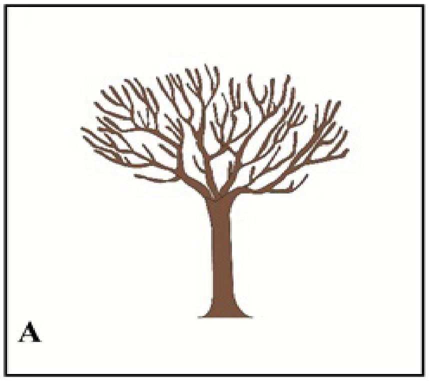

Figure 2a: Tree before pruning

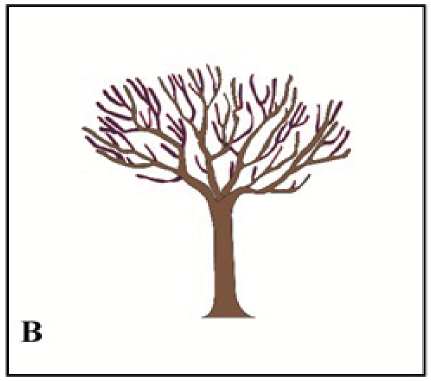

Figure 2b: Thinning
Selective removal of branches

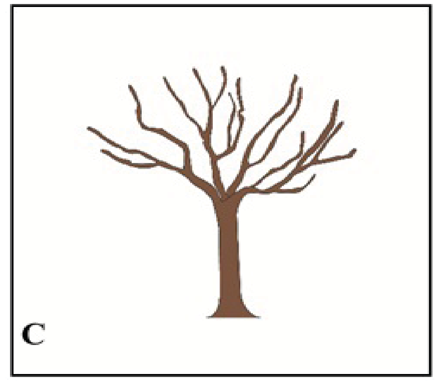

Figure 2c: Thinning
After thinning, open canopy

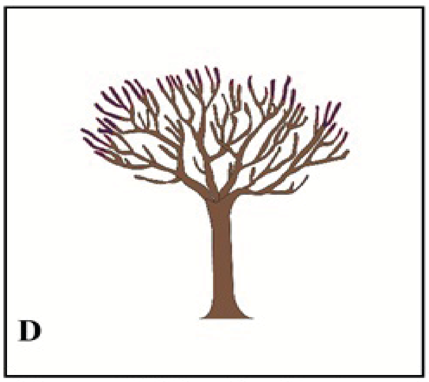

Figure 2d: Heading Back
Nonselective removal of terminal portion of branches (blue and red)

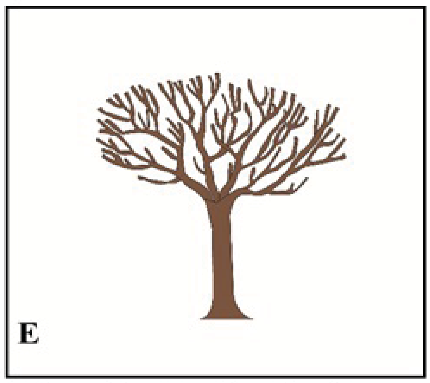

Figure 2e: Heading Back
Terminal portion of branches is removed

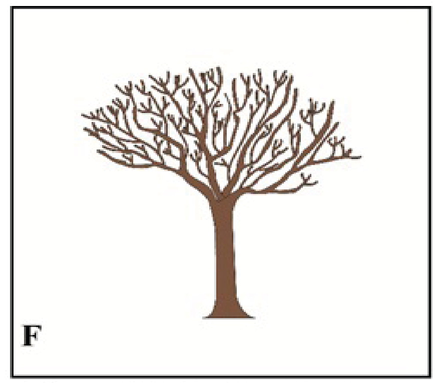

Figure 2f: Heading Back
After heading back, new lateral growth

Figure 2. The two types of pruning cuts, a: Tree before pruning; b–c: Thinning, selective removal of branches to open up the canopy; d–f: Heading back, nonselective removal of terminal portion of branches resulting in more lateral branching.
Credits: Tracy Bryant, UF/IFAS Communications

2020–2021 Florida Citrus Production Guide: Plant Growth Regulators[1]

Tripti Vashisth, Chris Oswalt, Mongi Zekri, Fernando Alferez, and Jamie D. Burrow[2]

Plant growth regulators (PGRs) are a tool used to manipulate vegetative and reproductive growth, flowering, and fruit growth and development. PGRs have been successfully used in agriculture for decades to amend plant growth characteristics to maximize yield and thus grower profit. Foliar-applied PGRs are routinely used in various fruit crops for flower and fruit thinning; improving fruit set, growth, and development; controlling vegetative growth; and reducing fruit drop. Citrus is no exception to the use of PGRs, which can provide significant economic advantages to citrus growers when used appropriately. According to the Florida state legislature, PGRs are defined "as any substance or mixture of substances intended, through physiological action, for accelerating or retarding the rate of growth or maturation or for otherwise altering the behavior of ornamental or crop plants or the produce thereof, but not including substances intended as plant nutrients, trace elements, nutritional chemicals, plant inoculants, or soil amendments."

Most PGRs are plant hormones, naturally occurring plant compounds. A plant hormone is a chemical signal produced in one part of the plant and then transported through vascular bundles to another part, where it triggers a response. Hormones regulate plant responses to various biotic and abiotic stimuli. PGRs are synthetic analogues of naturally occurring plant hormones (PGRs and hormones are used interchangeably throughout this document). There are five classic groups of PGRs: auxins, gibberellins, cytokinins, abscisic acid, and ethylene (Table 1).

In addition to the five classic PGRs, other groups of biochemicals are now also recognized as PGRs. They include jasmonates, salicylic acid, strigolactones, and brassinosteroids. Each group of PGRs has unique attributes and is involved in a number of different physiological processes.

It is very important to keep in mind that PGRs do not work in isolation. Plant response and efficacy of materials often depend on several factors, such as the concentrations of the materials, levels of other plant hormones, plant health, nutritional and water status, time of year, and climate. For example, the influence of gibberellins on citrus flowering, fruit set, seedlessness, color development, and preharvest fruit drop varies with many of these factors.

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Auxins

Auxins were among the first plant hormones identified. Auxins are known to be involved in plant-cell elongation, apical dominance, inhibition of lateral bud growth, promotion of rooting, suppression of abscission, inhibition of flowering, and seed dormancy. A well-known auxin is indoleacetic acid (IAA), which is produced in actively growing shoot tips and developing fruit.

Synthetic auxin analogs like 2, 4-dichlorophenoxyacetic acid (2, 4-D) and naphthalene acetic acid (NAA) are extensively used in fruit crop production. 2, 4-D is commonly used in agriculture as an herbicide. It is also used to control preharvest fruit drop and to increase fruit size, particularly in oranges, grapefruit, mandarin, and mandarin hybrids. The efficiency of 2, 4-D in reducing preharvest fruit drop increases when used with oil sprays. The timing of 2, 4-D application to reduce preharvest fruit drop should be carefully assessed to minimize undesirable effects on flowering and harvest timing.

NAA is used to inhibit the undesirable growth of suckers on tree trunks. As discussed earlier, NAA can inhibit lateral branching; therefore, its application to trunks keeps lateral buds in a dormant state. NAA can also promote fruit abscission and can therefore be used to thin excessive fruit and increase size of the remaining fruit. Environmental conditions can greatly influence uptake and activity of NAA. High temperatures and delayed drying of spray solution due to high humidity both contribute to greater thinning action. Best results are likely to occur when applied between 75°F and 85°F. Because uptake continues for several hours after the spray dries, heavy rain within six hours of application may significantly reduce NAA action.

Gibberellins

Gibberellins, abbreviated as GA for Gibberellic Acid, have many effects on plants but primarily stimulate elongation growth. Spraying a plant with GA will usually cause the plant to grow larger than normal. GA also influences plant developmental processes like seed germination, dormancy, flowering, fruit set, and leaf and fruit senescence.

In citrus, GA is often used to delay fruit senescence. GA delays changes in rind color, and application will result in fruit with green rinds and delayed coloring. This will have a negative effect when selling fruit early in the season for the fresh-fruit market. However, this effect is desirable for late-harvested fruit because it results in fruit that are paler in color than the deeper-colored fruit from untreated trees. GA also affects flowering in citrus. GA application can reduce the number of flowers and therefore fruit yield. It is important to carefully assess timing of GA applications to avoid yield losses. Depending on the application time, GA can reduce preharvest fruit drop and improve fruit set in some citrus varieties.

Cytokinins

Cytokinins derived their name from cytokinesis (cell division) because of their role in stimulating plant cells to divide. In addition to being involved in cell division, cytokinins were shown to have important effects on many physiological and developmental processes, including activity of apical meristems, shoot growth, inhibition of apical dominance, leaf growth, breaking of bud dormancy, and xylem and phloem development. Cytokinins also play an important role in the interaction of plants with both biotic and abiotic factors, including plant pathogens, drought and salinity, and mineral nutrition.

Abscisic Acid

Despite its name, abscisic acid (ABA) does not initiate abscission (drop). ABA is synthesized in the chloroplast of the leaves, especially when plants are under stress, and diffuses in all directions through the vascular bundles. ABA promotes dormancy, inhibits bud growth, and promotes senescence. It also plays a major role in abiotic stress tolerance. During water stress, ABA levels increase in leaves, which leads to the closing of stomata, thereby reducing water loss due to transpiration. ABA is costly to synthesize; therefore, its use in agriculture is limited.

Ethylene

Ethylene, a gaseous hormone, is well known for its role in promoting fruit ripening. In addition, it plays a major role in leaf, flower, and fruit abscission. Ethylene also affects cell growth, shape, expansion, and differentiation. Plants under biotic or abiotic stresses produce high levels of ethylene, which triggers an array of responses. For example, when leaves are damaged or infected with pathogens, high levels of ethylene are produced to promote abscission of those leaves. In citrus, ethylene is commonly used in postharvest to degreen oranges, tangerines, lemons, and grapefruit, making them more attractive to consumers. Ethylene treatment of mature but poorly colored fruit enhances the peel color and increases the marketability of fruit.

New Classes of Plant Hormones

Brassinosteroids

Brasssinosteroids (BR) play a pivotal role in a wide range of developmental processes in plants, such as cell division, cell differentiation, cell expansion, germination, leaf abscission, and stress response. Because of their involvement in many different physiological processes, application of BRs might be of interest in crop production. Successful use of BR in agriculture depends on the production of cost-effective, stable synthetic analogs of BR.

Strigolactones

This group of plant hormones is known for inhibiting shoot growth and branching and stimulating root-hair growth. Strigolactones also promote a symbiotic interaction with mycorrhizal fungi and facilitate phosphate uptake from the soil.

Jasmonates

This group of plant hormones is involved in plant defense responses. Herbivory, wounding, and pathogen attacks trigger the production of these hormones, which results in the regulation of plant-defense-related genes to fight the infection.

Salicylic Acid

Salicylic acid (SA) plays a role in plant growth and development processes, photosynthesis, and transpiration. SA is well known for mediating plants' defense response against pathogens. Their role in increasing plant resistance to pathogens is by inducing the production of pathogenesis-related proteins. It is involved in the systemic acquired resistance (SAR) response, in which a pathogenic attack on one part of the plant induces resistance in the affected area as well as in other parts of the plant.

General Consideration for Use of PGRs in Citrus Groves in Florida

Because PGRs function by directly influencing plant metabolism, plant response can vary considerably, depending on the variety and plant stress level. Therefore, it is recommended that growers become familiar with PGR effects before application. Preliminary trials in a small field plot should be conducted before using on a large acreage of trees. Most PGRs work best when used with an adjuvant (surfactant, sticker, or spreader). PGRs are regulated as pesticides and therefore, label instructions need to be followed—*the label is the law*. Table 2 summarizes some of the PGRs that are known to be effective in Florida citrus production.

Things to consider when applying PGRs are:

- Concentration of active ingredient
- Spray volume
- Method of application
- Time of day
- Season
- Compatibility with other chemicals in the tank mix
- Type of adjuvant
- Weather condition (humid, dry, sunny, cloudy, windy)
- Tree health (canopy density)

Use of PGRs for Huanglongbing-Affected Trees

Huanglongbing (HLB) affected trees often suffer from extensive preharvest fruit drop. Due to the ability of PGRs such as 2, 4-D and GA to reduce preharvest fruit drop, they were considered as good candidates to mitigate the extensive fruit drop associated with HLB. Results from field trials with HLB-affected trees suggest that PGRs are inconsistent in their effects. Therefore, it is suggested not to use PGRs to alleviate HLB-associated preharvest fruit drop.

If excessive flowering, prolonged flowering, or off-season flowering is identified as a problem in HLB-affected trees, GA applications in the fall (September–January) can be made at 10–20 g a.i., 100–120 gallons per acre without negatively affecting yield. Fall GA applications reduces flowering in the following season. However, GA can also cause delay in color break of the existing crop; therefore, for early-season varieties of sweet orange, mandarins, and grapefruit, applying GA after the fruit is harvested would be ideal. GA applications in 'Valencia' during fall may improve fruit size of the existing crop as well as next season's crop due to reduced flowering. Do not apply GA later than January, because late applications can suppress flowering significantly, resulting in low yields.

Table 1. Major plant growth regulator classes, associated function(s), and practical uses in agriculture.

Class	Associated Function(s)	Practical Uses
Auxins	Shoot elongation	Fruitlet thinning; increased rooting and flower formation; sprout inhibitor
Gibberellins	Stimulate cell division and elongation	Increase shoot length, fruit size, and fruit set
Cytokinins	Stimulate cell division	Prolong storage life of flowers and vegetables and stimulate bud initiation and root growth
Ethylene	Ripening, abscission, and senescence	Induces ripening and loosens fruit
Abscisic acid	Seed maturation, dormancy	Regulates plant stress
Jasmonates	Plant defense	Wound response
Salicylic acid	Systemic Acquired Resistance (SAR)	Defense against pathogenic invaders
Brassinosteroids	Developmental processes	Regulate germination and other developmental processes
Strigolactones	Suppress branching and promote rhizosphere interaction	Suppress branching, promote secondary growth, and promote root hair growth

Table 2. Plant growth regulator sprays—Florida citrus. **CAUTION:** Growth regulators may cause serious problems if misused. Excessive rates, improper timing, and fluctuating environmental conditions can result in phytotoxicity, crop loss, or erratic results. Under certain environmental conditions, 2, 4-D may drift onto susceptible crops in surrounding areas. Observe wind speed restrictions and follow all label directions and precautions.

Variety	**Response**	**Time of Application**	**Growth Regulator and Formulation**	**Product Rate or Volume per Acre**
Orange, Temple, and Grapefruit	Preharvest fruit drop	November–December. Do not apply during periods of leaf flush.	2, 4-D Dichlorophenoxyacetic acid (Citrus Fix, Isopropyl ester of 2,4-D 3.36 lb/gal)	3.2 oz
Navel orange	Reduction of summer-fall drop	6–8 weeks after bloom or August–September for fall drop. Do not make late application when fruit is to be harvested early. Do not apply during periods of leaf flush.	2, 4-D Dichlorophenoxyacetic acid (Citrus Fix, Isopropyl ester of 2,4-D 3.36 lb/gal)	2.4 oz
Tangerine and Murcott	Fruit thinning; activity is temperature dependent. Severe overthinning may result from applications made to trees of low vigor or under stress conditions.	Mid-May	Naphthaleneacetic acid, NAA (K-Salt Fruit Fix 200, 6.25%)	24–120 oz (100–500 ppm)
Grapefruit	Delay of rind aging process and peel color development at maturity; combine with 2, 4-D for fruit drop control.	August–November. Late sprays can result in re-greening.	Gibberellic acid, GA_3 (ProGibb 4%, ProGibb 40%, ProGibb LV Plus)[2]	16–48 gram a.i.[3]
Tangerine-hybrids				20–40 gram a.i.
Navel oranges				16–48 gram a.i.
All round orange				20–60 gram a.i.
Navel oranges Ambersweet orange Sweet orange	Improvement of fruit set and yield; can result in small size and leaf drop.	December–late January	Gibberellic acid, GA_3 (ProGibb 4%, ProGibb 40%, ProGibb LV Plus)[2]	15–25 gram a.i.
Tangerines Mandarins Grapefruit		Full bloom		8–30 gram a.i.
Processing oranges (late varieties)	To increase juice extraction yield	Color break	Gibberellic acid, GA_3 (ProGibb 4%, ProGibb 40%, ProGibb LV Plus)[2]	20 gram a.i.

[1]Rates are based on application of 500 gal. per acre to mature trees. The effects of applications at lower volumes (concentrate sprays) are unknown.
[2]Do not use in spray solutions above pH 8.
[3]Active ingredient; follow the label for variety-specific rates and conversion to fluid ounce per acre.

2020–2021 Florida Citrus Production Guide: Citrus Cold Protection[1]

Chris Oswalt and Tripti Vashisth[2]

No other single factor has affected the historical distribution of Florida citrus more than freezing temperatures. Since the introduction of citrus by the Spanish in the 1500s, freezing temperatures have dictated where the citrus production areas in Florida are located.

Early citrus production in Florida relied on principles of passive cold protection practices to mitigate the effects of freezing temperatures. Passive principles of cold protection are decisions made prior to planting the citrus trees. Site selection, horticultural selections, and cultural practices are considered passive methods. These practices are those that do not require the grower to actively participate in cold protection of citrus during a freeze event.

Passive Methods of Cold Protection

Traditionally, site selection decisions that would result in a higher level of protection from cold would include: planting on higher-elevation ground to better facilitate cold-air drainage; selecting areas on the south and southwest sides of lakes or large bodies of water, because they are warmer during freeze events; and planting in close proximity to natural windbreaks to reduce wind speeds, helping retain natural heat stored in the grove. Geographically, areas further south along the Florida peninsula are warmer than locations in north Florida. Soil texture can also affect minimum temperatures and citrus freeze damage in a given grove. For example, white-colored sand-sink soils are significantly colder on a given freeze night than other soil types.

Horticultural selection of citrus rootstocks and varieties can influence the susceptibility of trees to freeze damage. Citrus rootstock selection can often result in success or failure of a citrus grove in a particular geographical location. Generally, the more vigorous the rootstock, the more susceptible the tree will be to freeze damage. Rough lemon, Volkamer lemon, and Carrizo citrange are vigorous rootstocks and are more sensitive to freezing temperatures. Cleopatra mandarin and Swingle citrumelo are considered slower growing and therefore more cold tolerant. During the freezes of the 1980s, it was not unusual for rough lemon groves to be killed while groves on sour orange grown beside them would recover from the same damage. That said, if the minimum temperatures reach a critical threshold for long enough, no rootstock is resistant to freeze damage, as was observed in 1980's freeze in north and central Florida. The selection of citrus varieties used in a particular grove location should be influenced by the probability of freezing temperatures. Mandarin or tangerine trees are considered more cold tolerant than orange trees, and orange trees are considered more cold tolerant than grapefruit trees. The time of fruit maturity can also have an effect on the profitability of a particular grove, depending on the probability of freezing temperatures. Early-maturing varieties that can be harvested before freezing temperatures may result

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in growers making a profit in areas where later-maturing varieties would receive fruit damage. The crop load on trees during the winter can influence cold tolerance. Pineapple oranges and Murcott tangerines with excessive crop loads (“on” years) have been shown to be more susceptible to freeze damage.

Cultural practices can also provide some degree of cold protection. Practices such as increasing soil moisture during the day prior to the freeze can increase the thermal conductivity of the soil, allowing for this stored heat to be released overnight. In addition, during the winter, tree water status should be maintained at levels that reduce fruit drop and prevent water stress without stimulating vegetative growth. Citrus trees under drought stress are also more susceptible to freeze damage. Row-middle management in the form of low-growing turf or clean row-middle management (by discing or by trunk-to-trunk herbicide application) can increase the solar interception of the soil and allow storing heat during the day. Tall-growing weeds in row middles reduce the soil solar interception and may create cold-air dams that impede the drainage of cold air from a grove. Nutritional status of the citrus tree can affect the susceptibility to freeze damage. No single nutritional element will affect the cold hardiness of citrus trees, although excessive nutrition and nutritional deficiencies can lead to an increase in freeze susceptibility.

Active Methods of Cold Protection

Passive cultural practices can only provide a certain level of protection. Active cultural practices are used by growers during a freeze to reduce the freeze damage to citrus trees. During the 1900s, a number of these active cold-protection practices were used by growers to reduce freeze damage to citrus trees. These practices included heating, wind machines, low-volume irrigation, and tree wraps for young citrus trees.

Heating a citrus grove involves the use of grove heaters burning fossil fuel to prevent temperatures from reaching a critical temperature. Heating is very effective in protecting trees and fruit from freeze damage. Years ago, this was one of the more common methods to protect citrus trees and fruit. Depending on the grove, usually 35 to 40 heaters per acre were used. These heaters would burn about 1 gallon of fuel oil per hour. This type of system is quite labor-intensive and expensive due to the initial cost annually associated with setting out and picking up the heaters at the end of the winter. Additionally, refueling and lighting heaters before and during freeze events and the need for in-field refueling during a freeze adds to these costs. Moreover, there were also environmental concerns, such as fuel spills in and around the heaters. These problems, along with fuel costs and the fuel shortage of the 1970s, have resulted in the disuse of grove heaters in Florida citrus.

Wind machines are used extensively in “cold pockets,” depressed areas of elevation in the “ridge” production region where dense cold air drains on radiation freeze nights. One wind machine will protect about 10 grove acres if ideally located. Wind machines need the development of a strong temperature-inversion reversal at the height of the machine (about 30 feet above the ground) in order to be effective. Temperature inversions develop only during radiation-type freeze events. Cold air at the surface cools and displaces warmer air to levels above the ground where the warmer air is mixed by the wind machine, increasing grove temperature to an average of the volume of air mixed. The development of inversions can be monitored with the Florida Automated Weather Network (FAWN) tower locations by looking at the difference between 2-foot and 30-foot temperatures. FAWN data can be accessed on the following website: https://fawn.ifas.ufl.edu

Low-volume microsprinkler irrigation is the most widely used method in the Florida citrus industry to protect citrus trees from freezing temperatures. Early attempts in 1962 to use overhead irrigation for freeze protection resulted in widespread damage to trees due to insufficient volumes of water being applied. This resulted in growers being reluctant to use irrigation for cold protection until the early to mid-1980s. Widespread use of microsprinklers in the early 1980s allowed growers to apply sufficient volumes of water directly under and on the lower portions of citrus trees, resulting in protection of these trees from freeze damage. Irrigation used for freeze protection is based on a few simple principles. First, the sensible heat of water that is released when water hits the tree is beneficial. This sensible heat is due in large part to the actual temperature of well water (about 68˚F). There may also be some additional benefit if irrigation can cause the development of fog in the grove, which in turn will reduce the rate of temperature fall during the night (this is highly dependent on the dew point temperature). Secondly, the process of water turning to ice (called the latent heat of fusion) releases additional heat to the grove microclimate. The formation of ice also helps in insulating plant tissues above critical temperatures. Current recommendations call for application rates of 2000 gallons per acre per hour to protect trees from freezing temperatures. During radiation freezes, water applied under the canopy of citrus trees modifies the tree microclimate, resulting in limited protection of the tree and fruit from freeze damage. This modification of the tree microclimate decreases with height above the irrigation source. Generally, irrigation under mature trees will provide little protection of fruit on the exterior canopy of the tree, but it may limit damage to fruit located closer to the microsprinkler. During advective freezes, mature trees may not typically benefit from irrigation, but this would be highly dependent on evaporative cooling and the amount of irrigation heat removed from the grove due to increased wind speeds. Microsprinklers can provide excellent protection of young citrus trees from such freeze damage. Microsprinklers should be located on the north or northwest sides of the tree no further away than 2 to 3 feet. This will allow winds during an advective freeze to blow water at the tree. The type and pattern of emitter used is critical. Emitters should be the fan type, with either a 90˚ or 180˚ pattern applying a uniform distribution of water at the tree. This condition should provide for excellent protection of young citrus trees. Another version of this system would involve elevating 360˚ fan-type microsprinklers on PVC stakes, 24 to 36 inches in length, in the center (2 to 4 inches from the trunk) of young trees. The emitter tubing should be wrapped around the PVC stake to keep ice formation from pulling down the elevated emitter. This system has been shown to provide additional protection to greater heights in young citrus trees. Before making a decision on using irrigation for cold protection, a grower must understand some of the potential issues. Low-volume irrigation works as long as the heat added to the grove (sensible heat and the heat of fusion) is greater than what is lost. Heat losses from a grove when using irrigation will generally come from evaporative cooling. This process occurs when the dew point is low and evaporation of water exceeds that of ice formation. It takes 7.5 gallons of water freezing to equal the heat lost in one gallon of water evaporating. This demonstrates the importance of knowing the effects of dew point and wind speed on the effectiveness of low-volume irrigation. Another consideration is the power source of the irrigation system. Growers using electricity to power their irrigation systems should exercise caution. In past freezes, rolling power outages during peak demand have resulted in damage to citrus groves due to inadequate irrigation caused by ice plugging up emitters. Growers in this situation need to evaluate contingency plans for backup power sources. Growers also need to determine a critical temperature start time of microirrigation for cold protection. The start time needs to be prior to any formation of ice in the irrigation tubing; otherwise, the freeze protection could be compromised.

Tree wraps are used to protect the trunk and bud union of young citrus trees recently planted in the grove. The effectiveness of tree wraps is directly related to the insulating properties of the wrap used. Tree wraps are designed to reduce the rate of temperature fall around the trunk of young citrus trees. This reduction in the rate of temperature drop allows for critical temperatures to be reached after sunrise, past the time of minimum temperature. A number of tree wraps are available on the market today. Research has shown that some very poor insulating wraps can cause temperatures under the wrap to be lower than air temperature. Care should be used when determining if the tree wrap chosen will provide for adequate protection of the tree trunk. Tree wraps with good insulating properties have been demonstrated to be quite effective, yet most growers have tended to rely solely on irrigation for freeze protection in the past 20 years. Young citrus trees are more susceptible to freezing temperatures than mature trees, and wraps could be an attractive alternative to entire-grove irrigation when protection is needed for only young trees.

To summarize, there are a number of citrus cold-protection practices or decisions growers can make to ensure the success of a grove in surviving freezing temperatures. Some of these would be done prior to planting, but there are additional practices that can be deployed in an established grove.

2020–2021 Florida Citrus Production Guide: Citrus Under Protective Screen (CUPS) Production Systems[1]

Arnold W. Schumann, Ariel Singerman, Alan L. Wright, and Rhuanito S. Ferrarezi[2]

Citrus can be grown under protective screen structures for fresh-fruit production in order to completely exclude the Asian citrus psyllid (ACP, *Diaphorina citri*) and therefore huanglongbing (HLB) disease, or citrus greening. The benefits of eliminating HLB are immediate and include rapid, normal tree growth, higher yields of premium-quality fruit, negligible fruit drop, and uncomplicated fertilizer and irrigation requirements. Because CUPS is a relatively new citrus production system with new challenges, current guidelines are preliminary and undergoing constant refinement through research.

CUPS significantly increases the cost of citrus grove establishment due to the high cost of screen house construction (up to $1 per square foot). The 40- to 50-mesh high-density polyethylene screen may need replacement every 7 to 10 years (up to $0.50 per square foot). High-quality construction, including setting support poles in concrete, can help to minimize potential wind-related damage in the future. Mites and thrips may selectively enter through the permeable screen, while some of the larger beneficial pest predators are excluded. Greasy spot and other fungal diseases may also thrive in the more humid conditions of the screen-house environment. These nonlethal but economically important pests and diseases must be adequately controlled with integrated pest management approaches customized for CUPS in order to avoid loss of fruit quality and yield. Fortunately, ACP has been successfully excluded long-term by the UF/IFAS screen-house structures, which is the main goal of CUPS. Only one adult psyllid was found on a yellow sticky trap in the UF/IFAS Citrus Research and Education Center (CREC) CUPS during nearly three years of weekly scouting and monitoring, and no HLB incidence has been confirmed yet on the 1,000 screen-house-protected trees. The most vulnerable ACP entry point of a screen house is through the doors from movement of personnel and equipment, so standard decontamination procedures should be followed. In particular, citrus leaves and other grove debris that adhere to personnel or equipment should be carefully removed before personnel enter a CUPS facility, because grove debris could carry live ACP eggs, nymphs, or adults that can be dropped in the screen house and cause an infestation. Double-door or foyer entrances are the minimum requirement for preventing ACP entry into CUPS, and the trees should be regularly inspected for ACP and signs of their feeding damage on leaves.

In order for a CUPS production system to be profitable, the higher cost of CUPS must be offset by the highest possible yield of premium-quality fresh fruit with a high market price. Fortunately, the price of fresh fruit, especially for tangerine varieties, has been on an upward trend in recent years (e.g., Florida tangerines had an average fresh-fruit price per box of $10.95 in 2011/12, and $27.15 in 2015/16; FDACS). Fresh-fruit prices also vary greatly during the year, likely due to seasonal supply and demand, including

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the effects of production in other US citrus industries, like California's. For example, Florida Honey Tangerine average fresh-fruit prices per box in 2015/16 were $35.95 in January but declined to $19.45 by April. Early Tangerines in Florida performed better (i.e., had more stable prices), starting at $28.55 in September and ending at $27.95 in December. High price and market stability are therefore critically important additional criteria for selecting the best fresh-fruit variety to grow with CUPS, because the economic break-even price per box of fresh fruit is likely to be in the region of >$20. Early-maturing fresh-fruit varieties have additional advantages over late-maturing varieties because their fruits have to be protected from pests and diseases for less time. Thus, the risk of freeze damage to fruit is reduced, and routine pruning operations, including mechanical hedging and topping, can be conveniently conducted in the time between the end of harvest and the following bloom.

Trees can be grown in-ground and also in pots inside the CUPS. In-ground trees developed a fuller canopy more quickly than potted trees, although fruit yields were similar within the first three years. Juice quality, however, can be better (higher Brix, acidity) for potted than in-ground trees.

The fruit yields should also be produced as early as possible to achieve the desired early return on investment. Several different cultural methods for accelerating growth and optimizing early yields are being studied at the UF/IFAS CUPS facilities. These include intensive hydroponics with daily or hourly delivery of all essential nutrients by drip fertigation to the trees; higher planting densities (871 and 1,361 trees per acre); selecting heat-tolerant, self-pollinating, seedless, precocious varieties without strong alternate bearing habits; dwarfing rootstocks for limiting tree size when trees are grown in the ground; or even growing trees in containers to limit tree sizes with any rootstock.

In conclusion, CUPS is a new citrus production system for growing HLB-free fresh fruit. It works by total exclusion of the ACP vector. This solution to HLB may seem simple, but in reality it is more complex, relying on novel integrated approaches for optimizing all management practices, including pest and disease management, planting densities, variety and rootstock selection, irrigation and fertilization, hedging and topping, harvesting, and marketing.

Figure 1. Steel roll-up door with a second plastic strip door, inside the UF/IFAS CREC CUPS.
Credits: UF/IFAS

Figure 2. High density (871 trees per acre) 'Ray Ruby' grapefruit trees yielding 380 boxes/acre in year 2, UF/IFAS CREC CUPS.
Credits: Arnold W. Schumann, UF/IFAS

Figure 3. The UF/IFAS CREC CUPS facility near Lake Alfred, FL.
Credits: Arnold W. Schumann, UF/IFAS

CG097

2020–2021 Florida Citrus Production Guide: Asian Citrus Psyllid[1]

Lauren M. Diepenbrock, Jawwad Qureshi, and Lukasz Stelinski[2]

Psyllid Feeding Damage and Disease Transmission

The Asian citrus psyllid (ACP), *Diaphorina citri* Kuwayama, was first detected in Florida in 1998, and it has since become the key pest of citrus due to its role as vector of the pathogen that causes citrus greening disease, also known as huanglongbing (HLB). The HLB pathogen, *Candidatus* Liberibacter asiaticus (*C*Las), is transmitted and spread by adult ACP but acquired primarily by nymphs. ACP are sucking insects, related to aphids, that obtain most of their nutrition from phloem sap, which they access by feeding on leaves. Young flush is required by the female to mature eggs, for egg laying, and by nymphs for development. Developing leaf buds and feather-stage flush are preferred for egg laying. Feeding on young shoots results in twisting and distortion of the leaves due to toxins present in saliva that are injected during ingestion. *C*Las can be transmitted from an infected adult to the next generation of nymphs through the intermediary of the flush, enabling both the tree and the next generation of ACP to become infected within as little as a month. However, infected trees do not show characteristic HLB symptoms of leaf mottling, dieback, and fruit drop until the root system becomes at least partially dysfunctional.

Factors Affecting Psyllid Populations

Once young leaves have expanded and are no longer suitable for egg laying, adult psyllids may either feed on mature leaves of the same tree or leave in search of other host plants. ACP is only able to reproduce on citrus or citrus relatives like orange jasmine (*Murraya paniculata*), although other plants may be used for adult survival. Target plants may be citrus trees within the same grove (particularly young resets, which flush more often) or trees in neighboring groves. Therefore, psyllid management practices in one grove affect future psyllid populations in nearby surrounding citrus groves. Temperature is also closely linked to the abundance of psyllids in the field. Ideal temperatures for maximum egg production are between 77°F–86°F. Above 93°F, lifespan decreases to less than 30 days, with a corresponding decrease in fecundity. Egg laying below 60°F slows to under 2 per day, and development time increases to 2 months. ACP populations in Florida are consistently lower during the midsummer months and in winter compared to late spring and even early fall due to both temperature and flush availability.

1. This document is CG097, one of a series of the Entomology and Nematology Department, UF/IFAS Extension. Original publication date March 2019. Revised March 2020. This document partially supersedes ENY-734, *2018–2019 Florida Citrus Production Guide: Asian Citrus Psyllid and Citrus Leafminer.* Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

2. Lauren M. Diepenbrock, assistant professor, Entomology and Nematology Department, UF/IFAS Citrus Research and Education Center; Jawwad Qureshi, assistant professor, Entomology and Nematology Department, UF/IFAS Southwest Florida REC; and Lukasz Stelinski, professor, Entomology and Nematology Department, UF/IFAS CREC; UF/IFAS Extension, Gainesville, FL 32611.

Psyllid Management

ACP control slows spread of HLB and is critical for young trees, which are most susceptible to HLB and most attractive to ACP due to frequent flushing. However, effective management is also required on mature infected trees to reduce reinoculation of the pathogen and allow the tree to produce healthy flush. Thus, vector control is a critical component of HLB management. The goal of psyllid management programs in commercial citrus groves is to reduce psyllid populations to as low levels as possible and remain economically viable.

Chemical Control

Use of insecticides to control ACP is a major component of HLB management strategies in Florida and elsewhere. Management programs should optimize benefits while minimizing cost of pest control, risk of pest resistance to insecticides, and negative impacts of insecticides on beneficial insects and mites useful for control of ACP and other pests. The information provided in this chapter is intended to aid in the development of site-specific psyllid management. Products recommended in this chapter for psyllid suppression have been demonstrated in field trials conducted by UF/IFAS to be effective for reducing ACP populations. However, *most of these products will have negative effects on natural enemies of insect and mite pests.* Therefore, *new pest problems may develop as a result of increased insecticide use for psyllid suppression*. However, the problems posed by these other potential pests are generally less serious than the threat posed by ACP as vector of the HLB causal pathogen.

NONBEARING TREES

Young trees are most susceptible to infection with *C*Las. The multiple flushes they produce throughout the year place them at greater risk of disease infection, compared to mature trees, because adult psyllids are attracted to new flush. Even without HLB, young trees in the field need to be protected for about 4 years from psyllids and leafminers to grow optimally. Soil-applied systemic insecticides have historically provided the longest-lasting control of psyllids with the least impact on beneficial insects. Currently, three neonicotinoid (all group 4A mode of action) insecticides (imidacloprid, thiamethoxam, and clothianidin) and one group 28 insecticide (cyantraniliprole) are available for soil application to control ACP on young nonbearing trees. Because of the cost of the group 28 product, most use is presently restricted to 4A products. Depending on formulation, systemic insecticides are best applied to the soil, which is far more effective on young trees than foliar sprays.

Most soil applications of systemic insecticides are applied as drenches, and for reset trees, this is the only application method. However, injection is effective and efficient once roots have established around emitters in solid blocks on drip irrigation. Soil drenches are best applied using an applicator metered to deliver 8–10 oz of formulated drench solution per tree. Drench applications should be applied directly at the soil-rootstock interface. Use restrictions limit the number of applications that can be made in a growing season. Imidacloprid applications are limited to no more than 0.5 lb a.i./ac per growing season, regardless of application method. This equates to 14 fl oz/ac for 4.6F formulations, 16 fl oz/ac for 4F formulations or 32 fl oz/ac for 2F formulations. Thiamethoxam applications are limited to no more than 0.172 lb a.i./ac (or 3.67 oz Platinum 75 SG/ac) per growing season. Clothianidin (Belay 50 WDG) is currently labeled for use on nonbearing trees only and is limited to 0.4 lb a.i./ac (or 12.8 fl oz Belay 50 WDG/ac) per growing season. However, the Florida Department of Agriculture and Consumer Services (FDACS) has issued a Section 18 Emergency Exemption for Belay 2.13 Insecticide (EPA Reg. No. 59639-150) permitting two applications at a rate of 12 fl oz/ac each to bearing citrus trees. Applicators must have the 24c SLN label for Belay Insecticide and the letter issued by the Commissioner (FDACS) present when making applications of Belay Insecticide to bearing citrus.

Due to restrictions on the amount of neonicotinoid insecticide products that can be used per growing season, the number of allowed applications in solid plantings of trees 5′–9′ in height is greatly limited. It is also important to note that imidacloprid, thiamethoxam, and clothianidin share the same mode of action and are therefore not considered alternatives for rotation to prevent resistance. Foliar sprays of products with modes of action other than the ones used in drenches should be used between soil-drench applications to provide additional control of ACP and to help minimize pest selection for insecticide resistance development.

BEARING TREES

Foliar sprays of broad-spectrum insecticides targeting adults are most effective when used prior to the presence of new flush. Once psyllids begin reproducing on new flush, it becomes increasingly difficult to gain control of rapidly increasing populations. Management programs should begin by targeting overwintering adult psyllids with insecticidal sprays when the trees are not producing flush. Elimination of overwintering ACP adults greatly reduces populations in the following spring flushes and is recommended regardless of adult population size. Targeting adult

ACP with broad-spectrum insecticides (organophosphates, group 1B, or pyrethroids, group 3A; see Table 1) early in the year may provide sufficient suppression of psyllid populations to reduce the need for psyllid sprays during bloom, when pollinators are present and most pesticides cannot be applied. Additional sprays of insecticides for psyllids should be made when observing an increase in adult populations in a grove. A threshold of one adult per 10 tap samples during the growing season has been shown to provide an economically viable level of suppression in mature trees with high incidence of HLB and fruit destined for the process market. Rotating modes of action throughout the year is important to reduce pest selection for insecticide resistance and conserve critically needed products.

BEE CAUTION

Citrus growers should be aware that most insecticides recommended for psyllid control have restrictions on the pesticide label due to the impact these products may have on pollinators. Planning to control psyllids prior to the presence of bloom will help reduce the need to apply pesticides during the bloom period. Check the pesticide label for restrictions on application of a product when trees are in bloom. Currently, there are 4 products in addition to horticultural mineral oil that are considered effective and to have minimal effects on pollinators when used as directed. Products listed in Table 2 are recommended for psyllid control during the period when citrus is in bloom.

Biological Control

While a single female psyllid may lay up to 800 eggs in the laboratory, studies in Florida have shown that over 90% of the resulting nymphs never make it to adulthood in the field, even in the absence of insecticides. Most are consumed by predaceous insects such as ladybeetles and spiders. The parasitic wasp *Tamarixia radiata* has become established throughout Florida, is being actively released in many groves, and contributes some mortality. Additionally, there are many pests, such as mites, leafminers, scales, mealybugs, whiteflies, etc., that are currently suppressed or maintained at low levels in Florida citrus either by biological control or the additional sprays now being used to control psyllids. Excessive sprays could result in resurgence of these pests. Foliar insecticide applications to mature trees during the growing season are best made with selective insecticides to minimize impact on natural enemies that help control psyllids and other pests.

Other Management Considerations

Management practices used within a grove can affect psyllid populations, especially those practices that promote new flush such as hedging, topping, and fertilization. Trees should always be sprayed with a broad-spectrum insecticide prior to or just after hedging and topping and before flush develops. Management strategies that reduce or limit the duration of flush may help to keep psyllid populations at low levels and reduce the need for additional pesticide applications. Alternate host plants, such as orange jasmine (*Murraya paniculata*) and box orange (*Severinia buxifolia*), near the grove can serve as sources of psyllids for infestation. When possible, these plants should be removed from areas surrounding commercial citrus groves.

Recommended Chemical Controls

READ THE LABEL!

Some product labels specify rates per acre, while others specify rates per volume delivered (e.g., per 100 gallons). Refer to the label for details on how product should be mixed for desired targets.

Rates for pesticides are given as the maximum amount required to treat mature citrus trees unless otherwise noted. When treating smaller trees with commercial application equipment including handguns, mix the per-acre rate for mature trees in 100 gallons of water. Calibrate and arrange nozzles to deliver thorough distribution and treat as many acres as this volume of spray allows.

Table 1. Recommended chemical controls for the Asian citrus psyllid

IRAC MOA[1]	Pesticide Trade Name	Rate/Acre[2]	Comments	Other Pests Controlled
1B	**Chlorpyrifos**			
	Lorsban 4 E	80 fl oz	Restricted use pesticide. Highly toxic to bees; do not apply during bloom. Lorsban 4E has a 2(ee) label for control of Asian citrus psyllid; other formulations of chlorpyrifos are not currently labeled for psyllid control.	Mealybug, orange dog, katydids, grasshoppers, aphids, thrips
1B	**Dimethoate**			
	Dimethoate 4 E	16 fl oz	Highly toxic to bees; do not apply during bloom. Do not make more than 2 applications per crop season. Consult label for buffering instructions when water pH is greater than 7.	Aphids, scales except snow scale and black scale, flower thrips
1B	**Phosmet**			
	Imidan 70 W	1.0 lb	Highly toxic to bees; do not apply during bloom. Consult label for buffering instructions when water pH is greater than 7. Do not make more than 2 applications per season. EPA SLN No. 10163-169, FIFRA 2(ee).	Citrus root weevils
3A	**Beta-cyfluthrin**			
	Baythroid XL	3.2 fl oz	Restricted use pesticide, FIFRA 24(c). Maximum Baythroid XL allowed per crop season 6.4 fl oz/ac (0.05 a.i./ac)	Aphids, weevils
3A	**Fenpropathrin**			
	Danitol 2.4 EC	16 fl oz	Restricted use pesticide. Highly toxic to bees; do not apply during bloom.	Flower and orchid thrips, adult root weevils
3A	**Zeta-cypermethrin**			
	Mustang Insecticide	4.3 fl oz	Restricted use pesticide. Highly toxic to bees; do not apply during bloom. Do not make more than 4 applications (0.20 lb a.i.) per acre per season.	Citrus root weevils
4A	**Clothianidin (soil drench)**			
	Belay 50 WDG	3.2–6.4 oz	For use on nonbearing trees only, do not apply within 1 year of fruit harvest. Do not exceed 12.8 oz/ac (0.4 lb a.i./ac) of Belay 50 WDG per acre per year. Do not apply this product to blooming, pollen-shedding, or nectar-producing parts of plants if bees may forage on the plants during this time period.	Aphids, citrus leafminer
	Belay Insecticide	3–12 fl oz	Refer to the Section 24c SLN label issued by the Florida Department of Agriculture and Consumer Services for application directions of this product to bearing citrus trees. For bearing trees, do not apply more than 12 fl oz per acre per application, and do not apply more than 24 fl oz per acre in a 12-month period.	Aphids, citrus leafminer

IRAC MOA[1]	Pesticide Trade Name	Rate/Acre[2]	Comments	Other Pests Controlled
4A	**Imidacloprid**			
	Various products, 2F, 4F and 4.6F		Limit of 0.5 lb a.i./ac per growing season regardless of application type (soil and/or foliar) and trade name of imidacloprid product used.	Aphids
	Foliar Application	Half to full rate	Do not apply during bloom, within 10 days of bloom, or when bees are actively foraging.	
	Thiamethoxam (foliar application)			
	Actara	4.0–5.5 oz	Do not exceed a total of 11.0 oz/ac (0.172 lb a.i./ac) of Actara or 0.172 lb a.i. of thiamethoxam-containing products per acre per growing season. Do not apply during prebloom or during bloom when bees are actively foraging.	Aphids
	Thiamethoxam (soil drench)			
	Platinum 75 SG	1.83–3.67 oz	Do not exceed a total of 3.67 oz/ac (0.172 lb a.i./ac) of Platinum 75 SG or 0.172 lb a.i. of thiamethoxam-containing products per acre per growing season. Do not apply during prebloom or during bloom when bees are actively foraging.	Citrus leafminer, aphids, scales
4D	**Flupyradifurone (foliar application)**			
	Sivanto 200 SL	14 fl oz	Not recommended for soil applications against ACP. Do not tank mix with azole fungicides (FRAC group 3) during bloom period. In order to minimize exposure to pollinators, it is recommended that foliar insecticides are applied late in the afternoon, evening, or at night outside of daily peak foraging periods.	Aphids
5	**Spinetoram**			
	Delegate WG	4 oz + 2% v/v	Highly toxic to bees; do not apply during bloom. Do not apply more than 12 oz of product (0.188 lb a.i.) per acre per season. Do not make more than 3 applications per calendar year. Best when applied with horticultural mineral oil 97+% (FC 435-66, FC 455-88, or 470 oil).	Citrus leafminer
21A	**Tolfenpyrad**			
	Apta	14–27 fl oz	Do not apply by air. Do not apply more than 27 oz/ac per growing season. Do not make more than 2 applications per year. Allow at least 14 days between applications.	Citrus rust mite, spidermites (higher rates)
	Fenpyroximate			
	Portal	32–64 fl oz	Do not apply more than 4.0 pints per acre per growing season. Do not make more than 2 applications per growing season. Allow 14 days between applications.	Suppression of spider mites and rust mites (high rate)

IRAC MOA[1]	Pesticide Trade Name	Rate/Acre[2]	Comments	Other Pests Controlled
23	**Spirotetramat**		Only controls psyllid nymphs, not adults. Limit of 0.32 lb a.i. per acre per 12 months. Minimum interval of 21 days between applications.	Citrus rust mites, some scale insects, mealybugs
	Movento 240	10 fl oz + 3% v/v	Do not make more than one application during primary citrus bloom period. Recommended to be applied in 2% horticultural mineral oil.	
	Movento MPC	16 fl oz + 3% v/v	Do not apply within 10 days prior to bloom, during bloom, or until petal fall is complete. Recommended to be applied in 2% horticultural mineral oil.	
28	**Cyantraniliprole (Cyazypyr) (foliar application)**			
	Exirel	13.5–20.5 fl oz	Do not apply a total of more than 0.4 lb a.i./ac (20.5 fl oz Exirel/ac) or other cyantraniliprole-containing products per year. See label for bloom restrictions. Recommended to include 2% horticultural mineral oil.	Citrus leafminer, orange dog
	Cyantraniliprole (soil application)			
	Verimark	15–30 fl oz	Use the lower rate for trees 3 ft or less in height.	Citrus leafminer, orange dog
4A + 28	**Thiamethoxam + Chlorantraniliprole**			
	VoliamFlexi	7 oz	Do not exceed 14 oz/ac/season of VoliamFlexi or 0.172 lb a.i. of thiamethoxam-containing products per growing season. Do not apply during prebloom or during bloom when bees are actively foraging.	Aphids, citrus leafminer
4A + 6	**Thiamethoxam + Abamectin**			
	Agri-Flex	8.5 fl oz + 2% v/v	Do not exceed a total of 17 fl oz/ac or 3 applications per season of Agri-Flex or 0.172 lb a.i./ac of any thiamethoxam-containing products or 0.047 lb a.i./ac of abamectin containing products per growing season. Must be mixed with a minimum of 2 percent oil to be effective. Do not apply during prebloom or during bloom when bees are actively foraging.	Aphids, citrus leafminer, citrus rust mites
UN[3]	**Horticultural Mineral Oil**			
	97+% (FC 435-66, FC 455-88, or 470 oil)	5 gal	Do not apply when temperatures exceed 94°F. 470 weight oil has not been evaluated for effects on fruit coloring or ripening. These oils are more likely to be phytotoxic than lighter oils.	Citrus leafminer, citrus rust mite, aphids, scales

[1] Mode of action class for citrus pesticides from the Insecticide Resistance Action Committee (IRAC) Mode of Action Classification V.8.4 (2018).
[2] Lower rates may be used on smaller trees. Do not use less than the minimum label rate.
[3] Mode of action unknown. No resistance potential exists for these products.

Table 2. Recommended chemical controls for Asian citrus psyllid during bloom

IRAC MOA[1]	Pesticide Trade Name	Rate/Acre[2]	Comments	Other Pests Controlled
4D	**Flupyradifurone (foliar application)**			
	Sivanto 200 SL	14 oz	Not recommended for soil applications against ACP. Do not tank mix with azole fungicides (FRAC group 3) during bloom period. In order to minimize exposure to pollinators, it is recommended that foliar insecticides are applied late in the afternoon, evening, or at night outside of daily peak foraging periods.	Aphids
15	**Diflubenzuron**			
	Micromite 80WGS	6.25 oz	Controls psyllid nymphs only. Do not apply more than 3 applications per season. See restrictions on label. Do not apply when temperatures exceed 94°F. Recommended to be applied in 2% horticultural mineral oil 97.	Citrus root weevils, citrus rust mites, citrus leafminer
21A	**Fenpyroximate**			
	Portal	32–64 fl oz	Do not apply more than 4.0 pints per acre per growing season. Do not make more than 2 applications per growing season. Allow 14 days between applications.	Suppression of spider mites and rust mites at higher rate
23	**Spirotetramat**			
	Movento	10 fl oz	Only controls psyllid nymphs, not adults. Limit of 0.32 lb a.i. per acre per season. Do not make more than one application during primary citrus bloom period. Recommended to be applied in 2% horticultural mineral oil 97.	Citrus rust mite, some scale insects, mealybugs
UN[3]	**Horticultural Mineral Oil**			
	97+% (FC 435-66, FC 455-88, or 470 oil)	5 gal	Do not apply when temperatures exceed 94°F. 470 weight oil has not been evaluated for effects on fruit coloring or ripening and is more likely to be phytotoxic than lighter oils.	Citrus leafminer, citrus rust mite, aphids, scales

[1] Mode of action class for citrus pesticides from the Insecticide Resistance Action Committee (IRAC) Mode of Action Classification V.8.4 (2018).
[2] Lower rates may be used on smaller trees. Do not use less than the minimum label rate.
[3] Mode of action unknown. No resistance potential exists for these products.

2020–2021 Florida Citrus Production Guide: Citrus Leafminer[1]

Lauren M. Diepenbrock, Jawwad Qureshi, and Lukasz Stelinski[2]

Citrus Leafminer Biology

Citrus leafminer (CLM) adults, *Phyllocnistis citrella,* are tiny moths that hide within the canopy during the day, emerging at dusk and at night to lay eggs individually on young, expanding leaf flushes. The egg first appears as a tiny dew drop, usually alongside the midvein on the underside of the unexpanded leaf. The larva emerges directly into the leaf tissue, mining first along the midvein, then back and forth as it makes its way to the leaf margin, where pupation occurs.

Leafminer populations decline to their lowest levels during the winter due to cool temperatures and the lack of flush for larval development. Populations of leafminer build rapidly on the spring flush, although their presence is not apparent until late spring as populations increase while the amount of new flush decreases. Throughout the ensuing warm season, leafminer populations vary with the flushing cycles, and subsequent flushes are often severely damaged.

The spring and summer period of high leafminer damage coincides with the rainy season, when canker spread is most likely. CLM greatly exacerbates the severity of citrus canker caused by *Xanthomonas axonopodis* pv. *citri* (see Chapter 31 of the *2020–2021 Florida Citrus Production Guide*, PP-182, Citrus Canker). CLM is not a vector of the disease, although tunnels made by its larvae are especially susceptible to infection, and tunnels infected by canker pathogen produce many times the amount of inoculum than in the absence of leafminer. Control of leafminer should be optimized where infection by canker is high, especially in young trees and susceptible varieties such as grapefruit and, to a lesser extent, early oranges.

Leafminer Management

Nonbearing Trees

Leafminers are effectively controlled in young trees by systemic insecticides applied against Asian citrus psyllid (ACP). Soil applications of neonicotinoids should be made about 2 weeks prior to leaf expansion to allow time for the pesticide to move from the roots to the canopy. Applications of neonicotinoids in summer should be timed to avoid rain events within 24 hours, which would cause leaching of product away from the root zone. The appearance of leafminers in young flush of these trees is an indication that residual effects have worn off and reappearance of ACP is soon to follow. Foliar applications of products effective against CLM target larvae and at best provide no more than 3 weeks protection. Therefore, timing is important, and sprays directed against CLM should be applied when flush is about halfway extended to kill the maximum number of larvae.

1. This document is CG098, one of a series of the Entomology and Nematology Department, UF/IFAS Extension. Original publication date March 2019. Revised March 2020. This document partially supersedes ENY-734, *2018–2019 Florida Citrus Production Guide: Asian Citrus Psyllid and Citrus Leafminer.* Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

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Bearing Trees

Healthy trees with leafminer-damaged leaves are more likely to become sites for new canker infection if canker is already present nearby. The only products currently available for leafminer control on large trees are for use as foliar sprays (Table 1). While several products are effective against this pest, achieving control of leafminer using foliar sprays on large trees is difficult due to the unsynchronized flush typically encountered during summer and fall. However, because leafminers affect only developing leaves, coverage of peripheral leaves in the canopy should be adequate to achieve suppression with foliar pesticides. Foliar sprays are directed against the larvae and should be timed to coincide with the appearance of the first visible leaf mines, which occur immediately following the feather leaf stage, or about 13 days after budbreak. At this time, insecticide applications will provide protection for most of the leaves in the new flush. Pheromone traps are also available commercially to help monitor CLM population trends. The pheromone itself has been used for control by mating disruption with some success.

Historically, natural enemies present in Florida respond to leafminer infestations, causing up to 90% mortality of larvae and pupae. These natural enemies include the introduced parasitoid *Ageniaspis citricola*, which has established throughout most of Florida and has been responsible for up to 30% of this mortality, mostly later in the year.

Recommended Chemical Controls

READ THE LABEL!

Some product labels specify rates per acre, while others specify rates per volume delivered (e.g., per 100 gallons). Refer to the label for details on how product should be mixed for desired targets.

Rates for pesticides are given as the maximum amount required to treat mature citrus trees unless otherwise noted. When treating smaller trees with commercial application equipment including handguns, mix the per-acre rate for mature trees in 100 gallons of water. Calibrate and arrange nozzles to deliver thorough distribution, and treat as many acres as this volume of spray allows.

Table 1. Recommended chemical controls for citrus leafminer.

IRAC MOA[1]	Pesticide Trade Name	Rate/ Acre[2]	Comments	Other Pests Controlled
4A	**Clothianidin (soil drench)**			
	Belay 50 WDG	3.2–6.4 oz	For use on nonbearing trees only. Do not apply within 1 year of fruit harvest. Do not exceed 12.8 oz/ac (0.4 lb a.i./ac) of Belay 50 WDG per acre per year. Do not apply this product to blooming, pollen-shedding, or nectar-producing parts of plants if bees may forage on the plants during this time period.	Asian citrus psyllid, aphids
	Imidacloprid (soil drench)			
	Various products, 2F, 4F and 4.6F		Limit of 0.5 lb a.i. per acre per growing season regardless of application type (soil or foliar) and trade name of imidacloprid product used.	Asian citrus psyllid, aphids, scales
	Thiamethoxam (soil drench)			
	Platinum 75 SG	1.83–3.67 oz	Do not exceed a total of 3.67 oz/ac (0.172 lb a.i./ac) of Platinum 75 SG or 0.172 lb a.i. of thiamethoxam-containing products per acre per growing season. Do not apply during prebloom or during bloom when bees are actively foraging.	Asian citrus psyllid, aphids, scales
5	**Spinetoram**			
	Delegate WG + horticultural mineral oil 97+% (FC 435-66, FC 455-88, or 470 oil)	6 oz + 2% v/v	Do not apply more than 12 oz of Delegate WG in a growing season. Do not make more than 3 applications in a growing season. Do not apply within 7 days of last treatment.	Asian citrus psyllid, orange dog, thrips
	Spinosad			
	Entrust	1.25–6 oz	Recommended to include 2% horticultural mineral oil. Approved for organics.	Orange dog, thrips
6	**Abamectin**			
	Various 0.15 EC products	5 fl oz	Always apply with a minimum of 1 gal horticultural mineral oil 97+% (FC 435-66, FC 455-88, or 470 oil). Do not apply any abamectin-containing product, (1) within 30 days of last treatment, (2) more than 3 times in any one growing season, or (3) more than 0.47 lb a.i./ac in a growing season. Do not apply in citrus nurseries.	Citrus rust mite, Asian citrus psyllid at higher rates.
	Agri-Mek SC	1 fl oz	Always apply with a minimum of 1 gal horticultural mineral oil 97+% (FC 435-66, FC 455-88, or 470 oil). Do not apply any abamectin-containing product, (1) within 30 days of last treatment, (2) more than 3 times in any one growing season, or (3) more than 0.47 lb a.i./ac in a growing season. Do not apply in citrus nurseries.	Citrus rust mite, Asian citrus psyllid at higher rates
15	**Diflubenzuron**			
	Micromite 80 WGS	6.25 oz	Do not apply more than 3 applications per season. See restrictions on label. Do not apply when temperatures exceed 94°F. Recommended to apply with 2% horticultural mineral oil.	Citrus root weevils, citrus rust mites, citrus psyllids
18	**Methoxyfenozide**			
	Intrepid 2 F	8 fl oz	Do not apply more than 16 fl oz/ac per application or 64 fl oz/ac per season. Do not apply within 14 days of last application. No bloom restriction. Recommended to apply with 2% horticultural mineral oil.	Orange dog

IRAC MOA[1]	Pesticide Trade Name	Rate/ Acre[2]	Comments	Other Pests Controlled
28	**Cyantraniliprole (foliar application)**			
	Exirel	16 fl oz + 1% v/v	Do not apply a total of more than 0.4 lb a.i./ac of Cyazypyr or cyantraniliprole-containing products per year. Recommended to apply with 2% horticultural mineral oil. See label for bloom restrictions.	Asian citrus psyllid, orange dog
	Cyantraniliprole (soil application)			
	Verimark	15–30 fl oz	Use the lower rate for trees 3 ft or less in height.	Asian citrus psyllid, orange dog
	Chlorantraniliprole			
	Altacor	3–4.5 oz	No more than 3 applications per season. Not more than 9 oz or 0.2 lb a.i. of chlorantraniliprole-containing products per acre per year. Minimum treatment interval 7 days.	Orange dog
	Thiamethoxam + Chlorantraniliprole			
	Voliam Flexi	7 oz	Always apply with a minimum of 1 gal horticultural mineral oil 97+% (FC 435-66, FC 455-88, or 470 oil). Do not exceed 14 oz/ac/season of VoliamFlexi or 0.172 lb a.i. of thiamethoxam-containing products per growing season. Do not apply during prebloom or during bloom when bees are actively foraging.	Aphids, citrus psyllids
4A + 6	**Thiamethoxam + Abamectin**			
	Agri-Flex	8.5 fl oz + 2% v/v	Do not exceed a total of 17 fl oz/ac or 3 applications per season of Agri-Flex or 0.172 lb a.i./ac of any thiamethoxam containing products or 0.047 lb a.i./ac of abamectin-containing products per growing season. Must be mixed with a minimum of 0.2 percent oil. Do not apply during prebloom or during bloom when bees are actively foraging.	Aphids, citrus leafminer, citrus rust mites
UN[3]	**Horticultural Mineral Oil**			
	97+% (FC 435-66, FC 455-88, or 470 oil) NR[3]	5 gal	Do not apply when temperatures exceed 94°F. 470-weight oil has not been evaluated for effects on fruit coloring or ripening. These oils are more likely to be phytotoxic than lighter oils.	Asian citrus psyllid, aphids, mites, scales

[1] Mode of action class for citrus pesticides from the Insecticide Resistance Action Committee (IRAC) Mode of Action Classification V.8.4 (2018).
[2] Lower rates may be used on smaller trees. Do not use less than the minimum label rate.
[3] Mode of action unknown. No resistance potential exists for these products.

ENY-603

2020–2021 Florida Citrus Production Guide: Rust Mites, Spider Mites, and Other Phytophagous Mites[1]

Jawwad Qureshi, Lukasz Stelinski, Xavier Martini, and Lauren M. Diepenbrock[2]

Mites from four plant-feeding families commonly colonize citrus. These include 1) two citrus rust mite species in the family Eriophyidae: citrus rust mite *Phyllocoptruta oleivora* and the pink citrus rust mite *Aculops pelekassi*; 2) three species of spider mites in the family Tetranychidae: Texas citrus mite *Eutetranychus banksi*, citrus red mite *Panonychus citri*, and the six-spotted mite *Eotetranychus sexmaculatus*; 3) one species in the family Tarsonemidae: broad mite, *Polyphagotarsonemus latus*; and 4) three species of false spider mites in the family Tenuipalpidae: *Brevipalpus californicus*, *B. obovatus*, and *B. phoenicis*. The three species in the fourth group are associated with the spread of a disease called leprosis. This disease no longer occurs in Florida, but increasing risk of reestablishment in Florida exists with its recent spread in Latin America. Currently, rust mites, spider mites, and broad mites are common and cause economic damage to commercially grown citrus in the state.

Citrus Rust Mites

The citrus rust mite (CRM) and the pink citrus rust mite (PCRM) are found on all citrus varieties throughout Florida. Although they can coexist on the same leaf or fruit, the CRM is usually the prevalent species. PCRM generally develops to greater damaging populations early in the season (April–May). Both rust mites are important pests of fruit grown for the fresh market. On some specialty varieties (such as Sunburst tangerine), damage may be particularly severe on stems and foliage, causing leaf injury and possible abscission. Fruit damage is the main concern with other varieties. Both mites feed on green stems, leaves, and fruit, with the PCRM being potentially more destructive.

Each of the two species go through four developmental stages during their life cycle: egg, first instar (larva), second instar (nymph), and adult. Egg deposition begins within 2 days after the female reaches sexual maturity and continues throughout her life of 14 to 20 days. The female lays one to two spherical transparent eggs (CRM) or transparent flattened eggs (PCRM) per day and as many as 30 during her lifetime. Egg hatch occurs within approximately 3 days at 81°F. Newly hatched larvae resemble the adult, changing in color from clear to lemon yellow (CRM) or pink (PCRM) after molting to the nymphal stage. After about 2 days at 81°F, molting occurs. The first nymphal stage resembles the larval stage and requires about 2 days to molt to an adult at the above temperature. CRM adults

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have an elongated, wedge-shaped body about three times longer (0.15 mm) than wide. PCRM are narrower, smaller, and rounded. CRM is usually straw to yellow in color, and PCRM is usually pink, but color is not always an effective or accurate means of separating the two rust mites. Males and females have an average life span of 6 and 14 days, respectively, at 81°F. In the field, females can live nearly 30 days in the winter. Rust mites develop from eggs to adults in 6 days at 81°F.

PCRM populations can begin to increase in April to early May on new foliage, reaching a peak in mid-June to mid-July, although the time of peak density can vary by several weeks depending on geographical location and weather. PCRM are more abundant in drier weather conditions. CRM population densities increase in May–July, then decline in late August, but can increase again in late October or early November. Mite densities in the fall rarely approach those occurring early in the summer. During the summer, CRM are more abundant on fruit and foliage on the outer margins of the tree canopy. The bottom portion of the north side of the tree canopy is generally preferred and supports the highest mite populations. The least favorable conditions for CRM increase are found in the top portion of the south side of the tree canopy.

Visible characteristics of mite injury differ according to variety and fruit maturity when damage occurred. When rust mite injury occurs on fruit during exponential growth, before fruit maturity (April to September), epidermal cells are destroyed, resulting in smaller fruit. These destroyed epidermal cells fracture as the fruit enlarges, causing a rough form of russeting known as sharkskin. Damage to mature fruit creates a brown stain but does not destroy epidermal cells or the wax layer, leading to a polished look referred to as "bronzing." Fruit damage by rust mites affects the appearance and reduces grade initially but may also lead to reduced size, increased water loss, and increased drop under severe infestation.

Leaf injury caused by feeding of CRM exhibits many symptoms on the upper or lower leaf epidermis. When injury is severe, the upper cuticle can lose its glossy character, taking on a dull, bronze-like color or patches of yellowish discoloration where wounded epidermal cells have released ethylene. Damage to lower leaf surfaces results in collapse of spongy mesophyll cells, appearing first as yellow patches and later as necrotic spots. With the exception of upper leaf epidermal injury to some specialty varieties, such as Ambersweet, Fallglo, and Sunburst, defoliation caused by CRM is rarely severe.

Leaf injury caused by feeding of PCRM is dramatic at mite densities exceeding 200 or more per leaf. Both mature and developing leaves can be affected, resulting in varying degrees of leaf distortion, curling under of leaf margins, crinkling of leaf tissues, and ultimately burn and leaf dieback. PCRM feeds on the lower leaf surfaces following its movement from overwintering sites on buds in the early spring. Later populations move onto fruit and then back to leaves as the mites migrate or disperse, and then decline.

Many scientific methods for sampling or scouting rust mite populations have been described. Of these, three general approaches are in widespread use: 1) determining the percentage of fruit and/or leaves infested with rust mites; 2) qualitative rating scales; and 3) individual adult mite counts taken from fruit on randomly selected trees. These sampling approaches are similar in that they are designed to avoid bias by randomly selecting different representative areas within a grove for sampling, avoiding border rows, and selecting fruit and/or leaves within a tree randomly.

One sampling method based on rust mite density (rust mites/cm^2) is described.

Processed Fruit

Initiate rust mite monitoring for PCRM in early April on leaves and fruit and continue every 2 to 3 weeks throughout the fruit season. CRM will tend to develop later in the spring or summer. Select trees at random and within uniformly distributed areas throughout a 10-to-40-acre block representing a single variety with uniform horticultural practices. Avoid sampling adjacent trees. Fruit should be sampled at random representing the four quadrants of the tree and taken midway in the canopy (between interior and exterior). One fruit surface area should be examined midway between the sun and shade areas. The number of rust mites per cm^2 should be recorded and averaged for the 10 acres, represented by 20 trees with four fruit per tree or 80 readings per 10 acres. Six rust mites/cm^2 would be a planning threshold where pesticide intervention may be required within 10 to 14 days. Ten rust mites/cm^2 would be an action threshold where treatment would be required as soon as possible.

Fresh Fruit

Similar to above, except monitor every 10 to 14 days with an average of 2 rust mites/cm^2 as an action threshold, because damage to fruit peel reduces the quality and rating of fruit for the fresh market.

The need for chemical treatments to control rust mites is dictated by numerous biological attributes of the mites, horticultural practices, and marketing objectives for the fruit. These key biological factors include: 1) inherent ability of mites to quickly increase to injurious densities on fruit and sustain the potential for reproductive increase over time; and 2) small size, which makes it difficult to monitor population densities in the field and detect injurious levels until visible injury has occurred on the fruit. The marketing objective for fruit is particularly important. Cosmetic appearance is a priority for fruit grown for the fresh market. Fruit growth and abscission are not affected until 50% to 75% of the surface has been injured. Thus, there is reduced justification for chemical control of rust mites on fruit grown for processing. Citrus groves producing fruit designated for the fresh market may receive three or four miticides per year, typically during April, June, August, and October. In contrast, groves producing fruit designated for processing receive zero to two treatments per year. Miticides applied for the control of rust mites on fresh-fruit varieties are often combined with compatible fungicides in the spring and summer. An alternative approach is using FC 435-66, FC 455-88, or 470 petroleum oil both as a fungicide for greasy spot control and to suppress pest mites.

From a horticultural perspective, canopy density has an effect on rust mite populations and their ability to increase over a short period of time. The denser the canopy, the less favorable conditions are for a rapid rust mite increase. Because most registered miticides have no ovicidal activity and short residual activity on fruit and foliage, residual control is generally better if the miticide is applied when rust mite adult and egg population densities are low for fresh-market varieties.

Because external blemishes caused by rust mites, fungal diseases, and wind are less important when fruit are grown for processing, the chemical control strategy for rust mites can be modified significantly. A summer spray is often required for greasy spot control. Use of petroleum oil in place of copper will reduce the likelihood of requiring a subsequent miticide treatment. Further miticide treatment may be unnecessary. However, a second petroleum oil application may be required for greasy spot control on summer flush.

Spider Mites

Three species of spider mites are potential pests on Florida citrus: Texas citrus mite, citrus red mite, and six-spotted mite. The Texas citrus mite is the predominant species in most groves throughout the state. The citrus red mite is usually second in abundance, but in some grove and nursery operations, it is the predominant species. The Texas citrus and citrus red mites occur on citrus throughout the year and are usually most abundant in groves between March and June. They are found most commonly on the upper leaf surface of recently mature flush, and all stages of the mites orient along the midvein. As populations increase, they move to leaf margins and fruit.

The six-spotted mite is a sporadic pest occurring in colonies on the lower leaf surface and tends to be more abundant following cold winters, especially during December. Localized populations of this mite can be recognized by characteristic yellow blistering on mature leaves between March and May. Populations decline rapidly in June and remain very low through the remainder of the year.

Spider mites feed primarily on mature leaves and differ from rust mites by feeding beneath the epidermal layer of cells. They are capable of removing cellular contents, causing cell destruction and reducing photosynthesis. Mesophyll collapse and leaf drop can result when trees are stressed by high spider mite infestations alone or in combination with sustained dry, windy conditions that may occur in the late fall, winter, or early spring months. When populations of Texas citrus mite or citrus red mites are high, they will also feed on developing fruit. Spider mites prefer dry weather and low relative humidity in the range of 30% to 60% and generally do not pose a sustained problem in the higher humidity conditions that occur between June and September. Populations of Texas citrus and citrus red mites aggregate among leaves within and between citrus trees.

A sampling method has been developed that provides 25% or less error margins when motile mite densities (i.e., all stages except eggs) are above 2 mites per leaf. The sample unit is a mature leaf immediately behind flush leaves. Table 1 shows the optimum number of sample areas within a 10-acre block of citrus trees when using 1, 5, or 10 trees per area and collecting either 4 or 8 leaves per tree. For example, if you look at 1 tree/acre, then it is necessary to look at over 10 sample areas within a 10-acre block to achieve accuracy. If you examine 5 or 10 trees/area, then only 4 or 5 areas need to be examined. As mite densities increase above 2 mites per leaf, the optimal number of sample areas declines below 5. Table 1 provides examples of different sample sizes at different control thresholds.

When the control threshold is increased from 5 to 10 mites per leaf, there are corresponding reductions in the amount of sampling required within a 1- or 10-acre block. At weekly or biweekly intervals during periods of spider mite activity, collect either one leaf per quadrant (i.e., N, S, E, W) (4 leaves/tree) on each tree per sample area or two leaves per quadrant (8 leaves/tree). Sampling consistency is important because spider mite numbers can increase on one quadrant of a tree. Place leaves from individual trees into labeled paper bags and then into a cold ice chest for examination under a stereomicroscope *or* examine individual leaves in the field with a stereomicroscope or 10× hand lens. If one motile stage of a Texas citrus or citrus red mite is present on either the upper or lower leaf surface, then the leaf is infested. A good relationship was found between the average number of Texas citrus mites or citrus red mites and the percentage of leaves infested across 10-acre blocks of young orange trees. For example, an average of 5 motile spider mites per leaf equals 70% to 80% infestation rate. This constitutes a treatment threshold for processing fruit.

Spider mites are suppressed to low densities by several species of predacious mites, insects, and entomopathogens in some groves. However, when populations averaging 5 to 10 motile spider mites per leaf develop between September and May, it is reasonable to apply a miticide, especially if the trees are stressed. Infestations comprised predominantly of adults, particularly males, are in decline and would not require control. Adult mites are recognized by their large size relative to immatures, and females are distinguished by their round shape and shorter legs compared to males.

Need for controlling spider mites is based on temperature and humidity conditions, spider mite population levels, tree vigor, and time of year. Petroleum oil provides some ovicidal activity against spider mite eggs. None of the other miticides provide ovicidal activity, and their residual activity must be sufficiently long-lasting to kill subsequently emerging larvae.

Broad Mites

Broad mites are an economic problem on citrus grown in green- or shade-house conditions and on lemons and limes grown in the field. Broad mites are whitish in color and very small—about 160 microns in length. They are found on the lower surfaces of young apical leaves where their eggs are deposited. The life cycle is modified with an emerging larval stage lasting about one day and then molting. Pharate females (developing nymphs) are picked up by the males and moved to newly developing flush and young citrus fruit. Mating occurs immediately after the female emerges. Males are very active and live for about one week.

Broad mites are only capable of feeding on very young, tender leaf or fruit tissues. The toxic saliva that is injected by these mites can result in significant damage. New leaf growth that is fed upon becomes distorted and feathered. A delayed terminal dieback can occur on infested citrus seedlings. Subsequent development of damaged buds can result in a rosette and formation of a witches'-broom. Small fruit become silvered from intense feeding by broad mite with subsequent reduced fruit growth.

Optimal environmental conditions include warm temperatures, high humidity, and low light intensity. Adults can survive through prolonged exposure to freezing temperatures but are sensitive to temperatures greater than 90°F.

Application of Miticides

Selection of a miticide should be based on the target pests to be controlled, avoiding risks of phytotoxicity, products that will be tank-mixed, the time of year, treatment-to-harvest interval, and prior use of a product. With the current emphasis on Asian citrus psyllid and citrus leafminer control, it would be wise to choose a miticide that may also have some activity against one of these two pests, such as diflubenzuron (Micromite 80 WGS) or spirotetramat (Movento). Separate chapters of this production guide address Asian citrus psyllid and citrus leafminer management. With the exception of petroleum oil, no miticide should be applied more than once per year to avoid development of resistance. Time intervals for application of products to target mites are provided in Table 2. Products listed for more than one time interval can be effective in providing mite control during those times, but use is still allowed only once per year. Petroleum oil spray applications can be effectively applied during the postbloom, summer, or fall intervals. Sulfur is included since it has a short treatment-to-harvest interval and provides a highly effective means of cleaning up rust mite infestations prior to harvest when needed. Use of sulfur should be minimized given its toxic effects on several beneficial arthropods.

Recommended Chemical Controls

READ THE LABEL.

See Table 3.

Rates for pesticides are given as the maximum amount required to treat mature citrus trees unless otherwise noted. To treat smaller trees with commercial application equipment including handguns, mix the per-acre rate for mature trees in 250 gallons of water. Calibrate and arrange nozzles to deliver thorough distribution, and treat as many acres as this volume of spray allows.

TO MINIMIZE RISK OF RESISTANCE, DO NOT APPLY A SPECIFIC MITICIDE OTHER THAN PETROLEUM OIL MORE THAN ONCE PER ACRE PER SEASON.

Table 1. Control thresholds and appropriate sample sizes for 10 acres.

If the control threshold is:	**Sample size** (Sample trees should be uniformly scattered across a 10-acre block. Do not sample adjacent trees.)
5 mites/leaf	Examine 4 leaves/tree from 6 trees/area from 4 areas/10 acres = 96 leaves on 24 trees/10 acres
8 mites/leaf	Examine 4 leaves/tree from 6 trees/area from 3 areas/10 acres = 72 leaves on 18 trees/10 acres
10 mites/leaf	Examine 4 leaves/tree from 5 trees/area from 2 areas/10 acres = 40 leaves on 10 trees/10 acres
15 mites/leaf	Examine 4 leaves/tree from 4 trees/area from 2 areas/10 acres = 32 leaves on 8 trees/10 acres

Table 2. Citrus miticide selection.*

Supplemental (Early Spring)	**Postbloom**	**Summer**	**Fall**	**Supplemental Fall**
--	--	Agri-mek + oil	--	--
Apta	Apta	--	Apta	Apta
--	--	--	Comite	Comite
Envidor	Envidor	Envidor	Envidor	Envidor
--	Petroleum oil	Petroleum oil	Petroleum oil	--
--	--	--	Sulfur	Sulfur
--	--	Micromite	Micromite	--
--	--	--	Nexter	Nexter
Movento	Movento	Movento	--	--
Vendex	Vendex	--	Vendex	Vendex
*Except for petroleum oil, do not use the same miticide chemistry more than once a year.				

Table 3. Recommended chemical controls for mites.

IRAC MOA[1]	Pesticide Trade Name	Rate/Acre[2]	Comments	Pests Controlled
6	**Abamectin**			
	Agri-Mek 0.15 EC + Petroleum Oil 97+% (FC 435-66, FC 455-88 or 470 oil)	5 to 10 fl oz + min of 3 gal	Always apply with a minimum of 1 gal horticultural mineral oil 97+% (FC 435-66, FC 455-88, or 470 oil). Do not apply any abamectin-containing product, (1) within 30 days of last treatment, (2) more than 3 times in any one growing season, or (3) more than 0.047 lb a.i./ac in a growing season. Do not apply in citrus nurseries.	**Rust mites, broad mites**, citrus leafminer, Asian citrus psyllids at higher rates.
12B	**Fenbutatin-oxide**			
	Vendex 50 WP	2 lb	Restricted use pesticide. Tank-mixing with oil or copper results in reduced residual activity. Do not apply at rates greater than 20 oz/500 gal to fruit less than one inch in diameter within 10 days of an oil spray.	**Rust mites, spider mites**
12C	**Propargite**			
	Comite 6.55 EC	3 pt	Leaf distortion or fruit spotting may occur when used in the spring or if tank-mixed with oil or applied within 2 weeks prior to or following an oil application. Do not use in spray solution above pH 10.	**Rust mites, spider mites**
15	**Diflubenzuron**			
	Micromite 80 WGS	6.25 oz	Do not apply more than 3 applications per season. See restrictions on label. Do not apply when temperatures exceed 94°F. Recommended to apply with 2% horticultural mineral oil.	**Rust mites**, citrus root weevils, Asian citrus psyllids
21	**Pyridaben**			
	Nexter 75 WP	6.6 oz	Tank-mixing with oil or copper results in reduced residual activity.	**Spider mites**, false spider mites, rust mites
21A	**Tolfenpyrad**			
	Apta	14–27 fl oz	Do not apply by air. Do not apply more than 27 oz/acre per growing season. Do not make more than 2 applications per year. Allow at least 14 days between applications.	**Citrus rust mite, spider mites (higher rates)**, Asian citrus psyllids
23	**Spirodiclofen**			
	Envidor 2 SC	13–20 oz	Limit to one application per season. Use 20 oz rate if tank-mixing with oil. Tank-mixing with oil results in reduced residual activity.	**Rust mites, spider mites**
	Spirotetramat		Limit of 0.32 lb a.i./ac per 12 months. Minimum interval of 21 days between applications.	
	Movento 240	10 fl oz	Do not make more than one application during primary citrus bloom period. Recommended to be applied in 2% horticultural mineral oil.	**Citrus rust mites**, Asian citrus psyllid nymphs, aphids, mealybugs, scale insects, whiteflies
	Movento MPC	16 fl oz	Do not apply within 10 days prior to bloom, during bloom, or until petal fall is complete. Recommended to be applied in 2% horticultural mineral oil.	

IRAC MOA[1]	Pesticide Trade Name	Rate/Acre[2]	Comments	Pests Controlled
Unk[3]	Petroleum Oil 97+% (FC 435-66, FC 455-88 or 470 oil)	2% v/v	Do not apply when temperatures exceed 94°F. 470 weight oil has not been evaluated for effects on fruit coloring or ripening. These oils are more likely to be phytotoxic than lighter oils.	**Rust mites, spider mites**, scales, whiteflies, greasy spot, sooty mold
	Sulfur		Limit to one application per season where supplemental rust mite control is needed between main sprays. Do not combine with oil or apply within 3 weeks of oil as fruit burn may result. May cause eye irritation to applicators and fruit harvesters.	**Rust mites, broad mites** (Kumulus, Thiolux and Microthiol only)
	Kumulus 80 DF	15 lb		
	Microthiol 80 DF	15 lb		
	Thiolux 80 DF	15 lb		
	Wettable powder or dust	50 lb		

[1] Mode of action class for citrus pesticides from the Insecticide Resistance Action Committee (IRAC) Mode of Action Classification V.8.4 (2018).
[2] Lower rates may be used on smaller trees. Do not use less than the minimum label rate.
[3] Mode of action unknown.

2020–2021 Florida Citrus Production Guide: Soft-Bodied Insects Attacking Foliage and Fruit[1]

Lauren M. Diepenbrock, Lukasz Stelinski, Xavier Martini, and Jawwad Qureshi[2]

This section is focused on sucking insects that affect foliage, twigs, and fruit of citrus in Florida. Insects covered here include scales, mealybugs, whiteflies, and aphids, which can all impact the health of both young and mature trees and their fruit quality. These insects differ from each other in their biology, generation times, and injury to plants, but approaches to monitoring and management are similar. Individual discussions of some groups are provided, and the tables of management options are organized by active ingredient, with the target pests from this chapter in bold text. Information on the Asian citrus psyllid and citrus leafminer can be found in separate chapters of the *Florida Citrus Production Guide*.

Scale Insects

There are two major groups of scale insects: soft scales and armored scales. Soft scales generally become larger in size than armored scales and are somewhat mobile as nymphs. Nymphs and adult female armored scales are completely sessile, and adult males of both are tiny gnat-like insects with a single pair of wings. The cover and body of soft scales are attached, whereas the cover can be removed from armored scales, revealing the round body underneath. Another important distinction is that armored scales produce no honeydew, while soft scales produce copious amounts of honeydew that attracts ants and serves as substrate for sooty mold, which often accumulates on foliage below the infestation.

The most important soft-scale species in Florida citrus is probably the Caribbean black scale (*Saissetia neglecta*), followed by green and brown scales (*Coccus viridis* and *C. hesperidum*, respectively), cottony cushion scale (*Icerya purchasi*) and Florida wax scale (*Ceroplastes floridensis*). Mature females are usually found on scaffold limbs, especially those of young trees. Mobile first instars, or "crawlers," move out toward the outer canopy, and successive nymphal stages gradually migrate inward.

The most important armored-scale pests in Florida are snow scale (*Unaspis citri*), Florida red scale (*Chrysomphalus aonidium*), purple scale (*Lepidosaphes beckii*), Glover's scale (*Lepidosaphes gloveri*), and chaff scale (*Parlatoria pergandii*). Snow scale tends to infest the trunk and scaffold limbs, especially those of grapefruit. The name refers to the male nymphs, which are white, numerous, and indistinguishable from males of the related species, lesser snow scale,

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Pinnaspis strachani, and fern scale, *P. aspidistrae*. Female snow scales are relatively large, oyster-shaped, and purple in color with a median ridge. Lesser snow scale generally inhabits smaller limbs, and fern scale makes small, round colonies of males on leaves and fruit, with a single female off to the side. Florida red scale typically inhabits fruit and leaves, while purple, Glover's, and chaff scale may be found in any part of the canopy.

Historically, pest management of both armored- and soft-scale insects in Florida citrus has been based on highly successful action of native and introduced natural enemies, including predators, especially ladybeetles, parasitic wasps, and fungal pathogens. These relatively specific natural enemies coexist with their hosts in the citrus grove under most conditions and can respond to and suppress pest numbers when they periodically increase in individual groves. Thus, scale insects should not be considered key pests in development of seasonal programs. However, there are conditions under which natural enemies may not function well. It is in these cases that scale insects achieve importance in an overall Integrated Pest Management program. Factors that are most often responsible for increases in scale populations are: 1) weather conditions that disrupt biological control; 2) movement of the pest to groves where natural enemies do not occur; and 3) disruption of natural enemies by other practices, particularly repeated use of broad-spectrum insecticides during a period when natural enemies are active and exposed. When these disruptions occur, scale populations can increase sufficiently to damage leaves, fruit, twigs, branches, or trunks. The sessile nature of scale insects promotes high concentrations of scales in limited areas within the grove, and so building populations can go unnoticed for several generations. Generation times for most scale species require more than one month to progress from egg to adult. Thus, populations do not build quickly like some other pest groups such as mites or aphids.

The first consideration for management should be to determine if the problem is induced by management practices and can be solved by changing those practices. For example, if repeated applications of broad-spectrum pesticides are responsible for scale population increase, then the solution is to stop use of broad-spectrum products and opt for selective materials that can allow natural enemies to recover. If, on the other hand, seasonal fluctuations have brought about population levels of concern, then some intervention with insecticides may be required. The basis for this decision should be population levels of living scales that are deemed sufficient to cause direct damage or produce large quantities of honeydew, which promotes the growth of sooty mold (soft scales only). Scale bodies from previous generations often remain on the plant for several months and may be mistaken for living scales, resulting in the application of pesticides at inappropriate times. For effective suppression, most scale species should be in young nymphal stages (crawlers) at the time of application, because pesticides are not very effective against eggs, large nymphs, or adults. Crawler activity can be monitored using double-sided tape wrapped around a citrus branch and checked weekly. No economic injury levels or thresholds are available for scale insect pests in Florida. Thus, the manager must evaluate each situation, considering the intensity and extent of scale populations and how much damage is likely to result. Generally, the intent of spraying for scale insects is to reduce populations with a single application such that no additional sprays are necessary during that season and disruption to biological control is minimized.

Treatment, when warranted, should focus on selection of an appropriate material (see Table 1), but it is equally important that treatment be applied with thorough coverage in mind. Because scale insects are completely or largely immobile, direct contact is essential. Spray volume, ground speed, nozzle choice, and location of the pest populations should all be emphasized to get maximum target coverage. If only a few trees are involved, then spot treatment with a handheld sprayer or other focused application equipment will provide best results. Generally, spray applications designed for contact with pests on the outer canopy are not effective at suppressing scales, especially if the scales are numerous in the interior of the tree. The follow-up to insecticide application for scale insects should involve evaluation of live scale numbers on the appropriate parts of the tree. Dead scales will not be visibly distinguishable from living scales at first. Hatching crawlers will also create the impression that the spray was not effective. Complete elimination of scale insects following an insecticidal spray is neither practical nor necessary, and in fact may be counterproductive.

Soft scales are generally not pests needing treatment; however, high populations of scales can be damaging to citrus. Following mild winters and when populations build within specific groves, treatment, where needed, should be based on scouting for crawlers and young nymphs during the generation that develops in April–May. Applications at other times are ineffective.

Citrus snow scale likewise is a local problem requiring occasional treatment in specific groves or portions of groves. Evidence for the need to treat includes high populations of crawlers showing on patches of bark that have been brushed clean during the previous week and the association of visible snow scale populations with bark splitting, particularly on young trees that are rapidly increasing in trunk girth. Spot-treat wood of heavily infested trees to runoff with a handheld sprayer.

Mealybugs

Citrus mealybugs (*Planococcus citri*) are normally under good biological control by a complex of natural enemies in citrus. However, intensive spraying for psyllid control may disrupt their biological control. Mealybugs' waxy covering, sedentary lifestyle, and preference for feeding in concealed locations make them very difficult to kill with insecticides. Only the most toxic materials have appreciable efficacy against mealybugs, but these materials also pose risks to the environment and are likely to disrupt biological control of other pests. Consequently, treatment is warranted only in cases of severe infestations or when the fruit itself is attacked. Systemic materials give superior control while minimizing impacts on beneficials but may not act quickly enough to prevent damage when high populations are established.

Lebbeck mealybug (*Nipaecoccus viridis*), present in Florida since 2009, was recently reported in citrus, with the first population documented in the late spring of 2019. Like other mealybugs, it prefers to feed in cryptic locations, making it difficult to find until populations are high enough that large amounts of sooty mold develop and damage to fruit, leaves, and branches is visible. Severe infestations can result in twig dieback and even death of young trees. Several predatory insects have been found to consume this species; however, with concurrent ongoing management for psyllids, it is unlikely that a sufficient population of predatory insects will establish to gain control of this pest. Management actions timed with the presence of juvenile stages (crawlers/nymphs) are more effective than management actions taken during the ovisac stage where most of the population is largely protected by a waxy coating. Contact insecticides applied with adjuvant at reduced sprayer speeds (1.2–1.5 mph) are necessary to provide adequate coverage for reducing the pest population. Insecticides with promising efficacy data include those with 1B, 4A, B, C, D, 4D, 21A, and 28A IRAC MOA classifications. Pyrethroids (IRAC MOA 3A) have minimal impact on this pest. **All recommendations for Lebbeck mealybug are preliminary.**

Whiteflies

The most important whiteflies in Florida are citrus whitefly (*Dialeurodes citri*), the cloudy-winged whitefly (*Singhiella* [=*Dialeurodes*] *citrifolii*), the wooly whitefly (*Aleurothrixus floccosus*), and citrus blackfly (*A. woglumi*). These insects are generally present in most groves in very low numbers and are normally under good biological control by various specialist parasitoids and generalist predators. Whiteflies are dependent on new growth for their development and reproduction; consequently, they are active in citrus only during periods of flush. Populations are rarely high enough to warrant treatment unless biological control has been disrupted. Large populations of these insects can deposit considerable volumes of honeydew, leading to sooty mold accumulation. Serious infestations of whiteflies are an indication that management practices should be reviewed.

Aphids

The most common aphids in Florida citrus are the green citrus aphid or Spirea aphid (*Aphis spiraecola*) and the cotton or melon aphid (*A. gossypii*). The green citrus aphid is responsible for curling of young flush due to feeding injury. This aphid and the melon aphid attack many different plant species and migrate into citrus mostly in spring. The brown citrus aphid (*Toxoptera citricida*) is the most important vector of citrus tristeza virus (CTV), which is responsible for quick decline of trees on sour orange rootstock that often die suddenly with fruit still attached. Brown citrus aphid has a narrow host range restricted largely to Rutaceae, particularly citrus, and has now become rare in Florida, possibly due to intense spraying for psyllids. However, melon aphid is also a vector of CTV and is also dark in color, but mottled, distinguishing it morphologically from brown citrus aphid. Aphids are dependent on the availability of newly expanding leaves for their development and reproduction, so these insects may become problematic during periods of new citrus growth, primarily on young trees in spring and fall. Aphids are largely controlled by many generalist natural enemies, such as ladybeetles, hoverflies, and lacewings, that normally maintain their populations and those of other insects found in flush below levels that warrant treatment in producing groves. Excessive honeydew accumulation on leaves will result in the growth of sooty mold fungus that blocks light and reduces photosynthetic activity. However, mature groves sustain little damage and should not need treatment. Treatment is warranted only in young groves (< 3 years old) if a large portion (i.e., > 50%) of expanding terminals is infested. Surveys for aphids should be conducted early in flushing cycles when most terminals are still in the feather stage.

Systemic materials, such as Admire, applied to the soil will give good control with minimal impact on beneficial species, but the time required for uptake of these materials by the tree restricts their usefulness as preventive, rather than responsive, treatments.

Recommended Chemical Controls

READ THE LABEL. Some product labels specify rates per acre, while others specify rates per volume delivered (e.g., per 100 gallons). Refer to label for details on how product should be mixed for desired targets.

See Table 1.

Rates for pesticides are given as the maximum amount required to treat mature citrus trees unless otherwise noted. To treat smaller trees with commercial application equipment including handguns, mix the per-acre rate for mature trees in 250 gallons of water. Calibrate and arrange nozzles to deliver thorough distribution, and treat as many acres as this volume of spray allows.

Table 1. Recommended chemical controls for scales, mealybugs, whiteflies, and aphids.

IRAC MOA[1]	Pesticide Trade Name	Rate/Acre[2]	Comments	Pests Controlled
1B	**Chlorpyrifos**			
	Lorsban 4E	5 pt	Restricted Use Pesticide. Highly toxic to bees; do not apply during bloom.	**Aphids, mealybugs,** psyllids, orange dog, katydids, grasshoppers, thrips
1B	**Dimethoate**			
	various products	see label		**Aphids, scales,** psyllids
4A	**Clothianidin (soil drench)**			
	Belay 50 WDG	3.2–6.4 oz	For use on nonbearing trees only; do not apply within 1 year of fruit harvest. Do not exceed 12.8 oz/ac (0.4 lb a.i./ac) of Belay 50 WDG per acre per year. Do not apply this product to blooming, pollen-shedding or nectar-producing parts of plants if bees may forage on the plants during this time period.	**Aphids,** psyllids, citrus leafminer
	Belay Insecticide	3–12 fl oz	Refer to the section 24c SLN label issued by the Florida Department of Agriculture and Consumer Services for application directions of this product to bearing citrus trees (expires December 31, 2021). For bearing trees, do not apply more than 12 fl oz per acre per application, and do not apply more than 24 fl oz per acre in a 12-month period.	
4A	**Imidacloprid**			
	Various products, 2F, 4F and 4.6F	see label	Limit of 0.5 lb a.i./ac per growing season regardless of application type (soil and/or foliar) and trade name of imidacloprid product used.	**Aphids, mealybugs, scales, whiteflies,** psyllids, citrus leafminer (soil only)
	Foliar Application	Half to full rate	Do not apply during bloom or within 10 days of bloom or when bees are actively foraging.	
	Soil Application	Half to full rate	8 fl oz of Admire Pro 4.6F per acre per 12 months when applied to soil. Do not exceed 0.5 lb/a.i. per application. See SLN for additional information.	
4A	**Thiamethoxam**			
	Actara (foliar application)	4.0–5.5 oz	Do not exceed a total of 11.0 oz/ac (0.172 lb a.i./ac) of Actara or 0.172 lb a.i. of thiamethoxam-containing products per acre per growing season. Do not apply during prebloom or during bloom when bees are actively foraging.	**Aphids, mealybugs, scales, whiteflies,** psyllids
	Platinum 75 SG (soil drench)	1.83–3.67 oz	Do not exceed a total of 3.67 oz/ac (0.172 lb a.i./ac) of Platinum 75 SG or 0.172 lb a.i. of thiamethoxam-containing products per acre per growing season. Do not apply during prebloom or during bloom when bees are actively foraging.	**Aphids, mealybugs, scales, whiteflies,** psyllids, ctrus leafminer
16	**Buprofesin**			
	Applaud	1–2 fl oz	Apply for scale insects when crawler emergence is heavy.	**Mealybugs, scales, whiteflies**
23	**Spirotetramat**		Only controls psyllid nymphs, not adults. Limit of 0.32 lb a.i. per acre per 12 months. Minimum interval of 21 days between applications.	
	Movento 240	10 fl oz + 3% v/v	Do not make more than one application during primary citrus bloom period. Recommended to be applied in 2% horticultural mineral oil.	**Aphids, mealybugs**, **scales, whiteflies,** citrus rust mites, psyllids
	Movento MPC	16 fl oz + 3% v/v	Do not apply within 10 days prior to bloom, during bloom, or until petal fall is complete. Recommended to be applied in 2% horticultural mineral oil.	

IRAC MOA[1]	Pesticide Trade Name	Rate/Acre[2]	Comments	Pests Controlled
29	**Floconamid**			
	Beleaf 50SG	2.8 oz	Apply when populations begin to build.	**Aphids**
UN	**Horticultural Mineral Oil**			
	97+% (FC 435-66, FC 455-88, or 470 oil)	5 gal	Do not apply when temperatures exceed 94°F. 470 weight oil has not been evaluated for effects on fruit coloring or ripening. These oils are more likely to be phytotoxic than lighter oils.	**Aphid, scales,** leafminer, citrus rust mite, aphids, scales

[1] Mode of action class for citrus pesticides from the Insecticide Resistance Action Committee (IRAC) Mode of Action Classification V.8.4 (2018).
[2] Lower rates may be used on smaller trees. Do not use less than the minimum label rate.

2020–2021 Florida Citrus Production Guide: Plant Bugs, Chewing Insect Pests, Caribbean Fruit Fly, and Thrips[1]

Xavier Martini and Lauren M. Diepenbrock[2]

The insects listed in this section are generalist feeders for which citrus is not a preferred host. They are therefore only sporadic problems in Florida citrus. While these pests do not require routine treatment in all groves, periodic outbreaks can potentially have dramatic impacts on tree health or productivity. When these insects are detected at a damaging level, treatment is required. Some pests may migrate into citrus from adjacent field or forage crops when these are harvested. Given that the distribution of these insects is rarely uniform, some monitoring effort should be directed towards delineating the boundaries of an infestation prior to any chemical application so that treatment can be limited to affected blocks only. Benefits of "spot" applications, or restricting treatments to affected areas only, are twofold: (1) direct monetary savings realized through reduced labor and material costs, and (2) the preservation of unsprayed refuges for beneficial arthropods, which ensures rapid recovery of natural enemy populations and accelerates the post-treatment restoration of biological control. Frequent monitoring (especially during growth flushes), proper identification, and timely application of the appropriate control measures are all essential to reducing the impact of these pests. If insecticide treatment is needed, select in priority a product that is also efficient in controlling Asian citrus psyllid (ACP) in order to include the treatment for these erratic pests in your ACP program and reduce insecticide applications.

Plant Bugs

Plant bugs are Heteropteran insects that feed on a wide variety of plants and occasionally migrate into citrus in large numbers when adjacent field crops are harvested. The most important species affecting citrus are the citron bug (*Leptoglossus gonagra*), the leaf-footed plant bug (*L. phyllopus*), and the southern green stink bug (*Nezara viridula*). They may also develop on decaying undergrowth within the grove. Under normal conditions, plant bugs are rarely numerous enough to be any cause for concern. However, in large numbers, they tend to aggregate and move into trees during the fruit ripening period. In this period, they can cause substantial direct damage by puncturing the peel to suck juice. Pathogens enter through the puncture wound, producing a surrounding sunken area of necrotic tissue. If damage is done early enough, fruit will fall before harvest. Thin-skinned varieties such as Hamlin are especially vulnerable, as well as fruits destined for the fresh market.

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Timely weed control can avert plant bug problems, whereas mowing or herbicide treatment of infested weeds may exacerbate a problem. In such a case, insecticidal control may be necessary. If possible, spot treatments of infested areas are always preferable in the interest of conserving natural enemies.

Orange Dog

The adult of the orange dog is the giant swallowtail butterfly (*Papilio crephontes*). Orange-dog eggs are large, round, semitranslucent, orange, and easily recognized on the expanding terminals where they are typically laid. The developing larvae are shiny brown and white, resembling bird droppings, and they feed preferentially on the new leaves. Under normal conditions, populations are low and the damage is sufficiently dispersed that there is little cause for concern. However, especially in the fall, situations can arise wherein large numbers of butterflies deposit numerous eggs on very young trees that then suffer severe damage from developing larvae. As with most caterpillars feeding on fruits, damage can only be averted by chemical treatment if the problem is detected early (i.e., when most of the larvae are still in early stages of development). When larvae reach later instars, they are more resistant to insecticides, and most feeding damage will have already occurred. Careful monitoring of young groves early in flush cycles is necessary for timely detection and treatment. For all caterpillar issues, *Bacillus thuringensis* (Bt)-based materials provide effective control with the added advantage of being listed by OMRI, the Organic Materials Review Institute, as not affecting beneficial species.

Grasshoppers, Crickets, and Katydids

These insects rarely require chemical control, because they are only a problem sporadically and in specific circumstances. Grasshoppers, primarily the eastern lubber grasshopper (*Romalea microptera*) and the American locust (*Schistocera americana*), can cause serious damage to growth flushes and may also damage fruit, especially in its early stages. The broad-winged katydid (*Microcentum rhombifolium*), the restless bush cricket (*Hapithus agitator*), and the jumping bush cricket (*Orocharis luteolira*) may also attack citrus. However, these insects typically do not spend their entire life cycles on citrus and are usually only a problem if they enter groves in large numbers. Adjacent pastures, hay fields, and fallow lands can be significant sources of these insects, as can weedy swales and row middles. Timely weed control and regular mowing of the surrounding vegetation can often avoid this problem.

Asian Cockroach

The Asian cockroach (*Blattella asahinai*) is very similar in appearance to the German cockroach (*Blattella germanica*), although their habits are quite different. The Asian cockroach flies readily and rarely invades dwellings, in contrast to its German cousin. First detected in Lakeland in 1986, the Asian cockroach quickly spread throughout the state and is now present in most citrus-growing areas. They feed primarily on decaying vegetation and largely inhabit moist litter under trees. However, they can also climb into the canopy, especially at night, where they feed on tender flush, giving it a ragged appearance. Insecticide applications, if deemed necessary, should be directed at the soil under the canopy where the population resides and takes refuge.

Fire Ants

While fire ants (*Solenopsis invicta*) are largely predaceous and may attack pests such as citrus leafminer larvae or newly hatched root weevil larvae, some situations can favor a high density of fire ants and lead to direct damage to citrus. For example, trunk wraps applied to very young trees can provide a protected environment for fire ants to attack tender young bark. Density of fire ants can also dramatically increase on soil mounted to protect young trees from frost. Fire ant damage to trunks of young trees produces sap flows that are collected by the ants. Girdling and death of the tree may result from direct effects of ant feeding or foot rot caused by infection of Phytophthora. Leaf buds may also be damaged by feeding. High densities of fire ant mounds can create problems for grove workers during maintenance of irrigation systems and for fruit pickers at harvest. Long-term control is best obtained with food baits, although soil applications of contact insecticides or even foliar applications of oil may provide temporary relief sometimes needed during harvest.

Eastern Subterranean Termite

The eastern subterranean termite (*Reticulitermes flavipes*) is a native inhabitant of forests throughout the eastern United States, where it plays a major role in the decomposition cycle of wood into soil. Subterranean termites feed on seasoned wood, especially pines, and are major pests of wooden structures throughout their range. Only rarely do they attack living trees. This habit is poorly documented in the literature. Nevertheless, they can become serious pests of citrus in groves where pine woods had supported large termite populations. They persist on buried remnants of the original wood but will also girdle and kill young citrus. Populations in groves have been estimated at 5 million individuals and may range over thousands of square yards.

Termites are most prone to attack citrus in the summer when rising water tables force them to abandon other food sources, but attack may occur in any season. Attack commences below the soil line and thus may escape detection until tree death. The termites chew bark and cambium, generally above the scaffold roots and down to bare wood around the trunk. Lesions are characteristically clean and free of gumming. Feeding may advance above the soil line below the bark, in covered galleries, or under tree wraps. Rapid tree decline once girdling is 90% or more complete is characterized by shock bloom, interveinal chlorosis, loss of foliage, and death. Attack is usually limited to trees 5 or fewer inches in diameter.

Control consists of avoiding the problem, first by meticulous removal of wood residues from new grove sites, and then by creating physical or chemical barriers around trees. Eventually, the problem will usually subside due to tree growth beyond the susceptible stage or natural attrition of the colony through lack of sufficient food supply. The following recommended practices can be employed to avoid most losses:

- Remove as much wood as possible when preparing a new grove site, particularly on pine land.
- Scout suspected infested areas by looking for signs of girdling and inspecting tree crowns below the soil line for lesions and termite activity.
- Do not use tree wraps in infested areas.
- Wash soil from crowns, exposing scaffold roots to discourage termites from preferred attack site.
- Create a chemical barrier directly around the tree crown, preferably with a granular insecticide. This practice will give a maximum of 3 months protection.

Caribbean Fruit Fly

The Caribbean fruit fly, *Anastrepha suspensa*, is a pest of many tropical and subtropical fruits of south and central Florida. The Caribfly is about 1/4 inch long with a yellow and brown body and black markings on the wings. Eggs are laid singly under the surface of the peel on ripe or overripe fruit and hatch in 2–3 days. Larvae feed for 10–14 days and develop in decaying fruit. Larvae develop into pupae, and the adults emerge later to complete the cycle.

Caribfly does not pose a direct threat to Florida citrus production, but the management of this pest may be necessary to export fruit to certain domestic and foreign markets. For export fruit, fly-free zones may be created to produce fruit for export. The primary requirements are: 1) the designated area and a buffer zone must be maintained free of preferred hosts such as loquat, rose apple, guava, and Surinam cherry, and 2) routine trap surveys must be conducted to monitor any Caribfly movement into the area and document absence. When populations are sufficiently high on the survey traps, bait sprays are used to reduce fly numbers. In addition, postharvest protocols may be implemented to assure that fruit arrives at its destination free of live flies.

Growers and others interested in participating in the Caribfly program must contact the Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Caribbean Fruit Fly Protocol, 3501-0-03 South US #1, Ft. Pierce, FL 34982-6666; phone (772) 468-4092.

Flower and Orchid Thrips

Thrips are small, elongate insects in the order Thysanoptera, varying in size from less than 0.2 mm to over 2.0 mm in length. They are easily overlooked because of their minute size. The life cycle of a thrips species consists of an egg, two larval feeding stages, a nonfeeding prepupal stage, a nonfeeding pupal stage, and feeding adults. About 14–18 days are required to complete development from egg to adult in some *Frankliniella* species.

Flower Thrips

Flower thrips, *Frankliniella bispinosa* and *F. kelliae*, have been identified as causing injury to developing flowers of navel and Valencia oranges. Crop loss on other citrus varieties has not been evaluated to date. *F. bispinosa* is the prevalent species throughout the citrus-growing areas of the state, while *F. kelliae* occurs on citrus from Vero Beach and Hardee County in the north to Dade County in the south. Thrips feeding results in cellular evacuation 1–5 cells deep and subsequent necrosis that can result in abortion of the flower or small fruitlet. Adult populations of these two species migrate as "aerial plankton" prior to and during the regular flowering cycle between January and April each year. Both species have very wide host ranges and utilize flowers and pollen of many plants as food sources. High populations of these thrips can cause economic loss in navel or Valencia orange by reducing fruit set. Both thrips species insert eggs singly into all floral parts.

Examine orange blocks during flowering at least twice each week to identify periods when high populations of thrips (i.e., *Frankliniella* spp.) are migrating into the trees. The number of thrips per citrus flower that causes economic loss has not been determined. Adult thrips are about 1 mm long and yellow to straw-colored. Dark banding along the upper surface of the abdominal segments may be evident on some adult specimens. Larvae are white or yellow. Thrips are capable of entering buds as soon as individual petals begin to separate. Examine individual flowers at random with a 5–10× magnification (head set) and observe their numbers. Residual activity of insecticides is very short (i.e., 3–7 days). Timing of one insecticide application to protect the major flowering period between maximum bud swell and full bloom should be considered when thrips are abundant. This is best achieved by treating the block at maximum bud swell or onset of full bloom. Delay will allow thrips to enter the opening flowers and reduce exposure to the insecticide. Treatment recommendations (Table 1) are based on the need for chemical control to optimize fruit set for the fresh market. The recommended insecticides are toxic to honeybees, which are also active around citrus blooms.

Orchid Thrips

Orchid thrips (*Chaetanaphothrips orchidii* and *Danothrips trifasciatus*) and greenhouse thrips (*Heliothrips haemorrhoidalis*) cause rind-blemish problems on developing fruit (i.e., ring spotting or irregular russeting), on immature and mature clustered fruit, or where a leaf or twig is in direct contact with a fruit. For all these species, economic loss has been restricted to fruits directed to the fresh market, mainly red grapefruit and satsuma.

Orchid thrips females are yellow to straw-colored with distinctive dark banding on the wings. Larvae are white or yellow with distinctive minute spines present on the upper surface of the eighth abdominal segment. Adult female greenhouse thrips are black, while the larval and pupal stages are white. All stages of the greenhouse thrips are occasionally found on fruit. Orchid thrips is the most commonly found species associated with damaged grapefruit and occurs throughout the year. *D. trifasciatus* is usually present in lower numbers than other orchid thrips. Examine interior clusters of red grapefruit at random with a 5–10× magnification (head set) beginning the first week of May or just as clustered fruit begin to touch for presence of orchid and greenhouse thrips larvae and adult females. Either wash suspected infested fruit individually in a bucket containing 80% alcohol and record the grove location to verify pest thrips, or collect three or more samples of 20 clustered fruit at random from each 10-acre red grapefruit block. Each of the 20 interior-canopy red grapefruit should be immediately washed in a bucket containing about one pint of 80% alcohol. Fruit should be collected at random with not more than 4 fruit taken per tree and a minimum of 5 trees per sample. The presence of 20 or more adult or larval thrips warrants an insecticide treatment. If more than 5 thrips are found, the area should be resampled in a week. One or two insecticide applications (Table 1) between May and July may be required to prevent rind blemish damage on red or white grapefruit varieties. Thrips scouting samples should be collected at random with not more than 4 fruit taken per tree and a minimum of 5 trees per sample. The presence of 20 or more adult or larval thrips warrants an insecticide treatment. If more than 5 thrips are found, the area should be resampled in a week. One or two insecticide applications between May and July may be required to prevent rind blemish damage on red or white grapefruit varieties.

Recommended Chemical Controls

READ THE LABEL.

See Table 1.

Rates for pesticides are given as the maximum amount required to treat mature citrus trees unless otherwise noted. To treat smaller trees with commercial application equipment including handguns, mix the per-acre rate for mature trees in 250 gallons of water. Calibrate and arrange nozzles to deliver thorough distribution, and treat as many acres as this volume of spray allows.

Table 1. Recommended chemical controls for chewing pests.

IRAC MOA[1]	Pesticide Trade Name	Rate/Acre[2]	Comments	Pests Controlled
1A	**Carbaryl**			
	80S	3.75 lb	May increase spider mite populations. *4 EC is a restricted use material.	**Grasshoppers, crickets, katydids,** adult root weevils, scale insects
	4L	3 qt		
	Sevin XLR	3 qt		
1B	**Chlorpyrifos**			
	4E	5 pt	May increase spider mite populations. *4 EC is a restricted use material.	**Orange dog, grasshoppers, crickets, katydids,** aphids, crickets, flower and orchid thrips
	50W	5 lb		
	50W	1 qt	Soil, chemigation, or fertilizer applications. Multiple applications may be required. *4 EC is a restricted use pesticide.	Fire ants
	4E	1 qt	Soil, chemigation, or fertilizer applications. Multiple applications may be required (fire ants, cockroaches). Direct application to base of tree (termites). *4 EC is a restricted use pesticide.	**Fire ants, Asian cockroaches, Eastern Subterranean termites**, aphids, crickets, katydids, mealybugs, scale insects, orange dog
	15G	6.7 lb		
1B	**Malathion**			
	5EC	6 pt		Plant bugs
	8EC	3.75 pt		
11	***Bacillus thuringiensis***			
	Bacillus thuringiensis	see label		**Caterpillars (including orangedog)**
	Fire Ant Baits			
6	Clinch	1 lb	Bearing and nonbearing.	**Fire ants**
7A	Extinguish	1 lb	Bearing and nonbearing. Labeled for aerial application.	
7B	Award	1 lb	Nonbearing only. Two applications/season—spring and late summer.	

[1] Mode of action class for citrus pesticides from the Insecticide Resistance Action Committee (IRAC) Mode of Action Classification V.8.4 (2018).
[2] Lower rates may be used on smaller trees. Do not use less than the minimum label rate.

2020–2021 Florida Citrus Production Guide: Citrus Root Weevils[1]

Larry W. Duncan and Catharine Mannion[2]

Citrus root weevils represent a complex of species known to infest citrus trees and various alternate host plants in Florida. The most common species infesting citrus in order of greatest geographical distribution are the Diaprepes root weevil, *Diaprepes abbreviatus*, the blue-green citrus root weevils, *Pachnaeus litus* and *Pachnaeus opalus*, the little leaf notcher, *Artipus floridanus*, and the Fuller rose beetle, *Asynonychus godmani*. Other lesser species inhabit citrus on occasion.

All citrus root weevils have a similar life cycle. They have three immature stages: egg, larva, and pupa. Adult weevils emerge from the soil and lay eggs on host plants aboveground, the larvae drop to the soil to feed on roots, and the pupae and teneral adult stages are spent belowground. Adults emerge from the soil throughout the year. Peak emergence varies within species and by geographical region (ridge vs. coastal and interior flatwoods). Peak adult emergence for the blue-green root weevils and Fuller rose beetle is normally April and May. *Diaprepes* adult emergence from the soil peaks in late May to early July, while peak adult abundance on the tree canopy parallels adult emergence in May/June but can have a second peak in late August to mid-October. The second peak is sporadic. The little leaf notcher has three generations per year. Although there is some overlap of generations, adults appear most abundant on trees in April/May, July/August, and October/November. All adult weevils are attracted to the nonreflective silhouette of the citrus tree trunk. The little leaf notcher and Fuller rose beetle are flightless and must crawl up the trunk, but other species will fly to the canopy.

The most visible plant damage resulting from adult feeding is notching of the margins of leaves of young, tender shoots. Notching patterns differ slightly among species and can be confused with grasshopper injury. Prolonged leaf feeding by adults appears to cause no economic effects in mature groves; however, on occasion, feeding will cause virtual defoliation of small replants.

With the exception of little leaf notchers, which prefer a weed host, larval feeding injury to the roots by other root weevils, particularly Diaprepes root weevil, can have a devastating effect on citrus trees because all larval stages feed on the roots for most of the year. Tiny hatchlings feed on fibrous roots, whereas larger larvae feed on the larger structural roots, forming deep grooves as they consume the outer bark, including the cambium layer. Roots may be girdled and killed in the process, or the crown may be girdled causing tree death. Larval feeding sites predispose

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the root system to infection and girdling by *Phytophthora* spp., thereby exacerbating economic loss. The rootstocks trifoliate orange and hybrid Swingle citrumelo are resistant to the complex of *P. nicotianae* and Diaprepes root weevil, while Cleopatra mandarin is susceptible to this complex. When *P. palmivora* is coincident with *P. nicotianae* in fine-textured, poorly drained soils, Swingle citrumelo is more vulnerable to attack by the complex than is Cleopatra mandarin. See also PP-156, *Phytophthora Foot Rot and Root Rot* and the Diaprepes Task Force website (http://www.crec.ifas.ufl.edu/extension/diaprepes/index.shtml), especially the management key on the website (http://www.crec.ifas.ufl.edu/extension/diaprepes/key.shtml).

Pest Management

Methods of Sampling Root Weevil Larvae and Adults

The population abundance and distribution of endemic citrus root weevils, regardless of species, vary from grove to grove, within a grove, and within a season. The seasonal abundance of adults within a citrus grove can be monitored using ground traps to capture emerging adults or via visual sighting of adults in the tree. No methods exist for monitoring larvae in the soil. By monitoring adult emergence using traps, the approximate time and intensity of adult emergence can be estimated for each infestation. By knowing the species of weevil and their seasonal emergence pattern from soil, a grower can apply adult control measures when weevil populations are highest. Research suggests that adult emergence often coincides with the onset of summer rains in late May through June, soil temperature, and the summer flush in central Florida groves.

Cultural Considerations

Citrus root weevil management begins with the selection of a Phytophthora-resistant rootstock that is certified weevil-free. Optimal soil drainage is fundamental to citrus root weevil management, particularly in heavier soils common to the coastal and interior flatwoods where insect and pathogen populations are highest. Tree decline associated with Diaprepes distribution is often patchy within groves and most obvious in lowlands. Stressed trees frequently harbor higher populations of adults because these stressed trees frequently generate more leaf flushes as food for adults. Spot-treating these locations with a chemical or biological agent should help. Regular fertilization and irrigation are crucial to new root growth in weevil-infested groves. Fertigation at monthly intervals has been used by growers to promote the growth of fibrous roots after Diaprepes has destroyed the taproot and inner crown of the tree. Skirt pruning and trunk banding can be effective in controlling flightless weevil species. Weed control is also needed to prevent movement into trees from stems of grasses and/or broadleaf weeds. Weed control is probably beneficial in reducing populations of alternate host plants. **The use of sound cultural practices by the grower should be adequate for managing all citrus root weevils on mature trees except for the Diaprepes root weevil and blue-green citrus root weevils.**

A wide range of parasites, predators, and pathogens attack citrus root weevils at one or more developmental stages within the tree canopy or in the soil. Most of these natural enemies are widely distributed and are general feeders. When focusing on cultural tactics favoring tree health and not using chemical methods, growers are conserving and augmenting the natural enemies of citrus root weevils.

Pest Control Considerations

Pest management of Diaprepes and, to a lesser extent, other citrus root weevils must begin with control of different life stages, particularly adult weevils, using the following options: 1) foliar sprays for egg and adult suppression, 2) chemical barriers for larval control, and 3) biological control of all subterranean stages with nematodes. The application of these control tactics is timed according to monitoring of adult emergence and the onset of leaf flushing in the spring/summer period. Any of these tactics should reduce root injury and help sustain root health from grove to grove. For many groves, however, pest management might differ according to: 1) rootstock susceptibility to soilborne diseases (i.e., *Phytophthora* spp.) and 2) root stress caused by excessive flooding and poor drainage of sandy loam soils. In certain grove situations, a soil fungicide for control of *Phytophthora* spp. should be advised (see fungicide section below).

Newly planted resets and groves younger than 5 years old with an established Diaprepes infestation on a susceptible rootstock can decline within 2 years without adult and/or larval control. A similar grove situation involving a resistant rootstock will have lesser tree decline but will require adult suppression. **Remember, groves planted on deep, sandy soils will often require no supplemental control and can rely on biological control agents.**

Foliar sprays of different contact (knockdown) insecticides that include petroleum oil to improve residual effect are used to target adult weevils in the tree canopy. Although foliar sprays have been used by growers to suppress adults any time of the year, research in central Florida has shown conclusively that root injury is lessened and overall tree health improved when two foliar sprays are used 4 weeks apart during peak summer flush in late May through June, along with an egg sterilant in the last application. The purpose of adult suppression with foliar sprays is to limit the number of gravid females and egg deposition, thereby reducing the number of larvae entering the soil. An egg sterilant such as Micromite 80WGS has a 6-week residual effect, during which females lay sterile eggs and eggs contacting the leaf surface are nonviable. The addition of petroleum oil to the spray mixture affects the bonding characteristics of the substance bonding the egg mass to the leaf.

Multiple applications of most foliar sprays within a season can incite an abnormal increase in spider mite populations; any pesticide, when used frequently, might cause secondary pest outbreaks or lead to resistance.

A chemical barrier applied as a band to the soil surface beneath the tree through an herbicide applicator provides a treated surface that will kill newly hatched invasive larvae before they reach the root system. The chemical must be uniformly applied from the trunk to the dripline of the tree to a moistened soil surface devoid of litter. Greater spray volume (~40 gal/ac) should ensure greater uniformity of coverage. Disturbance of the soil beneath the trees should be minimized to protect the soil barrier. Because neonates are killed upon exposure to treated soil as they pass through the barrier, this control tactic is best used for resets and young plantings infested with Phytophthora and where root injury by larvae must be minimal.

Timing chemical application to the time of year when larval entry into the soil is highest requires monitoring of adult weevils in the tree. Because highest larva recruitment occurs just after peak adult emergence, growers should apply soil treatment in early July, about 2 weeks after peak adult emergence in central Florida. Peak adult emergence is generally 2 to 3 weeks earlier in coastal groves.

Currently, Brigade WSB, a synthetic pyrethroid, is the only chemical registered for neonatal larvae control and applied as a soil barrier. Brigade has about 3 weeks residual presence in the soil and will suppress ants foraging on the soil surface. Generally, ant predators will recover after 30 days.

Parasitic nematodes that specifically attack insects are infectious to all larval stages of citrus root weevils. They are naturally found in citrus soils, where they inflict mortality to all weevil life stages they contact. Depending on availability, nematodes are also sold as biopesticides to control citrus root weevil larvae. They should be applied during months when soil surface temperatures are expected to exceed 70°F. Weevil larvae are generally most abundant in the soil during the summer (mid-July through September); therefore, one or more nematode applications are recommended at this time of year if soil moisture via natural causes and/or irrigation is adequate. Nematodes should not be applied within 4 weeks of nematicide use. Properly modified herbicide applicators or microsprinkler irrigation systems are used to deliver nematodes into premoistened soil. Application of approximately one acre-inch of water should also be applied to the irrigated acre immediately following application. Application late in the day or on cloudy days is encouraged to reduce nematode desiccation and exposure to lethal UV radiation.

Nematode products are most effective when applied in sandy soils with coarser soil texture and are less effective in very fine-textured soils at recommended rates. Higher rates can be applied to very fine-textured soils.

A fungicide for control of *Phytophthora* spp. may be recommended under the following conditions as a supplemental strategy to larval and adult weevil control: 1) the soils are fine-textured, poorly drained, or high in pH and calcium carbonate, 2) the trees are on rootstocks susceptible to *Phytophthora* spp., and 3) populations are above the damaging levels (20 and 40 propagules per cm^3 soil) for *P. nicotianae* and *P. palmivora*, respectively. Remember, larval and/or adult weevil control must be effective before fungicide treatment is justified.

Recommended Chemical Controls

READ THE LABEL.

See Table 1.

Rates for pesticides are given as the maximum amount required to treat mature citrus trees unless otherwise noted. To treat smaller trees with commercial application equipment including handguns, mix the per-acre rate for mature trees in 250 gallons of water. Calibrate and arrange nozzles to deliver thorough distribution and treat as many acres as this volume of spray allows.

Table 1. Recommended chemical and biological controls for citrus root weevils.

IRAC MOA[1]	Pesticide Trade Name	Rate/Acre[2]	Comments	Pests Controlled
Parasitic nematodes				
NR	**Nemasys® R**			
	Nemasys® R	18,000–40,000 nematodes or greater per square foot	Nemasys® R contains live nematodes to reduce *Diaprepes* and *Pachnaeus* spp. subterranean stages. Make one or more applications per year during the rainy season through fall. Apply through microirrigation or through herbicide boom to moist soil; one-half to one inch irrigation is needed after application.	**Root weevils**
Soil Barrier				
3	**Bifenthrin**			
	Brigade WSB	0.25–0.5 lb a.i.	*Restricted use pesticides. Apply uniformly to moist, weed-free soil. Do not apply via irrigation. Do not exceed 32 oz per season.	**Root weevils**, fire ants, Asian cockroach
Foliar Spray				
1A	**Carbaryl**			
	Sevin 4 F + Petroleum Oil 97+% (FC435-66, FC 455-88, or 470 oil)	1–2 gal + 1 gal oil	Contact/residual foliar spray. Lower rates will result in reduced residual activity. Do not exceed 20 lb a.i./acre/year for all uses. Do not exceed 2 applications per season. May increase spider mite populations. Do not apply when temperature	**Root weevils**, orange dog, katydids, grasshoppers, crickets, scale
	Sevin XLR + Petroleum Oil 97+% (FC435-66, FC 455-88, or 470 oil)	1–2 gal + 1 gal oil		
1B	**Phosmet**			
	Imidan 70 WP	1–2 lb	Contact foliar spray.	**Root weevils**
3	**Fenpropathrin**			
	Danitol 2.4 EC	16–21 oz	*Restricted use pesticide. Contact foliar spray. Do not apply when temperatures exceed 94°F	**Root weevils**, thrips, citrus psyllid
15	**Diflubenzuron**			
	Micromite 80 WGS + Petroleum oil 97+% (FC435-66, FC 455-88, or 470 oil)	6.25 oz + 1 gal oil	*Restricted use pesticide. Residual foliar spray. Maximum of 3 applications per season. Do not apply when temperature exceeds 94°F. 470 weight oil has not been evaluated for effects on fruit coloring or ripening. Heavier oils are more likely to be phytotoxic than lighter oils. Do not combine with Boron within 21 days to harvest.	**Root weevils**, citrus leafminer, citrus rust mites

[1] Mode of action class for citrus pesticides from the Insecticide Resistance Action Committee (IRAC) Mode of Action Classification V.8.4 (2018).
[2] Lower rates may be used on smaller trees. Do not use less than the minimum label rate.

ENY-606

2020–2021 Florida Citrus Production Guide: Nematodes[1]

Larry W. Duncan, Joe W. Noling, and Renato N. Inserra[2]

Integrated pest management (IPM) for nematodes requires: 1) determining whether pathogenic nematodes are present within the grove; 2) determining whether population densities of some nematodes are high enough to cause economic loss; and 3) selecting a profitable management option. Attempting to manage nematodes may be unprofitable unless the above procedures are carefully followed. Similarly, some management methods pose risks to people and the environment, and therefore it is important to know that their use is justified by the actual conditions in a grove.

Nematode Pests

Although many different species of nematode have been found in association with citrus roots, relatively few have been documented to be economically important. The nematode species of major economic importance in Florida include the citrus nematode (*Tylenchulus semipenetrans*), causal agent of "slow decline" of citrus, and the burrowing nematode (*Radopholus similis*), causal agent of "spreading decline" of citrus. Other species of limited economic importance because they are more localized include the sting nematode (*Belonolaimus longicaudatus*) and two species of lesion nematode (*Pratylenchus coffeae* and *P. brachyurus*). The incidence and abundance of dagger nematodes (*Xiphinema vulgare* and *Xiphinema americanum* group) in citrus groves appears to be increasing. The ecology and economic importance of these dagger nematodes in citrus are the subjects of ongoing research.

Typical Symptoms

Most nematode species that are known pathogens of citrus do not actually kill the tree but can significantly reduce tree vigor, growth, and grove productivity. Nematode-infested trees generally grow more slowly and may ultimately be of smaller size and quality. Aboveground symptoms that develop due to root damage include thinner canopies with less new foliar growth and twig dieback within the upper tree canopy. Symptoms of decline frequently increase with time and are more apparent during periods of environmental stress (i.e., drought or freezing temperature) or when combined with other damaging soil pests (i.e., root weevils, *Phytophthora*).

Monitoring Nematodes

The distribution and abundance of nematodes in soil prior to or after planting will affect the severity of the problem and define the need for nematode management. The only effective way of determining the presence or distribution of nematodes within a grove is by soil and root tissue sampling of undercanopy areas of individual trees. A representative

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grove sample for most nematode species consists of soil and roots (using a shovel or soil sampling tube) collected from the undercanopy areas of 20–30 trees within a 5-acre block. When sampling for burrowing nematodes, collect a large quantity of fibrous roots from the surface 0–12 inches beneath 10–12 declining trees (enough to loosely fill a 1-gallon freezer bag). Immediately after collecting the sample, thoroughly rinse soil from the roots and from inside the bag and place the roots back in the freezer bag. Once soil and root samples have been collected, they should never be subjected to overheating, freezing, drying, or to prolonged periods of exposure to direct sunlight. Samples should be submitted immediately to a commercial laboratory or to the UF/IFAS Nematode Assay Laboratory for analysis and recommendations.

Managing Nematodes

Nematode management should be considered only after the results of soil and root sampling are available. The agency or company that processed the samples should be able to indicate whether potential nematode problems exist within a grove. In most cases, nematode management should not be considered until all other potential causes of tree decline are evaluated and corrected. For more detailed information on treatment decisions and methods of nematode management in citrus, consult the *Florida Citrus Rootstock Selection Guide* (EDIS publication SP248), *Best Management Practices for Soil-Applied Agricultural Chemicals* (chapter 6 in this guide), or local UF/IFAS Extension personnel.

Sanitation

Once established, nematodes cannot be eradicated from groves, so the best method to manage plant-parasitic nematodes in new plantings is to exclude them from a grove by using only trees from nurseries certified to be nematode-free by FDACS Division of Plant Industry. Use of certified trees will virtually eliminate the possibility of nematode problems in new groves planted in virgin soils or in old citrus soils never infested by nematodes, provided that care is taken to always use clean equipment in those groves. Use of certified trees also reduces damage during the early years of growth in old, previously infested groves if soil nematode populations are low. High soil nematode densities hinder the beneficial effects of the use of certified trees. Sanitation of equipment to remove soil and root debris before moving between groves is an effective means of preventing the spread of nematodes.

Cultural Practices

Proper grove management is critical to mitigate damage caused by plant-parasitic nematodes. There is no value to managing nematodes if other problems (poor soil drainage, insufficient irrigation, foot rot and fibrous root rot, root weevils, improper fertilization, poor disease control) limit root function and/or reduce tree quality. In the case of burrowing nematodes, specific cultural practices (avoidance of disking, frequent irrigation, and fertigation) are critical to maintain a vigorous root system in the shallow soil horizons where the nematode is much less active.

Rootstock Resistance

Resistant rootstocks are also available to manage citrus and burrowing nematodes. Swingle citrumelo is a widely planted rootstock with resistance to citrus nematode. Milam lemon, Ridge Pineapple, and Kuharski Carrizo citrange are all resistant to burrowing nematode. The existence of races of these nematodes capable of breaking resistance compromises their value somewhat; nevertheless, large numbers of groves are currently growing well on resistant rootstocks in the presence of these nematodes.

Chemical Control

Environmental concerns and deregistration of numerous pesticides have dramatically reduced the availability of chemical products for nematode management. Currently, there are no soil fumigants recommended for preplant nematode control. Postplant nematicides can provide temporary suppression of nematodes in the shallow part of the root zone. Because of Florida's uniquely porous soils, soil-applied pesticides have the potential to contaminate groundwater. Consequently, their use should be restricted to the mid-to-late autumn and early spring, when rainfall is least in Florida. These materials should not be applied near irrigation or drinking-water wells or where the water table is close to the soil surface. Irrigation systems should always be inspected prior to pesticide application to soil to prevent overapplication of pesticide or water due to line breaks, faulty line-end pressure valves, or missing emitters. Additional considerations for the application of fumigants and nematicides to soil are outlined below.

Tree response to postplant chemical treatment often requires a period of one to two years of repeated treatment for growth improvement and significant yield returns. Response to preplant fumigants in newly planted young trees may be particularly slow, because nematode population increase may be delayed until canopy closure of adjacent trees occurs. Note that to protect groundwater, preplant fumigants can only be used in areas with an underlying impermeable layer within 6 feet of the soil surface capable of supporting seep irrigation. Because nematicides are not eradicants, repeated treatments are required to periodically suppress nematode repopulation of soil and roots to maintain high grove productivity. Preplant nematode management programs (sampling, selection of appropriate rootstocks, use of certified trees) are therefore important considerations for maximizing young tree growth and eventual long-term productivity, because it may not be possible to assure satisfactory tree growth with postplant chemical management programs alone. However, if nematode problems do arise on young trees, early management of the populations can have a prolonged beneficial effect on subsequent growth and productivity of the trees. Nematode control with postplant, nonfumigant nematicides occurs primarily within the zone of application and, to a much lesser degree, within and around roots outside of the zone of application due to the systemic activity of these pesticides.

Because a large majority of fibrous roots grow within the surface 24–30 inches of soil and decrease in abundance from the tree trunk to the row middle, proper nematicide placement to maximize undercanopy coverage is of critical importance. Nematicide placement under the tree canopy can significantly improve overall nematode control by targeting applications to areas of highest fibrous root and nematode density. Treatments will be most effective if made when soil temperatures are warm enough for nematode development and uptake by the tree. Natural degradation of nematicides moving downward in soil also increases with increasing soil temperature, thereby reducing the likelihood of groundwater contamination. To confirm the value of treatment programs, it is wise to designate areas of grove that will remain untreated in order to evaluate product performance and tree growth response.

A lack or loss of nematicidal efficacy and citrus yield response can be associated with factors other than improper pesticide application rate, placement, and application timing. The repeated use of nematicides often results in diminished efficacy in successive years due to accelerated microbial degradation. This process is caused when populations of microorganisms capable of metabolizing these products increase in soil following use of the compound. The degradation process can be initiated after a single treatment. Most postplant nematicides do not necessarily kill nematodes upon direct contact: efficacy usually requires long, continuous exposure to sublethal, yet toxic, concentrations in soil. Nematode population reduction results from a disruption of normal nematode behavior necessary to complete the life cycle. Disappearance rates of nematicides in soil (due to leaching and/or microbial degradation) are therefore critical determinants of treatment efficacy.

Pesticide leaching to depths below the primary root zone can occur as a direct result of excessive irrigation or rainfall. Given the sandy, permeable nature of citrus soils and generally low soil organic matter content, irrigation schedules based on soil moisture deficits are likely to improve nematode control and grove response to treatment by maximizing retention of toxic concentrations within the citrus tree root zone and prevent problems of environmental contamination. Undercanopy weed growth may reduce nematicide effectiveness by interception or absorption of pesticide residues targeted for citrus roots or nematodes in soil. Undercanopy weeds also interfere with microsprinkler operation and can prevent uniform coverage of chemigated nematicides.

2020–2021 Florida Citrus Production Guide: Huanglongbing (Citrus Greening)[1]

Megan M. Dewdney, Tripti Vashisth, and Lauren M. Diepenbrock[2]

Huanglongbing (HLB; citrus greening) is caused by the bacterium *Candidatus* Liberibacter asiaticus. The name huanglongbing means "yellow shoot disease," and it derives from the bright yellow shoot symptom that commonly occurs on a sector of an infected tree. HLB is a serious citrus disease because it causes tree decline and affects all citrus cultivars. The HLB-causing bacterium found in Florida is the Asian species, which occurs in warm low-altitude areas and is transmitted by the Asian citrus psyllid (*Diaphorina citri* Kuwayama). The Asian citrus psyllid was discovered in Florida in 1998 and is now found throughout the state wherever citrus is grown.

Early HLB symptoms on leaves include vein yellowing and an asymmetrical chlorosis referred to as "blotchy mottle." The blotchy mottle of the leaf is the most diagnostic symptom of the disease, especially on sweet orange. The blotchy mottle symptom also may be confused with other diseases or damage such as severe forms of citrus tristeza virus (CTV), Phytophthora root rot, waterlogging, citrus blight, leafminer tunnels, or citrus stubborn disease (an exotic disease to Florida). Leaves may be small and upright with a variety of chlorotic patterns that often resemble mineral deficiencies such as those of zinc, iron, and manganese. Some leaves may be totally devoid of green or exhibit green islands. Young trees decline quickly and rarely become productive if they are infected shortly after planting. As mentioned above, early symptoms of yellowing may appear on a single shoot or branch. The yellowing usually spreads throughout the tree canopy over several years. It is common for affected trees to show twig dieback. Fruit are often few in number and small, may be lopsided with a curved central core, and fail to color properly, remaining green at the stylar (flower) end. Many fruit drop prematurely from afflicted trees in the month prior to harvest. A yellow stain may be present just beneath the peduncle (stem) on a cut fruit. The affected fruit often contain aborted seeds and have a salty, bitter taste reminiscent of unripe fruit. Root systems are heavily damaged by HLB, with 30%–50% root loss occurring in the early phases of the disease. More than 70% root loss has occurred by the time canopy decline is visible. Current information about the effects of HLB on root systems is available in chapter 18, *Root Health Management*.

The causal bacterium present in Florida, *Ca.* Liberibacter asiaticus, has not been cultured, and formal diagnosis is done by PCR. Detection of the bacterium is usually only possible from blotchy mottle symptomatic tissues. The host range of the *Ca.* Liberibacter spp. that cause HLB includes all citrus species regardless of rootstock. Normally symptoms are severe on sweet orange, mandarins, and mandarin hybrids and moderate on lemon and sour orange. Grapefruit symptoms are moderate initially but become suddenly severe after several years. Lime, pomelo, and trifoliate orange are listed as more tolerant, but this does not mean that the bacterium is unable to infect and multiply in those

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cultivars. Severe symptoms have been observed on pomelo and lime.

The consequences of unmanaged HLB can be grave. Mature trees start to decline slowly and eventually become nonproductive after infection. Consequences are worse for young trees. In most cases, the trees never reach full production, and in the worst case, the trees die within 1–2 years of planting. Because HLB also can be transmitted with infected budwood, the use of certified disease-free planting materials is essential to maximize planting success.

Psyllids are the primary vector for HLB spread and are present in Florida year-round, so their management is a necessary part of an integrated management program. Peak activity and movement occur in the spring and summer with the development of new flush. Because HLB is very common in Florida citrus, psyllids are likely to carry the bacterium between plants when they move, increasing the disease pressure in plants that are already infected and establishing the bacteria in young plants. Despite the high pest and disease pressure, citrus can still be productive thanks to nutritional inputs to maintain the health of trees. New tools are also under evaluation to determine the best way to protect young trees from HLB. In addition to management within the field, noncrop hosts for psyllids require attention because they can be a source of this pest. The Asian citrus psyllid feeds on many rutaceous plant species. Of these plants, orange jessamine (*Murraya paniculata*) and orange boxwood (*Severinia buxifolia*) serve as hosts for both the psyllid and *Ca.* Liberibacter spp. Movement of these ornamentals is restricted under state compliance agreements, and they should not be moved from areas where the disease occurs.

Recommended Practices

Overall, integrated pest management strategies should focus on the following: use of disease-free nursery trees, an optimal nutritional regime, reduction of the inoculum by frequent disease surveys, removal of symptomatic trees, and focused management of Asian citrus psyllid populations. Specific recommendations based on tree age are listed below.

A. Young Trees/New Plantings

1. The use of clean budwood and certified healthy trees is essential for successful replanting. It is now mandatory in Florida that budwood sources and nursery production be carried out under psyllid-proof enclosures and certified HLB-free.

2. Preventing psyllid access to flush is important in managing HLB. Systemic insecticides, such as imidacloprid, have traditionally been used for this purpose (see chapter 23, *Asian Citrus Psyllid*). However, resistance to imidacloprid and several other commonly used insecticides has been detected in specific regions in the state. Therefore, it is recommended to contact your local UF/IFAS Extension agent or citrus entomology state specialist to assist in developing insecticide-based management plans. Some biological control for psyllids is available, but the amount of control provided by introduced parasitoids has been insufficient to slow disease spread. New tools that can reduce psyllid pressure including reflective mulch and exclusion netting are available for purchase but have not been fully evaluated for efficacy.

3. Scouting for HLB-affected trees should be done routinely in young plantings so that infected trees can be removed quickly. It is recommended that scouting be conducted four or more times per year in areas where HLB is not widespread (e.g., north Florida). The frequency of scouting may be higher in areas that have high rates of HLB. Symptoms are the easiest to find from October to March, although they may be present at other times of the year too. The current methods used to scout are walking or all-terrain vehicles. Symptomatic tree numbers and the rows in which they are found should be marked with colored flagging tape, and GPS coordinates should be taken or the sites marked on a map to facilitate relocation and removal of these trees. In some cases, an HLB PCR diagnostic test may be necessary to confirm the disease (see diagnosis below). Scouting resources are available on the following websites: https://crec.ifas.ufl.edu/hlb-information/greening/ or https://edis.ifas.ufl.edu/ch200.

B. Mature Trees

1. Diagnosis of HLB by symptoms alone may be difficult because some nutrient deficiency symptoms and other problems are often confused with some of the symptoms associated with HLB. Samples of trees suspected to be infected with HLB may be sent for PCR diagnosis to the Southern Gardens Diagnostic Laboratory or the Florida Division of Plant Industry. The procedures for submission of suspect samples to labs for PCR testing are available at the following web site: https://crec.ifas.ufl.edu/hlb-information/greening/diagnostics/.

2. In mature groves, psyllid management will vary based on growers' needs but should be based on the goal of reducing the population to minimize impacts of reinoculation and potential for spread to young plantings. Population

reduction is most often achieved using insecticides. When using insecticides, modes of action **must** be rotated for resistance management (see ENY-854, *Quick Reference Guide to Citrus Insecticides and Miticides*). Insecticide resistance has been detected in several counties; therefore, it is prudent for growers to contact their county Extension agents or state specialist for advice on which materials to use in programs.

Windbreaks in the form of trees have been evaluated and found to reduce psyllid migration into fields. Windbreaks may also provide habitat for predatory insects that can help reduce local psyllid populations. Predatory insects, including the imported parasitoid *Tamarixia radiata*, lady beetles, and lacewings, can help in reducing the young psyllid populations within a field.

C. Nutrition/Irrigation Management for All Groves

1. Plant nutrition is essential for optimum growth and yield of high-quality fruit. A fertilizer program should include all mineral nutrients. An excess or deficiency of any single nutrient can adversely affect tree performance. HLB-affected trees have smaller and weaker root systems when compared to healthy trees; therefore, it is suggested to apply fertilizer and irrigation in frequent small doses because it improves their uptake potential by the tree. Controlled-release fertilizer and fertigation can be strategic alternatives to multiple applications of conventional dry granular fertilizer. Because no single nutrient has been observed to be more beneficial for HLB-affected trees, the focus should be on all essential nutrients applied in split doses throughout the year.

2. Soil and irrigation-water pH also play an important role in nutrient availability to the plant. HLB-affected trees perform better when the soil pH is around 6.0–6.5. Intensive fertilizer and irrigation management will not cure the tree from HLB but can potentially improve the quality and productivity of HLB-affected trees. It is highly recommended that before making any changes to a fertilizer program for HLB-affected or healthy trees, leaf and soil nutrient analysis is performed and taken into consideration. The goal of the fertilization program should be to have all the leaf nutrients in the high end of the optimum range. Refer to chapter 15, *Irrigation Management of Citrus Trees*, chapter 16, *Nutrition Management for Citrus Trees*, and chapter 18, *Root Health Management*, for more information.

D. Removal or Pruning of Infected Trees

1. Removal of infected trees is the only way to ensure that they will not serve as a source of the bacterium for psyllid acquisition and subsequent transmission. Generally, removal happens when the tree is no longer productive or is infected very early and will never be productive. In regions where HLB is not widely established, infected trees should be treated with a foliar insecticide (e.g., Danitol, fenpropathrin) to kill all adult psyllids feeding on that tree. Failure to control psyllids will result in them dispersing to new plants once the diseased tree is removed, potentially infecting new resets or plantings.

2. Pruning of trees/symptomatic limbs has been attempted; however, because HLB is systemic, pruning is not successful because tree roots are infected before canopies are symptomatic. Additionally, because the tree is still infected after pruning, the new flush produced will serve as a feeding site for adult psyllids to acquire an even higher concentration of the bacterium than before. The infected psyllids may then disperse to uninfected trees once the new flush hardens off. Moreover, pruning can stress the root system even further, resulting in an overall weak tree and reduced root system. Refer to chapter 19, *Canopy Management*.

Additional Information

Links to websites on HLB and EDIS documents can be accessed through the UF/IFAS Citrus Research and Education Center website at the following addresses:

https://crec.ifas.ufl.edu

https://citrusresearch.ifas.ufl.edu/

2020–2021 Florida Citrus Production Guide: Citrus Canker[1]

Megan M. Dewdney and Evan G. Johnson[2]

Citrus canker is a leaf-, fruit-, and stem-blemishing disease that affects most citrus. Severe infections can cause significant fruit drop. It is caused by the bacterium *Xanthomonas citri* subsp. *citri*. Grapefruit, Mexican lime, and some early oranges are highly susceptible to canker. Lemons, limes, and Navel, Pineapple, and Hamlin oranges are moderately susceptible to canker. Mid-season oranges, Valencias, tangors, tangelos, and other tangerine hybrids are less susceptible, and tangerines are the least susceptible. Little is known about the canker susceptibility of the many new cultivars released recently. If you notice that there is a problem on one cultivar or that one is particularly tolerant, please inform your local Extension specialist.

Symptoms

Young lesions are raised on both leaf surfaces, particularly on the lower leaf surface. The pustules later become corky and crater-like with raised margins and sunken centers and are surrounded by a yellow halo. Fruit lesions vary in size, because the rind is susceptible for a long time, and more than one infection cycle can occur on fruit. Twig and stem infections resemble those on fruit. The lesions are raised with a corky appearance and can support long-term survival of the bacterium. Older lesions may darken when they become colonized by saprophytic fungi such as *Colletotrichum* spp.

Major citrus canker outbreaks generally occur when new shoots emerge or when fruit are in the early stages of development, especially if a major rainfall event occurs during this critical time. Frequent rainfall in warm weather, especially storms, contributes to disease development. Citrus canker is a cosmetic disease, but when conditions are highly favorable for infection, it causes defoliation, shoot dieback, and fruit drop. Leaf susceptibility is complicated by the citrus leafminer. The galleries caused by leafminer larvae do not heal quickly and increase leaf susceptibility. Leaves then have highly susceptible wounds for long periods of time where the bacterium can infect the leaf. Lesion number and individual lesion size increase greatly and magnify the inoculum pressure in a grove compared to citrus canker without leafminer.

Biology

The bacterium reproduces in lesions on leaves, stems, and fruit. When there is free moisture on the lesions, the bacteria ooze out and can spread to new growth and other trees. Wind-driven rain is the main means of movement, and wind speeds >18 mph aid in the penetration of bacteria through the stomatal pores or wounds made by thorns, insects, and blowing sand. Tissues become resistant to infection as they mature, except when exposed to extreme windblown rain such as in a hurricane. Almost all leaf

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and stem infections occur within the first 6 weeks after growth initiation unless there is a leafminer infestation or tropical-storm-force winds. The most critical period for fruit infection is when the fruit are between 0.5–1.5 inches in diameter for grapefruit and 0.25–1.25 inches in diameter for oranges. In this stage, the stomates on the fruit surface are opening, and fruit are particularly susceptible to bacterial penetration. After petal fall, fruit remain susceptible during the first 60 to 90 days for oranges or tangerines and 120 days for grapefruit. Infection after this time can result in the formation of small, inconspicuous pustules.

Most spread of the bacterium by wind and rain is over short distances, such as within trees or to neighboring trees. Canker is more severe on the side of the tree exposed to wind-driven rain. Spread over longer distances, up to miles, can occur during heavy winds, severe tropical storms, hurricanes, and tornadoes. Long-distance spread occurs more commonly with the movement of diseased plant material such as budwood, rootstock seedlings, budded trees, or less commonly, fruit and leaves. Workers can carry bacteria from one location to another on hands, clothes, and equipment. Grove equipment can spread the bacteria within and among plantings, especially when trees are wet.

Management

The Citrus Health Response Plan (CHRP) does not require removal of affected trees. Thus, growers should use their best judgment in management of citrus canker. The entire state of Florida is under quarantine, and fruit movement is subject to specific regulations depending on market destination.

Canker losses can be severe under Florida conditions and can be difficult to control on grapefruit and the most susceptible early-season orange varieties. Areas that are currently canker-free should be protected to the extent possible.

Protecting Canker-Free Areas

Decontamination

Where canker is absent, decontamination protocols are still in place and should be followed. With widespread canker around the state, the likelihood of further spread is greater than ever. In moving equipment and personnel from grove to grove, every effort should be made to make sure that plant material is not moved inadvertently and that all equipment has been thoroughly decontaminated. Decontamination is especially important in harvesting operations, hedging and topping, and any other practices involving extensive contact with foliage. Obviously, when equipment is moved from blocks where canker is endemic to other infected blocks, decontamination serves little purpose.

Tree Removal

If canker is detected in areas previously free of the disease, removal and burning of trees on site may slow the establishment of the disease. For tree removal to be effective, canker has to be localized and limited to a small number of trees. Tree removal is not likely to be effective if canker is already present within a mile of the grove, because it can spread with the wind and rain; therefore, tree removal is no longer a viable option in most of Florida.

Defoliation and Pruning

Defoliation and pruning are not recommended because they induce large, highly susceptible flushes. The young flushes are vulnerable to infection from stem lesion inoculum or infected neighboring groves during storms with high winds.

Endemic Canker

In most of Florida where canker is endemic, the primary means of control are: 1) plant windbreaks, 2) protect fruit and leaves with copper or an integrated program of Blockade and copper applications, and 3) control leafminer populations.

Windbreaks

Windbreaks are highly effective to reduce canker spread, but more importantly, they reduce the severity of the infection in endemic situations. When canker lesions are wetted, millions of bacteria ooze onto the leaf surface. While the bacterium can drip down to lower leaves and fruit, the vast majority of the infection occurs by windblown rains that spread the bacteria throughout a tree and to neighboring trees. Winds above 18 to 20 mph are needed to force bacteria into stomates on leaves and fruit; in so doing, bacteria can bypass copper barriers.

Windbreaks reduce wind speed for a distance of five to ten times the height of the windbreak. For example, a 30 ft tall windbreak will exert an effect for about 150 to 300 ft. To be effective for canker control, windbreaks do not need to be dense. All that is required is to reduce wind speed to < 20 mph. The need for windbreaks and the distance between rows will depend on the destination of the fruit, fresh or processed, and cultivar susceptibility. Fresh-market grapefruit in Florida is best with a windbreak that surrounds each 5- to 10-acre block. The tree species *Corymbia* *torelliana* has proved to function well in grapefruit blocks because the tree retains its leaves and branches all the way to the ground, reducing wind penetration through the lower canopy. Replacement of windbreak trees that fail to thrive or have been killed by lightning is recommended to prevent breaches that allow for local wind penetration and incursions of the bacteria. In many groves with less-susceptible citrus cultivars, a windbreak down the row about every 300 ft may be sufficient. In situations where some protection exists and tolerant varieties are grown for processing, windbreaks are unnecessary. Additionally, not topping outside rows of citrus can also serve as a viable, harvestable windbreak. Currently, the recommendation is that growers plant windbreaks along fence lines, ditches, around wetlands, or wherever they can plant without removing citrus trees. If it becomes obvious that more windbreak protection is needed, rows of citrus or end trees can be removed to accommodate more windbreaks.

For more information on selection of plant species and design, see the UF/IFAS CREC website (http://www.crec.ifas.ufl.edu/extension/windbreaks/).

Copper Sprays

Over the last 30 years, IFAS has evaluated dozens of products for canker control. Products such as antibiotics, compounds that induce resistance in plants, and disinfectants provide limited canker control, but no material has proven more effective than copper products.

Copper products are quite effective for preventing fruit infection but much less effective for reducing leaf infection. Application of copper to young leaves protects against infection, but the protection is soon lost due to rapid expansion of the surface area. Also, copper has limited value in reducing disease spread. Fruit grows more slowly than leaves and is easier to protect. Oranges develop resistance in mid- to late July. Grapefruit remain moderately susceptible through full expansion in late September to mid-October. Infection through wounds can occur at any stage of fruit growth.

For oranges with endemic canker, most infections will occur from April to July. No more than five copper sprays applied at 21-day intervals are recommended for early processing oranges: one in early April (fruit at 0.25- to 0.5-inch stage), a second in late April, a third in mid-May, a fourth in early June, and a fifth in late June to early July when the fruit is about 1.5 inches diameter. Three applications at a 21-day interval should be sufficient for Valencias and midseason varieties, in mid-April (fruit at 0.25- to 0.5-inch stage), in early/mid-May, and late May/early June. Varieties of early oranges grown for higher color score (Early Gold, Westin, Ruby, Itaborai) and Navel are more susceptible than Hamlin. They may require additional sprays before April and beyond July. HLB results in early bloom, so first applications may need to be adjusted into late March. Consult the Citrus Copper Application Scheduler to ensure that copper residue levels are adequate for disease control. The 21-day interval is an approximate timing, but growth rate and rainfall can cause copper residues to decay faster or slower than otherwise expected. More details are available in EDIS publication PP289, *A Web-Based Tool for Timing Copper Applications in Florida Citrus*.

Programs for fresh fruit are more complex, but many copper sprays are already used on these varieties. For fresh-market grapefruit, a low rate of copper should be added to the last spray of spring flush for scab. Subsequently, the copper spray program used for melanose control should also control canker, but additional applications will be required every 21 days when the fruit reach 0.5- to 0.75-inch size until fruit are fully grown in October. Copper may need to be added to applications of fungicides or petroleum oil. Use caution when mixing copper with oil, because it increases the phytotoxicity risk.

Most tangerines are fairly tolerant to canker. Copper programs used for Alternaria control should also protect against canker. Fallglo is less susceptible, and probably three sprays in April, May, and June would suffice. Newly planted trees in canker-exposed settings are more susceptible because they produce leaf flushes more often, and the flush tissue represents a high proportion of the canopy volume. The recommendation for the more susceptible varieties (grapefruit and early oranges) is that the trees be sprayed every 3 to 4 weeks to coincide with vegetative flush cycles from spring though the fall. Sprays should be applied with a hoop sprayer that thoroughly covers the foliage on all sides of the canopy.

The rates of copper products depend on the length of protection expected and the weather. As little as 0.5 to 1.0 lb of metallic copper will protect spring flush growth or fruit during the dry spring season. However, in the rainy season, more than 1 lb of metallic copper may be required to protect fruit for 3-week periods.

To the extent possible, copper usage should be minimized because this metal accumulates in soil and may cause phytotoxicity to the fruit peel or create environmental concerns.

Leafminer Control

Leafminers do not spread canker, but damage from leafminer larval feeding galleries enables entry of the bacterium into leaves and greatly increases inoculum levels, making the disease difficult to control. Leafminers are not usually a problem on the spring flush, and no control is needed at that time. Leafminer control on the first summer flush can reduce disease pressure considerably. If properly timed, applications of petroleum oil, Agri-mek, Micromite, Spintor, or Assail will reduce damage by leafminer. Late summer flushes tend to be erratic, and effective control at that time is more difficult. (See EDIS publication CG098, *Citrus Leafminer*, chapter 24 of this guide.)

Activation of Systemic Acquired Resistance (SAR)

SAR is a natural induction of resistance to disease, in this case canker, throughout the plant, and it can be chemically stimulated. The disease may occur or continue to develop before SAR can be naturally induced or take full effect. The SAR activator, Blockade (formerly Actigard) triggers the natural defense mechanism before the onset of disease but has no direct effect on the pathogen. High inoculum levels can overcome defense activation, so it is important to apply Blockade before weather and host flush conditions are favorable for infection at the beginning of each season. There are two methods of application, drench or chemigation, but drench was found to be more effective. Use scenarios for Blockade vary with age and size of trees.

New Plantings (Trees 0–3 Years Old)

- Blockade limits establishment of citrus canker during the nonbearing stage.
- Initiate treatments after planting when trees have overcome transplant shock and begun active growth. Continue through the entire nonbearing cycle.
- Use in conjunction with soil-applied neonicotinoid insecticides, which can also induce SAR. Blockade cannot replace a soil-applied neonicotinoid scheduled for Asian citrus psyllid management.
- Use in conjunction with other canker management tactics like windbreaks in highly susceptible grapefruit.
- Continue applications throughout the spring, summer, and fall at 60-day intervals.

Young Bearing Plantings (Trees 4–5 Years Old)

- Blockade limits development of lesions on foliage, thereby reducing potential for fruit infection.
- Initiate post-bloom but prior to conditions favorable for citrus canker.
- Use in conjunction with other canker management tactics. Do not reduce rates of other products.
- Continue throughout spring, summer, and fall at 45- to 60-day intervals, depending on tree size and planting density (Table 2).

Mature Bearing Plantings (Trees 6 Years and Older)

- Blockade limits development of lesions on foliage, thereby reducing potential for fruit infection.
- Initiate postbloom but prior to conditions favorable for citrus canker.
- Use in conjunction with other canker management tactics. Do not reduce rates of other products.
- Continue throughout summer season at 45- to 60-day intervals, depending on tree size and planting density (Table 2).

The rules and regulations regarding canker are changeable. For current information on disease status and regulations, see the website of the Florida Department of Agriculture and Consumer Services: https://www.fdacs.gov/Divisions-Offices/Plant-Industry/Agriculture-Industry/Citrus-Health-Response-Program or the UF/IFAS CREC website: https://crec.ifas.ufl.edu/citrus-production/plant-pathology/citrus-canker/.

Contact your Local UF/IFAS Extension citrus agent (https://citrusagents.ifas.ufl.edu/Citrus_Agents_Home_Page/index.shtml) for additional information, training materials, and programs.

Recommended Chemical Controls

READ THE LABEL.

See Table 1.

Rates for pesticides are given as the maximum amount required to treat mature citrus trees unless otherwise noted. To treat smaller trees with commercial application equipment including handguns, mix the per-acre rate for mature trees in 125 gallons of water. Calibrate and arrange nozzles to deliver thorough distribution, and treat as many acres as this volume of spray allows.

For applications of Blockade (drench or chemigation), use rates are expressed as the amount of Blockade per tree. Recommended drench water volume is 8 to 16 fl oz/tree.

Table 1. Recommended chemical controls for citrus canker.

Pesticide	FRAC MOA[1]	Mature Trees Rate/Acre[2]
Blockade 50WG (formally Actigard)	P 01	See Table 2
copper fungicide	M 01	Use label rate

[1] Mode of action class for citrus pesticides from the Fungicide Resistance Action Committee (FRAC) 2020. Refer to ENY624, *Pesticide Resistance and Resistance Management*, chapter 4 in the *2020–2021 Florida Citrus Production Guide* for more details.
[2] Lower rates can be used on smaller trees. Do not use less than the minimum label rate.

Table 2. Recommended rates and use patterns for Blockade 50WG/100 trees.

Number of Applications/Year[1]	Tree Age and Rate[2,4] (oz)/Application			
	< 1 year[3]	1–2 years	2–3 years	>3 years
4 or less	0.125–0.25	0.25–0.50	0.50–0.75	0.75–1.5
5 or more	0.125	0.25	0.50	0.75–1

[1] Minimum interval between applications is 30 days. If tree stunting, yellowing or other symptoms of possible phytotoxicity are observed, reduce the use rates in subsequent applications to the low end of the recommended rate range and increase the application interval to 60 days.
[2] Do not use more than 12.8 oz/ac/year and no more than 3.2 oz/ac/application.
[3] For newly planted trees, delay applications until trees become established and overcome transplant shock, and initiate treatment at 0.125 oz/100 trees.
[4] As tree size increases during the season, dosages should be adjusted toward the upper end of the recommended rate range.

2020–2021 Florida Citrus Production Guide: Phytophthora Foot Rot, Crown Rot, and Root Rot[1]

Megan M. Dewdney and Evan G. Johnson[2]

Foot rot results from scion infection near the ground level, producing bark lesions that extend down to the bud union on tolerant rootstocks. Crown rot results from bark infection below the soil line when susceptible rootstocks are used. Root rot occurs when the cortex of fibrous roots is infected, turns soft, and appears water-soaked. Fibrous roots slough off their cortex, leaving only a white thread-like stele (inner tissue of the fibrous root). Foot rot, crown rot, and root rot can be caused by *Phytophthora nicotianae* or *P. palmivora*. When managing phytophthora-induced diseases, integration of cultural practices (e.g., disease exclusion with phytophthora-free planting stock, tolerant rootstocks, proper irrigation practices [see chapter 12, *Irrigation Management of Citrus Trees*]) and chemical control methods is necessary. Phytophthora management with chemical control should not be considered until other potential causes of decline in tree production are evaluated and corrected. See also chapters on Blight, Huanglongbing, and Nematodes.

Cultural Practices to Manage

Field locations not previously planted with citrus are probably free of citrus-specific *P. nicotianae.* Planting stock should be free from *Phytophthora* spp. in the nursery, and inspection for fibrous root rot in the nursery or grove before planting is advised. If uncertain, testing of nursery stock for *Phytophthora* spp. is recommended. In groves with a previous history of foot rot, consider use of Swingle citrumelo or other tolerant rootstocks (see Florida Citrus Rootstock Selection Guide) for replanting. Tolerance to *Phytophthora* spp. can be compromised when planted in unfavorable soils for the rootstock (e.g., Swingle citrumelo in calcareous soils). Rootstocks tolerant to foot and root rot normally do not support damaging populations once trees are established. Cleopatra mandarin should be used with caution because it is prone to develop crown and foot rot when roots are infected in the nursery or when trees are planted in flatwoods situations with high or fluctuating water tables and fine-textured soils. When resetting, Cleopatra mandarin should never be used in a grove with a history of damaging phytophthora, regardless of region. Trees should be planted with the bud union more than 6 inches above the soil line and provided with adequate soil drainage. Overwatering, especially of young trees, promotes buildup of phytophthora populations in the soil and increases risk of foot rot infection. Prolonged wetting of the trunk, especially if tree wraps are used on young trees, should be avoided by using early to midday irrigation schedules. Control of fire ants prevents their nesting under trunk wraps and feeding damage to moist, tender bark, which is then susceptible to infection.

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Sampling for Spp.

Population densities of the fungus-like organism in grove soils should be determined to assist decisions of whether to treat with fungicides. Soil samples containing fibrous roots should be collected from March to November from under the canopy within the irrigated zones. When sampling trees of average canopy condition, combine individual small amounts from the top ten inches of soil from 20 to 40 locations in the microsprinkler zones within a 10-acre block into one resealable plastic bag to retain soil moisture. Samples must be kept cool but not refrigerated for transport to an analytical laboratory. Currently, populations in excess of 10 to 20 propagules per cm^3 soil of total *Phytophthora* spp. (*P. nicotianae* + *P. palmivora*) are considered damaging. The same soil sample should be tested for populations of nematodes to assess whether they occur at damaging levels.

Chemical Control

Use of fungicides in young groves should be based on rootstock susceptibility, likelihood of *Phytophthora* spp. infestation in the nursery, and history of phytophthora disease problems in the grove. For susceptible rootstocks, such as Cleopatra mandarin and sweet orange, fungicides may be applied to young trees for foot rot on a preventive basis. For young trees on other rootstocks, fungicide treatments should commence when foot rot lesions develop. The fungicide program for foot rot should be continued for at least one year for tolerant rootstocks but may continue beyond the first year for susceptible rootstocks. In mature groves, the decision to apply fungicides for root rot control is based on yearly soil sampling to determine whether damaging populations of *P. nicotianae* occur in successive growing seasons. Timing of applications should coincide with periods of susceptible root flushes after the spring leaf flush, usually from late spring to early summer and after the fall leaf flush in October to November. Soil application methods with fungicides should be targeted to irrigated areas under the canopy with the highest fibrous root density. To avoid leaching from the root zone, soil-applied fungicides should not be followed by excessive irrigation. Aliette, phosphite salts, Ridomil, or Presidio are effective, but alternation of the materials should be practiced to minimize the risk of the development of fungicide resistance. It is recommended to alternate the soil-applied Ridomil and Presidio on the major spring and fall root flushes as well as to continue to apply Aliette or phosphite salts on a calendar schedule per the label.

Larval Feeding Injury to Citrus Roots and Its Relationship to Invasion by Spp.

Association of phytophthora root rot with root damage by larvae of *Diaprepes abbreviatus* has been called the *Phytophthora-Diaprepes* (PD) complex (see chapter 28, ENY-611, *Citrus Root Weevils* or the Diaprepes Root Task Force website). A far more severe interaction has been identified between *P. palmivora* and Diaprepes root weevil than for *P. nicotianae*. The damage caused by *P. palmivora* is often associated with poorly drained, fine-textured soils and rootstocks like Swingle citrumelo and Carrizo citrange that are normally tolerant of *P. nicotianae*. In the more severe form, structural roots collapse from what appears to be moderate larval damage followed by aggressive spread of *P. palmivora* through the structural roots.

Rootstock susceptibility to damage by the PD complex depends on which *Phytophthora* sp. is present and whether the soil and water conditions are conducive to the fungus-like organism or to rootstock stress. In most situations, *P. nicotianae* is the predominant pathogen, and Swingle citrumelo appears to perform acceptably as a replant in weevil-infested groves, provided soil conditions are suited for this rootstock (e.g., favorable pH and calcium carbonate status, sandy soil texture, well-drained, etc.). When *P. palmivora* is present in poorly drained soils high in clay, pH, or calcium carbonate, Diaprepes root weevils render normally tolerant Swingle citrumelo and Carrizo citrange susceptible to phytophthora root rot infection. Thus, tolerance of Swingle citrumelo is restricted to the Ridge and certain flatwoods soils. For further information about rootstock selection, refer to chapter 12 on Rootstock and Scion Selection and the Rootstock selection guide.

Management of the Complex

Selection of tolerant rootstocks for replanting Diaprepes root weevil–affected groves is important for management of future losses. For existing trees, fungicides in conjunction with careful water and fertilizer management have been utilized to maintain tolerance to Diaprepes root weevil and phytophthora damage. Fertigation maximizes water and nutrient uptake efficiency by roots in well-drained soils. However, use of fertigation to regenerate roots is limited in poorly drained soils and high water tables typical in the flatwoods. In these situations, there may be increased reliance on fungicides to control root damage by *Phytophthora* spp.

Based on studies of the PD complex, aggressive control of Diaprepes root weevil larvae and adult stages should be implemented as soon as infestation is discovered to minimize the more severe phytophthora damage that follows larval feeding on roots. The IPM program may include carefully scheduled fertigation in well-drained soils to promote regeneration of fibrous roots after damage. In the flatwoods, IPM may include use of fungicides under the following conditions: 1) the soils are fine textured, poorly drained, high in pH, or calcareous, 2) the trees are on rootstocks susceptible to either or both *Phytophthora* spp., and 3) populations are above the damaging levels (10 to 20 propagules per cm^3 soil). A key to assist growers making *Phytophthora-Diaprepes* management decisions is available at the Diaprepes Root Weevil Task Force website as well as the citrus rootstock selection guide.

Management of the Phytophthora-HLP Interaction

Management of phytophthora root rot is complicated by huanglongbing [HLB; see chapter 30, PP-225, *Huanglongbing (Citrus Greening)*] because the causal bacterium infects all parts of the citrus tree, including the roots. HLB accelerates phytophthora infection and fibrous root damage. HLB predisposes roots to *P. nicotianae* infection apparently by increasing attraction of zoospores to roots, accelerating infection, and lowering resistance to root invasion. The spread of HLB has led to more frequent cases of damaging phytophthora populations. Most recently, there has been a multiyear cycling of phytophthora populations apparently associated with lower fibrous root density and bursts of root growth as trees continue to decline from HLB. This has heightened concern for the root health of HLB-affected trees and initiation of measures to reduce root stress, which includes *Phytophthora* spp., citrus nematodes, *Diaprepes*, and abiotic soil factors. While all of these factors need to be considered and assessed on a case-by-case basis depending on site and rootstock, specific factors must be considered when controlling phytophthora with high-incidence HLB.

Although HLB causes fibrous root dieback, it also increases new growth of fibrous roots. Similar to leaf flushing, new root growth is no longer as synchronized into flush events. This is important because phytophthora preferentially infects new root growth. Constant availability of new root growth is a likely cause of rapid development of damaging phytophthora populations under favorable conditions. The cycles of root dieback and root flushing caused by HLB leads to large swings in phytophthora propagule counts in a grove. Preliminary data indicate also that chemical management has reduced effectiveness for control of *Phytophthora* spp. and prevention of root loss. Therefore, it is important to monitor phytophthora propagule counts before major summer and fall root growth events. If a damaging population is developing, it is important to time chemical applications to protect those major root flushes.

Web addresses for links:

Diaprepes Root Weevil Task Force: http://www.crec.ifas.ufl.edu/extension/diaprepes/index.shtml

Citrus Rootstock Selection Guide: https://crec.ifas.ufl.edu/extension/citrus_rootstock/

Irrigation Management of Citrus Trees chapter: http://edis.ifas.ufl.edu/cg093

Group 4 fungicides (metalaxyl and mefenoxam) are not recommended for phytophthora control in citrus nurseries.

Recommended Chemical Controls

READ THE LABEL.

See Tables 1 and 2.

Rates for pesticides are given as the maximum amount required to treat mature citrus trees unless otherwise noted. To treat smaller trees with commercial application equipment including handguns, mix the per-acre rate for mature trees in 250 gallons of water. Calibrate and arrange nozzles to deliver thorough distribution, and treat as many acres as this volume of spray allows.

Table 1. Recommended chemical controls for phytophthora foot rot, crown rot and root rot—fosetyl AL and phosphite salts products.

Pesticide	FRAC MOA[1]	Rate[2]	Method of Application	Comments
Aliette WDG[3,4]	P 07	--	--	Protectant and curative systemic. Buffering to pH 6 or higher is recommended to avoid phytotoxicity when copper has been used prior to, with, or following Aliette. To prevent phytotoxicity, do not tank-mix Aliette with copper, and mixing with surfactants or foliar fertilizers is discouraged.
Nonbearing		5 lb/100 gal	Foliar spray	
		2.5–5 lb/5 gal	Trunk paint or spray[5]	Use higher rate when lesions are present.
		Up to 5 lb/acre	Microsprinkler	Adjust rate according to tree size.
Bearing		5 lb/acre or 1 lb/100 gal	Foliar spray in 100–250 gal/acre. Do not exceed 500 gal/acre.	Apply up to 4 times/year (e.g., March, May, July, and September) for fibrous root rot control.
		5 lb/10 gal/acre	Aerial	Fly every middle. Do not apply in less than 10 gal/acre.
		5 lb/acre	Surface spray on weed-free area followed by 0.5 inch irrigation or by microsprinkler in 0.1–0.3 inch of water.	Apply up to 4 times/year (e.g., March, May, July, and September) for fibrous root rot control.
Phostrol	P 07			Protectant and curative systemic. Do not apply when trees are under water stress or high-temperature conditions.
Bearing or Nonbearing		4.5 pt/acre	Foliar spray	Apply up to 4 times/year (e.g., March, May, July, and September).
Bearing or Nonbearing		2–5 pt/5 gal	Trunk paint or spray[5]	Use higher rate when lesions are present.
ProPhyt	P 07			Protectant and curative systemic. Do not apply when trees are under water stress or high-temperature conditions.
Nonbearing		2 gal/100 gal	Drench	1/2 pt solution per seedling in 2 gallon pot; can be applied through microsprinkler.
Bearing		4 pt/acre	Foliar spray	Apply up to 4 times/year (e.g., March, May, July, and September) for fibrous root rot control.

[1] Mode of action class for citrus pesticides from the Fungicide Resistance Action Committee (FRAC) 2020. Refer to ENY-624, *Pesticide Resistance and Resistance Management*, chapter 4 in the *2020–2021 Florida Citrus Production Guide* for more details.
[2] Lower rates may be used on smaller trees. Do not use less than the minimum label rate.
[3] For combinations of application methods, do not exceed 4 applications or 20 lb/acre/year.
[4] Fungicide treatments control fibrous root rot on highly susceptible sweet orange rootstock, but are not effective against structural root rot and will not reverse tree decline.
[5] Apply in May prior to summer rains and/or in the fall prior to wrapping trees for freeze protection.

Table 2. Recommended chemical controls for phytophthora foot rot and root rot—mefenoxam and copper products.

Pesticide	FRAC MOA[1]	Rate[2]	Method of Application	Comments
Ridomil Gold SL[3,4]	4	--	--	Protectant and curative systemic. Do not apply tank mixes of Ridomil and residual herbicides to trees less than 3 years old. Apply herbicide first, then wait 3–4 weeks to apply Ridomil. Do not apply to bare roots. Do not apply rates higher than 1 qt/ac to citrus resets or new plantings (less than 5 years old) to prevent potential phytotoxicity. Do not make trunk gummosis sprays and soil applications to the same tree in the same cropping season. Time applications to coincide with root flushes.
Nonbearing		1 qt/acre of treated soil surface	Surface spray on weed-free area, followed immediately by 0.5 inch irrigation or by microsprinkler in 0.1–0.3 inch of water.	Make the 1st application at time of planting. Make up to 2 additional applications per year at 3 month intervals for maximum control; in most cases a late spring and late summer application should be sufficient
		½ pt/grove acre	Through irrigation injection.	
		1.0–1.5 fl oz/20 trees	Individual Tree Treatment for Resets/New Plantings: Mix desired amount of Ridomil Gold SL in a water solution. Apply as a directed spray to individual trees (generally 8–12 fl oz/tree) around the base of the tree and outward to cover the fibrous root system. Follow with sprinkler irrigation to move product into root zone.	Make 1st application at time of planting. Make up to 2 additional applications per year at 3 month intervals for maximum control; in most cases a late spring and late summer application should be sufficient.
Bearing		1 pt/acre of treated soil surface if propagule counts are 10–20 propagules/cm^3 soil. 1 qt/acre of treated soil surface if propagule counts are >20 propagules/cm^3 soil.	Surface spray on weed-free area, followed immediately by 0.5 inch irrigation or microsprinkler in 0.1–0.3 inch of water.	Begin applications during the spring root flush period. Apply up to 3 times/year on 3-month intervals (late spring, summer, early fall).
		½ pt/grove acre if propagule counts are 10–20 propagules/cm^3 soil. 1 pt/grove acre if propagule counts are >20 propagules/cm^3 soil.	Through irrigation injection.	
		1 qt/10 gal	Trunk spray for gummosis: Spray the trunks to thoroughly wet the cankers.	May be applied up to 3 times/yr.

Pesticide	FRAC MOA[1]	Rate[2]	Method of Application	Comments
Ridomil Gold GR[2]	4	--	--	
		--	--	Do not apply Ridomil Gold GR and residual herbicides to trees less than 3 years old simultaneously. Apply herbicide first, then wait 3–4 weeks to apply Ridomil. Do not apply more than 240 lb of apply Ridomil Gold GR/acre/year. Time applications to coincide with root flushes.
Nonbearing		40–80 lb/acre of treated soil surface.	Apply as banded application under the canopy. For banded applications, use a band wide enough to cover the root system. If rain is not expected for 3 days, follow by 0.5–1.0 inch of irrigation.	Make 1st application at time of planting. Make up to 2 additional applications per year at 3 month intervals for maximum control; in most cases a late spring and late summer application should be sufficient.
Bearing		40–80 lb/acre of treated soil surface.	Banded application under the canopy. If rain not expected for 3 days, follow by 0.5–1.0 inch of irrigation.	Begin applications during the spring rot flush period. Apply up to 3 times/year on 3 month intervals (late spring, summer, early fall).
Ultra Flourish[3,4]	4	--	--	Protectant and curative systemic. Do not apply tank mixes of Ultra Flourish and residual herbicides to trees less than 3 years old. Apply herbicide first, then wait 3–4 weeks to apply Ultra Flourish.
Nonbearing		2–4 qt/acre of treated soil surface.	Surface spray on weed-free area, followed immediately by 0.5 inch irrigation or by microsprinkler in 0.1–0.3 inches of water.	Apply every 3 months for maximum control; in most cases a late spring and late summer application should be sufficient. No more than 4 pt/acre to prevent phytotoxicity on new trees.
		1 pt/grove acre	Through irrigation injection.	
		2–3 oz/100 gal	Soil drench; apply 5 gal of mix in water ring.	Apply every 3 months for maximum control; in most cases a late spring and late summer application should be sufficient.
Bearing		1 qt/acre of treated soil surface <20 propagules/cm^3 soil. 2 qt/grove acre >20 propagules/cm^3 soil.	Surface spray on weed-free area, followed immediately by 0.5 inch irrigation or microsprinkler in 0.1–0.3 inch of water.	Apply 3 times/year (late spring, summer, early fall).
		1 pt/grove acre	Through irrigation injection	
		4 pt/10 gal	Trunk spray	Thoroughly wet the lesions. Apply up to 3 times/year.
Presidio	43	--	--	Do not apply more than one application per year. Apply before disease development.
Nonbearing		3–4 fl oz/acre	Surface spray on weed-free area, followed immediately or microsprinkler in 0.5–0.75 inch of water plush flush time.	Minimum ground application volume 10 GPA.
		3–4 fl oz/20 gal	Individual trees for resets or new plantings. Apply 10 fl oz evenly around root zone of each tree.	If rainfall does not occur within 24 hours postapplication, irrigate with sufficient water to move product into root zone. Depending on soil type and root depth, this could require 0.5–1 inch of water.
Bearing		3–4 fl oz/acre	Surface spray on weed-free area, followed immediately or microsprinkler in 0.5–0.75 inch of water plush flush time.	Minimum ground application volume 10 GPA.

Pesticide	FRAC MOA[1]	Rate[2]	Method of Application	Comments
Copper—Wettable Powder	M 01	0.5 lb (metallic) Cu/1 gal water	Trunk paint[5]	Protectant.
Copper-Count-N	M 01	1 qt in 3 qt water	Trunk paint[5]	Protectant. Do not apply to green bark; may cause gumming.

[1] Mode of action class for citrus pesticides from the Fungicide Resistance Action Committee (FRAC) 2020. Refer to ENY-624, *Pesticide Resistance and Resistance Management*, chapter 4 in the *2020–2021 Florida Citrus Production Guide* for more details.
[2] Lower rates may be used on smaller trees. Do not use less than the minimum label rate.
[3] Do not exceed the equivalent of 6 lb a.i./acre/year of mefenoxam-containing products.
[4] Do not apply to bare roots or higher than 1 qt/acre of treated soil surface to citrus resets or trees less than 5 years old to avoid potential phytotoxicity.
[5] Apply in May prior to summer rains and/or in the fall prior to wrapping trees for freeze protection.

2020–2021 Florida Citrus Production Guide: Brown Rot of Fruit[1]

Megan M. Dewdney and Evan G. Johnson[2]

Management of brown rot, caused by *Phytophthora nicotianae* or *P. palmivora*, is needed on both processing and fresh-market fruit. While the disease affects all citrus types, it is usually most severe on Hamlin, Navel, and other early-maturing sweet orange cultivars. See chapter 32 in this guide, PP-156, *Phytophthora Foot Rot, Crown Rot, and Root Rot*, for information on other phytophthora diseases.

Phytophthora brown rot is a localized problem, usually associated with restricted air and/or water drainage. It commonly appears from mid-August through October following extended periods of high rainfall. It can be confused with fruit drop from other causes at that time of the year. If caused by *P. nicotianae*, brown rot is limited to the lower third of the canopy because the fungus is splashed onto fruit from the soil. *P. palmivora* produces abundant sporangia on infected fruit that can splash onto fruit throughout the canopy.

Early-season inoculum production and spread of *Phytophthora* spp. are minimized with key cultural practice modifications. Skirting of trees reduces the opportunity for soilborne inoculum to contact fruit in the canopy. The edge of the herbicide strip should be maintained just inside of the dripline of the tree to minimize the exposure of bare soil to direct impact by rain. This will limit rain splash of soil into the lower canopy.

Fruit on the ground become infected and produce inoculum, especially in *P. palmivora,* where fruit-grown sporangia can readily splash upward into the tree canopy. The sporangia can infect green fruit and result in brown rot infection in the canopy as early as July. The beginning of the epidemic is very difficult to detect before the fruit are colored and showing typical symptoms. Boom application of herbicides and other operations dislodge low-hanging fruit. Furthermore, trees affected by huanglongbing (HLB; citrus greening) are prone to premature fruit drop. Application of residual herbicides earlier in the summer may reduce the need for postemergence materials later and minimize fruit drop throughout this early stage of inoculum production from fallen fruit.

Usually a single spray application of Aliette, Phostrol, or ProPhyt before the first signs of brown rot appear in late July is sufficient to protect fruit through most of the normal infection period. No more than 20 lb/acre/year of Aliette should be applied for the control of all phytophthora diseases. Aliette, Phostrol, and ProPhyt are systemic fungicides that protect against postharvest infection and provide 60–90 days control. Copper fungicides are

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2. Megan M. Dewdney, associate professor, and Evan G. Johnson, research assistant scientist, Plant Pathology Department; UF/IFAS Citrus Research and Education Center, Lake Alfred, FL 33850.

primarily protective but are capable of killing sporangia on the fruit surface and thus reducing inoculum. They may be applied in August before or after the appearance of brown rot and provide protection for 45–60 days. If the rainy season is prolonged into the fall, a follow-up application of either systemic fungicide at one-half of the label rate or copper in October may be warranted. If a second application is needed, follow the preharvest intervals carefully (see chapter 45, ENY-601, *Pesticides Registered for Use on Florida Citrus*). With average-quality copper products, usually 2–4 lb of metallic copper per acre are needed for control.

Precautions should be taken during harvesting to exclude fruit affected by brown rot from field containers because this could result in rejection at the processing or packing facility.

Recommended Chemical Controls

READ THE LABEL.

See Table 1.

Rates for pesticides are given as the maximum amount required to treat mature citrus trees unless otherwise noted. To treat smaller trees with commercial application equipment including handguns, mix the per-acre rate for mature trees in 250 gallons of water. Calibrate and arrange nozzles to deliver thorough distribution, and treat as many acres as this volume of spray allows.

Table 1. Recommended chemical controls for brown rot of fruit.

Pesticide	FRAC MOA[2]	Mature Trees Rate/Acre[1]
Aliette WDG	P 07	5 lb—not more than 4 applications per year for all uses and no more than 20 lb/ac.
Phostrol	P 07	4.5 pints
ProPhyt	P 07	4 pints
copper fungicide	M 01	Use label rate.

[1] Lower rates may be used on smaller trees. Do not use less than minimum label rate.
[2] Mode of action class for citrus pesticides from the Fungicide Resistance Action Committee (FRAC) 2020. Refer to ENY-624, *Pesticide Resistance and Resistance Management*, chapter 4 in the *2020–2021 Florida Citrus Production Guide* for more details.

2020–2021 Florida Citrus Production Guide: Greasy Spot[1]

Megan M. Dewdney[2]

Greasy spot is caused by the fungus *Mycosphaerella citri*, which recently has been renamed *Zasmidium citri-griseum*. Management must be considered in groves intended for processing and fresh-market fruit. Greasy spot is usually more severe on leaves of grapefruit, pineapples, Hamlins, and tangelos than on Valencias, Temples, Murcotts, or most tangerines and their hybrids. Greasy spot rind blotch (GSRB) is particularly problematic for grapefruit destined for the fresh-fruit market.

Airborne ascospores produced in decomposing leaf litter on the grove floor are the main inoculum source for greasy spot. These spores germinate on the fruit and the underside of the leaves, where the fungus grows for a time on the leaf surface before penetrating through the stomates (natural openings on fruit and lower leaf surfaces). Internal growth is slow, and symptoms do not appear for several months. Warm, humid nights and high rainfall, typical of Florida summers, promote infection and disease development. Major ascospore releases usually occur from April to early June with favorable conditions for infection occurring from June through September. Leaves are susceptible throughout their lives.

On processing Valencias, a single spray of oil (5–10 gal/acre) or copper + oil (5 gal/acre) should provide acceptable control when applied from mid-May to June. With average-quality copper products, 2 lb of metallic copper per acre usually provides adequate control. The strobilurin-containing fungicides (Abound, Amistar Top, Gem, Headline, or Pristine) and Enable 2F are also suitable with or without petroleum oil. On early and mid-season oranges as well as processing grapefruit, two sprays may be needed, especially in the southern part of the state, where summer flushes constitute a large portion of the foliage. Two applications also may be needed where severe defoliation from greasy spot occurred in the previous year. In those cases, the first spray should be applied from mid-May to June and the second soon after the major summer flush has expanded. Copper fungicides provide more consistent control than oil sprays. Control of greasy spot on late summer flushes is less important than on the spring and early summer growth flushes because the disease develops slowly and defoliation will not occur until after the next year's spring flush. Thorough coverage of the underside of leaves is necessary for maximum control of greasy spot, which can be achieved with higher spray volumes. Slower tractor speeds may be needed than for control of other pests and diseases.

The treatment program is essentially the same for fresh fruit. That is, a fungicide application in May–June and a second in July should provide control of rind blotch. A third application in August may be needed if rind blotch has been severe in the grove. Petroleum oil alone is less

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2. Megan M. Dewdney, associate professor, Plant Pathology Department, UF/IFAS Citrus Research and Education Center, Lake Alfred, FL 33850.

effective than other fungicides for control of GSRB. Heavier oils (455 or 470) are more effective for GSRB control than lighter oils (435). Copper fungicides are effective for control of GSRB but may result in fruit spotting, especially if applied at high rates in hot, dry weather, or if applied with petroleum oil. If copper fungicides are applied in summer, they should be applied when temperatures are moderate (< 94°F) at rates no more than 2 lb of metallic copper per acre, without petroleum oil or other additives, and using spray volumes of at least 125 gal/acre. Copper residue levels can be monitored with the Citrus Copper Application Scheduler. Further details are available in EDIS publication PP289, *A Web-Based Tool for Timing Copper Applications in Florida Citrus*. Enable 2F can be applied for greasy spot control at any time but is especially indicated in mid-to-late summer for rind blotch control.

The strobilurin-containing fungicides (Abound, Amistar Top, Gem, Headline, or Pristine) or Enable 2F can be applied at any time to all citrus and provide effective control of the disease on leaves or fruit. Use of a strobilurin (Abound, Amistar Top, Gem, Headline, or Pristine) is especially recommended in late May and early June since it controls both melanose and greasy spot and avoids potential fruit damage from the copper fungicides applied at that time of year. A strobilurin-containing fungicide should not be applied more than once a year for greasy spot control because of the potential for the development of resistance. The addition of petroleum oil increases the efficacy of these products.

Web addresses for links:

Citrus Copper Application Scheduler: http://agroclimate.org/tools/citrus-copper-application-scheduler/

EDIS publication PP289, *A Web-Based Tool for Timing Copper Applications in Florida Citrus*: https://journals.flvc.org/edis/article/view/119506

Recommended Chemical Controls

READ THE LABEL.

See Table 1.

Rates for pesticides are given as the maximum amount required to treat mature citrus trees unless otherwise noted. To treat smaller trees with commercial application equipment including handguns, mix the per-acre rate for mature trees in 250 gallons of water. Calibrate and arrange nozzles to deliver thorough distribution, and treat as many acres as this volume of spray allows.

Table 1. Recommended chemical controls for greasy spot.

Pesticide	FRAC MOA[2]	Mature Trees Rate/Acre[1]
Petroleum Oil 97+% (FC 435-66, FC 455-88, or 470 oil)	NC[3]	5–10 gal. Do not apply when temperatures exceed 94°F. 470 weight oil has not been evaluated for effects on fruit coloring or ripening. These oils are more likely to be phytotoxic than lighter oils.
copper fungicide	M 01	Use label rate.
copper fungicide + Petroleum Oil 97+% (FC 435-66, FC 455-88, or 470 oil)	M 01 and NC	Use label rate + 5 gal. Do not apply when temperatures exceed 94°F. 470 weight oil has not been evaluated for effects on fruit coloring or ripening. These oils are more likely to be phytotoxic than lighter oils.
Abound[4]	11	12.0–15.5 fl oz. Do not apply more than 90 fl oz (1.5 lb a.i.)/acre/season for all uses. Best applied with petroleum oil.
Amistar Top (formerly Quadris Top)[4,5]	11/3	10–15.4 fl oz. Do not apply more than 61.5 fl oz/acre/season for all uses. Do not apply more than 0.5 lb a.i./acre/season difenoconazole. Do not apply more than 1.5 lb a.i./acre/season azoxystrobin.
Enable 2F[5]	3	8 fl oz. Do not apply more than 3 times per year; no more than 24 fl oz. (0.38 lb a.i.)/acre. Minimum retreatment interval is 21 days. Do not apply with polymer-based spray adjuvants.
Gem 500 SC[4]	11	1.9–3.8 fl oz. Do not apply more than 15.2 fl oz/acre/season for all uses. Best applied with petroleum oil. Do not apply within 7 days of harvest.
Headline SC[4]	11	9–12 fl oz. Do not apply more than 54 fl oz (0.88 lb a.i.)/acre/season for all uses. Best applied with petroleum oil.
Pristine[4,5]	11/7	16–18.5 oz. Do not apply more than 74 oz/acre/season for all uses. Do not apply more than 1.17 lb a.i./acre/season of boscalid. Do not apply more than 0.592 lb a.i./acre/season of pyraclostrobin as Pristine.

[1] Lower rates can be used on smaller trees. Do not use less than the minimum label rate.
[2] Mode of action class for citrus pesticides from the Fungicide Resistance Action Committee (FRAC) 2020. Refer to ENY624, *Pesticide Resistance and Resistance Management*, chapter 4 in the *2020–2021 Florida Citrus Production Guide* for more details.
[3] No resistance potential exists for these products.
[4] Do not use more than 4 applications of strobilurin-containing fungicides/season. Do not make more than 2 sequential applications of strobilurin fungicides.
[5] Do not make more than 4 applications of Pristine or Amistar Top/season. Do not make more than 2 sequential applications of Pristine or Amistar Top before alternating to a non-strobilurin, non-SDHI, non-DMI fungicide.

2020–2021 Florida Citrus Production Guide: Melanose[1]

Megan M. Dewdney[2]

Management of melanose, caused by the fungus *Diaporthe citri*, is often necessary in mature groves where fruit is intended for the fresh market, particularly if recently killed twigs and wood are present because of freezes or other causes. Melanose management is not usually needed in groves fewer than 10 years old or in those where fruit is intended for processing. As a caveat, more dead wood is present in canopies of young trees because of huanglongbing (HLB) than historically was the case. Growers should monitor young groves for dead wood and start applications before melanose becomes economically damaging. Grapefruit is especially susceptible to melanose but all citrus may be damaged by the disease.

Spores produced by *D. citri* in the asexual stage are the primary inoculum of this fungus. The sexual stage is relatively unimportant for the disease. The asexual spores are produced in flask-shaped structures embedded in dead twigs in the tree canopy, especially those twigs that have died within the last several months. In addition to producing spores on melanose-affected twigs after they die, *D. citri* is able to colonize dead twigs that were originally healthy and can produce inoculum on them as well. Spores are produced during wet periods and dispersed to young, susceptible fruit, leaves, and twigs by rain splash. No spores are produced on symptomatic leaves, fruit, or living twigs. At 75°F–80°F (23.8°C–26.7°C), 10–12 hours of leaf wetness are required for infection, and at lower temperatures up to 18–24 hours may be needed. These leaf wetness periods are not uncommon in Florida.

Grapefruit is susceptible to melanose infection from fruit set until it reaches 2.5–3.0 inches (6.4–7.6 cm) in diameter, normally in late June or early July. Fungicides are effective for only short periods when applied to rapidly expanding fruit or leaves. Because April is usually a low-rainfall month and fruit is small and growing rapidly, the first spray for melanose control is not usually applied until mid-to-late April. One or two applications are sufficient for control on oranges and most tangerines unless the trees have abundant dead wood, as in a year after a freeze. For fresh-market grapefruit, the first application should be made when the fruit reaches a diameter of 0.25 to 0.5 inch (0.64–1.3 cm) (about mid-to-late April depending on local conditions). With average-quality copper products, usually about 2 lb/acre of metallic copper are needed for each 3-week period. Rates can be reduced if applications are made more frequently or increased if applications are made less often. If using a calendar application schedule, additional applications should be made at 3-week intervals until the fruit becomes resistant. For melanose control on large trees, no more than 8–12 lb metallic copper are needed per year even if copper is also used for the control of scab, canker, or greasy spot.

Copper residues are reduced with fruit expansion and as a result of rainfall. The Citrus Copper Application Scheduler is a model that estimates whether residues remaining on fruit are sufficient to control the disease. It is based on fruit growth models, the rate and time of the last application, and rainfall since the last application. It has proven helpful

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2. Megan M. Dewdney, associate professor, Plant Pathology Department, UF/IFAS Citrus Research and Education Center, Lake Alfred, FL 33850.

for optimizing the timing of applications for melanose control. Further information about the model is available in EDIS publication PP289, *A Web-Based Tool for Timing Copper Applications in Florida Citrus*.

An early-June application of copper to manage late melanose damage will serve as the first greasy-spot spray. However, applications of copper in hot, dry weather may cause fruit spotting or darken existing blemishes. If copper fungicides are applied from May to September, they should be applied when temperatures are moderate (<94°F) at rates no more than 2 lb of metallic copper per acre, without petroleum oil, and using spray volumes of at least 125 gal/acre.

The strobilurin-containing fungicides Abound, Amistar Top, Gem, Headline, and Pristine are also effective for melanose control and can be used at any time for disease control. Copper fungicides are more economical and are most important for melanose control. However, because copper fungicides applied in hot weather can damage fruit, use of strobilurin-containing fungicides at that time will avoid phytotoxicity and control greasy spot as well as melanose. Strobilurins appear to have lower residual activity for melanose control than do copper fungicides. Thus, applications may have to be made at shorter intervals, especially when rainfall is high.

Fungi may develop resistance to strobilurin fungicides. These materials (FRAC 11) should never be used more than twice in a row, and no more than two strobilurin-containing applications should be used for melanose control.

Web addresses for links:

Citrus Copper Application Scheduler: http://agroclimate.org/tools/citrus-copper-application-scheduler/

EDIS publication PP289, *A Web-Based Tool for Timing Copper Applications in Florida Citrus*: https://journals.flvc.org/edis/article/view/119506

Recommended Chemical Controls

READ THE LABEL.

See Table 1.

Rates for pesticides are given as the maximum amount required to treat mature citrus trees unless otherwise noted. To treat smaller trees with commercial application equipment including handguns, mix the per-acre rate for mature trees in 125 gallons of water. Calibrate and arrange nozzles to deliver thorough distribution, and treat as many acres as this volume of spray allows.

Table 1. Recommended chemical controls for melanose.

Pesticide	FRAC MOA[2]	Mature Trees Rate/Acre[1]
copper fungicide	M 01	Use label rate.
Abound[3]	11	12.0–15.5 fl oz. Do not apply more than 90 fl oz (1.5 lb a.i.)/acre/season for all uses.
Amistar Top (formerly Quadris Top)[3]	11/3	15.4 fl oz. Do not apply more than 61.5 fl oz/acre/season for all uses. Do not apply more than 0.5 lb a.i./acre/season difenoconazole. Do not apply more than 1.5 lb a.i./acre/season azoxystrobin.
Gem 500 SC[3]	11	1.9–3.8 fl oz. Do not apply more than 15.2 fl oz/acre/season for all uses. Do not apply within 7 days of harvest.
Headline SC[3]	11	12–15 fl oz. Do not apply more than 54 fl oz (0.88 lb a.i.)/acre/season for all uses.
Pristine[3]	11/7	16–18.5 oz. Do not apply more than 74 oz/acre/season for all uses. Do not apply more than 1.17 lb a.i./acre/season of boscalid. Do not apply more than 0.592 lb a.i./acre/season of pyraclostrobin as Pristine.

[1] Lower rates can be used on smaller trees. Do not use less than the minimum label rate.
[2] Mode of action class for citrus pesticides from the Fungicide Resistance Action Committee (FRAC) 2020. Refer to ENY624, *Pesticide Resistance and Resistance Management*, chapter 4 in the *2020–2021 Florida Citrus Production Guide* for more details.
[3] Do not use more than 4 applications of strobilurin-containing fungicides/season. Do not make more than 2 sequential applications of strobilurin-containing fungicides.
[4] Do not make more than 4 applications of Pristine or Amistar Top/season. Do not make more than 2 sequential applications of Pristine or Amistar Top before alternating to a non-strobilurin, non-SDHI, non-DMI fungicide.

2020–2021 Florida Citrus Production Guide: Citrus Black Spot[1]

Megan M. Dewdney, Callie Walker, Pamela D. Roberts, Natalia A. Peres, Timothy S. Schubert, and Mark R. Estes[2]

Citrus black spot is caused by the fungus *Phyllosticta citricarpa* (formerly known as *Guignardia citricarpa*). The disease causes fruit blemishes and significant yield losses, especially on sweet oranges. Black spot can affect all commercial citrus species and cultivars commonly grown in Florida. Lemons are the most susceptible, but sweet oranges, especially mid-to-late-maturing types such as 'Valencia', are highly susceptible to this disease. 'Hamlin' sweet oranges and tangerine/mandarin types are moderately susceptible. Based on symptoms in Florida, grapefruit is thought to be moderately susceptible, but little information is available on relative susceptibility. Management is required in groves intended for processing and fresh-market fruit in quarantine and surrounding areas. It should be considered in all others.

Black spot fruit symptoms are wide-ranging and have many different names. Hard spot is the most diagnostic symptom of black spot. The 0.1–0.4 inch (3–10 mm) diameter lesions are nearly circular and depressed with gray necrotic tissue at the middle with a brick-red to black margin that can be cracked around the edges. Fruiting structures (pycnidia) that produce the asexual spores (conidia) are often present in the center of lesions and resemble slightly elevated black dots. Hard spot lesions appear as the fruit begin to color before harvest. They first occur on the side of the fruit with the greatest light exposure. False melanose symptoms appear on green fruit early in the season and do not contain pycnidia. The slightly raised lesions are 1–3 mm (0.04–0.1 inch) in diameter and can vary in color from tan to chocolate brown. Under favorable infection conditions, false melanose can resemble the mud-cake symptoms of authentic melanose but are very dark brown rather than rust red. False melanose symptoms can develop into hard spot as the season progresses. Cracked spots is a symptom that has only been observed in the Americas and is reported to be an interaction between rust mites and *P. citricarpa*. Cracked spots are large, diffuse smooth lesions that form raised cracks. Hard spots can form in the center of these lesions. The most concerning black spot symptom is virulent spot. Early virulent spot (freckle spot) lesions start as irregularly shaped, sunken lesions with a reddish color. Early virulent spot can either coalesce to cover a large proportion of the fruit surface or become hard spot. When early virulent spot lesions coalesce, they turn brown to black and the older lesion surface becomes leathery. Many pycnidia can be

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found in early and expanded lesions. Virulent spot occurs on mature, severely infected fruit at the end of the season. Virulent spot symptoms can appear postharvest on apparently symptomless fruit, sometimes in transit to markets. Despite the unsightliness of black spot lesions, they rarely cause internal fruit rot, so those fruit that remain on the tree until ripe are still suitable for processing. Significant fruit drop is a common symptom in heavily infected groves.

It was recently discovered that only one type of spore from *P. citricarpa* is present in Florida. These spores are the asexual spores (conidia), which are formed in fruit lesions, leaf litter, and twigs. The conidia are spread by rain splash and can infect fruit and leaves. These spores germinate and directly infect the leaves and fruit. There is a long latent period for this disease, which means that most symptoms do not appear for several months, usually not until the fruit begins to ripen. The fungus requires a long wetting period of 24–48 hours to infect, and the disease is favored by warm humid weather such as occurs during the summer months. Conidia are present in the leaf litter most of the year, but the most favorable infection conditions occur from May through September. Fruit remain susceptible most of the growing season. An exact figure on how long leaves remain susceptible is unknown but is thought to be approximately 10 months.

Despite having only one type of spore, monthly applications of fungicides such as copper, strobilurins (Abound, Gem, or Headline), or other labeled fungicides (Amistar Top, Enable, Pristine) will be needed from early May to mid-September to control black spot. If there is substantial rain in April, starting fungicide applications in April is advised. Our fungicide recommendations have been based on efficacy data from trials in other countries with black spot and products registered for use on citrus in Florida, with preliminary field testing in Florida. Field tests in Florida of fungicides including Abound, Amistar Top, copper-based products, Enable, Gem, Headline, and Pristine indicate that all of these fungicides can be useful in a black-spot management program. Because only four strobilurin fungicide applications, including the premixes Pristine and Amistar Top, can be used in a season for any purpose, it is recommended for fresh fruit to reserve the strobilurin-containing fungicides for times when phytotoxicity from copper applications is a concern (temperatures >94°F). For processing fruit, fungicides containing strobilurins can be used earlier in the season and applications combined with those for greasy spot and melanose. To manage pathogen resistance, it is recommended that fungicides containing strobilurins not be applied in two consecutive sprays but instead rotated with a fungicide containing another mode of action.

It is important to remember that copper residues are reduced with fruit expansion and as a result of rainfall. A model, http://agroclimate.org/tools/citrus-copper-application-scheduler/, is available to determine whether residues remaining on fruit are sufficient to control the disease. It is based on fruit growth models, the copper rate and time of the last application, and rainfall since the last spray. It has proven helpful for timing of sprays for black spot control. Further information about the model is available in EDIS publication PP289, *A Web-Based Tool for Timing Copper Applications in Florida Citrus*.

In addition to chemical control measures, practices to accelerate leaf litter decomposition beneath the trees to reduce the leaf litter inoculum may be beneficial. Enhancing leaf litter degradation should commence in mid-March. There are three methods that have reduced the ascospore inoculum of *Mycosphaerella citri*, the fungus that causes greasy spot. The first is to increase the microsprinkler irrigations to at least 5 times a week for approximately a ½ hour per irrigation period for 1.5 months. The leaf litter decomposition will be greater compared to that with the traditional irrigation frequency. A drawback is that leaf litter reduction will be confined to the areas where the microsprinklers reach. A second method is to apply urea (187 lb/treated acre) or ammonium sulfate (561 lb/acre) to the leaf litter. If using ammonium sulfate as a method to control leaf litter inoculum, make sure you monitor your soil pH to ensure that it does not become too low. The leaf litter decay will be less than without urea, but when tested with *M. citri*, the number of spore-producing structures was reduced and fewer spores were produced. Nitrate-based fertilizers are ineffective. The final method is to apply dolomitic lime or calcium carbonate (2226 lb/treated acre) to the leaf litter. The decay rate is greater for litter treated with lime, and inoculum production is reduced. All treatments worked equally well with *M. citri*, and there is no indication that one method is better than another. Lime or irrigation methods should not be used in conjunction with the high N treatments, because they have opposite methods of action.

Several cultural practices can aid control and help restrict further spread of black spot. It is essential to minimize plant trash movement among groves and even among blocks within groves. While there are generally few symptoms on leaves, the main inoculum is formed within the fallen leaves. As leaf litter decomposes, the spores form and are splashed into the canopy. It is very easy to inadvertently move the fungus from one site to another with symptomless leaves and other trash. This is the basis of the tarping requirement from quarantine areas, but any grove equipment or vehicle can move leaf litter or trash from one location to another.

Declining trees should be removed from a grove regardless of the cause. Trees that are declining will often have off-season bloom as a symptom of stress. Where there is more than one age of fruit present on the tree, the asexual spores on the fruit can be transferred to new fruit, amplifying the disease. This problem is especially troublesome on Valencia when new and old fruit crops overlap. Fruit do not appear to become resistant to infection as they age. In addition, nutritionally stressed trees will often express black spot symptoms first. A good nutritional program (http://edis.ifas.ufl.edu/pdffiles/SS/SS47800.pdf) helps to minimize symptoms and maintain yields.

Where possible, open the tree canopy by skirting to reduce the leaf wetness periods. The fungus requires between 24–48 hours of leaf wetness to infect. It is also important to minimize dead wood in the canopy. Like the melanose pathogen, the black spot fungus can colonize and reproduce in dead twigs. Canopies with significant numbers of dead twigs will have more problems with black spot than those without.

Finally, as with all fungal diseases, it is important to use clean nursery stock. Currently, there are no nurseries within the geographical citrus black spot quarantine zones; however, this may change as we gain a better understanding of the distribution of the disease.

Regulatory Considerations

Care must be exercised in handling and moving citrus fruit with leaves, twigs and debris from citrus black spot (CBS) Quarantined Areas, because the disease may be easily and unwittingly spread to other citrus trees, nurseries, or groves. The following rules are in addition to stipulations imposed as a result of Florida's statewide citrus canker quarantine.

The US Department of Agriculture Animal and Plant Health Inspection Service (APHIS) issued a Federal Order effective October 14, 2010, to help prevent the spread of the plant fungal pathogen *P. citricarpa*. The initial CBS Quarantined Areas and Regulated Areas were located in Collier and Hendry Counties and were announced and delineated in the Federal Order (DA-2010-47). An updated Federal Order (DA-2012-09) was released on March 16, 2012, expanding existing quarantines in Collier and Hendry Counties. Additional sections were quarantined since that date in Collier, Hendry and Polk Counties, as specified in APHIS Information and Action notice DA-2013-08, issued March 22, 2013. Six sections were subsequently added in Lee County along with additional sections in both Collier and Hendry counties by APHIS Information and Action notice DA-2015-16, issued on March 31, 2015. (Note that no positive detections were made in Lee County; the six sections serve as portions of buffer zones extending from adjacent counties.) Additional CBS Information and Action notices of quarantine expansion, DA-2016-69, DA-2017-20, and DA-2018-27 (with two sections added in Charlotte County) were issued by APHIS on November 22, 2016, June 9, 2017, and August 10, 2018, respectively. The latest CBS Information and Action notice of quarantine expansion, DA-2019-16, was issued July 25, 2019, and also included two sections in Charlotte County. Details of current regulations and quarantined areas of record for CBS may be accessed through the State's Citrus Health Response Program (CHRP) website along with other relevant compliance information at the following address: https://www.FDACS.gov/Divisions-Offices/Plant-Industry/Agriculture-Industry/Citrus-Health-Response-Program/Citrus-Diseases/Citrus-Black-Spot-Information.

Growers, Caretakers, Harvesters, and Haulers

Citrus growers, caretakers, harvesters, and haulers must operate under compliance agreements with regulations that serve to protect the citrus industries of Florida, the United States, and international trade partners. When harvesting citrus in groves, vehicles used to transport fruit from CBS Quarantined Areas must meet the following minimum standards: all conveyances, whether bulk-filled with fruit or loaded in pallet boxes or field bins and stacked on trucks or trailers, must be completely covered with no openings greater than ½ inch, with the exception of bulk loads with side and rear walls constructed of expanded metal, with openings not to exceed ¾ × 1-11/16 inches. Tarpaulins (tarps) used as fruit covers may be of any fabric with a weave of less than ½ inch. Details of transport vehicle regulations may be found in CBS Federal Order DA-2012-09.

Each load of fruit must be identified by issuing a clearly written, serially numbered trip ticket with the following information: Grove Name, Block or Sub-Block of Origin, Land Owner or Agent, Lessee, Harvester; Number of Boxes, Variety; Tag Number; Grower C/A Number; Destination (receiving facility or Disposal Site ID); Date of Harvest; and Harvesting Permit Number if issued; "TARP" and "Q" must be written clearly on the ticket as "TARP-Q," preferably near the bottom.

Prior to departing any citrus grove, all personnel are required to inspect all vehicles and equipment for plant material and debris and clean all vehicles, equipment, picking sacks and clothing to ensure that they are free of fruit, limbs, leaves, soil and debris prior to applying a microbial decontaminant. All plant material and debris cleaned from said vehicles and equipment is to be left on the grove property, or if moved, must be transported under a limited permit away from citrus production areas to a location that will not pose a risk to citrus nurseries or groves. Once cleaned, citrus waste hauling equipment and grove caretaking and harvesting equipment must be decontaminated using one of the materials from List A (under "Disposal of Citrus Debris").

Processing and Packing Facilities and Haulers

All citrus fruit harvested from a Citrus Black Spot Quarantined Area must move intrastate either directly to a processor operating under a state compliance agreement for processing into a product other than fresh fruit, or to a packinghouse operating under a federal compliance agreement. Distribution of fresh citrus fruit from a CBS Quarantined Area directly to markets within Florida is prohibited.

Each load of fruit harvested from a quarantined area is required to be covered by a tarp in accordance with federal regulations to preclude the loss of leaves, fruit, and debris in transit to a packing or processing facility. The load must arrive tarped at the receiving facility, and all quarantined fruit, leaves, and debris in the truck or trailer must be unloaded completely. The vehicle must be thoroughly cleaned out and decontaminated prior to departing the receiving facility. If any citrus leaves or other citrus waste material is to be moved from a receiving facility (or from a grove), it must be placed in bags or be covered in transit in order to prevent the loss of leaves, fruit, or debris. Once emptied and cleaned of all leaves and plant debris, all trailers, truck beds, field boxes, and bins must be disinfected by using one of the decontaminant materials in List A (below).

Disposal of Citrus Debris

All leaves, culled or eliminated fruit, and other plant debris originating from a CBS Quarantined Area, cleaned from trailers, tarpaulins, field boxes, or field bins at a receiving facility, or hauled from a CBS Quarantined Area must be moved under limited permit in an enclosed or covered conveyance, as stipulated in the Federal Order, that will prevent the loss of fruit, leaves, or debris while in transit. When citrus plant material comes in contact with a vehicle, the vehicle must be decontaminated following movement with a sanitizer in List A (below).

List A—Equipment Decontaminants

A1. 200 ppm solution of sodium hypochlorite with a pH of 6.0 to 7.5; or

A2. 0.2% solution of a quaternary ammonium chloride (QAC) cleaner/disinfectant compound; or

A3. Peroxyacetic acid (PPA) solution at 85 ppm.

Citrus waste in the form of culls, peel, pulp, leaves, limbs, or plant debris originating from a CBS quarantined area must be handled or treated by one of the following methods subject to monitoring by an authorized CHRP inspector.

List B—Waste Treatments

B1. Heat-treated to a minimum of 180°F for at least one hour; or

B2. Incinerated; or

B3. Buried at a landfill or other FDACS- or APHIS-approved disposal site and covered with dirt at the end of each day that dumping occurs.

Interstate Shipment of Fruit

Fresh fruit from groves within a CBS Quarantined Area is eligible for movement interstate *under federal certificate* to all states under the following conditions:

The fruit must be washed and brushed, disinfested, and sanitized with a product from List C (below), then treated at labeled rates with imazalil or thiabendazole (TBZ) and waxed at the time of packing in a packinghouse operating under an APHIS-approved packinghouse procedure prior to shipment. The fruit must be free of leaves and other plant material, and attached stems must be less than 1 inch in length. The fruit must be packed in a packinghouse with a signed APHIS compliance agreement. The fruit must be accompanied by a federal certificate issued by a person or inspector operating under compliance with APHIS, and the certificate must be present on the packed cartons or containers of fruit and the accompanying paperwork.

Fresh fruit from groves within a CBS Quarantined Area is eligible for movement interstate *under federal limited permit* to noncommercial citrus-producing states under the following conditions:

The fruit must be washed, brushed, and surface disinfested with a treatment from List C (below) or an organic disinfectant, such as hydrogen dioxide or PAA at labeled rates in a packinghouse operating under an APHIS-approved packinghouse procedure prior to shipment. The fruit must be free of leaves and other plant material, and attached stems must be less than 1 inch in length. The fruit must be packed in a packinghouse with a signed APHIS compliance agreement. The fruit must be accompanied by a limited permit issued by a person or inspector operating under compliance with APHIS. In addition, the limited permit must be present on the packed cartons or containers of fruit and the accompanying paperwork.

List C—Fruit Treatments

Must be applied in accordance with APHIS-approved Packinghouse procedures for CBS: https://www.aphis.usda.gov/plant_health/plant_pest_info/citrus/citrus-downloads/citrus-black-spot/cbs-packing-house-procedures.pdf.

C1. Sodium hypochlorite solution at 200 PPM for at least 2 minutes; or

C2. Sodium o-phenylphenate (SOPP) solution at 1.86 to 2.0% total solution; or

C3. Peroxyacetic acid (PAA) solution at 85 PPM for at least 1 minute.

Export Shipment of Fruit

Rules for Grove Operations outside Citrus Black Spot Quarantines

Growers planning to ship fresh citrus fruit to the European Union (EU) must comply with the following provisions to meet 2017 amendments to EU Annexes of Council Directive 2000/29/EC on plant protective measures. These amendments affect growers planning to ship fruit from areas of Florida outside of counties quarantined for citrus black spot (CBS), under statewide citrus canker quarantine (refer to chapter 31 of the *2020–2021 Florida Citrus Production Guide*, PP-182, Citrus Canker, for recommended cultural practices and guidance in pest and disease management):

Cultural Practices—Citrus growers and caretakers must implement cultural practices to minimize the incident and spread of citrus canker disease in each production unit and buffer area under caretaker's supervision. These practices could include, for example, the planting and maintenance of windbreaks, such as eucalyptus trees.

- Please note that production unit freedom (from citrus canker) is no longer required.
- Appropriate Treatment—Copper (for example) should be applied to a grove to prevent disease damage to fruit, leaves, and stems caused by citrus canker, along with maintaining an appropriate pest management program as recommended by the UF/IFAS *Florida Citrus Production Guide*.
- The packinghouse must also treat the fruit with sodium o-phenylphenate (SOPP) or equivalent.
- Fruit harvested from source block(s) must be found free of citrus canker symptoms during an official packinghouse inspection of a representative sample defined in accordance with international standards.
- All packed citrus fruit must be traceable back to the grove block (production unit) as provided on the Federal Phytosanitary Certificate and trip tickets must include the Grower C/A Number.
- CHRP regulatory staff will conduct random inspections to determine grower compliance with appropriate cultural practices, treatments and decontamination.
- In addition, trip tickets for fresh fruit destined for the EU must include the notation "CC" to indicate that the grower is following the recommended practices in the UF/IFAS *Florida Citrus Production Guide* to mitigate the incidence of citrus canker disease.

Growers planning to ship fresh citrus fruit to the European Union (EU) must also comply with the following provisions to meet 2017 amendments to EU Annexes with respect to citrus black spot (CBS) in areas outside the EU observed countywide quarantines in Florida:

- Inspection of the fruit is required in the packinghouse with no symptoms of citrus black spot observed.
- Proof of area freedom from citrus black spot (CBS) is required and must be validated by Citrus Black Spot Survey, Multi-Pest Survey, both Grove and Residential, statewide.

Rules for Grove Operations in Citrus Black Spot Quarantine Areas

Florida growers planning to ship fresh citrus fruit to the European Union (EU) must comply with the following provisions to meet 2017 amendments to EU Annexes of Council Directive 2000/29/EC on protective measures with respect to citrus black spot (CBS) in areas within the EU-observed countywide CBS Quarantines. Refer to the UF/IFAS *Florida Citrus Production Guide* for recommended cultural practices and instructions in pest and disease management.

Cultural Practices—Citrus growers and caretakers must implement cultural practices as recommended by UF/IFAS to minimize the incidence and spread of citrus black spot disease in each production unit (with no buffer area required). As an example, leaves may be raked from under trees or be treated in place with an approved material. Additionally, dead wood should be removed from the trees and any diseased and declining trees removed from the groves.

- Appropriate Treatment—Fungicides, such as copper, strobilurins, or other labeled fungicides, should be applied to the trees at intervals as recommended by UF/IFAS to help prevent the damage and spread of citrus black spot disease. Leaf litter should also be controlled by various methods and treatments as recommended by UF/IFAS.
- Growers seeking a Citrus Fruit Harvesting Permit (FDACS 08123) to ship fresh fruit to the European Union (EU) or to other restricted markets must request and fill out an Application for Participation (FDACS 08415) and send to the local FDACS CHRP field office in order to receive a field inspection of the proposed source grove block(s) for symptoms of citrus black spot and citrus canker diseases.
- Upon receipt of a grower's Application for Participation, the FDACS field office will schedule a field inspection of the grove block(s) requested. The fruit will be field-inspected by the department in the production unit by Multi-Block(s), with no buffer required; if no symptoms of citrus black spot or citrus canker are observed on the fruit, the grower will be issued a Citrus Fruit Harvesting Permit.
- Fruit harvested for fresh-fruit shipment must be packed in an APHIS-compliant packinghouse, washed, brushed, surface disinfested with sodium o-phenylphenate or equivalent, treated at labeled rates with imazalil and/or thiabendazole at the time of packing, and waxed.
- Fruit harvested from source block(s) must be found free of CBS and citrus canker symptoms during an official packinghouse inspection of a representative sample defined in accordance with international standards.
- All packed citrus fruit must be traceable back to the grove block (production unit) of origin as provided on the Federal Phytosanitary Certificate. Trip tickets must include the Grower C/A Number.
- CHRP regulatory staff will conduct random inspections to determine grower compliance with appropriate cultural practices, treatments, and decontamination.
- Each load of fruit must be identified by issuing a clearly written, serially numbered trip ticket with the following information: Grove Name, Block or Sub-Block of Origin, Land Owner or Agent, Lessee, Harvester; Number of Boxes, Variety; Tag Number; Grower C/A Number; Destination (receiving facility or Disposal Site ID); Date of Harvest; and Harvesting Permit Number. In addition trip tickets must include the following information near the trip tickets must include the following information near the bottom of the ticket: "TARP-Q" & "CC," to indicate that the fruit is moving from a Citrus Black Spot Quarantine Area, under statewide citrus canker quarantine, that the fruit is destined for the EU, and that the grower is following the recommended practices in the UF/IFAS *Florida Citrus Production Guide* for pest and disease management. If using a computer-generated trip ticket, the grower/harvester must make sure that all of the above information is on the ticket and that it highlights whether the load is from a citrus black spot quarantine area and the load is tarped.
- CHRP regulatory staff will conduct random inspections to determine grower compliance with appropriate cultural practices, treatments, and decontamination.

Regulated fruit from groves in a CBS Quarantined Area that is not eligible for interstate movement under the conditions stated for consumption in the United States may be moved through Florida or interstate only for immediate export. Regulated fruit for export must be accompanied by a "Limited Permit for Export" issued by an inspector or a trained individual operating under a compliance agreement and must be moved in a container under APHIS seal directly to the port of export. No transloading will be allowed at ports located in citrus-producing states.

Regulatory Remarks

Although truckloads of citrus fruit harvested from perimeter areas of CBS Quarantines have not been required to be covered by tarpaulins destined to receiving facilities, covering this fruit is highly recommended as a precautionary measure for the protection of citrus groves in non-quarantine areas of our state.

Please check for updates and information on federal quarantines, regulations, and the interstate movement of citrus at the APHIS Citrus Health Response Program website: http://www. aphis.usda.gov/plant_health/plant_pest_info/citrus/index.shtml.

Recommended Chemical Controls

READ THE LABEL.

See Table 1.

Rates for pesticides are given as the maximum amount required to treat mature citrus trees unless otherwise noted. To treat smaller trees with commercial application equipment including handguns, mix the per-acre rate for mature trees in 250 gallons of water. Calibrate and arrange nozzles to deliver thorough distribution, and treat as many acres as this volume of spray allows.

Table 1. Recommended chemical controls for citrus black spot.

Pesticide	FRAC MOA[2]	Mature Trees Rate/Acre[1]
copper fungicide	M 01	Use label rate.
Enable 2F[4]	3	8.0 fl oz. Do not apply more than 3 applications or 24 fl oz/acre/season.
Abound[3]	11	9.0–15.5 fl oz. Do not apply more than 90 fl oz/acre/season for all uses. Best applied with petroleum oil.
Amistar Top (formerly Quadris Top)[3,4]	11 + 3	15.4 fl oz. Do not apply more than 61.5 fl oz/acre/year.
Gem 500 SC[3]	11	1.9–3.8 fl oz. Do not apply more than 15.2 fl oz/acre/season for all uses. Best applied with petroleum oil. Do not apply within 7 days of harvest.
Headline SC[3]	11	12–15 fl oz. Do not apply more than 54 fl oz/acre/season for all uses. Best applied with petroleum oil.
Pristine[3,4]	11 + 7	16–18.5 oz. No more than 74 oz/acre/season.

[1] Lower rates can be used on smaller trees. Do not use less than minimum label rate.
[2] Mode of action class for citrus pesticides from the Fungicide Resistance Action Committee (FRAC) 2020. Refer to ENY624, *Pesticide Resistance and Resistance Management*, chapter 4 in the *2020–2021 Florida Citrus Production Guide* for more details.
[3] Do not use more than 4 applications of strobilurin fungicides/season. Do not make more than 2 sequential applications of strobilurin fungicides (FRAC MOA 11).
[4] Do not make more than 4 applications of Pristine or Amistar Top/season. Do not make more than 2 sequential applications of Pristine or Amistar Top before alternating to a non-strobilurin, non-SDHI (FRAC MOA 7), non-DMI (FRAC MOA 3) fungicide.

2020–2021 Florida Citrus Production Guide: Citrus Scab[1]

Megan M. Dewdney[2]

Citrus scab, caused by the fungus *Elsinoë fawcettii,* affects grapefruit, Temples, Murcotts, tangelos, and some other tangerine hybrids. There is no need to control citrus scab on processing fruit, except possibly on Temples, where severe early infection reduces fruit size. Reduction or elimination of overhead irrigation on susceptible varieties during the active growth period of the fruit will decrease disease severity.

Spores of this fungus are produced directly on scab pustules that occur on leaves and fruit. One to 2 hours of wetting are sufficient for spore production, and only an additional 3–4 hours are needed for infection. Spores are spread to healthy tissues by water splash.

If leaves from the previous season are heavily infected by citrus scab, 3 applications of fungicide are needed to control the disease: onthe first at about 1/4 expansion of the spring flush, a second at petal fall, and a third about three weeks later. With citrus scab, the timing of the spray applications is critical, but if there is little carryover of disease from the previous season, the first spray can be omitted. Ferbam, Enable 2F, Abound, Gem, or Headline are good choices for the first application because they are all able to kill the fungus in old lesions and thus reduce inoculum as well as protect foliage. Any of these products can be used in the petal fall spray, but do not use strobilurin products (Abound, Gem, or Headline) twice in a row. Copper fungicides, Abound, Gem, or Headline are good choices for the third spray because they will protect fruit from early melanose as well as from scab, but copper products are less effective for scab and should not be selected where scab pressure is high.

On Minneola tangelos, Murcotts, and certain other varieties, Alternaria brown spot and scab can occur in the same grove. In those cases, copper fungicides, Abound, Gem, or Headline may be preferred because Ferbam and Enable 2F are less effective for Alternaria control. If canker is a concern, the only product that can manage both diseases is copper. With average-quality copper products, about 2 lb of metallic copper per acre is usually sufficient for scab control. The scab fungus may develop resistance to Abound, Gem, or Headline if these products are not frequently rotated with alternate modes of action. Resistance has been documented in Florida for citrus scab. These products are all strobilurin fungicides, and only one should be selected for scab control each season.

Fruit usually becomes resistant to scab by sometime in May, about 2 months after petal fall.

1. This document is PP-146, one of a series of the Plant Pathology Department, UF/IFAS Extension. Original publication date May 2000. Revised March 2020. Visit the EDIS website at http://edis.ifas.ufl.edu.

2. Megan M. Dewdney, associate professor, Plant Pathology Department, UF/IFAS Citrus Research and Education Center, Lake Alfred, FL 33850.

DO NOT APPLY ABOUND, GEM, OR HEADLINE IN NURSERIES. Application of these fungicides in nurseries can result in selection of resistant strains, which are then distributed on nursery stock to groves.

Recommended Chemical Controls

READ THE LABEL.

See Table 1.

Rates for pesticides are given as the maximum amount required to treat mature citrus trees unless otherwise noted. To treat smaller trees with commercial application equipment including handguns, mix the per-acre rate for mature trees in 125 gallons of water. Calibrate and arrange nozzles to deliver thorough distribution, and treat as many acres as this volume of spray allows.

Table 1. Recommended chemical controls for citrus scab.

Pesticide	FRAC MOA[2]	Mature Trees Rate/Acre[1]
copper fungicide	M 01	Use label rate.
Enable 2F	3	8 fl oz. Do not apply more than 3 times per year; no more than 24 fl oz. (0.38 lb a.i.)/acre. Minimum retreatment interval is 21 days.
Ferbam Granuflo	M 03	5–6 lb. Maximum 3 applications a year, and do not apply more than 7.9 lb/acre (6 lb a.i.) in a single application.
Abound[3]	11	12.0–15.5 fl oz. Do not apply more than 90 fl oz (1.5 lb a.i.)/acre/season for all uses.
Gem 500 SC[3]	11	1.9–3.8 fl oz. Do not apply more than 15.2 fl oz/acre/season for all uses. Do not apply within 7 days of harvest.
Headline SC[3]	11	9–12 fl oz. Do not apply more than 54 fl oz (0.88 lb a.i.)/acre/season for all uses.

[1] Lower rates can be used on smaller trees. Do not use less than the minimum label rate.
[2] Mode of action class for citrus pesticides from the Fungicide Resistance Action Committee (FRAC) 2020. Refer to ENY624, *Pesticide Resistance and Resistance Management*, chapter 4 in the *2020–2021 Florida Citrus Production Guide* for more details.
[3] Do not use more than 4 applications of strobilurin fungicides/season. Do not make more than 2 sequential applications of strobilurin fungicides. Do not use in citrus propagation nurseries.

2020–2021 Florida Citrus Production Guide: Alternaria Brown Spot[1]

Megan M. Dewdney[2]

Alternaria brown spot, caused by the fungus *Alternaria alternata*, affects Minneola tangelos, Dancy tangerines, Murcotts, and less frequently Orlando tangelos, Novas, Lees, and Sunburst. In rare cases, it may also infect grapefruit. Where severe, the disease results in extensive fruit drop and must be controlled on processing and fresh-market fruit.

Spores of *Alternaria* are airborne. Most spores are produced by lesions on mature leaves on the tree or recently fallen infected leaves in the leaf litter on the grove floor. Many management practices are helpful in reducing the severity of Alternaria brown spot. When new groves of susceptible varieties are planted, they should be established with disease-free nursery stock. Trees grown in greenhouses without overhead irrigation are usually free of Alternaria but should be inspected carefully to ensure that no trees have unexpected lesions. Even though spores are airborne, plantings of healthy trees will remain disease-free for long periods. If Alternaria is present from the outset, it builds to high populations during the period of vegetative growth on young trees and subsequently is difficult to control on fruit. When establishing new plantings, it is best to locate susceptible varieties in higher areas where air drainage and ventilation are good and leaves dry more rapidly. Less vigorous rootstocks, such as Cleopatra mandarin, should be selected rather than vigorous stocks, such as Carrizo citrange. Minneola tangelo groves in low, wet areas have conditions so favorable for Alternaria brown spot that it may be virtually uncontrollable. Susceptible trees should be spaced more widely than oranges to promote rapid canopy drying. In existing plantings, it is important not to promote excessive vegetative growth. Overwatering and excessive fertilization should be avoided. Light hedging should be done regularly rather than hedging severely but less frequently.

Copper fungicides, Ferbam, Abound, Amistar Top, Gem, Headline, and Pristine are the registered products that are effective for disease control. Disease favorability varies considerably according to the susceptibility of the variety, the grove disease history, and the environmental conditions each year. Generally, the first spray should be applied when the spring flush is about ¼–½ of full expansion and before disease development. In severe cases, another spray may be needed when the flush is near full expansion because if high levels of infection occur on the spring flush, brown spot becomes difficult to control on fruit. Another spray should be applied shortly after petal fall. Ferbam, Abound, Amistar Top, Gem, Headline, or Pristine may be the best choice for one or both of these two applications, especially if the grove has problems with both citrus scab and Alternaria brown spot. Thereafter, all sprays should be applied solely to maintain a protective coating on the fruit. During April and

1. This document is PP-147, one of a series of the Plant Pathology Department, UF/IFAS Extension. Original publication date December 1995. Revised February 2020. Visit the EDIS website at http://edis.ifas.ufl.edu.

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May, applications may be needed as often as every 10 days or as infrequently as once per month. Spray intervals are based on the frequency of rainfall and grove disease history. By June, high rainfall and humid nights usually assure an abundant supply of inoculum and favorable conditions for infection. In most cases, two applications will be needed during this month. Copper fungicides may blemish the fruit if applied during hot weather. Thus, Abound, Amistar Top, Gem, Ferbam, Headline, or Pristine are good substitutes for copper applications as needed from May to July. The fruit generally becomes resistant to Alternaria brown spot by early to mid-July, although affected fruit may continue to drop for some time afterward. The scenario described is for difficult cases, and it is sometimes possible to use many fewer sprays.

The preferred method to time fungicide sprays is the ALTER-RATER, a weather-based model. Table 1 indicates the points assigned in the ALTER-RATER model. Brown spot is most severe when rainfall is greater than 0.1 inch, daily leaf wetness duration exceeds 10 hr, and average daily temperature is between 68°F and 83°F. Table 2 indicates the suggested thresholds to be applied with the ALTER-RATER. Make a fungicide application when the threshold is reached.

With such frequent sprays, low rates of copper may be used. With average-quality products, usually about 2 lb of metallic copper per acre is needed for each 3-week period, or 1 lb if sprays are more frequent. Even lower rates of metallic copper can be used if high-quality products are employed. The copper residue levels over time can be monitored with the use of the Citrus Copper Application Scheduler. More details are available in EDIS publication PP289, *A Web-Based Tool for Timing Copper Applications in Florida Citrus*.

Fungicide Resistance

Abound, Amistar Top, Gem, Headline, and Pristine are all strobilurin-containing fungicides, and Alternaria has been documented to be resistant to strobilurins in most parts of the Florida tangerine production areas. Strobilurin (FRAC 11), DMI (FRAC 3), or SDHI (FRAC 7) fungicides should not be used for Alternaria control more than four times in a season; never use more than two applications of the same mode of action in a row. Gem is slightly less effective for control of this disease and should be used at the high rate where disease is moderate to severe. Ferbam is less effective for Alternaria control than copper, Abound, Amistar Top, Gem, Headline, or Pristine.

DO NOT APPLY ABOUND, AMISTAR TOP, GEM, HEADLINE, OR PRISTINE IN NURSERIES. Application of these fungicides in nurseries can result in selection of resistant strains, which are then distributed on nursery stock to groves.

Web addresses for links:

Citrus Copper Application Scheduler: http://agroclimate.org/tools/citrus-copper-application-scheduler/

EDIS publication PP289, *A Web-Based Tool for Timing Copper Applications in Florida Citrus*: https://journals.flvc.org/edis/article/view/119506

Recommended Chemical Controls

READ THE LABEL.

See Table 3.

Rates for pesticides are given as the maximum amount required to treat mature citrus trees unless otherwise noted. To treat smaller trees with commercial application equipment including handguns, mix the per-acre rate for mature trees in 125 gallons of water. Calibrate and arrange nozzles to deliver thorough distribution, and treat as many acres as this volume of spray allows.

Table 1. The number of points assigned to each day with ALTER-RATER according to the environmental conditions on that day. Daily point scores are added until the selected spray threshold is reached.

Rainfall > 0.1 inch	Leaf Wetness > 10 hr	Avg DailyTemp (°F)	Daily Points Assigned
+	+	68–83	11
+	+	> 83	8
+	+	< 68	6
+	–	68–83	6
+	–	> 83	4
+	–	< 68	3
–	+	68–83	6
–	+	> 83	6
–	+	< 68	4
–	–	68–83	3
–	–	> 83	0
–	–	< 68	0

Table 2. Suggested threshold scores to be used in different situations with the ALTER-RATER.

Suggested Threshold Scores	Situation
50	Heavily infested Minneola, Dancy, Orlando, Sunburst; many flatwoods groves, east coast and SW Florida
100	Moderately infested Minneola or Dancy, many Murcotts; Ridge and north Florida groves
150	Light infestations, any variety; mostly Ridge and north Florida groves

Table 3. Recommended chemical controls for Alternaria brown spot.

Pesticide	FRAC MOA[1]	Mature Trees Rate/Acre[2]
copper fungicide	M 01	Use label rate.
Ferbam Granuflo	M 03	5–6 lb. Maximum 3 applications a year, and do not apply more than 7.9 lb (6 lb a.i.)/acre in a single application.
Abound[3]	11	12.0–15.5 fl oz. Do not apply more than 90 fl oz (1.5 lb a.i.)/acre/season for all uses.
Amistar Top (formerly Quadris Top)[4]	11/3	15.4 fl oz. Do not apply more than 61.5 fl oz/acre/season for all uses. Do not apply more than 0.5 lb a.i./acre/season of difenoconazole. Do not apply more than 1.5 lb a.i./acre/season of azoxystrobin.
Gem 500 SC[3]	11	1.9–3.8 fl oz. Do not apply more than 15.2 fl oz/acre/season for all uses. Do not apply within 7 days of harvest.
Headline SC[3]	11	12–15 fl oz. Do not apply more than 54 fl oz (0.88 lb a.i.)/acre/season for all uses. Do not apply more than 1.17 lb a.i./acre/season of boscalid. Do not apply more than 0.592 lb a.i./acre/season of pyraclostrobin.
Pristine[4]	11/7	16–18.5 oz. Do not apply more than 74 oz/acre/season for all uses.

[1] Mode of action class for citrus pesticides from the Fungicide Resistance Action Committee (FRAC) 2020. Refer to ENY624, *Pesticide Resistance and Resistance Management*, chapter 4 in the *2020–2021 Florida Citrus Production Guide* for more details.
[2] Lower rates can be used on smaller trees. Do not use less than the minimum label rate.
[3] Do not use more than 4 applications of strobilurin fungicides/season. Do not make more than 2 sequential applications of strobilurin fungicides. Do not use in citrus propagation nurseries.
[4] Do not make more than 4 applications of Pristine or Amistar Top/season. Do not make more than 2 sequential applications of Pristine or Amistar Top before alternating to a non-strobilurin, non-SDHI, or non-DMI fungicide.

2020–2021 Florida Citrus Production Guide: Postbloom Fruit Drop[1]

Natalia A. Peres and Megan M. Dewdney[2]

Postbloom fruit drop (PFD) must be controlled on processing and fresh-market fruit. PFD, caused by the fungus *Colletotrichum acutatum*, affects all species and cultivars of citrus, but severity on a given cultivar varies according to the time of bloom in relation to rainfall. Navel and Valencia oranges have experienced the most severe damage in Florida because they tend to have extended or multiple blooms.

Most spores of this fungus are produced directly on the surface of infected petals. Spores are splash-dispersed by rain to healthy flowers, where they infect within 24 hours and produce symptoms in 2–3 days. The fungus survives between bloom periods as resistant resting structures on the surface of leaves, buttons, and twigs. Flowers are susceptible from the button stage (with white tissue present) until they are open.

Groves with persistent calyxes (buttons) from the previous year should be closely examined once the bloom begins. If infected flowers are present on scattered early bloom, fungicide application recommendations should be followed once sufficient bloom is present for the fungicide application to be economical. Groves with a history of PFD should be scouted twice weekly during the bloom period. Ground and aerial applications are effective for control of PFD. Low-volume application equipment can be used if good coverage of the flowers is provided and minimum volume levels are followed according to the label. To reduce disease severity, remove declining trees, such as those with HLB, blight, or phytophthora, where off-season blooms may provide a site for fungal spore buildup, and limit overhead irrigation during bloom.

The Citrus Advisory System (CAS; Figure 1) was developed recently to further facilitate grower's decisions on the need for fungicide applications. The system uses real-time weather data from Florida Automated Weather Network (FAWN) stations throughout the state to determine whether risk for PFD is low (green), moderate (yellow), or high (red). Specific fungicide spray recommendations are given according to the disease risk conditions. CAS is available at http://agroclimate.org/tools/cas. If desired, notifications can be sent via SMS or e-mail for an alert to check the system because an infection event has occurred.

Because the number of fungicides available as well as the number of applications for each fungicide are limited, preventive fungicide programs are difficult to implement, especially in groves with large numbers of declining trees, which might bloom for an extended period. As a reminder, groves with a history of PFD should be checked twice

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weekly during bloom. If symptomatic flowers are found on scattered bloom, CAS recommendations should be followed once sufficient bloom is present to justify a fungicide application.

Of the products recommended for control of PFD, the strobilurin-containing fungicides Abound, Amistar Top, Gem, Headline, Priaxor, and Pristine are effective but do not have a long residual effect. Ferbam is less effective and should not be used alone, but it can be combined with low rates of other products to maximize protection and reduce the risk of resistance development. No resistance has been detected to date. The strobilurin-containing fungicides should not be used alone more than once per season, but they can be used more than once if combined with Ferbam.

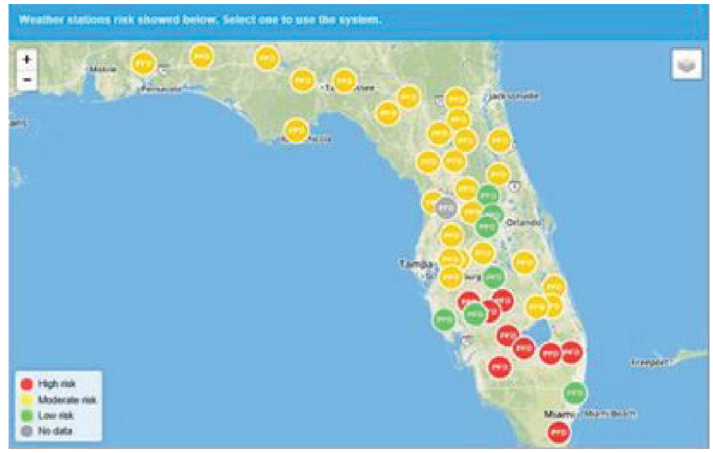

Figure 1. Citrus PFD Advisory System available at http://agroclimate.org/tools/cas.

Recommended Chemical Controls

READ THE LABEL.

Rates for pesticides are given as the maximum amount required to treat mature citrus trees unless otherwise noted. To treat smaller trees with commercial application equipment including handguns, mix the per-acre rate for mature trees in 125 gallons of water. Calibrate and arrange nozzles to deliver thorough distribution, and treat as many acres as this volume of spray allows.

Table 1. Recommended chemical controls for postbloom fruit drop.

Pesticide	FRAC MOA[2]	Mature Trees Rate/Acre[1]
Ferbam Granuflo	M 03	5–6 lb. Maximum 3 Ferbam applications a year, and do not apply more than 6 lb a.i./acre in a single application.
Abound[3]	11	12.0–15.5 fl oz. Do not apply more than 90 fl oz/acre/season for all uses.
Abound[3] + Ferbam	11, M 03	12.0 fl oz + 5 lb. Do not apply more than 90 fl oz/acre/season of Abound for all uses. Maximum 3 Ferbam applications a year, and do not apply more than 6 lb a.i./acre in a single application.
Amistar Top (formerly Quadris Top)[3,4]	11 + 3	15.4 fl oz. Do not apply more than 61.5 fl oz/acre/year. Do not apply more than 0.5 lb a.i./acre/season difenoconazole. Do not apply more than 1.5 lb a.i./acre/season azoxystrobin.
Gem 500 SC[3]	11	1.9–3.8 fl oz. Do not apply more than 15.2 fl oz/acre/season for all uses. Do not apply within 7 days of harvest.
Gem[3] + Ferbam	11, M 03	1.9 fl oz + 5 lb. Do not apply more than 15.2 fl oz/acre/season of Gem for all uses. Do not apply within 7 days of harvest. Maximum 3 Ferbam applications a year, and do not apply more than 6 lb a.i./acre in a single application.
Headline SC[3]	11	12–15 fl oz. Do not apply more than 54 fl oz (0.88 lb a.i.)/acre/season for all uses.
Headline[3] + Ferbam	11, M 03	12 fl oz + 5 lb. Do not apply more than 54 fl oz (0.88 lb a.i.)/acre/season of Headline for all uses. Maximum 3 Ferbam applications a year, and do not apply more than 6 lb a.i./acre in a single application.
Pristine[3,4]	11 + 7	16–18.5 oz. Do not apply more than 74 oz/acre/season for all uses. Do not apply more than 1.17 lb a.i./acre/season of boscalid. Do not apply more than 0.592 lb a.i./acre/season of pyraclostrobin as Pristine.
Priaxor[3,4]	11 + 7	9–11 fl oz. Do not apply more than 44 fl oz/acre/year.

[1] Lower rates can be used on smaller trees. Do not use less than the minimum label rate.
[2] Mode of action class for citrus pesticides according to the Fungicide Resistance Action Committee (FRAC) 2020. Refer to ENY624, *Pesticide Resistance and Resistance Management*, chapter 4 in the *2020–2021 Florida Citrus Production Guide* for more details.
[3] Do not use more than 4 applications of strobilurin fungicides/season. Do not make more than 2 sequential applications of strobilurin fungicides.
[4] Do not make more than 4 applications of Pristine, Amistar Top, or Priaxor/season. Do not make more than 2 sequential applications of Pristine, Amistar Top, or Priaxor before alternating to a non-strobilurin, non-SDHI (FRAC MOA 7), non-DMI (FRAC MOA 3) fungicide.

2020–2021 Florida Citrus Production Guide: Exocortis, Cachexia, and Other Viroids[1]

Amit Levy, Ozgur Batuman, and Ronald H. Brlansky[2]

Exocortis and cachexia are diseases caused by viroids and can lead to stunted growth and reduced yields in infected plants. Viroids are small, infectious circular-RNA molecules. Exocortis causes dwarfing and bark scaling on rootstocks such as trifoliate orange and many of its hybrids, including Rangpur lime, Carrizo citrange, and others.

Stunting is usually severe on trifoliate orange rootstock, less severe on citranges and Rangpur lime, and mild on Swingle citrumelo. Swingle citrumelo does not usually show bark scaling. Cachexia, also called xyloporosis, causes severe pitting and gumming in the bark and wood of the trunks and branches on some tangerines and their hybrids. Orlando tangelo is especially sensitive. Rootstocks affected include *Citrus macrophylla*, some mandarins, and sweet lime. Another viroid that occurs commonly in Florida is citrus dwarfing viroid (formerly citrus viroid III), which affects the same rootstocks as citrus exocortis viroid and causes stunting but no scaling.

Viroids are transmitted primarily by the introduction and propagation of infected budwood. There is a constant risk that symptomless budwood is actually carrying viroids and will spread them without showing any disease symptoms. Viroids will also spread mechanically from tree to tree on pruning equipment, budding knives, and hedging and topping equipment if they are not disinfected. Viroids can be detected by indexing on sensitive biological indicators, such as Etrog citron for exocortis and dwarfing viroids, and Parson's Special mandarin for cachexia. Biological indexing on Etrog citron requires 3–6 months, and indexing on Parson's Special mandarin for cachexia requires at least one year. In the laboratory, detection is much more rapid by sensitive laboratory procedures, such as several PCR or hybridization techniques. In Florida, the decrease in the incidence of viroid diseases is because budwood sources used by nurseries are always certified free of viroids through the Bureau of Citrus Budwood Registration.

Recommended Practices

1. Budwood sources used by nurseries should be certified free of viroids, especially if the rootstock or cultivars employed are sensitive to these viroids. Growers should only purchase trees propagated from certified sources.

2. Knives and pruning tools in the nursery should be disinfested with a ***fresh*** solution of bleach (1% free chlorine) when moving from one budwood source to another.

3. Groves suffering from severe stunting caused by exocortis or from cachexia should be removed and replaced with healthy trees.

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4. Although hedging and topping can spread viroids, infection of mature trees with viroids is usually not detrimental to productivity. It is recommended to disinfect equipment when using sensitive rootstock varieties.

5. Extra cautions are needed when using newly released citrus rootstock varieties, whose sensitivity to viroids is still unknown.

2020–2021 Florida Citrus Production Guide: Blight[1]

Ozgur Batuman, Pamela D. Roberts, and Ronald H. Brlansky[2]

Citrus blight is a wilt-and-decline disease of citrus, and its cause has not been determined. The first symptoms on huanglongbing (HLB)-free trees are usually a mild wilting and grayish cast to the foliage, often accompanied by zinc deficiency symptoms on trees. Trees rapidly decline with extensive twig dieback, off-season flowering, and small fruit. Blighted trees reach a stage of chronic decline but seldom die. Currently, however, it is difficult to recognize blight due to HLB symptoms, and there is an increased incidence of rapid decline and death among trees with mixed infections of blight and HLB.

The disease affects only bearing trees and usually first appears when the trees in the grove are 6–8 years old. The first affected trees in a grove are usually randomly distributed, but groups of blighted trees may eventually occur, either as clusters or down the row. The disease has been transmitted by root grafts, but not by limb grafts or with budwood. The means of spread, other than by root grafts, is not known.

Blight symptoms can be confused with other decline diseases (e.g., HLB, tristeza decline, etc.), and accurate diagnosis is important in order to follow proper practices. Citrus blight is characterized by: 1) high zinc content in trunk bark and wood; 2) presence of amorphous plugs in the xylem; 3) failure to absorb water injected into the trunk; and 4) presence of blight-associated citrus proteins in roots and leaves. The best procedure for diagnosis of individual trees in the field, particularly in spring months (March, April, and May), is to test water uptake into the trunk, which is done by using a battery-powered drill to open a small hole (⅛ inch) and injecting water from a plastic syringe without a needle. Healthy trees or trees declining from Phytophthora root rot, nematodes, water damage, tristeza, or HLB will usually take up about 10 ml of water in 30 seconds. *Trees affected by citrus blight take up no water regardless of the amount of pressure applied.* A laboratory test is being developed that will be more accurate, and with proper equipment, many samples will be processed in a short time. However, the syringe test is the only method currently available for confirmation of blight.

All scion varieties of citrus as well as ungrafted seedlings may be affected by citrus blight. Trees on all rootstocks are susceptible, but significant differences between rootstocks exist. The rootstocks that are the most severely affected by blight are rough lemon, Rangpur lime, trifoliate orange, Carrizo citrange, and some others. Those most tolerant to blight are sweet orange, sour orange, and Cleopatra mandarin. Swingle citrumelo was listed as tolerant; however, there appears to be an increase in blight incidence on that rootstock. Sweet orange and sour orange have not been recently recommended because of susceptibility to Phytophthora root rot and tristeza, respectively.

Recommended Practices

There is no cure for citrus blight. Once trees begin to decline, they never recover. Severe pruning of blighted trees will result in temporary vegetative recovery, but trees decline again once they come back into production. The

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only procedure recommended for management of citrus blight is:

- Remove trees promptly once yield of affected trees has declined to uneconomical levels.

When planning to plant or replace trees there are two strategies recommended:

- Plant or replace trees with trees on rootstocks that do not develop blight at an early age, such as Cleopatra mandarin (if Phytophthora root rot is not present in the grove) or Swingle citrumelo; or
- Plant trees on vigorous and productive rootstocks that develop blight at an early age, such as Carrizo citrange or rough lemon, and replace trees that decline as soon as they become unproductive. Production can be maintained at relatively high levels despite blight with these rootstocks.

2020–2021 Florida Citrus Production Guide: Tristeza Decline[1]

Ozgur Batuman, Amit Levy, Mark E. Hilf, Peggy J. Sieburth, William O. Dawson, and Ronald H. Brlansky[2]

Citrus tristeza virus (CTV) is a major cause of the decline and eventual death of trees on sour orange rootstocks. Initially, affected trees have small leaves and twig dieback. Diseased trees often produce very small fruit, and the yield declines. Eventually, large limbs die back and the tree gradually declines. In extreme cases, trees may suffer from quick decline and wilt, dying in a matter of weeks. On sour orange rootstock, some isolates of CTV cause an incompatibility at the bud union, which results in the loss of fibrous roots and reduced ability for water uptake. Bark flaps cut from across the graft union of declining trees often show pitting consisting of small holes (honeycombing) on the inside face of the bark flap from the rootstock side of the union. Quick-decline trees may only have a yellow-brown stain at the bud union and not show the honeycombing. Only trees on sour orange rootstock are affected by tristeza decline. Sweet oranges usually are more affected than grapefruit, whereas lemons on sour orange rootstock may not be affected. Losses from CTV-induced decline have been offset by the use of nonsusceptible rootstocks, primarily trifoliate hybrids. Furthermore, because huanglongbing (HLB) is endemic in Florida, many trees most likely have a mixed infection with CTV and HLB and may show more profound decline regardless of the rootstock used.

Citrus tristeza virus is transmitted by aphids. They acquire it within minutes of feeding on an infected plant and transmit it to healthy plants within minutes of picking up the virus. The brown citrus aphid (*Toxoptera citricida*), which first appeared in Florida in 1995, is considered the most efficient vector of the virus. The cotton or melon aphid (*Aphis gossypii*) is a less efficient but still effective vector, whereas the green citrus or spirea aphid (*Aphis spiraecola*) and the black citrus aphid (*Toxoptera aurantii)* are considered to be less efficient vectors of CTV in Florida. The establishment of *T. citricida* in Florida is believed to have resulted in a more rapid spread of decline-inducing isolates of tristeza.

Citrus tristeza virus is a population of related but genetically distinct viruses that induce symptoms with varying severities in different scion-rootstock combinations. Mild isolates, inducing no stem-pitting nor decline, have been widely disseminated in Florida by aphids and in infected budwood. The incidence of decline has been reduced due to the usage of tolerant (non–sour orange) rootstocks such as Swingle citrumelo and Carrizo citrange. However, many of the trees on these tolerant rootstocks are likely infected with CTV decline isolates without showing symptoms. Therefore, there is still a high risk for reemergence of

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tristeza decline disease if the sour orange rootstock is used in Florida.

In some countries, some CTV isolates also cause stem-pitting in citrus scions including grapefruit and sweet orange regardless of the rootstock used. Grooves and pits appear in the wood of the trunk, branches, and twigs and also may appear in the rootstock. Externally, pitting can cause branches to appear twisted and ropy, and twigs may become brittle. Trees affected severely by stem-pitting grow poorly and have lower yields and smaller fruits. Experimentally and in the field, CTV can cause stem-pitting in nearly all citrus types. Tangerines are generally tolerant of stem-pitting isolates, but some may show symptoms. Isolates that cause decline of sweet orange on sour orange also may cause stem-pitting in trees on other rootstocks, but many decline isolates produce no stem-pitting in grapefruit or oranges. Isolates that are genetically similar to severe stem-pitting isolates found in other countries have been found in Florida. Some of these isolates give a degree of sweet orange stem-pitting, but it is difficult to assess whether they cause economic losses in field trees due to the widespread presence of HLB.

Virtually all isolates of CTV can be detected by graft inoculation of sensitive biological indicators, such as Mexican lime. More modern and much faster techniques, such as molecular tests including reverse transcriptase (RT)-PCR or ELISA using polyclonal antisera, are nowadays preferred. The monoclonal antibody MCA-13 detects most CTV isolates that cause decline on sour orange rootstocks in Florida and also reacts with most stem-pitting isolates, but it does not react with mild Florida isolates. If an appropriate and reliable laboratory test for CTV is needed, contact your local Extension agents, Extension specialists, or FDACS-DPI (FDACS-DPI Helpline Number 352-395-4600).

Budwood propagated for commercial distribution must be free of CTV. Most stem-pitting isolates are MCA-13-reactive, but not all. Polymerase chain reaction (PCR)-based methods can identify stem-pitting isolates, but the only absolute means to detect stem-pitting isolates is by graft inoculation of grapefruit and sweet orange seedlings and examination of symptoms after 6–15 months (a.k.a. indexing).

Recommended Practices

1. Budwood propagated for commercial distribution must be free of CTV. Even in the presence of HLB, it is still recommended that growers only use decline-resistant rootstocks. The key to preventing problems with stem-pitting in Florida is to avoid introduction, propagation, and distribution of stem-pitting isolates.

2. Once tristeza-affected trees on sour orange rootstocks begin to decline, there is no treatment. The diseased trees should be replaced with certified trees on tolerant rootstocks as the yields of affected trees decline to uneconomical levels. Even though it may be hard to determine if decline results from CTV or HLB, these trees should nonetheless be replaced with a CTV-tolerant rootstock (See the rootstock selection guide).

3. In groves with trees on sour orange rootstock that are currently unaffected by tristeza decline, it may be possible to inarch trees with seedlings of a tolerant rootstock. Inarching is most effective with relatively young groves that are still actively growing, and in order to be effective, the inarches must be well established before trees become infected. Given the high cost of the practice, it is probably advisable only in the case of high-value crops in groves that are well separated from areas with severe strains of tristeza virus. It is more likely to be successful with younger than with older trees.

4. Chemical or biological control of the aphid is unlikely to stop the spread of the virus in commercial groves, because acquisition and transmission of the virus by the aphid usually occurs before the aphid is killed by an insecticide. Keeping aphid populations in check in the grove may help reduce feeding damage and secondary spread of the virus onto resets. However, rigorous aphid control in nurseries and on budwood-source trees could reduce infection rates (see chapter 26, ENY-604, *Soft-Bodied Insects Attacking Foliage and Fruit*).

5. Cross protection, which is the practice of inoculating trees with mild virus strains to protect them from the effects of severe strains, has been effective in South Africa and Australia in reducing losses in grapefruit due to stem-pitting, and against losses in sweet orange in Brazil. Cross protection against tristeza decline on sour orange rootstock has not yet been developed as an effective control measure.

2020–2021 Florida Citrus Production Guide: Decay Control of Florida Fresh Citrus[1]

Mark A. Ritenour, Jiuxu "John" Zhang, Liliana M. Cano, and Megan M. Dewdney[2]

Citrus fruit decay is one of the most important constraints that affect fresh citrus quality and marketing values. It is most often caused by fungal or oomycete pathogens that grow and develop in the hot and wet conditions typical of Florida. The most common postharvest fungal decays of Florida citrus are Diplodia stem-end rot (*Lasiodiplodia theobromae*), green mold (*Penicillium digitatum*), and Phomopsis stem-end rot (*Diaporthe citri*). Other fungal decays include sour rot (*Geotrichum citri-aurantii*), anthracnose (*Colletotrichum gloeosporioides*), blue mold (*Penicillium italicum*), and less frequently, Alternaria stem-end rot (black rot; *Alternaria alternata*). Decays by oomycete pathogens are mainly brown rot (primarily *Phytophthora palmivora* and *P. nicotianae*/*P. parasitica*) that occasionally cause commercially important losses of citrus fruit. Losses from these diseases can be reduced using the practices discussed below.

Degreening Management

Citrus fruit harvested early in the season usually have inadequate color development and require degreening before packing. During degreening, fruit are exposed to minute levels of a natural plant hormone (ethylene) that stimulates the breakdown of chlorophyll and unmasks the characteristic orange and yellow colors of the peel. However, ethylene exposure also increases the development of Diplodia stem-end rot and anthracnose, which is related to the length of the degreening treatment and ethylene concentration used. If degreening is necessary, fruit should first be drenched with a suitable fungicide and then degreened at 82°F–85°F (27.8°C–29.4°C) with 3–5 ppm ethylene and 90%–95% relative humidity only as long as necessary to obtain adequate peel color (depending on fruit variety and degree of color break). See *Recommendations for Degreening Florida Fresh Citrus Fruits* (https://edis.ifas.ufl.edu/hs195) for more information. A benefit of these degreening conditions is the promotion of a fruit-curing effect that reduces the development of green mold.

Minimizing Fruit Injuries

Mechanical injuries to the fruit peel during fruit harvesting and subsequent handling are the principle sites for infection by wound-mediated pathogens such as *P. digitatum* (green mold), *P. italicum* (blue mold), and *G. citri-aurantii* (sour rot). To reduce pathogen infection and decay, care should always be taken to minimize fruit injuries during fruit harvesting, packing, storage, and shipping.

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Importance of Sanitation

Effective sanitation practices during postharvest handling can greatly reduce decay frequency. All fruit, leaves, and other trash should be removed from the floor and machinery in the packinghouse at least daily to reduce inoculum sources. Decayed fruit should be separated from healthy fruit immediately after dumping on the packing line to prevent contamination of the line by fungal inoculum. Decayed fruit should not be left near the packinghouse because spores can be carried by wind and insects into the packinghouse. Decayed fruit should never be repacked within the packinghouse.

An approved sanitizing agent (e.g., chlorine, peroxyacetic acid, etc.) or hot water (at least 160°F [71.1°C]) should be used to treat fruit-contact surfaces after the equipment is cleaned at the end of each day. Approved quaternary ammonia (QA) compounds may also be used but require a fresh-water rinse if used at concentrations above 200 ppm. Empty pallet boxes (pallet bins) should be clean and free of debris before each trip to the field.

If water dumps or soak tanks are necessary, free chlorine should be maintained in the water at about 100 ppm and near a pH of 7 for maximum effectiveness. See *Chlorine Use in Produce Packing Lines* (https://edis.ifas.ufl.edu/ch160) for more information.

Citrus Decay Control Using Fungicides

The following fungicides can be used for decay control of citrus. Follow the label if the instructions are different from below, because the label is the law.

Thiabendazole (TBZ): TBZ is applied with truck or bin drenchers and on the packinghouse line. Stem-end rot and green mold are both effectively controlled when TBZ is applied correctly. It also provides some anthracnose control but does not control sour rot or black rot.

Concentration and Formulation—TBZ should be applied at a concentration of 1,000 ppm (0.1%) as a water suspension, or at 2,000 ppm (0.2%) in a water-based wax. The higher concentration of TBZ in wax is due to its reduced efficacy when mixed in wax compared to aqueous application.

Methods of Application—TBZ is only slightly soluble in water; therefore, suspensions must be constantly agitated to ensure uniformity of solution concentration during application. TBZ can be applied as a recovery drench on unwashed fruit before degreening, or as a nonrecovery spray or drip on washed fruit that has been damp-dried with absorber (donut) rolls or by other methods. Recovery drenches should contain chlorine at the proper pH to control fungal contamination, and the concentration of TBZ must be monitored periodically. Following a nonrecovery water application of TBZ to washed fruit, excess fungicide suspension may have to be removed with absorber rolls if dryer capacity is inadequate. Brushing after nonrecovery water applications reduces fungicide residues. Fruit should not be brushed or rolled in the dryer after waxes are applied except for a half turn midway through the drying operation.

Imazalil: Imazalil is especially effective against green mold and against mold sporulation. Imazalil is less effective than TBZ for control of Diplodia and Phomopsis stem-end rots, and it is ineffective against sour rot and brown rot.

Concentration and Formulation—Imazalil should be applied at 1,000 ppm (0.1%) as a water suspension or at 2,000 ppm (0.2%) in a water-based wax. The higher concentration of imazalil in wax is due to its reduced efficacy when mixed in wax compared to aqueous application.

Methods of Application—These are identical to the recovery and nonrecovery postharvest applications of TBZ described above, except that some heating or other sanitizers (not chlorine) are applied in imazalil bin drenchers because chlorine and imazalil are not compatible.

Sodium o-phenylphenate (***SOPP***): SOPP reduces green mold and provides some control of Diplodia and Phomopsis stem-end rots as well as sour rot.

Concentration and Formulation—A 2% aqueous solution of SOPP applied at pH 11.5–12.0 is the most effective treatment. One formulation contains 2% SOPP, 0.2% sodium hydroxide for pH control, and 1% hexamine to minimize phytotoxicity. Water emulsion waxes with 1% SOPP are also available, but they have little fungicidal value. Residues are expressed in terms of o-phenylphenol (OPP).

Methods of Application—SOPP may be applied as a soap or foam to replace the detergent during washing. This application provides less fungicidal efficacy than an aqueous flood recovery treatment, but it helps kill inoculum from decayed fruit on the brushes and reduces the chance of infecting healthy fruit during the washing process. Unwashed or washed fruit treated with a foam or flood of SOPP should be rinsed with fresh water after treatment. Application times less than 2 minutes provide less decay control, while time exceeding 2 minutes may cause peel injuries. Washer brushes should be rinsed at the end of each day's run to remove SOPP residues that may cause matting of the brushes. Concentrations of SOPP solutions applied with hexamine should be maintained near 2.5° with a Brix hydrometer standardized at 68°F (20.0°C). The pH of aqueous solutions lacking hexamine must be maintained at 11.5–12.0 to prevent peel injury. The maximum legal residue tolerance for SOPP may be exceeded if waxes containing SOPP are applied to fruit previously treated with aqueous applications of SOPP.

Fludioxonil and azoxystrobin: Fludioxonil and azoxystrobin are newer postharvest fungicides registered for use on citrus. The mixture of fludioxonil and azoxystrobin is marketed as Graduate A+. Fludioxonil is effective against Diplodia stem-end rot and green mold; azoxystrobin is effective for green mold control and has some activity against Diplodia stem-end rot. Graduate A+ provides good control for Diplodia stem-end rot, green mold and *Penicillium* sporulation. It also mitigates the development of *Penicillium* resistance because fludioxonil and azoxystrobin have different chemical modes of action against fungal pathogens. Neither fludioxonil nor azoxystrobin control sour rot.

Concentration and Formulation—Graduate A+ should be applied at 1,200 ppm (600 ppm fludioxonil, 600 ppm azoxystrobin), both as a water suspension. However, the efficacy of these products incorporated into wax coatings under Florida conditions still needs to be determined.

Methods of Application—These are identical to the recovery and nonrecovery postharvest applications of TBZ described above. Fludioxonil and azoxystrobin are compatible with chlorine in fruit drenching treatment.

Pyrimethanil**:** Pyrimethanil is a postharvest fungicide registered for citrus and marketed as Penbotec**.** It has good activity against Penicillium decay, but less activity against Diplodia stem-end rot compared to TBZ, imazalil, and fludioxonil. Pyrimethanil can be used to manage Penicillium resistance development to TBZ/imazalil because it has a different mode of action, but it has not been tested under Florida conditions.

Preharvest Copper, Aliette, Phostrol, and ProPhyt: These fungicides are applied before harvest for control of brown rot in fruit from blocks of trees that historically develop the disease or in seasons when climatic conditions favor brown rot development. Aliette has a preharvest interval of 30 days before fruit can be harvested following fungicide application. See chapter 33 in the *2020–2021 Florida Citrus Production Guide*, PP-148, *Brown Rot of Fruit,* for more details (https://edis.ifas.ufl.edu/cg022).

Summary of Fungicide Treatments

Effective fungicide treatments are summarized in Table 1 for the control of specific postharvest diseases that predominate during various months of the season. It is important to use fungicides with different modes of action (Table 2) to help prevent the development of pathogen resistance to the materials.

Temperature

Fruit decay development can be delayed by cooling the fruit and maintaining the "cold chain" throughout transportation and distribution (Table 3). Such practices also greatly slow fruit metabolism and reduce development of stem-end rind breakdown (see https://edis.ifas.ufl.edu/hs193 for details). However, varietal and seasonal differences in susceptibility to chilling injury must be considered when selecting optimum temperatures. Chilling injury is a physiological disorder that occurs when most citrus fruit (especially grapefruit, lemons, and limes) are stored at low—though not freezing—temperatures. It is most often characterized by areas of the peel that collapse and darken to form pits after at least 3–6 weeks at low shipping and storage temperatures. See *Chilling Injury of Grapefruit and Its Control* (https://edis.ifas.ufl.edu/hs191) for more information.

Humidity Control

Rapid handling of fruit at high relative humidities and application of a protective wax coating to retard desiccation are the best means of reducing fruit water loss. High relative humidity during handling, storage, and transit helps maintain fruit turgidity and freshness and enhance healing of minor injuries, thereby reducing susceptibility to green mold. When fruit are held in plastic containers, such as pallet boxes, the relative humidity should be 90%–95%. However, when fruit are packed in fiberboard cartons, the humidity should be lower (85%–90%) to prevent carton deterioration.

Residue Tolerances

Because maximum residue limits (MRLs) for various export markets change frequently, growers, packers, and shippers are encouraged to stay informed about such changes through their respective trade groups and through one or more web resources. A table of citrus MRLs for domestic and important export markets is posted on the University of Florida Postharvest Resources website (https://irrec.ifas.ufl.edu/postharvest) and is updated as needed throughout the year. This site also includes links to other useful MRL sites, such as a global MRL database (https://bcglobal.bryantchristie.com/) and sites for specific markets, such as the European Union, Canada, and Japan. While all these websites are useful as a starting point, no guarantee can be made as to their accuracy; always verify these values with other knowledgeable sources.

Table 1. Major postharvest decays, seasonal development, fruit susceptibility, and effective fungicide treatments

Disease	Months of Prevalence	Treatments[a]
Brown rot	Aug–Dec	Preharvest (Aliette[b], 5 lb/ac; Phostrol, 4.5 pints/ac[c]; ProPhyt[c], 4 pints/ac; copper[c], label rate)
Diplodia SER[d]	Sept–Dec	Bin drench (TBZ[e] or imazalil[f], 1000 ppm; Graduate A+[f], 1200 ppm) Packing line (TBZ, 1000 ppm aqueous, 2000 ppm water wax; Graduate A+, 1200 ppm aqueous)
Anthracnose	Sept–Nov	Bin drench (TBZ, 1000 ppm)
Green mold	Dec–June	Bin drench (TBZ or imazalil, 1000 ppm; Fludioxonil, 600–1200 ppm; Graduate A+, 1200 ppm) Packing line (SOPP[g], 2%; TBZ and/or imazalil[h], 1000 ppm aqueous, 2000 ppm water wax; Graduate A+[h], 1200 ppm aqueous)
Sour rot	Nov–Feb Apr–June	Packing line (SOPP, 2%)
Phomopsis SER	Jan–June	Packing line (TBZ and/or imazalil, 1,000 ppm aqueous, 2,000 ppm water wax)
Alternaria SER	July–Sept	Packing line (Imazalil, 1,000 ppm aqueous, 2,000 ppm water wax)

[a] Postharvest materials are specified as ppm or % of active ingredient. Preharvest fungicides except copper are indicated as rates of formulation.
[b] Apply Aug–Dec, 30-day preharvest interval.
[c] Apply Aug–Dec, 0-day preharvest interval.
[d] SER: Stem-end rot.
[e] TBZ: thiabendazole.
[f] Use when TBZ residues are a problem for fruit going to juice.
[g] SOPP: sodium o-phenylphenate.
[h] Effective for sporulation control on fruit within packed cartons.

Table 2. Modes of action and pesticide details.

Pesticide	FRAC MOA[1]	Notes
Aliette WDG	P 07	Do not exceed 4 applications/season or 20 lb/acre/year; for foliar application, do not exceed 500 GPA
Copper	M 01	Use label rate
Graduate A+	11/12	Do not make more than 2 applications to citrus fruit
Imazalil (examples: DECCOZIL EC-289, Freshgard 700, Fungaflor 500EC)	3	See label
Phostrol	P 07	Can cause phytotoxicity if applied above 90°F, at color break, or after rainfall
ProPhyt	P 07	None
Sodium o-phenylphenate (SOPP) (examples: DECCOSOL 125, FreshGard 5)	--	See label
Thiabendazole (TBZ) (examples: Freshgard 598, Alumni, DECCO Salt No. 19)	1	See label

[1] Mode of action class for citrus pesticides from the Fungicide Resistance Action Committee (FRAC) 2020. Refer to ENY624, *Pesticide Resistance and Resistance Management*, chapter 4 in the *2020–2021 Florida Citrus Production Guide* for more details.

Table 3. Optimum holding temperatures for maximum quality and shelf life of fresh Florida citrus fruit.

Citrus Type	Optimum Holding Temperatures
Grapefruit	50°F–60°F (10.0°C–15.6°C)
Lemons, limes	50°F (10.0°C)
Mandarin-type fruits	40°F (4.4°C)
Oranges	32°F–34°F (0.0°C–1.1°C)

Note: Somewhat lower temperatures can be used if fruit coatings are used that substantially restrict gas permeability (e.g., some shellac formulations).

2020–2021 Florida Citrus Production Guide: Weeds[1]

Ramdas Kanissery, Stephen H. Futch, and Brent A. Sellers[2]

Weed management in Florida citrus is an important component of any successful integrated pest management (IPM) program. IPM programs utilize a combination of control practices including but not limited to cultural, preventive, mechanical, chemical, or biological methods. Weed management is expensive and a major component of the total citrus production program. Time spent developing this production program can provide significant economic and environmental returns. The goal of weed management is to minimize the competitive effect of weeds on the citrus tree, be it young or mature. An understanding of the growth and competitive nature of the weed is important. The objective of today's weed management program is to suppress and control weeds so that they do not cause damage to the tree, impact yield, or impede grove and harvesting operations. Complete and total elimination of all weeds from the grove floor is neither necessary nor warranted.

When developing a weed management program, growers must consider: 1) application site (tree age, soil type, and location, including ridge vs. flatwoods and county limitations); 2) weeds present; 3) the stage of weed growth; 4) herbicide selection; 5) spray nozzle and herbicide bandwidth; 6) spray volume and pressure; and 7) amount of herbicide used. All of these factors will directly affect cost and the success of the weed management program.

Tree Age and Variety

From years of experience and trials, growers know that weed growth is greater in young groves as compared to mature groves. Generally speaking, young groves will require greater attention to material selection and rate because the areas around the tree are more sun exposed and have greater weed pressure than do larger trees, which have greater shaded areas with lower weed pressure. An exception to lower weed pressure for mature trees is where vines are present. Vines can germinate in shaded areas and grow into the tree canopy, creating a host of problems for the tree and fruit-harvesting operations. Young trees generally will not tolerate herbicide rates as high as mature trees. Additionally, weeds compete with young trees for nutrients, water, light, and space at a greater rate as compared to mature trees.

When using herbicides for weed control, rates should be adjusted for tree age, with lower rates on young trees. Also, be aware that some herbicide products may only be labeled for nonbearing sites, which means that product can only be applied if a crop is not going to be harvested within 12 months.

Consideration should also be given to product selection based upon variety. Some products specify that they may

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only be used on oranges, thus prohibiting their use on tangerines.

Impact of Weeds on Tree Growth

Weeds can impact tree growth and subsequent yields by altering the spray pattern of low-volume irrigation systems, intercepting soil-applied chemicals (fertilizer and agricultural chemicals), reducing grove temperatures during freeze events, and interfering with harvesting operations. The presence of weeds in a grove can also affect insect populations and disease incidences.

Ground cover in the row middles also plays an important role in grove management by reducing soil erosion, sandblasting during windy conditions, and retaining nutrients, but it can also impact tree growth when allowed to compete with the citrus tree. Sod-forming Bahia and Bermuda grass are typically used as ground cover between the tree rows, but Bermuda can be more competitive than Bahia. Ground cover can be beneficial if it is less competitive than any weeds that may be present in the grove. Thus, the selection of row-middle vegetation is an important consideration in IPM.

Direct reduction in citrus tree growth and yield can occur when weeds compete with trees for light, water, nutrients, and space. However, not all weeds compete with citrus trees in the same way or with the same level of competition. Water requirements for vegetation regrowth after mowing can impact water availability within the grove. During this regrowth period, grasses use more water from the soil compared to broadleaf plants. Vines can be more competitive for sunlight than other plants. Weeds can also compete with citrus trees in many ways, but with varying intensities. The ability of plants to intercept varying levels of water, light, and nutrients makes some weeds more competitive with citrus than other species. Therefore, highly competitive weeds should be of great importance to the production manager. Successful weed control is extremely important in groves containing weeds that are highly competitive. In an IPM program, the most competitive weeds are identified and removed before they produce seeds. With time, seeds in the soil can be reduced through suppression, cultural, and sanitation methods.

To ensure competitive weeds are suppressed, proper plant identification is a critical first step in developing an effective program. Weed species will vary with location, climate, season, soil type, previous site history, and current and past management programs. Scouting should be conducted in all areas in and near the grove but not limited to tree row, row middle, water furrows, ditch banks, fence rows, and adjacent off-site locations. Each of these sites may receive different cultural practices, but different weeds may be found. Scouting off-site locations may prevent small, isolated problems from becoming larger problems. Because weeds emerge throughout all growing seasons, schedule weed surveys throughout the year. Scouting should occur even if weeds are not easily visible or appear to be dead. A rapid regrowth from perennial plants that appear to be dead can occur and is particularly problematic when replanting new trees into weed-infested sites. Scouting should be conducted by walking throughout the groves, because small, easy-to-control weed seedlings may go unnoticed when driving through the grove. If weeds are properly identified while in the seedling or vegetative stage, then proper control can be achieved through: 1) increased flexibility in timing control options; 2) possible reduced herbicide application rate; and 3) reduced impact from control measures.

When scouting for weeds, records should be developed and recorded as to species abundance, location, and identity. Changes over time can be tracked to provide control strategy effectiveness. When scouting a large area, it is common to find a large number of weed species. The species present will vary with season and location.

Weeds can be identified or grouped as: 1) broadleaf (including vines); 2) grass; or 3) sedge. The identification of weeds can be aided by looking for specific characteristics of the plant. These specific characteristics can include shape of the leaves, stems, seed, seed head, plant size, root system, and the type and color of flowers, if present. Weeds can be classified by their life cycle: annual, biennial, or perennial. Annual plants have a one-year life cycle, growing from seed, maturing, and producing seed for the next generation of plants in one year or less. Annuals can be further divided into summer (sprout in spring, grow, mature, and produce seed and die before winter) or winter (sprout in the fall, grow, mature, produce seed and die before summer). Biennials have a two-year life cycle, growing from seed and developing a heavy root system the first year, followed by seed production in the second year and then plant death. Perennials live more than two years, with seed production occurring as early as the first year.

Detailed information on weed identification in citrus groves is available from the following UF/IFAS publications: HS-926/HS185, *Identification of Vine Weeds in Florida Citrus*, HS-896/HS150, *Identification of Broadleaf Weeds in Citrus*, HS-955/HS175, *Identification of Grass Weeds in Florida Citrus*, HS-962/HS205, *Identification of Sedge and*

Sedge-Like Weeds in Florida Citrus, and SP-341, *Identification of Weeds in Florida Citrus*.

Weed Management Options

Many approaches are used to suppress or control weeds (vegetation) within the grove. These practices will vary with location, time (season), tree spacing, vegetation species present, cost, and grower preference. Each method of weed control has its own advantages and disadvantages.

Preventive

Preventive programs are often overlooked as a method of weed control. Preventive programs entail the use of such practices as sanitation, spot spraying, or hand labor to prevent the source of weed infestation (seed or vegetative) from widespread dissemination throughout an area. By removing the undesirable weed species prior to seed development, dissemination by the wind or mechanical transport on equipment can be effectively delayed. While preventive programs will not stop the spread of new weed species, these practices may slow the spread of undesirable weed species, thereby reducing the cost of current weed control programs.

Mechanical

Cultivation or tillage has been used in the past for many years in citrus production. Tillage is an effective method of controlling annual weeds by severing stems and roots of the weeds, but it is not very effective on perennial grasses. Tillage use is decreasing as a weed control method as more groves are planted on raised beds, and tillage increases the chances for soil erosion. Additionally, tillage damages the fibrous roots close to the soil surface, which is the main reason for the reduction in use. These shallow fibrous roots close to the soil surface are very important in groves where the root systems are limited due to high water tables, Phytophthora root rot, or root weevils. With the use of low-volume irrigation systems and closer in-row planting distances, tillage in both directions is no longer possible.

Mechanical mowing is generally more expensive than tillage due to the cost of equipment and energy requirements. Mechanical mowing can also throw seed under the tree canopy, increasing weed pressure in the under-canopy area of the tree. The frequency of cultivation or mechanical mowing is dependent on the weeds present and the season.

Chemical

Chemical weed-control programs will vary from location to location within the state and can even vary within a given site based on specific conditions such as soil type, variety, method of herbicide application, and the presence of specific weed species. Herbicides used in a grove are generally divided into two groups: 1) soil-applied preemergence herbicides that should be applied to fairly clean soil surfaces prior to weed emergence, and 2) foliar-applied postemergence herbicides that are applied after germination of weed seed.

Preemergence herbicides can be absorbed through emerging stems in the soil or through roots. Preemergence herbicides are most effective before germination and early seedling growth stages.

Postemergence herbicides can be further divided into systemic or contact. Systemic herbicides are translocated within the target plant, killing the foliage and root system of the contacted plant. Contact herbicide kills only the plant parts that are contacted by the spray application. All herbicides used in citrus are selective in that they kill some plants (weeds) without significantly injuring other plants (citrus trees) if applied at the correct rate and manner.

Preemergence herbicides are generally applied two to three times per year, and the total annual amount of herbicide materials will be nearly the same, regardless of the application frequency. For preemergence materials, application should be properly timed so that the maximum amount of herbicide is in the upper soil profile (0 to 2 inches) slightly before peak weed emergence. Material applied too early will not have enough herbicide concentration to provide adequate weed control due to herbicide losses caused by leaching or degradation on the soil surface or within the soil profile.

Chemical Mowing

Chemical mowing use is increasing each year as the cost of mechanical mowing increases due to rising equipment, maintenance, and fuel costs. Chemical mowing consists of sublethal rates of systemic herbicide (glyphosate) to suppress the growth or regrowth of grasses and broadleaf weeds that grow in the row middle for up to 45–90 days. Prior to the chemical mowing application, the vegetation within the row middle is mowed and allowed to slightly regrow.

Chemical Weed Control Programs

Successful herbicide programs start with selecting the right herbicide or herbicide mixtures. All herbicides have a label that states the use requirements, application rates, weeds controlled, and personal protective equipment required during mixing and application. Remember that the label is the law and must be followed.

The herbicide use rate, the stage of weed growth, climate, and method of application can affect control. Climatic extremes that stress plants, including drought, flooding, and extreme temperatures, could result in reduced herbicide performance. Stressed plants take up and translocate less herbicide than nonstressed plants. Poor herbicide performance is minimized when the proper herbicide is selected and applied at recommended rates in the correct spray volume to the right stage of the seedling's growth.

Selecting the proper herbicide requires an understanding of how herbicides work on plants. Herbicides applied to the soil before weed emergence are referred to as preemergence (Table 1). Other herbicides can be applied directly to weeds and are referred to as postemergence (Tables 2 to 5).

Environmental Considerations

Herbicide selection should be based upon a number of factors, including weed species that are present or anticipated from weed surveys, vegetation developmental stages, product solubility and leaching potential, soil type at the location of application, rainfall distribution, county location, and other factors present on the product label.

Herbicides may move through the soil to groundwater if used improperly. Factors influencing the rate of herbicide movement in the soil include but are not limited to irrigation practices, rainfall, herbicide solubility, soil type, and organic matter.

Additional consideration should be given to products containing bromacil, which are prohibited on deep, sandy, ridge-type soils. Also, some product labels restrict the annual application of diuron within Highlands County. Please consult your local county Extension or USDA-NRCS office for information on soil type restrictions.

Application Technology

Advances in herbicide application technology have resulted in the development of sophisticated equipment for the precision application of selected products within a grove setting. This sophisticated equipment is capable of selective delivery of multiple herbicide products, each directly injected or contained in multiple tanks that are injected into multiple lines or controlled by electronic sensors.

When applying preemergence herbicides via an herbicide boom, complete uniform coverage of the soil surface is important for improved weed control. Factors that can affect the uniformity of coverage include worn or damaged nozzle tips, boom height, and vegetation present. As nozzles become worn, delivery rates increase and distribution patterns from the individual nozzles become distorted. Weeds present will also affect spray patterns as well as block the herbicide from reaching the soil surface when preemergence herbicides are being applied. The herbicide label may also state application equipment requirements. These requirements may include special herbicide boom designs that minimize material drift or potential contact with tree foliage.

Application pressure is also important because it affects the size of the spray droplets. Higher spray pressure decreases the spray droplet size, thereby increasing the chances of off-target damage due to spray drift. The manufacturer's specified operation pressure range should be considered when selecting nozzles.

Additional information about herbicide equipment and its calibration can be found in EDIS publication HS-1012/HS252, *Citrus Herbicide Boom Sprayer Calibration*.

Band Width

Application band width has a major impact on the amount of herbicide material applied per grove acre, thus directly affecting total weed control costs. When trees are small, herbicide band width should be rather narrow, only covering an area of 3 to 4 feet on each side of the tree. As the canopy width increases, the herbicide band width should likewise increase. Narrow band widths on small trees will aid in minimizing soil erosion and assist in maintaining water quality in bedded-grove situations.

Position of the Off-Center Nozzle on the Herbicide Boom

Herbicide applicators should think about the angle of the off-center (OC) nozzle on the end of the herbicide boom. The nozzle angle will have a major impact on where the spray is directed upward as well as the distance from the end of the boom. The greater the nozzle angle, the higher and further beyond the end of the boom the spray is directed, greatly increasing the chances of phytotoxicity occurring in the tree canopy. The height of the boom and its angle will also impact the distance and height that the spray is directed into the canopy of the citrus tree.

Herbicide Resistance Management

In many crops, the discovery of resistance to various herbicides has been well documented. Resistance is the ability of a specific weed to survive treatment with a given herbicide to which the species is normally susceptible. With repeated use of the same herbicide, the risk of resistance is increased. Due to its frequent and widespread use, glyphosate is a particular concern in Florida citrus. Weed resistance to glyphosate is a documented issue in numerous crop systems and should be expected. Rotating between herbicide classes will minimize the potential for development of herbicide resistance. A listing of the recommended herbicides are provided in Table 6, which identifies the chemical class of each herbicide material.

Chemical Control of Root Sprouts

Various forms of glyphosate and triclopyr currently have label recommendations allowing these products to be used on recently cut citrus stumps. Triclopyr (Remedy Ultra) has an EPA 24(c) special local need registration for application to citrus stumps in Florida. This product should be applied in a manner that minimizes the application to the soil surface adjacent to the cut tree trunk.

Complete coverage of the cut surface will enhance control of vegetative regrowth from the stump. Stumps should be treated as soon as possible after cutting because effectiveness is reduced with time. If root grafting with desirable adjacent trees is present, the material may be translocated to healthy trees, causing significant damage.

Products should be applied in a manner that minimizes drift from the application site (cut stump) to the adjacent tree(s).

Be sure to read and follow all label requirements.

Recommended Chemical Controls

Table 1. Preemergence soil residual herbicides

Table 2. Nonselective postemergence systemic herbicides

Table 3. Nonselective postemergence systemic herbicides—glyphosate conversions

Table 4. Nonselective postemergence contact herbicides

Table 5. Selective postemergence systemic herbicides

Table 6. Herbicide chemical family

Table 7. Recommended chemical controls for citrus root sprouts

Table 1. Preemergence soil residual herbicides.

Herbicide Name	HRAC MOA[1]	Rate per Treated Acre; Time of Application	Comments
Indaziflam Alion	L – Cellulose-biosynthesis inhibitor	5 to 6.5 oz/ac. Do not exceed 10.3 oz/ac per 12-month period.	Preemergence control of seed-germinating grass and broadleaf weeds. A postemergence herbicide should be tank mixed to control weeds that have already emerged at the time of application. Best control is achieved when minimal weed debris is present on the soil surface at application. Avoid direct or indirect spray contact with foliage, because it may cause localized chlorotic speckling. Do not apply Alion within 30 days prior to planting or within 30 days after planting citrus trees. For repeat application, allow a minimum of 90 days between applications.
Bromacil Hyvar X 80 WP	C1	Ridge: Do not use on vulnerable, deep-sandy, ridge soil types. See product label under general precautions and use restrictions for specific soil series.	Controls annual and perennial grasses and annual broadleaf weeds. Postemergence activity, particularly with a surfactant.
		Flatwoods: Do not exceed a total of 6 lb product per acre per year.	
Trees 4 years and older		2–4 lb product. The higher recommended rates may be required for heavier soil types and for certain established perennial grass species. Apply prior to weed emergence or early postemergence.	
Trees established 1–3 years		2–3 lb product. Use lower recommended rates on lighter soils or in low weed-infestation areas. Do not exceed maximum allowable yearly rates.	
Bromacil:Diuron Krovar I DF	C1, C2	Ridge: Do not use on vulnerable, deep-sandy, ridge soil types. See supplemental product label for further details.	Controls annual broadleaf weeds, annual vines, and annual and perennial grasses. Extra diuron in product increases activity on broadleaf weeds. Contact activity enhanced by the surfactant.
		Flatwoods: Do not exceed 12 lb product per acre per year.	
Trees 3 years and older		4–6 lb product per acre. Apply prior to weed emergence or early postemergence.	
Trees established 1–3 years		2–4 lb product per acre. Do not exceed 8 lb per year.	
		Use lower rates on lighter soils or in low weed-infestation areas.	

Herbicide Name	HRAC MOA[1]	Rate per Treated Acre; Time of Application	Comments
Flumioxazin Chateau	E	6–12 oz/ac. Maximum rate of 24 oz/ac per 12-month period. Do not make a sequential application within 30 days of the first application.	Application should be made to weed-free soil surface. Residual weed control will be reduced if vegetation prevents herbicide from reaching the soil surface. When weeds are present, application must be mixed with a labeled surfactant and burndown product. Do not apply to trees less than one year old unless protected from spray contact by nonporous wrap. Rainfall or irrigation of at least ¼ inch is required to activate the herbicide into soil for weed control.
Diuron	C2		Do not exceed 8 lb active ingredient per acre per year on flatwoods soils. Do not exceed 6.4 lb active ingredient per acre per year on ridge soils. In Highlands County, do not exceed 4.8 lb active ingredient per acre per year. Do not exceed 2 lb or 2 qt per application on trees less than 1 year old on shallow, poorly drained soils. Do not apply to row middles. Apply prior to weed emergence or early postemergence.
Diuron 80DF		2–4 lb product	Controls annual broadleaf weeds and annual grasses. Contact activity enhanced by addition of surfactant. Foliage contacted by diuron may develop a bleached or bronzed appearance.
Direx / Diuron 4L		1.6–3.2 qt	
Karmex 80DF		2–4 lb product	
Norflurazon Solicam 80DF	F1	2.5–5 lb of product per acre. Do not exceed 10 lb per year. For best results apply prior to weed emergence.	Controls annual and perennial grasses and certain broadleaf weeds. Spectrum of broadleaf weeds controlled increased by tank mixing with simazine or diuron. Suppresses established nutsedge and perennial grasses; control requires repeat applications. Dense weed growth should be controlled with contact or systemic herbicides prior to Solicam application to allow maximum contact with the soil surface. Tank mixes with postemergence contact or systemic herbicides may be used where weed growth is low growing and sparse. Solicam activity is highly dependent on good soil moisture following application, i.e., rainfall or irrigation. Contact with tree canopy can result in a bleached appearance and some distortion of young growth flushes.
Solicam 80DF Water ring treatment	F1	2.3 oz per 500 gal water. Apply 10 gal per tree assuming a ring diameter of 4 ft. Adjust rate according to ring diameter and amount of water. Apply prior to weed emergence. See product label for details. Apply at second or third watering—not during the planting operation.	
Chemical injection through low-volume subcanopy irrigation systems		2–3 lb. Apply prior to weed emergence as a supplemental treatment to herbicide strip. No treated area should receive more than 10 lb Solicam per acre per year from any combination of applications.	Solicam applied through irrigation systems will prolong weed control in areas influenced by emitters from which herbicides may have leached. Rate per acre should be based on measurement of area wetted by emitters and number of emitters per acre. See product label for calibration procedures. **CAUTION:** To be used only through irrigation systems that meet state requirements for chemical injection.

Herbicide Name	HRAC MOA[1]	Rate per Treated Acre; Time of Application	Comments
Oryzalin Oryzalin 4 AS Surflan 4 AS	K1	Do not exceed 1.5 gal per year. Apply prior to weed emergence; Surflan does not have postemergence activity. 0.5–1.5 gal of product per acre.	Controls annual grasses and certain broadleaf weeds. Does not control perennial grasses or sedges. Spectrum of broadleaf weeds controlled is increased by tank mixing with simazine, diuron, or Krovar I. Will not control weeds that have germinated prior to application. Tank mixes with postemergence herbicides, such as paraquat or glyphosate, should be used to control existing weeds. One-half to 1 inch rainfall or sprinkler irrigation is required to activate oryzalin and move it into the zone of weed-seed germination. Oryzalin will extend residual control of susceptible weeds when used in tank mixes with other products.
Chemical injection through low volume subcanopy irrigation systems		Apply prior to weed emergence as supplemental treatment to herbicide strip. No treated area should receive more than 1.5 gal per tree of oryzalin per acre per year from any combination of applications. See label for instructions for calculating product rates.	Oryzalin applied through irrigation systems will prolong weed control in areas influenced by emitters from which other herbicides have leached. Rate per acre should be based on measurement of area wetted by emitters and number of emitters per acre. See product label for further restrictions and for calibration procedures. **CAUTION:** To be used only through irrigation systems that meet state requirements for chemical injection.
Pendimethalin Prowl 3.3EC (Nonbearing only)	K1	2.4–4.8 qt of product per acre. Do not exceed 7.3 qt per acre per year.	Controls annual grasses. Does not control sedges. Spectrum of broadleaf weeds controlled is increased by tank mixing with diuron. Tank mixes with postemergence herbicides, such as paraquat or glyphosate, should be used to control existing weeds. Rain or irrigation is required within 21 days to move pendimethalin into the zone of weed seed germination.
Prowl H_20		2.1–6.3 pt per acre. Do not exceed 6.3 qt per acre per year.	
Simazine	C1	For application to oranges and grapefruit only. Do not exceed 8 lb active ingredient per acre per year.	
Caliber 90WDG		4.4 lb (spring and/or fall) or a single application of 8.8 lb in the spring applied once per 12 months.	Controls annual broadleaf weeds, annual vines, and annual grasses. Does not control perennial grasses.
Princep 4L		1.0 gal of product (spring and/or fall) or a single application of 2.0 gal product per acre in the spring once per 12 months.	Higher single application rates are intended for difficult species, such as balsam-apple and Spanish needles, and for a spring application. Do not exceed 4 lb a.i. per treated acre per year on trees established for less than 1 year, on sandy soils with low organic matter content, or on poorly drained sites. Apply only prior to weed emergence unless mixed with a postemergence contact or systemic herbicide. Has no contact activity. Avoid application during summer rainy period.
Simazine 4L		1.0 to 2.0 gal product. 2 gal per acre in spring (Ridge), 3.2 qt in bedded groves; apply only once per year.	
Simazine 90DF		4.4 lb (spring and/or fall) or a single application of 8.8 lb in the spring applied once per 12 months.	

[1] Mode of action class for citrus pesticides from the Herbicide Resistance Action Committee (HRAC). Refer to ENY-624, *Pesticide Resistance and Resistance Management*, chapter 4 in the *2020–2021 Florida Citrus Production Guide* for more details.

Table 2. Nonselective postemergence systemic herbicides.

Herbicide Name	HRAC MOA[2]	Rate per Treated Acre in Acid Equivalent (A.E.); Time of Application[1]	Comments
Glyphosate—undertree	G	Annual weeds: 0.75–1.5 lb A.E. per acre, depending on stage of maturity. Perennial weeds: 1.5–3.75 lb A.E. per acre. Use higher rates for more difficult-to-control grasses, woody vines, and shrubs. Refer to product labels for annual maximum rate per acre.	Consult label rates for specific weed species. Some weeds require repeat application for control. Apply in (water volume of) 10–40 GPA. Glyphosate may be tank mixed with labeled residual herbicides. Water sources containing Ca, Mg, Fe, and Al at levels above 400 ppm may require the use of ammonium sulfate at a 1%–2% solution (8.5 to 17 lb per 100 gal) for optimum activity. Rainfall within 1–6 hours after application may reduce effectiveness. **AVOID CONTACT WITH CITRUS FRUIT, FOLIAGE, AND GREEN BARK.** Application to early-maturing varieties in late summer/early fall may result in fruit drop when contacted by spray drift. Not all formulations of glyphosate contain surfactant. Addition of surfactant improves weed control if not present in original product.
Middles Management			
Glyphosate—chemical mowing	G	Bahia grass 0.125 lb A.E. followed by a second application 45 days later Bermuda grass 0.125–0.37 lb A.E.	For suppression of grasses and broadleaf weeds in row middles for 45–90 days. Do not mow within 1 week before or after chemical mowing application.
Glyphosate—wiping	G	5%–10% solution—carpet wiper; 50%–100% solution—panel wiper	Use wipers to remove tall-growing and difficult-to-control weed species from desirable turf.
Glyphosate—Spot treatment	G	1%–2% solution	**AVOID CONTACT WITH CITRUS FRUIT, FOLIAGE, AND GREEN BARK.**
Landmaster II	G, O	Annual weeds: 1–8 qt Perennial weeds: 4–8 qt Dependent on weed species—see supplemental label for weeds controlled and recommended rates. Application of glyphosate will improve effectiveness. Maximum of 8 qt per year. Do not apply within 7 days of harvest.	Applications should be applied with shielded boom with at least a 4-inch leading shielded edge and recessed boom with a back boom cover. Supplemental labeling must be in possession of the user at the time of application. Do not apply in vicinity of 2,4-D sensitive crops, such as tomatoes, or other desirable vegetation. See label for minimum distance from susceptible crops and recordkeeping requirements, including hourly wind speed, wind direction, location of application, amount used, etc. Applications should be made only when there is no hazard for spray drift. See label for additional restrictions. Rainfall or irrigation within 4 hours may reduce effectiveness. Sprayer cleanup: rinse entire system then add 1 qt ammonia per 25 gal water and allow to soak for 24 hours. Failure to clean tank may result in injury to desirable crops when subsequently sprayed.

[1] NOTE—Please see Table 3 for conversion of A.E. to amount of product to use to achieve desired weed control.
[2] Mode of action class for citrus pesticides from the Herbicide Resistance Action Committee (HRAC). Refer to ENY-624, *Pesticide Resistance and Resistance Management*, chapter 4 in the *2020–2021 Florida Citrus Production Guide* for more details.

Table 3. Nonselective postemergence systemic herbicide-glyphosate conversions.

Product[1] Acid Equivalence (A.E.) (lb/gal)	Rate per Treated Acre in A.E. (from Table 2)						
	0.094 lb	0.188 lb	0.282 lb	0.37 lb	0.75 lb	1.5 lb	2.25 lb
	Amount of Product to Equal the Above Pounds of A.E.						
3.0	4 oz	8 oz	12 oz	16 oz	1 qt	2 qt	3 qt
4.0	3 oz	6 oz	9 oz	12 oz	24 oz	48 oz	72 oz
4.5	2.7 oz	5.4 oz	8.1 oz	10.8 oz	21.5 oz	43 oz	64.5 oz
5.0	2.4 oz	4.8 oz	7.2 oz	9.5 oz	19.2 oz	38.4 oz	57.6 oz

[1] Various formulations of glyphosate are currently registered for use in Florida citrus. It is important to adjust the application rate used according to the product concentration. A product concentration is stated in pounds per gallon of acid equivalent (A.E.) on the label.

Table 4. Nonselective postemergence contact herbicides.

Nonselective Postemergence Herbicide	HRAC MOA[1]	Rate per Treated Acre; Time of Application	Comments
Carfentrazone-ethyl Aim EC	E	Up to 2.0 fl oz of product per application and not to exceed 7.9 fl oz per year. Tank-mixing with other postemergence products increases weed spectrum controlled. Higher rates are needed when larger weeds are present.	An adjuvant, such as a nonionic surfactant or crop oil concentrate, is required. Avoid contact with green tissue or fruit. Good coverage is essential for control. Apply in a finished spray volume of at least 20 GPA. Do not make applications less than 14 days apart.
Glufosinate-ammonium Rely 280	H	48–82 fl oz per acre per application with higher rates on taller, susceptible weeds. Do not apply more than 246 fl oz (4.5 lb a.i./ac) per year. Do not make more than 3 applications at maximum rate per year. Do not apply within 14 days of harvest.	For best results, apply to emerged, young, actively growing weeds. Warm temperatures, high humidity, and bright sunlight improve the performance. Avoid application to weeds under stress. Avoid application during conditions where temperature inversions that would favor drift are likely. Avoid contact or spray drift with green bark, stems, or foliage, because injury may occur. Young trees with green stems should have a nonporous wrap in place to avoid contact with susceptible tissue. Follow-up applications must be a minimum of 14 days apart.
Paraquat Gramoxone SL 2.0	D	2.5–4.0 pt of product per acre. Do not apply in excess of 20 pt per acre per year. Apply as required alone or in combination with residual herbicides to control emerged weeds. Apply before weed growth becomes too dense as thorough spray coverage is required.	Controls all green weed tissue contacted. Rapid regrowth can be expected from perennial species. New labeling requirements require mandatory training program be completed by all applicators, and all applicators must be certified applicators of restricted use pesticides. Addition of a surfactant is essential for maximum contact activity. **AVOID CONTACT WITH CITRUS FOLIAGE**, **GREEN STEMS, AND FRUITS.** Maximum of five applications per year.

[1] Mode of action class for citrus pesticides from the Herbicide Resistance Action Committee (HRAC). Refer to ENY-624, *Pesticide Resistance and Resistance Management*, chapter 4 in the *2020–2021 Florida Citrus Production Guide* for more details.

Table 5. Selective postemergence systemic herbicides.

Herbicide Name	HRAC MOA[1]	Rate per Treated Acre; Time of Application	Comments
Fluazifop Fusilade DX 2 E	A	Do not apply more than 24 fl oz of product per acre per application and not more than 72 fl oz per acre per year, with a minimum of 21 days between applications. Apply as needed to control emerged actively growing grasses. Repeat applications may be necessary to control many species. Plants are more susceptible in early stages of development rather than when mature (at seedhead formation).	Controls annual grasses and perennials such as Bermuda, guinea, and torpedo. **Does not control broadleaf weed species.** Repeat applications (at 3–4 week intervals) will be required for guinea grass and torpedograss. Guinea grass should be treated when 6–12 inches tall. **Do not apply Fusilade to grasses under stressed conditions.** Visible effects of herbicide activity on most grasses will be apparent in 2–3 weeks. If used according to label directions, Fusilade will not injure citrus. For spot treatment, use 1% v/v solution Fusilade with 1% crop oil concentrate or 0.25% nonionic surfactant in 30–40 GPA.
Mesotrione Broadworks 4 L	F2	Do not exceed 6 fl oz/ac at the first application. Do not exceed 12 fl oz/ac or more than 3 applications within a 12-month period. Allow at least 12 weeks between two subsequent applications of 6 fl oz/ac each, and at least 6 weeks between one application of 6 fl oz/ac and one or two subsequent applications of 3 fl oz/ac.	The use of a crop oil concentrate at 1% v/v or nonionic surfactant at 0.25% v/v is recommended. The addition of ammonium sulfate is suggested. Provides short-term residual weed control, and can be tank mixed with non-selective postemergence products to broaden the weed control spectrum, or with several preemergence products to lengthen residual weed control. Consult the label for allowable tank-mix partners.
Sethoxydim Poast Plus 1.0 EC	A	2.25–3.75 pt of product per acre. Do not exceed 15 pt per acre per year. Apply as needed to control actively growing grasses. Repeat applications may be necessary for perennial species and guinea grass.	Controls annual and perennial grasses such as Bermuda, guinea, and torpedo. **Does not control broadleaf weeds.** Repeat applications (at 3–4 week intervals) may be required for control of more troublesome species. It is advantageous to apply Poast Plus to grasses less than 12 inches in height. **Do not apply Poast Plus to grasses under stress conditions.** Visible effects will generally be observed within 2–3 weeks, depending upon environmental conditions. Carrier volume should not exceed 20 GPA. For spot treatment use a 1.5%–2.25% v/v solution of Poast Plus with 1% crop oil concentrate. If used according to label directions, Poast Plus will not injure citrus.
Saflufenacil Treevix	E	1.0 oz of product per treated acre as a postemergence-directed spray application. For optimum burndown activity, an adjuvant such as methylated seed oil must be used and should be combined with ammonium sulfate.	Controls many broadleaf weeds. **Does not control grass weeds.** Thorough spray coverage is required for control of emerged broadleaf weeds. Avoid contact with tree trunks, especially young trees, until bark is fully formed. Do not exceed 3 applications per year and applications must be separated by 21 days. Increased efficacy has been observed at spray volumes of 20 to 40 GPA.

[1] Mode of action class for citrus pesticides from the Herbicide Resistance Action Committee (HRAC). Refer to ENY-624, *Pesticide Resistance and Resistance Management*, chapter 4 in the *2020–2021 Florida Citrus Production Guide* for more details.

Table 6. Herbicide chemical family.

Herbicide Common Name	Chemical Family	HRAC MOA[1]	Weeds Controlled	
			Broadleaf	Grasses
Preemergence				
bromacil	uracil	C1		X
bromacil:diuron	uracil + urea	C1, C2	X	X
diuron	urea	C2	X	
flumioxazin	N-phenylphthalimide	E	X	X
indaziflam	alkylazine	L[2]	X	X
norflurazon	pyridazinone	F1	X	X
oryzalin	dinitroaniline	K1		X
pendimethalin	dinitroaniline	K1		X
simazine	triazine	C1	X	X
Postemergence				
carfentrazone-ethyl	aryl triazinone	E	X	
fluazifop-P-butyl	aryloxyphenoxy propionate	A		X
glyphosate	glyphosate	G	X	X
glufosinate	phosphinic acid	H	X	X
glyphosate + 2,4-D	glyphosate + phenoxy	G, O	X	X
mesotrione	triketone	F2	X	
paraquat	paraquat dichloride salt	D	X	X
sethoxydim	cyclohexanedione	A		X
saflufenacil	uracil	E	X	

[1] Mode of action class for citrus pesticides from the Herbicide Resistance Action Committee (HRAC). Refer to ENY-624, *Pesticide Resistance and Resistance Management*, chapter 4 in the *2020–2021 Florida Citrus Production Guide* for more details.
[2] Cellulose-biosynthesis inhibitor

Table 7. Recommended chemical controls for citrus root sprouts.

Herbicide/Chemical	Application	Comments
Glyphosate (check specific product labels)	Apply in 50% to 100% solution to freshly cut surface immediately after cutting to cover the entire cambium layer of the stump. Delays in application may result in reduced performance.	Do not make stump application when roots of desirable trees may be grafted to the roots of the cut stump. Injury may result from root grafting in adjacent trees allowing materials to move systemically into the nearby tree. **NOTE:** Not all glyphosate products contain a statement for stump treatments.
Remedy Ultra	Apply as a 25% solution in diesel, kerosene or quality basal oil (1 qt in 3 qt oil). Apply spray mixture directly to cut stump, and avoid applications that allow spray solution to contact soil surface adjacent to the cut stump.	Applications to the soil adjacent to cut stump may injury newly transplanted trees. Do not replant within 30 days of treatment. Do not make stump applications when the roots of adjacent desirable trees may be grafted to the roots of cut stump. Injury or symptoms resulting from root grafting may occur in adjacent trees. Avoid application methods that would allow spray drift to occur.

2020–2021 Florida Citrus Production Guide: Pesticides Registered for Use on Florida Citrus[1]

Lauren M. Diepenbrock, Megan M. Dewdney, Tripti Vashisth, Ramdas Kanissery, and Stephen H. Futch[2]

The following are lists of products that are registered for use on citrus, regardless of whether or not they are recommended for use. In cases where there are many similar products, such as copper fungicides, sulfurs, or petroleum oils, separate tables have been set up for each. All other products are listed in Table 4 and grouped according to use: 1) insecticides, acaricides, and nematicides, 2) fungicides, 3) herbicides, and 4) other products such as plant growth regulators and fumigants.

READ THE LABEL.

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Table 1. Copper fungicides registered for citrus and the diseases for which they have been evaluated.

Trade Name	Common Name	Cu (%)[1]	EPA Reg. No.	Evaluated for:[2]				
				Melanose	Greasy Spot	Alternaria	Scab	Canker
Americop 40 DF	copper hydroxide	40	35484-4	X	X	ND	ND	X
Badge SC	copper oxychloride + copper hydroxide	20	80289-3-10163	X	X	X	ND	X
Badge X_2	copper oxychloride + copper hydroxide	28.2	80289-12-10163	ND	ND	ND	ND	X
Basic Copper 50W HB	basic copper sulfate	50	42750-168	ND	ND	ND	ND	ND
Basic Copper 53	basic copper sulfate	53	45002-8	ND	ND	ND	ND	ND
Basic Copper Sulfate	basic copper sulfate	53	19713-72	X	ND	ND	ND	ND
Champ DP	copper hydroxide	37.5	55146-57	X	X	X	X	X
Champ Formula 2 Flowable	copper hydroxide	24.4	55146-64	X	X	ND	X	ND
Champ WG	copper hydroxide	50	55146-1	X	ND	ND	ND	X
ChampION++	copper hydroxide	30	55146-115	ND	ND	ND	ND	ND
COC DF	copper oxychloride	50	45002-17	ND	ND	ND	ND	ND
COC WP	copper oxychloride	50	45002-17	ND	ND	ND	ND	X
C-O-C-S WDG	copper oxychloride + basic copper sulfate	51.25	34704-326	ND	ND	ND	ND	ND
Copper-Count-N	copper diammonia diacetate complex	8	10465-3	X	ND	X	ND	ND
Copper Sulfate Crystals	copper sulfate pentahydrate	25.0	56576-1	ND	ND	ND	ND	ND
Triangle Brand Copper Sulfate Instant Powder	copper sulfate pentahydrate	25.2	81882-1	ND	ND	ND	ND	ND
Cueva	copper octanoate	1.8	67702-2-70051	ND	ND	ND	ND	ND
Cuprofix Ultra 40 Disperss	basic copper sulfate	40	70506-201	X	X	ND	ND	X
Cuproxat FL	basic copper sulfate	15.2	55146-151	ND	ND	ND	ND	ND
Cuproxat Flowable	basic copper sulfate	15.2	35935-3	ND	ND	ND	ND	ND
Instill	copper sulfate pentahydrate	5.4	49538-5-92632	ND	ND	ND	ND	ND
Kalmor	copper hydroxide	30	91411-11-59807	ND	ND	ND	ND	ND
Kentan DF	copper hydroxide	40	80289-2	X	ND	X	ND	X
Kocide 2000	copper hydroxide	35	91411-10-70051	X	X	X	X	X
Kocide 3000	copper hydroxide	30	91411-2-70051	X	X	X	X	X
Kocide HCu	copper hydroxide	50.1	91411-2-70051	ND	ND	ND	ND	ND
KOP-Hydroxide	copper hydroxide	24.4	19713-301	ND	ND	ND	ND	ND
KOP-Hydroxide 5	copper sulfate pentahydrate	5	19713-695	ND	ND	ND	ND	ND
KOP-Hydroxide 50W	copper hydroxide	50	19713-321	ND	ND	ND	ND	ND
Magna-Bon CS 2005	copper sulfate pentahydrate	5.0	66675-3	ND	ND	ND	ND	X

Trade Name	Common Name	Cu (%)[1]	EPA Reg. No.	Evaluated for:[2]				
				Melanose	Greasy Spot	Alternaria	Scab	Canker
MasterCop	copper sulfate pentahydrate	5.4	55272-18-66222	ND	ND	ND	ND	ND
Nordox 30/30 WG	cuprous oxide	30	48142-7	ND	ND	ND	ND	X
Nordox 75 WG	cuprous oxide	75	48142-4	ND	ND	ND	ND	X
Nu-Cop 3L	copper hydroxide	24.4	42750-75	ND	ND	ND	ND	ND
Nu-Cop HB	copper hydroxide	50	42750-132	X	X	ND	ND	ND
Nu-Cop 30 HB	copper hydroxide	30	42750-281	ND	ND	ND	ND	ND
Nu-Cop 50 DF	copper hydroxide	50	45002-4	ND	ND	X	ND	ND
Nu-Cop 50 WP	copper hydroxide	50	45002-7	ND	ND	ND	ND	X
Phyton 27 AG[3]	copper sulfate pentahydrate	5.4	49538-5	ND	ND	ND	ND	ND
Previsto	copper hydroxide	3.3	10163-330	ND	ND	ND	ND	ND
Quimag Copper Sulfate Crystals	copper sulfate pentahydrate	25.2	73385-1	ND	ND	ND	ND	ND
Stretch	copper hydroxide	2.16	68292-3	ND	ND	ND	ND	ND
Top-Cop with Sulfur	tribasic copper sulfate + sulfur	4.4	57538-6	ND	ND	ND	ND	ND

[1] Percentage of metallic copper.
[2] X —Products indicated have been evaluated and have provided adequate control of the disease in question; ND—No data. Most of the products would be expected to provide adequate disease control.
[3] Do not apply with oil because of phytotoxicity risk.

Table 2. Sulfur products registered for use on citrus and spectrum of activity against pest mites on citrus in Florida.

Trade Name and Formulation	Common Name	% Sulfur	EPA Reg. No.	Registered[1] for Use on		Efficacy[2]	
				Citrus Rust Mite	Broad Mite	Citrus Rust Mite	Broad Mite
Citrusperse Sulfur	sulfur	90%	5905-350	X	–	ID	ID
Cosavet DF	sulfur	80%	70905-1	X	–	ID	ID
Dusting Sulfur	sulfur	98%	34704-735	X	–	ID	ID
Kolodust	sulfur	84%	34704-733	X	–	ID	ID
Kumulus DF	sulfur	80%	51036-352	X	X	+	+
Liquid Sulfur Six	sulfur	52%	5905-437	X	–	ID	ID
Micro Sulf	(micronized) sulfur	80%	55146-75	X	X	ID	ID
Micronized Gold	(micronized) sulfur	90%	19713-238	X	X	+	+
Microthiol Disperss	(micronized) sulfur	80%	4581-373	X	X	+	+
Microthiol 80 DF	(micronized) sulfur	80%	4581-373	X	X	+	+
Sulfur 6 F	sulfur	52%	51036-16-34704	X	X	+	ID
Sulfur 6 L	sulfur	52%	51036-16-9779	X	X	+	ID
Sulfur Flowable 6	sulfur	52%	51306-16-34704	X	X	+	ID
Sulfur 6 L	sulfur	52%	51306-16	X	X	+	ID
Sulfur 6 FL	sulfur	52%	34704-70	X	–	ID	ID
Sulfur 90 W	(micronized) sulfur	90%	19713-238	X	X	ID	ID
Super Six	sulfur	52%	65343-1	X	–	ID	ID
Thiolux	(micronized) sulfur	80%	100-835	X	–	ID	ID
Thiolux Jet	(micronized) sulfur	80%	100-1138	X	–	ID	ID
Thiosperse 80% (CSC)	(micronized) sulfur	80%	55429-4	X	–	ID	ID
Yellow Jacket Wettable Sulfur	sulfur	90%	6325-13	X	–	ID	ID

[1] X indicates product registered for control of citrus rust or broad mites; – = not registered.
[2] + indicates product is effective; ID indicates incomplete data available; sulfurs are generally effective for false spider mites and ineffective for spider mites, while efficacy data on pink citrus rust mites are incomplete.

Table 3. Spray oils registered for use on Florida citrus.

Company	Trade Name	Midpoint Boiling Range	EPA No.[1]	Efficacy[2]	
				Greasy Spot	Citrus Rust Mite
Brandt	TresOil	435°F	48813-1	ID	ID
BVA	Spray 10	412°F	55206-1	ID	ID
BVA	Spray 13	435°F	55206-2	+	+
BVA	Spray 15	455°F	55206-3	+	+
BVA	Spray 22	471°F[3]	55206-4	ID	ID
Calumet	Orchex 692	415°F	75652-2	ID	ID
Calumet	Orchex 796	435°F	75652-1	+	+
Diamond R	435 Soluble Oil	435°F	35276-1	ID	ID
Drexel	435 Oil 98.8	435°F	19713-394	ID	ID
Drexel	455 Oil 98.8	455°F	19713-396	ID	ID
Helena Chemical	Sol-Oil 97	435°F	5905-294	ID	+
Helena Chemical	Mite-E-Oil	435°F	5905-302	+	+
Loveland Products	BioCover UL	415°F	34704-806	ID	+
Loveland Products	BioCover MLT	435°F	34704-805	+	+
Loveland Products	BioCover LS	455°F	34704-808	+	+
Loveland Products	BioCover SS	470°F[3]	34704-809	+	+
Loveland Products	Glacial Spray Fluid	435°F	34704-849	ID	ID
Petro-Canada	PureSpray Green	435°F	69526-9	ID	ID
Petro-Canada	PureSpray spray oil 10E	408°F	69526-5	ID	ID

[1] Most oils are registered for use against citrus rust mite, greasy spot, spider mites, scale insects, whitefly, and other homopterans, and for removal of sooty mold.
[2] + = effective; – = not effective; ID = incomplete data; Orchex 796 has been found to control pink citrus rust mite without harm to beneficial mites; others have not been tested.
[3] 470 weight oils have not been evaluated for their effects on fruit coloring or ripening and are more likely to be phytotoxic than lighter oils.

Table 4. Pesticides registered for use on Florida citrus—insecticides, acaricides, and nematicides

Trade Name or Generic Name	Common Name (IRAC MOA)[9]	EPA Registration Number[1]	Tolerance Fruit (ppm)	Days to Harvest	Field Posting Required[2]	REI Hr	EPCRA[3] TPQ (lb a.i.)[4] 1	EPCRA[3] TPQ (lb a.i.)[4] 2	EPCRA[3] RQ (lb a.i.)[5]
Abacus	Abamectin (6)	81578-1 83100-4-83979	0.02	7	NO	12	-	10,000	-
Other Use Requirements: RESTRICTED PESTICIDE.[7] Toxic to fish, mammals, and aquatic organisms. Highly toxic to honeybees.[6] Limit of 3 applications of abamectin per growing season. Do not apply more than 40 fl oz/ac (0.047 lb a.i./ac) of any abamectin product in a growing season.									
Abamectin E-AG 0.15 EC	Abamectin (6)	79676-58	0.02	7	NO	12	-	10,000	-
Other Use Requirements: RESTRICTED PESTICIDE.[7] Toxic to fish, mammals, and aquatic organisms. Highly toxic to honeybees.[6] Limit of 3 applications of abamectin per growing season. Do not apply more than 40 fl oz/ac (0.047 lb a.i./ac) of any abamectin product in a growing season.									
ABBA 0.15EC	Abamectin (6)	72167-43-73220 72167-43-66222 66222-139	0.02	7	No	12	-	10,000	-
Other Use Requirements: RESTRICTED PESTICIDE.[7] Toxic to fish, mammals, and aquatic organisms. Highly toxic to honeybees.[6] Limit of 3 applications of abamectin per growing season. Do not apply more than 40 fl oz/ac (0.047 lb a.i./ac) of any abamectin product in a growing season.									
Acephate products									
Other Use Requirements: Do not harvest citrus for one year after treatment. Minimum 3 days spray interval for up to 0.5 lb a.i./ac and 7 days for rates greater than 0.5 lb a.i./ac.									
Acephate 75	Acephate (1B)	70506-1-55467	Nonbearing	12 months	NO	24	-	10,000	-
Acephate 75 WSP		70506-1							
Acephate 90 SP		51036-238							
Acephate 90 WSP		34704-862							
Acephate 97		70506-8-55467							
Acephate 97 UP		70506-8							
Other Use Requirements: Do not harvest citrus for one year after treatment. Minimum 3 days spray interval for up to 0.5 lb a.i./ac and 7 days for rates greater than 0.5 lb a.i./ac.									
Acramite-50WS	Bifenazate (UN)	400-503	Nonbearing	12 months	NO	12	-	-	-
Other Use Requirements: One application per year.									
Actara 25 WG	Thiamethoxam (4A)	100-938	0.4	0	NO	12	-	-	-
Other Use Requirements: Do not exceed a total of 11.0 oz/ac (0.172 lb a.i./ac) of Actara or 0.172 lb a.i. of thiamethoxam-containing products per acre per growing season. Do not apply during pre-bloom or during bloom when bees are actively foraging.									
Admire 2 F (see also Provado)	Imidacloprid (4A)	264-758	0.7	0	NO	12	-	-	-
Other Use Requirements: Highly toxic to honeybees.[6] Toxic to aquatic invertebrates. Limit to 32 oz/ac/year (0.5 lb a.i./ac/year).									
Admire Pro	Imidacloprid (4A)	00264-00827	0.7	0	NO	12	-	-	-
Other Use Requirements: Highly toxic to honeybees.[6] Toxic to aquatic invertebrates. Limit to 14 oz per acre per season (0.5 lb a.i./ac/year). SLN FL-120008, permits up to 1.0 lb a.i. per acre per 12 months when applied as a soil drench. See SLN label for specific details.									

<table>
<tr><th rowspan="3">Trade Name or Generic Name</th><th rowspan="3">Common Name (IRAC MOA)[9]</th><th rowspan="3">EPA Registration Number[1]</th><th rowspan="3">Tolerance Fruit (ppm)</th><th rowspan="3">Days to Harvest</th><th rowspan="3">Field Posting Required[2]</th><th rowspan="3">REI Hr</th><th colspan="3">EPCRA[3]</th></tr>
<tr><th colspan="2">TPQ (lb a.i.)[4]</th><th rowspan="2">RQ (lb a.i.)[5]</th></tr>
<tr><th>1</th><th>2</th></tr>
<tr><td>Advise 2 FL</td><td>Imidacloprid (4A)</td><td>1381-205</td><td>0.7</td><td>0</td><td>NO</td><td>12</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td colspan="10">Other Use Requirements: Highly toxic to honeybees.[6] Toxic to aquatic invertebrates. Limit to 32 oz/acre/year (0.5 lb a.i./ac/year).</td></tr>
<tr><td>Agri-Flex miticide/ insecticide</td><td>Abamectin (6)
Thiamethoxam (4A)</td><td>100-1350</td><td>0.02
0.4</td><td>7</td><td>NO</td><td>12</td><td>-</td><td>10,000</td><td>-</td></tr>
<tr><td colspan="10">Other Use Requirements: RESTRICTED USE PESTICIDE.[7] Toxic to fish, mammals, and aquatic organisms. Do not apply during pre-bloom or during bloom when bees are actively foraging. To avoid illegal residues, Agri-Flex must be mixed with a minimum of 0.20% oil. Do not apply more than 17 fl oz/ac of Agri-Flex or more than 0.047 lb a.i./ac of any foliar-applied abamectin product or more than 0.172 lb a.i./ac of any foliar-applied thiamethoxam product per growing season. Do not make more than 3 applications of Agri-Flex or other foliar-applied abamectin-containing product per growing season. Refer to product label for additional use requirements.</td></tr>
<tr><td>Agri-Mek 0.15 EC</td><td>Abamectin (6)</td><td>100-898</td><td>0.02</td><td>7</td><td>NO</td><td>12</td><td>-</td><td>10,000</td><td>-</td></tr>
<tr><td colspan="10">Other Use Requirements: RESTRICTED PESTICIDE.[7] Toxic to fish, mammals, and aquatic organisms. Highly toxic to honeybees.[6] Limit of 3 applications of abamectin per growing season. Do not apply more than 40 fl oz/ac (0.047 lb a.i./ac) of any abamectin product in a growing season.</td></tr>
<tr><td>Agri-mek SC</td><td>Abamectin (6)</td><td>100-1351</td><td>0.02</td><td>7</td><td>NO</td><td>12</td><td>-</td><td>10,000</td><td>-</td></tr>
<tr><td colspan="10">Other Use Requirements: RESTRICTED PESTICIDE.[7] Toxic to fish, mammals, and aquatic organisms. Highly toxic to honeybees.[6] Limit of 3 applications of abamectin per growing season. Do not apply more than 8.5 fl oz/ac of Agri-mek SC or 0.047 lb a.i./ac of any abamectin-containing product per growing season.</td></tr>
<tr><td>Alias 2F</td><td>Imidacloprid (4A)</td><td>00264-00758-66222</td><td>0.07</td><td>0</td><td>NO</td><td>12</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td colspan="10">Other Use Requirements: Highly toxic to honeybees.[6] Toxic to aquatic invertebrates. Limit to 32 oz per acre per season (0.5 lb a.i./ac/year).</td></tr>
<tr><td>Altacor</td><td>Chlorantraniliprole (28)</td><td>352-730</td><td>1.4</td><td>1</td><td>NO</td><td>4</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td colspan="10">Other Use Requirements: Do not make more than 3 applications per season. Do not apply more than 9 oz of Altacor or 0.2 lb a.i. of chlorantraniliprole-containing product per acre per crop season.</td></tr>
<tr><td>Apta</td><td>Tolfenpyrad (21A)</td><td>71711-36</td><td>1.5</td><td>14</td><td>NO</td><td>12</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td colspan="10">Other Use Requirements: Do not apply more than 27.0 fl oz per acre per growing season. Do not make more than 2 applications per year. Do not apply by air.</td></tr>
<tr><td>Applaud 70DF IGR</td><td>Buprofezin (16)</td><td>71711-21</td><td>2</td><td>3</td><td>NO</td><td>12</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td colspan="10">Other Use Requirements: Limit to 2 applications per year.</td></tr>
<tr><td>Assail 30SG</td><td>Acetamiprid (4A)</td><td>08033-00036-82695
8033-36-70506</td><td>0.5</td><td>7</td><td>NO</td><td>12</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td colspan="10">Other Use Requirements: Limit to 5 applications per year. Limit to 0.55 lb a.i. or 29.3 oz of product per acre per crop.</td></tr>
<tr><td>Assail 70WP</td><td>Acetamiprid (4A)</td><td>8033-23-4581</td><td>0.5</td><td>7</td><td>NO</td><td>12</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td colspan="10">Other Use Requirements: Limit to 5 applications per year. Limit to 0.55 lb a.i. or 12.5 oz of product per acre per crop.</td></tr>
<tr><td>Atrapa
(see also Fyfanon and Malathion)</td><td>Malathion (1B)</td><td>(ULV) 1812-407
(5E) 1812-406
(8E) 1812-408
67760-34-1381</td><td>8.0</td><td>7</td><td>NO</td><td>12</td><td>-</td><td>10,000</td><td>100</td></tr>
<tr><td colspan="10">Other Use Requirements: Toxic to aquatic invertebrates; highly toxic to honeybees.[6] Do not apply directly to water. Undiluted droplets will damage vehicle finishes. Unless written informed consent is obtained from adjacent landowners, ground application equipment must be used.</td></tr>
</table>

Trade Name or Generic Name	Common Name (IRAC MOA)[9]	EPA Registration Number[1]	Tolerance Fruit (ppm)	Days to Harvest	Field Posting Required[2]	REI Hr	EPCRA[3]		
							TPQ (lb a.i.)[4]		RQ (lb a.i.)[5]
							1	2	
Award	Fenoxycarb (7B)	100-722	Nonbearing	12 months	NO	12	-	10,000	-
Other Use Requirements: Limit to 2 applications per year.									
Aza-Direct	Azadirachtin (UN)	71908-1-10163	Exempt	0	NO	4	-	-	-
Other Use Requirements: None									
Azatin XL	Azadirachtin (UN)	70051-27-59807	Exempt	0	NO	4	-	-	-
Other Use Requirements: None									
Azatrol EC	Azadirachtin (UN)	2217-836	Exempt	0	NO	4	-	-	-
Other Use Requirements: None									
Bacillus thuringiensis			Exempt	0	NO	4	-	-	-
Agree	B.t. aizawai Strain GC-91 (11)	70051-47							
Biobit HP	B.t. kurstaki Strain ABTS-351	73049-54							
Condor	B.t. kurstaki Strain EG2348	70051-78							
Crymax	B.t. kurstaki Strain EG7841	70051-86							
Deliver	B.t. kurstaki	70051-69							
DiPel DF	B.t. kurstaki Strain H0-1	73049-39							
Javelin WG	B.t. kurstaki	70051-66							
Lepinox WDG	B.t. kurstaki Strain EG7826	70051-89							
XenTari DF	B.t. aizawai Strain ABTS-1857	73049-40							
Other Use Requirements: None									
Baythroid XL							-	-	-
Baythroid	Beta-cyfluthrin (3A)	264-840	0.2	0	NO	12	-	-	-
Other Use Requirements: RESTRICTED PESTICIDE.[7] Toxic to aquatic invertebrates; highly toxic to honeybees.[6] Do not apply directly to water.									
Belay	Clothianidin (4A)	5939-15 (WDG) 59639-152	0.07	365	NO	12	-	-	-
Belay 50 WDG							-	-	-
Other Use Requirements: Do not harvest citrus for one year after treatment. Toxic to aquatic invertebrates; highly toxic to honeybees up to 5 days post application.[6] Do not apply directly to water.									

Trade Name or Generic Name	Common Name (IRAC MOA)[9]	EPA Registration Number[1]	Tolerance Fruit (ppm)	Days to Harvest	Field Posting Required[2]	REI Hr	EPCRA[3] TPQ (lb a.i.)[4] 1	EPCRA[3] TPQ (lb a.i.)[4] 2	EPCRA[3] RQ (lb a.i.)[5]
Bifenthrin EC Bifenthrin 2 EC AG	Bifenthrin (3B)	70506-57 66330-336	0.05	1	NO	12	-	10,000	-
Other Use Requirements: RESTRICTED PESTICIDE.[7] Use as a soil barrier application; do not allow application to contact fruit or foliage. Apply only to individual citrus resets, not solid planted rows. Do not apply more than 0.5 lb a.i./ac/year.									
Bifenture EC	Bifenthrin (3B)	70506-57	0.05	1	NO	12	-	-	-
Other Use Requirements: RESTRICTED PESTICIDE.[7] Use as a soil barrier application; do not allow application to contact fruit or foliage. Apply only to individual citrus resets, not solid planted rows. Do not apply more than 0.5 lb a.i./ac/year.									
BioVector 355	*Steinernema riobravis* (NR)	NA	Exempt	-	-	-	-	-	-
Other Use Requirements: None									
Bracket 90	Acephate (1B)	51036-238-9779	Nonbearing	12 months	NO	24	-	10,000	-
Other Use Requirements: Do not harvest citrus for one year after treatment. Minimum 3 days spray interval for up to 0.5 lb a.i./ac and 7 days for rates greater than 0.5 lb a.i./ac.									
Brigade 2 EC	Bifenthrin (3B)	279-3313	0.05	1	NO	12	-	10,000	-
Other Use Requirements: RESTRICTED PESTICIDE.[7] Use as a soil barrier application; do not allow application to contact fruit or foliage. Apply only to individual citrus resets, not solid planted rows. Do not apply more than 0.5 lb a.i./ac/year.									
Brigade WSB	Bifenthrin (3B)	00279-03108	0.05	1	NO	12	-	10,000	-
Other Use Requirements: RESTRICTED PESTICIDE.[7] Soil application only. Do not allow contact with fruit or foliage. Toxic to fish and aquatic organisms; highly toxic to honeybees.									
Capture 2EC	Bifenthrin (3B)	279-3069	0.05	1	NO	12	-	-	-
Other Use Requirements: Use as a soil barrier application; do not allow application to contact fruit or foliage. Apply only to individual citrus resets, not solid planted rows. Do not apply more than 0.5 lb a.i./ac/year.									
Carbaryl (see also Sevin)	Carbaryl (1A)	(4L) 19713-49, 34704-447 (80S) 19713-50	10	5	NO	12	10	10,000	1
Other Use Requirements: Highly toxic to aquatic invertebrates and honeybees.[6] Do not apply more than 20 qt per acre per crop.									
Cheminova Acephate 75 SP	Acephate (1B)	59639-26-67760	Nonbearing	12 months	NO	24	-	10,000	-
Other Use Requirements: Do not harvest citrus for one year after treatment. Minimum 3 days spray interval for up to 0.5 lb a.i./ac and 7 days for rates greater than 0.5 lb a.i./ac.									
Chlorpyrifos (see also Lorsban)	Chlorpyrifos (1B)	(15G) 51036-300, 19713-505 (4E AG) 51036-291, 66222-19	1	Foliar—21 Soil—28	NO	5 days	100	10,000	1
Other Use Requirements: RESTRICTED PESTICIDE.[7] Toxic to fish, aquatic organisms, mammals, and birds. Limit 2 applications per season.									
Clinch Ant Bait	Abamectin (6)	100-894	0.02	0	NO	12	-	-	-
Other Use Requirements: None									
Comite	Propargite (12C)	400-104	5	21	YES	7 days	-	10,000	10
Other Use Requirements: Do not mix with oil, products with petroleum-based solvents, lime, or lime sulfur. Do not apply within 2 weeks of oil application. Avoid application to immature leaves and fruit. After 48 hours, workers may enter treated area if they wear proper personal protective equipment. Limit 2 applications per season. Toxic to fish.									

Trade Name or Generic Name	Common Name (IRAC MOA)[9]	EPA Registration Number[1]	Tolerance Fruit (ppm)	Days to Harvest	Field Posting Required[2]	REI Hr	EPCRA[3]		
							TPQ (lb a.i.)[4]		RQ (lb a.i.)[5]
							1	2	
Couraze 1.6F	Imidacloprid (4A)	264-763-67760	0.7	0	NO	12	-	-	-
Other Use Requirements: Highly toxic to honeybees.[6] Toxic to aquatic invertebrates. Limit to 32 oz per acre per season.									
Couraze 2F	Imidacloprid (4A)	264-758-67760	0.7	0	NO	12	-	-	-
Other Use Requirements: Highly toxic to honeybees.[6] Toxic to aquatic invertebrates. Limit to 32 oz per acre per season.									
Cryolite 96, Prokil	Cryolite (UN)	10163-41	7	15	NO	12	-	-	-
Other Use Requirements: Do not mix with lime, compounds containing free lime, or calcium foliar nutrients. Minimum of 30 days between applications.									
Danitol 2.4 EC Spray	Fenpropathrin (3A)	59639-35	2	1	NO	24	-	10,000	100
Other Use Requirements: RESTRICTED PESTICIDE.[7] Toxic to fish, aquatic organisms, and honeybees. Do not apply during bloom.									
Delegate WG	Spinetoram (5)	62719-541	0.3	1	NO	4	-	-	-
Other Use Requirements: Do not apply more than 12 oz of product (0.188 lb a.i.) per acre per season. Do not make more than 3 applications per calendar year.									
Dibrom 8 Emulsive	Naled (1B)	5481-479	3	7	NO	48	-	10,000	10
Other Use Requirements: RESTRICTED PESTICIDE.[7] Limit 1 pint per acre in Florida. Do not use with highly alkaline materials such as lime or Bordeaux.									
Dimate 4 EC	Dimethoate (1B)	51036-110-9779 9779-273	2	15–45 (depending on rate)	YES[10]	10 days	500	10,000	10
Other Use Requirements: Limit to 2 applications to mature fruit. Highly toxic to honeybees.[6] Toxic to aquatic organisms.									
Dimethoate	Dimethoate (1B)		2	15–45 (depending on rate)	YES[10]	10 days	500	10,000	10
2.67		19713-232							
2.67 EC		34704-489							
267		51036-198							
4 EC		5905-493							
4 EC		19713-231							
4		10163-160							
400		34704-207							
4 E		51036-110, 34704-207-67760, 66330-223							
5 lb		5905-497							
E 267		10163-56							
Other Use Requirements: Limit to 2 applications to mature fruit. Highly toxic to honeybees.[6] Toxic to aquatic organisms.									
Distance	Pyriproxyfen (7C)	59639-96	Nonbearing	12 months	NO	12	-	10,000	100
Other Use Requirements: Limit 2 applications per season.									

Trade Name or Generic Name	Common Name (IRAC MOA)[9]	EPA Registration Number[1]	Tolerance Fruit (ppm)	Days to Harvest	Field Posting Required[2]	REI Hr	EPCRA[3]		
							TPQ (lb a.i.)[4]		RQ (lb a.i.)[5]
							1	2	
Distance Fire Ant Bait	Pyriproxyfen (7C)	1021-1728-59639	Nonbearing	12 months	NO	12	-	-	-
Other Use Requirements: None									
DiTera ES DiTera DF	*Myrothecium verrucaria* (NR)	73049-43 73049-67	Exempt	0	NO	4	-	-	-
Other Use Requirements: None									
Ecotrol EC	Peppermint oil Rosemary oil	Exempt	Exempt	0	NO	0	-	-	-
Other Use Requirements: None									
Ecozin 3% EC	Azadirachtin (UN)	5481-476	Exempt	0	NO	12	-	-	-
Other Use Requirements: None									
Entrust	Spinosad (5)	62719-282	0.3	1	NO	4	-	-	-
Other Use Requirements: Limit to 2 applications per year. Limit to 9 oz of product (0.45 lb a.i. spinosad) per acre per season.									
Envidor 2SC	Spirodiclofen (23)	00264-00831	0.5	7	NO	12	-	-	-
Other Use Requirements: Limit to 1 application per year. Limit to 20 oz product per acre per season.									
Epi-mek 0.15EC	Abamectin (6)	00100-01154	0.02	7	NO	12	-	10,000	-
Other Use Requirements: RESTRICTED PESTICIDE.[7] Toxic to fish, mammals, and aquatic organisms. Highly toxic to honeybees.[6] Limit of 3 applications of abamectin per growing season. Do not apply more than 40 fl oz/ac (0.047 lb a.i./ac) of any abamectin product in a growing season.									
Esteem Ant Bait	Pyriproxyfen (7C)	59639-114	0.3	1	NO	12	-	-	-
Other Use Requirements: None									
Esteem 0.86 EC	Pyriproxyfen (7C)	59639-95	0.3	1	NO	12	-	10,000	100
Other Use Requirements: Limit to 2 applications per season. Limit to 26 fl oz per acre per season.									
Evergreen EC 60-6	Pyrethrins + piperonyl butoxide (3A)	01021-01770	Pyrethrins (1) Piperonyl butoxide (8)	0	NO	12	10,000	-	1
Other Use Requirements: None									
Exirel	Cyantraniliprole (28)	352-859	0.70	1	NO	12	-	-	-
Other Use Requirements: Do not apply a total of more than 0.4 lb a.i./ac of any cyantraniliprole-containing product per year. See label for pollinator restrictions.									
Extinguish	Methoprene (7A)	2724-475	Exempt	0	NO	4	-	-	-
Other Use Requirements: None									
Fanfare 2EC	Bifenthrin (3A)	66222-99	0.05	1	NO	12	-	10,000	-
Other Use Requirements: RESTRICTED PESTICIDE.[7] Soil application only. Do not allow contact with fruit or foliage. Toxic to fish and aquatic organisms. Highly toxic to honeybees.[6]									

Trade Name or Generic Name	Common Name (IRAC MOA)[9]	EPA Registration Number[1]	Tolerance Fruit (ppm)	Days to Harvest	Field Posting Required[2]	REI Hr	EPCRA[3] TPQ (lb a.i.)[4] 1	EPCRA[3] TPQ (lb a.i.)[4] 2	EPCRA[3] RQ (lb a.i.)[5]
Fyfanon (see also Malathion and Atrapa)	Malathion (1B)	(56.4%) 5905-196 (8 lb emulsion) 5905-250-ZA (ULV) 67760-34 SLN FL-40004	8	7	NO	12	-	10,000	100
Other Use Requirements: Highly toxic to honeybees.[6]									
GF-120 GF-120 NF	Spinosad (5)	62719-359 62719-498	0.3	0	NO	4	-	-	-
Other Use Requirements: Toxic to aquatic invertebrates. Do not apply directly to water.									
Govern 4 E	Chlorpyrifos (1B)	62719-220-55467	1	21	YES	5 days	100	10,000	1
Other Use Requirements: RESTRICTED PESTICIDE.[7]									
Imida E-AG 2 F	Imidacloprid (4A)	81959-22	0.7	0	NO	12	-	-	-
Other Use Requirements: Highly toxic to honeybees.[6] Toxic to aquatic invertebrates. Limit to 32 oz/acre/year (0.5 lb a.i./ac/year).									
Imidan 70-W	Phosmet (1B)	10163-169 SLN FL-10006	5	7	NO	24	10	-	10
Other Use Requirements: Limit 5 applications per year. Toxic to fish and aquatic organisms. Highly toxic to honeybees.[6]									
Impulse 1.6 FL	Imidacloprid (4)	42750-109	0.7	0	NO	12	-	-	-
Other Use Requirements: Highly toxic to honeybees.[6] Toxic to aquatic invertebrates. Limit to 40 oz/acre/year (0.5 lb a.i./ac/year).									
Intrepid 2F	Methoxyfenozide (18)	62719-442	10	1	NO	4	-	-	-
Other Use Requirements: 24(c) SLN-FL-100001; do not apply more than 16 fl oz per acre per application or 64 fl oz of Intrepid 2F (1 lb a.i.) per acre per season. Do not apply within 14 days of last application.									
Justice Fire Ant Bait	Spinosad (5)	62719-00329	0.3	0	NO	4	-	-	-
Other Use Requirements: None									
Kanemite 15SC	Acequinocyl (20B)	66330-00038	0.2	7	NO	12	-	-	-
Other Use Requirements: None									
Knack IGR	Pyriproxyfen (7C)	59639-95	0.3	1	NO	12	-	10,000	100
Other Use Requirements: Limit to 2 applications per season. Limit to 26 fl oz product per acre per season.									
Kryocide	Cryolite (UN)	4581-116	7	15	NO	12	-	-	-
Other Use Requirements: Limit to 90 lb per acre per season.									
Lorsban (see also Chlorpyrifos)	Chlorpyrifos (1B)	(4E) 62719-220 (Advanced) 62719-591 (50-W) 62719-221, 62719-221-10163 (15G) 62719- 34 (75WG) 62719-301, 62719- 301-10163	1	Foliar—21 Soil—28	YES[10]	5 days	100	10,000	1
Other Use Requirements: Foliar—Highly toxic to honeybees.[6] Limit to 2 applications/season with 30-day interval. Soil—Limit to 3 applications/season with maximum of 10 qt/ac/season. 4E Formulation is RESTRICTED PESTICIDE.[7]									

Trade Name or Generic Name	Common Name (IRAC MOA)[9]	EPA Registration Number[1]	Tolerance Fruit (ppm)	Days to Harvest	Field Posting Required[2]	REI Hr	EPCRA[3]		
							TPQ (lb a.i.)[4]		RQ (lb a.i.)[5]
							1	2	
Macho 2.0 FL	Imidacloprid (4A)	42750-110	0.7	0	NO	12	-	-	-
Other Use Requirements: Highly toxic to honeybees.[6] Toxic to aquatic invertebrates. Limit to 32 oz/ac/year (0.5 a.i./ac/year).									
Malathion (see also Fyfanon and Atrapa)	Malathion (1B)		8	7	NO	12	-	10,000	100
5		9779-5							
5 EC		51036-104, 1386-124							
57 EC		34704-108							
8 Aquamul		34704-474							
8 E		34704-452							
8 EC		34704-119, 51036-214							
8 Flowable		10163-21							
8 Spray		2935-83							
Other Use Requirements: Highly toxic to honeybees.[6]									
MBI-203 EP	Chromobacterium subtsugae	84059-10	EXEMPT	0	NO	4	-	-	-
Other Use Requirements: Highly toxic to honeybees[6]; do not apply during bloom.									
Micromite 25WS Micromite 4L Micromite 80WGS	Diflubenzuron (15)	400-471 400-476 (SLN-FL-960014) 400-487	0.5	21	NO	12	-	10,000	-
Other Use Requirements: RESTRICTED PESTICIDE.[7] Toxic to aquatic invertebrates.									
Minecto Pro	Cyantraniliprole (28) Abamectin (6)	100-1592	0.70 0.002	7	NO	12	-	-	-
Other Use Requirements: Do not apply more than 0.4 lb a.i. per calendar year of any cyantraniliprole-containing product. Do not apply from onset of flowering until petal fall is complete.									
Mocap EC	Ethoprop (1B)	264-458 SLN-FL-870001	Nonbearing	12 months	YES	48	1,000	10,000	100
Other Use Requirements: RESTRICTED PESTICIDE.[7] Acute dermal toxicity.									
Montana 2F	Imidacloprid (4A)	83100-7-83979	0.7	0	NO	12	-	-	-
Other Use Requirements: Highly toxic to honeybees.[6] Toxic to aquatic invertebrates. Limit to 32 oz/ac/year (0.5 lb a.i./ac/year).									
Movento	Spirotetramat (23)	264-1050	0.6	1	NO	24	-	-	-
Other Use Requirements: Do not apply more than 20 fl oz/ac (0.32 lb a.i./ac) per crop season. Do not apply within 10 days prior to bloom, during bloom, or until petal fall is complete.									
Movento MPC	Spirotetramat (23)	264-1065	0.6	1	NO	24	-	-	-
Other Use Requirements: Do not apply more than 32 fl oz/ac (0.32 lb a.i./ac) per growing season. Do not apply within 10-days of bloom, during bloom, or until petal fall is complete.									

Trade Name or Generic Name	Common Name (IRAC MOA)[9]	EPA Registration Number[1]	Tolerance Fruit (ppm)	Days to Harvest	Field Posting Required[2]	REI Hr	EPCRA[3] TPQ (lb a.i.)[4] 1	EPCRA[3] TPQ (lb a.i.)[4] 2	EPCRA[3] RQ (lb a.i.)[5]
M-Pede	Potassium salts of fatty acids	53219-6 15G62119-34 62719-515	Exempt	0	NO	12	-	-	-
Other Use Requirements: Do not mix with chlorothalonil, Formetanate hydrochloride, Fosetyl-Al, gibberellic acid, Mancozeb, or sulfur.									
Mustang Insecticide	Zeta-cypermethrin (3A)	279-3126	0.35	1	NO	12	-	10,000	-
Other Use Requirements: RESTRICTED PESTICIDE.[7] Do not make more than 4 applications (0.20 lb a.i.) per crop season. Do not make applications less than 14 days apart. Highly toxic to honeybees[6]; do not apply during bloom.									
Mustang Max EW	Zeta-cypermethrin (3A)	279-3328	0.35	1	NO	12	-	10,000	-
Other Use Requirements: RESTRICTED PESTICIDE.[7] Do not make more than 4 applications (0.10 lb a.i.) per crop season. Do not make applications less than 14 days apart. Highly toxic to honeybees[6]; do not apply during bloom.									
Neemix 4.5	Azadirachtin (UN)	70051-9	Exempt	0	NO	12	-	-	-
Other Use Requirements: None									
Nexter Miticide/ Insecticide	Pyridaben (21A)	81880-4-10163	0.5	7	NO	12	-	-	-
Other Use Requirements: Highly toxic to honeybees[6] and fish. Do not exceed 2 applications/season. Do not apply by air or handgun.									
Nufos 15G	Chlorpyrifos (1B)	67760-14	1	28	YES	24	-	-	1
Other Use Requirements: Limit 3 applications per year.									
Nufos 4E	Chlorpyrifos (1B)	67760-28	1	21	YES	5 days	1,000	10,000	1
Other Use Requirements: RESTRICTED PESTICIDE.[7] Limit 2 applications per season.									
Nuprid 1.6F	Imidacloprid (4A)	228-488	0.7	0	NO	12	-	-	-
Other Use Requirements: Highly toxic to honeybees.[6] Toxic to aquatic invertebrates. Limit to 32 oz per acre per season (0.5 lb a.i./ac/year).									
Nuprid 2F	Imidacloprid (4A)	228-484	0.7	0	NO	12	-	-	-
Other Use Requirements: Highly toxic to honeybees.[6] Toxic to aquatic invertebrates. Limit to 32 oz per acre per season (0.5 lb a.i./ac/year).									
Nuprid 4.6F Pro	Imidacloprid (4A)	228-527	0.7	0	NO	12	-	-	-
Other Use Requirements: Highly toxic to honeybees.[6] Toxic to aquatic invertebrates. Limit to 14 fl oz per acre per season (0.5 lb a.i./ac/year).									
Omite-30WS Omite-CR	Propargite (12C)	400-427 400-426	Nonbearing	12 months	YES	28 days	-	10,000	10
Other Use Requirements: After 48 hours, workers may enter treated area if they wear proper personal protective equipment. Limit 2 applications per season.									
OR-Cal Slug & Snail Bait	Metaldehyde	71096-7	0.26	0	NO	12	-	-	-
Other Use Requirements: None									

Trade Name or Generic Name	Common Name (IRAC MOA)[9]	EPA Registration Number[1]	Tolerance Fruit (ppm)	Days to Harvest	Field Posting Required[2]	REI Hr	EPCRA[3] TPQ (lb a.i.)[4] 1	EPCRA[3] TPQ (lb a.i.)[4] 2	EPCRA[3] RQ (lb a.i.)[5]
Orthene	Acephate (1B)	(75 S) 59639-26 (97) 59639-91	Nonbearing	12 months	NO	24	10	10,000	1
Other Use Requirements: Highly toxic to honeybees.[6] Toxic to fish and birds. Do not harvest citrus for one year after treatment. Minimum 3 days spray interval for up to 0.5 lb a.i./ac and 7 days for rates greater than 0.5 lb a.i./ac.									
Pasada 1.6F	Imidacloprid (4A)	00264-00763-66222	0.7	0	NO	12	-	-	-
Other Use Requirements: Highly toxic to honeybees.[6] Highly toxic to aquatic invertebrates. Limit to 32 oz per acre per season (0.5 lb a.i./ac/year).									
Platinum 75 SG	Thiamethoxam (4A)	100-1291	0.4	0	NO	12	-	-	-
Other Use Requirements: Do not exceed a total of 3.67 oz/ac (0.172 lb a.i./ac) of Platinum 75 SG or 0.172 lb a.i. of thiamethoxam-containing products per acre per growing season. Do not apply during prebloom or during bloom when bees are actively foraging.									
Portal	Fenpyroximate (21)	71711-19	0.6	14	NO	12	-	-	-
Other Use Requirements: Do not apply more than 4 pt per season.									
Prey 1.6	Imidacloprid (4A)	34704-894	0.7	0	NO	12	-	-	-
Other Use Requirements: Highly toxic to honeybees.[6] Toxic to aquatic invertebrates. Limit to 40 oz/ac/year (0.5 lb a.i./ac/year).									
Prokil Cryolite 96	Sodium aluminoflouride (UN)	10163-41	7	15	NO	12	-	-	-
Other Use Requirements: Do not apply more than 90 lb per acre per year.									
Prokoz Sevin SL	Carbaryl (1A)	432-1227-72112	10	5	NO	12	10,000	-	100
Other Use Requirements: None									
Provado 1.6 F	Imidacloprid (4A)	264-763	0.7	0	NO	12	-	-	-
Other Use Requirements: Highly toxic to honeybees.[6] Toxic to aquatic invertebrates. Limit to 40 oz/ac/season (0.5 lb a.i./ac/year).									
Pyganic EC 1.4 II Pyganic EC 5.0 II	Pyrethrins (3A)	1021-1771 1021-1772	1	0	NO	12	-	-	1
Other Use Requirements: None									
Pyrellin E.C.	Pyrethrins (3A) Rotenone (21)	30573-2	1	5	NO	12	-	-	1
Other Use Requirements: None									
Reaper 0.15EC	Abamectin (6)	34704-923	0.02	7	NO	12	-	10,000	-
Other Use Requirements: RESTRICTED PESTICIDE.[7] Toxic to fish, mammals**,** -- and aquatic organisms. Highly toxic to honeybees.[6] Limit of 3 applications of abamectin per growing season. Do not apply more than 40 fl oz/ac (0.047 lb a.i./ac) of any abamectin product in a growing season.									
Savey 50 DF	Hexythiazox (10A)	10163-250	Nonbearing	12 months	NO	12	-	-	-
Other Use Requirements: Limit 1 application per year. Toxic to fish and aquatic invertebrates.									

Trade Name or Generic Name	Common Name (IRAC MOA)[9]	EPA Registration Number[1]	Tolerance Fruit (ppm)	Days to Harvest	Field Posting Required[2]	REI Hr	EPCRA[3]		
							TPQ (lb a.i.)[4]		RQ (lb a.i.)[5]
							1	2	
Sevin (see also Carbaryl)		(80 S) 264-316 (4 F) 264-349 (XLR) 264-333 (SL) 432-1227 (80WSP) 264-526 (80 WSP) 432-1226	10	5	NO	12	-	10,000	100
Other Use Requirements: Do not apply more than 20 lb a.i./ac/year for all uses. Highly toxic to honeybees.[6] Toxic to aquatic invertebrates.									
Sivanto 200 SL	Flupyradifurone (4D)	264-1141	3.0	1	NO	12	-	-	-
Other use Requirements: Do not apply more than 28.0 fl oz/ac per year.									
Sniper	Bifenthrin (3A)	34704-858	0.05	1	NO	12	-	10,000	100
Other Use Requirements: RESTRICTED PESTICIDE.[7] Use as a soil barrier application; do not allow application to contact fruit or foliage. Apply only to individual citrus resets, not solid planted rows. Do not apply more than 0.5 lb a.i./ac/year.									
Spintor 2 SC	Spinosad (5)	62719-294	0.3	1	NO	4	-	-	-
Other Use Requirements: Do not apply more than 29 ounces (0.45 lb) per acre per crop year. Limit 2 applications per season.									
Sulfur	Sulfur (NR)	See Table 2	Exempt	0	NO	24	-	-	-
Other Use Requirements: Do not apply within 21 days of an oil spray.									
Surround WP	Kaolin (NR)	70060-00014	Exempt	0	NO	4	-	-	-
Other Use Requirements: None									
Temprano	Abamectin (6)	67760-71-400	0.02	7	NO	12	-	10,000	-
Other Use Requirements: RESTRICTED PESTICIDE.[7] Toxic to fish, mammals, and aquatic organisms. Highly toxic to honeybees.[6] Limit of 3 applications of abamectin per growing season. Do not apply more than 40 fl oz/ac (0.047 lb a.i./ac) of any abamectin product in a growing season.									
Torrent 1.6F	Imidacloprid (4A)	60063-32	0.7	0	NO	12	-	-	-
Other Use Requirements: Highly toxic to honeybees.[6] Toxic to aquatic invertebrates. Limit to 40 fl oz/ac/season (0.5 lb a.i./ac/year).									
Torrent 2 F	Imidacloprid (4A)	60063-31	0.7	0	NO	12	-	-	-
Other Use Requirements: Highly toxic to honeybees.[6] Toxic to aquatic invertebrates. Limit to 32 oz/ac/year (0.5 lb a.i./ac/year).									
Vendex 50WP	Fenbutatin oxide (12B)	352-658	20	7	NO	48	-	10,000	-
Other Use Requirements: RESTRICTED PESTICIDE[7]. Toxic to fish; limited to 2 applications/12-month period with at least a 60-day interval.									
Verimark	Cyantraniliprole (28)	352-860	0.70	1	NO	4	-	-	-
Other Use Requirements: Do not apply more than 0.4 lb a.i./ac of any cyantraniliprole containing product per year, regardless of whether applications are made to the soil or foliarly.									
Voliam Flexi	Chlorantraniliprole (28); Thiamethoxam (4A)	100-1319	1.4; 0.4	1	NO	12	-	-	-
Other Use Requirements: Highly toxic to honeybees.[6] Do not apply when bees are actively foraging. Do not exceed a total of 14.0 oz of Voliam Flexi or 0.172 lb a.i. of thiamethoxam containing products or 0.2 lb a.i. of chlorantraniliprole-containing products per acre per growing season.									
Vydate L	Oxamyl (1A)	352-372	3	7	NO	48	100	10,000	1

Trade Name or Generic Name	Common Name (IRAC MOA)[9]	EPA Registration Number[1]	Tolerance Fruit (ppm)	Days to Harvest	Field Posting Required[2]	REI Hr	EPCRA[3]		
							TPQ (lb a.i.)[4]		RQ (lb a.i.)[5]
							1	2	
Other Use Requirements: SL[8]; RESTRICTED PESTICIDE.[7] Toxic to birds and mammals. Limit to 6 applications per year.									
Warhawk	Chlorpyrifos (1B)	62719-220-34704	1	21	YES	5 days	-	10,000	1
Other Use Requirements: RESTRICTED PESTICIDE.[7]									
Whirlwind	Chlorpyrifos (1B)	62719-220-5905	1	21	YES	5 days	-	10,000	1
Other Use Requirements: RESTRICTED PESTICIDE.[7]									
Widow	Imidacloprid (4A)	34704-893	0.7	0	NO	12	-	-	-
Other Use Requirements: Highly toxic to honeybees.[6] Toxic to aquatic invertebrates. Limit to 32 fl oz/ac/season (0.5 lb a.i./ac/year).									
Zoro Miticide/ Insecticide	Abamectin (6)	67760-71	0.02	7	NO	12	-	10,000	-
Other Use Requirements: RESTRICTED PESTICIDE.[7] Toxic to fish, mammals, and aquatic organisms. Highly toxic to honeybees.[6] Limit of 3 applications of abamectin per growing season. Do not apply more than 40 fl oz/ac (0.047 lb a.i./ac) of any abamectin product in a growing season.									

[1] Extracted from product labels, Code of Federal Regulations, and other federal and state regulations.
[2] Read product label for specific use precautions, especially Worker Protection Standards and environmental concerns.
[3] Emergency Planning and Community Right-To-Know Act. Information presented here is not intended to take the place of the actual regulation. Call the State Emergency Response Commission at 1-800-635-7179 for additional details.
[4] Threshold Planning Quantity. If the grower meets or exceeds this amount, notification must be made. Placard vehicle not a facility. (1 = active ingredient is a gas, is molten, in solution of or is a fine powder; 2 = is a granular or other larger particle form).
[5] The amount of active ingredient that when spilled or released requires reporting to authorities within 15 minutes. Should be reported by telephone to 850-413-9919 or 800-320-0519.
[6] Will kill bees for 24 hours following application.
[7] A certification license is required to purchase and apply or must be under the supervision of a licensee and only for those uses covered by the certified applicator's certification.
[8] SL = See Label for use restrictions.
[9] Mode of action class for citrus pesticides from the Insecticide, Fungicide, and Herbicide Resistance Action Committees. Refer to ENY-624, *Pesticide Resistance and Resistance Management* , in the *2020–2021 Florida Citrus Production Guide* for more details.
[10] Under revisions to the WPS, mandatory posting is required for any product with an REI greater than 48 hours. Refer to CPMG-07, *Quick Reference Guide to the Worker Protection Standard (WPS) as Revised in 2015* in the *2020–2021 Florida Citrus Production Guide* for more details.

Table 5. Pesticides registered for use on Florida citrus—fungicides.

Trade Name or Generic Name	Common Name (FRAC MOA)[1]	EPA Registration Number[2]	Tolerance Fruit (ppm)[3]	Days to Harvest	Field Posting Required[4]	REI Hr	EPCRA[5] TPQ (lb a.i.)[6] 1	EPCRA TPQ 2	EPCRA RQ (lb a.i.)[7]
A-Zox 25 SC	Azoxystrobin (11)	83529-64	Fruit (group 10-10) 15 20 (dried pulp) 40 (oil)	0	NO	4	--	--	--
Other Use Requirements: Do not apply more than 92.3 fl oz/ac/season for all uses or 1.5 lb a.i./ac/season. Not for use in nursery propagation.									
Abound Flowable Fungicide	Azoxystrobin (11)	100-1098	Fruit (group 10-10) 15 20 (dried pulp) 40 (oil)	0	NO	4	--	--	--
Other Use Requirements: Do not apply more than 90 fl oz/ac/season for all uses or 1.5 lb a.i./ac/season. Not for use in nursery propagation.									
Acadia 2 SC	Azoxystrobin (11)	91234-74	Fruit (group 10-10) 15 20 (dried pulp) 40 (oil)	0	NO	4	10,000	--	--
Other Use Requirements: Do not apply more than 92.3 fl oz/ac/season for all uses or 1.5 lb a.i./ac/season. Not for use in nursery propagation.									
Actinovate AG	*Streptomyces lydicus* WYEC 108 (BM 02)	73314-1 or 524-641	Exempt	0	NO	4	--	--	--
Other Use Requirements: None									
Adorn Fungicide	Fluopicolide (43)	59639-141	Nonbearing Fruit (group 10-10) 0.01 0.03 (dried pulp) 1.0 (oil)	NA[8]	NO	12	--	--	--
Other Use Requirements: Nonbearing only; must be tank-mixed with another fungicide for resistance management—see label for details; no more than 2 applications per cropping cycle.									
Aframe	Azoxystrobin (11)	100-1098	Fruit (group 10-10) 15 20 (dried pulp) 40 (oil)	0	NO	4	--	--	--
Other Use Requirements: Do not apply more than 90.0 fl oz/ac/season for all uses or 1.5 lb a.i./ac/season. Not for use in nursery propagation.									
Aliette WDG	Fosetyl-AL (Aluminum tris) (P07)	264-516	fruit (group 10-10) 9.0	30	NO	12	--	--	--
Other Use Requirements: Do not exceed 4 applications/season or 20 lb/ac/year; for foliar application, do not exceed 100 or 500 GPA nonbearing and bearing, respectively.									
Alude	Mono- and dibasic sodium, potassium, and ammonium phosphorous acid (P 07)	55146-83	Exempt	0	NO	4	--	--	--
Other Use Requirements: None									

Trade Name or Generic Name	Common Name (FRAC MOA)[1]	EPA Registration Number[2]	Tolerance Fruit (ppm)[3]	Days to Harvest	Field Posting Required[4]	REI Hr	EPCRA[5] TPQ (lb a.i.)[6] 1	EPCRA[5] TPQ (lb a.i.)[6] 2	EPCRA[5] RQ (lb a.i.)[7]
Alumni	Thiabendazole (1)	100-889	15 (oil) Fruit (group 10 PH) 10	PH	NA	12	--	--	--
Other Use Requirements: None									
Amistar Top	Azoxystrobin (11) Difenoconazole (3)	100-1313	A fruit (group 10-10) 15 A 20 (dried pulp) A 40 (oil) D fruit (group 10) 0.60 D (dried pulp) 2.0 D 25 (oil)	0	NO	12	--	--	--
Other Use Requirements: Do not apply more than 61.5 fl oz/ac/season for all uses. Do not apply more than 0.5 lb a.i. difenoconazole/ac/season. Do not apply more than 1.5 lb a.i. azoxystrobin/ac/season. Not for nursery production use.									
AmTide Propiconazole 41.8% EC	Propiconazole (3)	83851-10	Nonbearing 1000 (oil) Fruit (group 10) 8	NA	NO	12	--	--	>1,000 gal 100 p-xylene
Other Use Requirements: Nonbearing only. Do not apply more than 24 fl oz/ac/season for all uses. Do not apply more than 0.67 lb a.i. propiconazole/ac/season.									
AVIV	*Bacillus subtilis* IAB/BS03 (NC)	91473-1-86182	Exempt	0	NO	4	--	--	--
Other Use Requirements: None									
Azoxy 2SC PRIME	Azoxystrobin (11)	89442-21	Fruit (group 10-10) 15 20 (dried pulp) 40 (oil)	0	NO	4	--	--	--
Other Use Requirements: Do not apply more than 92.3 fl oz/ac/season for all uses or 1.5 lb a.i./ac/season. Not for use in nursery propagation.									
AzoxyStar	Azoxystrobin (11)	42750-261	Fruit (group 10-10) 15 20 (dried pulp) 40 (oil)	0	NO	4	--	--	--
Other Use Requirements: Do not apply more than 92.3 fl oz/ac/season for all uses or 1.5 lb a.i./ac/season. Not for use in nursery propagation.									
Azoxyzone FC 3.3	Azoxystrobin (11)	71532-35-91026	Fruit (group 10-10) 15 20 (dried pulp) 40 (oil)	0	NO	4	--	--	--
Other Use Requirements: Do not apply more than 92.3 fl oz/ac/season for all uses or 1.5 lb a.i./ac/season. Not for use in nursery propagation.									

Trade Name or Generic Name	Common Name (FRAC MOA)[1]	EPA Registration Number[2]	Tolerance Fruit (ppm)[3]	Days to Harvest	Field Posting Required[4]	REI Hr	EPCRA[5]		
							TPQ (lb a.i.)[6]		RQ (lb a.i.)[7]
							1	2	
AZteroid FC	Azoxystrobin (11)	89118-3 89118-11	Fruit (group 10-10) 15 20 (dried pulp) 40 (oil)	0	NO	4	--	--	--
Other Use Requirements: Do not apply more than 116 fl oz/ac/season (FC) or 58.2 fl oz (FC 3.3) for all uses or 1.5 lb a.i./ac/season. Not for use in nursery propagation.									
Banner MAXX II	Propiconazole (3)	100-1326	Nonbearing 1000 (oil) Fruit (group 10-10) 8	12 months	NO	12	--	--	--
Other Use Requirements: Nonbearing only; do not apply more than 5.4 gallons/ac/season.									
BioSpectra 100SC	Natamycin (48)	7681-93-8	Exempt	0	NA	NA	--	--	--
Other Use Requirements: Postharvest only.									
Bio-Tam 2.0	*Trichoderma gamsii* and *T. asperellum* (BM 02)	80289-9	Exempt	0	NO	4	--	--	--
Other Use Requirements: None									
Blockade 50WG	Acibenzolar-S-methyl (P 01)	100-922	Fruit (group 10-10) 0.02	0	NO	12	--	--	--
Other Use Requirements: Do not apply more than 3.2 oz/ac/application (0.1 lb a.i.) or 12.8 oz/ac/year (0.4 lb a.i.).									
BotryStop Biofungicide	*Ulocladium oudemansii* (U3 strain)	75747-2-68539	Exempt	0	NO	4	--	--	--
Other Use Requirements: None									
Broadform	Trifloxystrobin (11) Fluopyram (7)	432-1537	T 1.0 (dried pulp) T 38 (oil) T Fruit (group 10) 0.6 F Fruit (group 10-10) 1.0 F 8.0 (oil)	7	NO	12	--	--	--
Other Use Requirements: Do not apply more than 27.1 fl oz/ac/year. Do not exceed more than 0.446 lb fluopyram or 0.5 lb trifloxystrobin per year for all uses.									
Bumper 41.8 EC ES	Propiconazole (3)	66222-270 66222-42 66222-241	Nonbearing 1000 (oil) Fruit (group 10-10) 8	12 months	NO	12	--	--	--
Other Use Requirements: Nonbearing only or within 12 months of harvestable fruit; do not apply more than 24 fl oz/ac/season. Do not apply more than 0.67 lb a.i./ac/season of propiconazole.									
Carb-O-Nator	Potassium bicarbonate	70051-117	Exempt	0	NO	4	--	--	--
Other Use Requirements: None									

Trade Name or Generic Name	Common Name (FRAC MOA)[1]	EPA Registration Number[2]	Tolerance Fruit (ppm)[3]	Days to Harvest	Field Posting Required[4]	REI Hr	EPCRA[5]		
							TPQ (lb a.i.)[6]		RQ (lb a.i.)[7]
							1	2	
Compass	Trifloxystrobin (11)	432-1371	Nonbearing 1.0 (dried pulp) 38 (oil) Fruit (group 10-10) 0.6	12 months	NO	12	--	--	--
Other Use Requirements: Rotate to a non–MOA Group 11 fungicide for a minimum of two applications before rotating back.									
Confine Extra	Mono- and di-potassium salts of phosphorous acid (P 07)	1381-244	Exempt	0	NO	4	--	--	--
Other Use Requirements: Do not apply at less than a 3-day interval.									
Copper fungicides	Various (M 01)	See Table 1	Exempt	0	NO	SL[9]	--	--	--
Other Use Requirements: None									
Dorado	Propiconazole (3)	100-741	Nonbearing 1000 (oil) Fruit (group 10-10) 8	12 months	NO	12	--	--	--
Other Use Requirements: Nonbearing only**.** Do not apply more than 5.4 gal/ac/year.									
Double Nickle 55 LC	*Bacillus amyloliquefaciens* strain D747 (BM 02)	70051-108 70051-107	Exempt	0	NO	4	--	--	--
Other Use Requirements: None									
EcoSwing Botanical	Extract of *Swinglea glutinosa* (BM 01)	10163-357	Exempt	0	NO	4	--	--	--
Other Use Requirements: None									
Empress Intrinsic	Pyraclostrobin (11)	7969-355	12.5 (dried pulp) 9.0 (oil) Fruit (group 10-10) 2.0	12 months	NO	12	--	--	--
Other Use Requirements: Do not apply more than 54 fl oz/ac/season or 0.88 lb a.i./ac/season or other MOA Group 11 fungicides/season. Do not use more than 2 sequential applications/season.									
Enable 2F	Fenbuconazole (3)	62719-416	5.0 (dried pulp) 40 (oil) Fruit (group 10) 1.0	0	NO	12	--	--	--
Other Use Requirements: No more than 3 applications/year; no more than 0.38 lb (24 fl oz Enable) a.i./ac/year; minimum retreatment interval is 21 days. Do not apply with polymer adjuvants.									

Trade Name or Generic Name	Common Name (FRAC MOA)[1]	EPA Registration Number[2]	Tolerance Fruit (ppm)[3]	Days to Harvest	Field Posting Required[4]	REI Hr	EPCRA[5]		
							TPQ (lb a.i.)[6]		RQ (lb a.i.)[7]
							1	2	
Endura	Boscalid (7)	7969-197	4.5 (dried pulp) 85.0 (oil) fruit (group10-10) 2.0	0	NO	12	--	--	--
Other Use Requirements: Do not apply more than 27.2 oz/ac/season or 1.20 lb a.i./ac/season.									
Ferbam Granuflo	Ferbam (M 03)	45728-7	4.0 fruit (group 10)	0	NO	24	--	--	--
Other Use Requirements: No more than 3 applications. No more than 7.9 lb/ac (6.0 lb a.i.) per single application.									
Fireline 17 WP 45 WP	Oxytetracycline Hydrochloride (41)	80990-1 80990-6	Fruit (group 10-10) 0.01	40	YES	12	--	--	--
Other Use Requirements: Do not use more than 4.5 lb (17 WP) or 1.69 lb (45 WP) (0.82 a.i.) oxytetracycline/ac/season.									
Firewall 50 WP*	Streptomycin sulfate (25)	80990-3	Fruit 2.0 Dried pulp 6.0 Grapefruit 0.15 Grapefruit dried pulp 0.40	40	YES	12	--	--	--
Other Use Requirements: Do not use more than 33 oz streptomycin/ac/year. *Section 18 effective 12/31/2019–12/31/2020									
Fitness	Propiconazole (3)	34704-1031	Nonbearing 1000 (oil) Fruit (group 10-10) 8	12 months	NO	12	--	--	100 Naph-thalene
Other Use Requirements: Do not use more than 0.67 lb a.i. or 24 fl oz. propiconazole/ac/season.									
Fosphite	Phosphorous acid, mono- and dipotassium salts (P 07)	68573-2	Exempt	0	NO	4	--	--	--
Other Use Requirements: Minimum retreatment interval is 3 days; to avoid phytotoxicity, do not apply less than 20 days after copper-based products.									
Fungi-Phite	Phosphorous acid, mono- and dipotassium salts (P 07)	73771-5	Exempt	0	NO	4	--	--	--
Other Use Requirements: If chemigating, do not apply more than 4 times/crop cycle.									
Gem 500 SC	Trifloxystrobin (11)	264-826	1.0 (dried pulp) 38 (oil) Fruit (group 10) 0.6	7	NO	12	--	--	--
Other Use Requirements: Do not apply more than 15.2 fl oz/ac/season for all uses. No more than 4 applications of Gem 500 SC or other MOA Group 11 fungicides/season.									
Graduate MAX MP	Fludioxonil (12)	100-969 100-1242	500 (oil) Fruit (group 10-10) 10	PH[8]	NO	0	--	--	--
Other Use Requirements: Do not make more than 2 applications to citrus fruit.									

Trade Name or Generic Name	Common Name (FRAC MOA)[1]	EPA Registration Number[2]	Tolerance Fruit (ppm)[3]	Days to Harvest	Field Posting Required[4]	REI Hr	EPCRA[5]		
							TPQ (lb a.i.)[6]		RQ (lb a.i.)[7]
							1	2	
Graduate A+	Fludioxonil (12) Azoxystrobin (11)	100-1308	F 500 (oil) Fruit (group 10-10) 10 A 20 (dried pulp) A 40 (oil) A fruit (group 10-10) 15	PH[8]	NO	0	--	--	--
Other Use Requirements: Do not make more than 2 applications to citrus fruit. Maximum rate per crop 128 fl oz. Do not exceed 1.99 lb a.i./crop of fludioxonil- or azoxystrobin-containing products.									
Gunner 14.3 MEC	Propiconazole (3)	91234-36	Nonbearing 1000 (oil) Fruit (group 10-10) 8	12 months	NO	12	10,000	--	--
Other Use Requirements: Do not use more than 0.67 lb a.i. or 24 fl oz propiconazole/ac/season.									
Headline SC	Pyraclostrobin (11)	7969-186 7969-289	12.5 (dried pulp) 9.0 (oil) Fruit (group 10-10) 2.0	0	NO	12	--	--	Naphalene (100 lb) SC
Other Use Requirements: Do not apply more than 54 fl oz/ac/season or 0.88 lb a.i./ac/season or other MOA Group 11 fungicides/season. Do not use more than 2 sequential applications/season.									
HDH Foam 26	Sodium ortho-phenylphenate (NC)	83103-2	10	PH[8]	NA	NA	--	--	--
Other Use Requirements: None									
Honor Guard PPZ	Propiconazole (3)	66222-41-53883	Nonbearing 1000 (oil) Fruit (group 10-10) 8	12 months	NO	12	--	--	--
Other Use Requirements: Do not use more than 0.67 lb a.i. or 24 fl oz propiconazole/ac/season.									
Indar 2F	Fenbuconazole (3)	62719-416	5.0 (dried pulp) 40 (oil) Fruit (group 10) 1.0	0	NO	12	--	--	--
Other Use Requirements: No more than 3 applications/year; no more than 0.38 lb (24 fl oz Indar) a.i./ac/year; minimum retreatment interval is 21 days.									
Insignia SC Intrinsic	Pyraclostrobin	7969-290	Nonbearing 12.5 (dried pulp) 9.0 (oil) Fruit (group 10-10) 2.0	12	NO	0	--	--	--
Other Use Requirements: Do not apply more than 54 fl oz/ac/season or 0.88 lb a.i./ac/season or other MOA Group 11 fungicides/season. Do not use more than 2 sequential applications/season.									

Trade Name or Generic Name	Common Name (FRAC MOA)[1]	EPA Registration Number[2]	Tolerance Fruit (ppm)[3]	Days to Harvest	Field Posting Required[4]	REI Hr	EPCRA[5]		
							TPQ (lb a.i.)[6]		RQ (lb a.i.)[7]
							1	2	
Jet-Ag	Peroxyacetic acid (NC) Hydrogen peroxide (NC)	81803-6	Exempt Exempt when ≤ 1% per application	0	YES	4	--	--	Acetic acid 73,529
Other Use Requirements: None									
KeyPlex 350 Organic	Yeast extract hydrolysate from *Saccharomyces cerevisiae* (NC)	73512-1 73512-4	Exempt	0	NO	4	--	--	--
Other Use Requirements: None									
K-Phite 7LP	mono + dipotassium salts of Phosphorous Acid (P07)	73806-1	Exempt	0	NO	4	--	--	--
Other Use Requirements: Do not apply at intervals less than 3 days.									
Linebacker WDG	Fosetyl-AL (P 07) Also known as aluminum tris (O-ethyl phosphonate)	61842-9	Fruit (group 10-10) 9.0	0	NO	24	--	--	--
Other Use Requirements: Do not exceed 4 applications or 20 lb/ac/year. Do not exceed 500 GPA for foliar applications.									
Luna Sensation	Trifloxystrobin (11) Fluopyram (7)	264-1090	T 1.0 (dried pulp) T 38 (oil) T Fruit (group 10) 0.6 F Fruit (group 10-10) 1.0 F 8.0 (oil)	7	NO	12	10,000 lb	--	--
Other Use Requirements: Maximum 24 fl oz/ac/year. Do not apply more than 0.67 lb a.i./ac/year of propiconazole.									
Marazo	Propiconazole	91234-25-92488	Nonbearing 1000 (oil) Fruit (group 10-10) 8	12 months	NO	12	10,000 lb	--	--
Other Use Requirements: Maximum 24 fl oz/ac/year. Do not apply more than 0.67 lb a.i./ac/year of propiconazole.									
Mazolin	Azoxystrobin (11)	92647-2-92488	Fruit (group 10-10) 15 20 (dried pulp) 40 (oil)	0	NO	4	10,000 lb	--	--
Other Use Requirements: Do not apply more than 92.3 fl oz/ac/season for all uses or 1.5 lb a.i./ac/season. Not for use in nursery propagation.									
Mefenoxam 2 AQ	Mefenoxam (4)	53883-433	Nonbearing	12 months	NO	48	--	--	--
Other Use Requirements: Do not use in greenhouse citrus nursery stock intended for commercial fruit production.									

Trade Name or Generic Name	Common Name (FRAC MOA)[1]	EPA Registration Number[2]	Tolerance Fruit (ppm)[3]	Days to Harvest	Field Posting Required[4]	REI Hr	EPCRA[5]		
							TPQ (lb a.i.)[6]		RQ (lb a.i.)[7]
							1	2	
Mentor EC	Propiconazole (3)	100-780 100-1562	1000 (oil) Fruit (group 10-10) 8	PH[8]	NO	0	--	--	--
Other Use Requirements: Postharvest use. Make no more than 2 postharvest applications.									
MetaStar 2E 4S	Metalaxyl (4)	71532-5-91026 71532-36-91026	1.0 fruit, citrus 7.0 (oil) 7.0 (citrus pulp)	0	NO	48	--	--	--
Other Use Requirements: Do not use in greenhouse citrus nursery stock. Do not apply more than 6 gal/ac/year.									
MilStop SP	Potassium bicarbonate (NC)	70870-1-68539 68539-13	Exempt	0	NO	1	--	--	--
Other Use Requirements: None									
Miravis Top	Pydiflumetofen (7) Difenoconazole (3)	100-1602	P Fruit (group 10-10) 1 P Oil 30	0	NO	12	--	--	--
Other Use Requirements: Maximum 24 fl oz/acre/year. Do not apply more than 0.67 lb a.i./ac/year of propiconazole.									
Mycoshield**	Calcium oxytetracycline (41)	55146-97	Fruit (group 10-10) 0.01	40	YES	12	--	--	--
Other Use Requirements: Do not use more than 4.5 lb or 0.82 a.i. oxytetracycline/ac/season. **Supplemental label expires 6/28/2020									
Nufarm Propiconazole SPC 14.3 MEC	Propiconazole (3)	228-623	Nonbearing 1000 (oil) Fruit (group 10-10) 8	12 months	NO	24	--	--	--
Other Use Requirements: Do not use more than 0.67 lb a.i. or 24 fl oz. propiconazole/ac/season.									
Omni Brand Propiconazole 41.8% EC	Propiconazole (3)	38167-35-5905	Nonbearing 1000 (oil) Fruit (group 10-10) 8	12 months	NO	12	--	--	--
Other Use Requirements: Do not use more than 0.67 lb a.i. or 24 fl oz propiconazole/ac/season.									
Orondis	Oxathiapiprolin (49)	100-1571	Fruit (group 10-10) 0.06 0.09 (dried pulp) 2.0 (oil)	0	NO	4	--	--	--
Other Use Requirements: Do not use in a nursery. Do not apply sequentially more than two soil applications or one foliar application.									
OSO 5%SC	Polyoxin D zinc salt (19)	68173-4-70051	Exempt	0	NO	4	--	--	--
Other Use Requirements: Do not apply more than 4.3 oz a.i./ac/year.									

Trade Name or Generic Name	Common Name (FRAC MOA)[1]	EPA Registration Number[2]	Tolerance Fruit (ppm)[3]	Days to Harvest	Field Posting Required[4]	REI Hr	EPCRA[5]		
							TPQ (lb a.i.)[6]		RQ (lb a.i.)[7]
							1	2	
OxiDate 2.0 5.0 Tree and Vine	Peroxyacetic acid (NC) Hydrogen dioxide (NC)	70299-12 70299-28 70299-28	P Exempt HD Exempt when ≤ 1% per application	0	YES	1	500 (Peroxyacetic acid) 1000 (hydrogen peroxide)	--	500 (Peroxyacetic acid) 1000 (hydrogen peroxide)
Other Use Requirements: Posting required when applying through chemigation; consult the label.									
OxiPhos	mono + dipotassium salts of Phosphorous Acid (P 07) Hydrogen peroxide (NC)	70299-22	Exempt when ≤ 1% per application	0	NO	4	1000 (hydrogen peroxide)	--	1000 (hydrogen peroxide)
Other Use Requirements: None									
PacRite Azoxy 250 SC	Azoxystrobin (11)	42750-261-64864	15 (Fruit group 10-10) 20 (dried pulp) 40 (oil)	PH[8]	NA	NA	--	--	--
Other Use Requirements: Postharvest only. Do not make more than 2 postharvest applications.									
PacRite FDL	Fludioxonil (12)	64864-70	500 (oil) 10 (fruit group 10-10)	PH[8]	NA	NA	--	--	--
Other Use Requirements: Postharvest only. Do not make more than 2 postharvest applications.									
PacRite Fungaflor 500 EC 75 WSF	Imazalil (3)	43813-6-64864 43813-26-64864	200 (oil) 10 (PH fruit) 25 (dried pulp)	PH[8]	NA	NA	--	--	--
Other Use Requirements: Postharvest only.									
PacRite Penbotec EC 400 SC	Pyrimethanil (9)	43813-32-64864	150 (oil) 10.0 (fruit group 10-10)	PH[8]	NA	NA	--	--	--
Other Use Requirements: Postharvest only. May be applied to citrus fruits by a maximum combination of three application methods.									
PacRite TBZ 4.0 SC	Thiabendazole (1)	64864-66	15 (oil) 10 (fruit group 10)	PH[8]	NA	NA	--	--	--
Other Use Requirements: Postharvest only.									
PerCarb	Sodium Carbonate Peroxyhydrate (NC)	70299-15	Exempt	0	NO	1	--	--	--
Other Use Requirements: Do not apply through an irrigation system or directly to the soil.									
Ph-D fungicide	Polyoxin D zinc salt (19)	66330-56	Exempt	0	NO	4	--	--	--
Other Use Requirements: Do not apply more than 6 applications of polyoxin as the active ingredient (4.2 oz a.i./ac) per season.									

Trade Name or Generic Name	Common Name (FRAC MOA)[1]	EPA Registration Number[2]	Tolerance Fruit (ppm)[3]	Days to Harvest	Field Posting Required[4]	REI Hr	EPCRA[5]		
							TPQ (lb a.i.)[6]		RQ (lb a.i.)[7]
							1	2	
Phostrol	Mono- + dibasic sodium, potassium and ammonium salts (P 07)	55146-83	Exempt	0	NO	4	--	--	--
Other Use Requirements: None									
Pilato SC	Fludioxonil (12)	91234-93	500 (oil) 10 (fruit group 10-10)	PH[8]	NA	NA	10,000	--	--
Other Use Requirements: Do not make more than 2 applications to fruit.									
PPZ 41.8 Select	Propiconazole (3)	89442-3	Nonbearing 1000 (oil) Fruit (group 10-10) 8	12 months	NO	12	--	--	--
Other Use Requirements: Do not use more than 0.67 lb a.i. or 24 fl oz propiconazole/ac/season.									
Presidio Fungicide	Fluopicolide (43)	59639-140	1.0 (oil) 0.03 (dried pulp) 0.01 fruit (group 10-10)	30	NO	12	--	--	--
Other Use Requirements: Do not make more than 1 application or 12 fl oz/ac/year.									
Priaxor Xemium	Pyraclostrobin (11) Fluxapyroxad (7)	7969-311	P 12.5 (dried pulp) P 9.0 (oil) P fruit (group 10-10) 2.0 F 3.0 (dried pulp) F 40 (oil) F fruit (group 10-10) 1.0	0	NO	12	--	--	--
Other Use Requirements: No more than 4 (44 oz) applications/ac/year.									
Pristine	Pyraclostrobin (11) Boscalid (7)	7969-199	P 12.5 (dried pulp) P 9.0 (oil) P fruit (group 10-10) 2.0 B 4.5 (dried pulp) B 85.0 (oil) B fruit (group10-10) 2.0	0	NO	12	--	--	--
Other Use Requirements: No more than 74 oz/ac/year (1.17 lb boscalid, 0.592 lb pyraclostrobin).									
Procidic Concentrate	Citric acid (NC)	--	Exempt	0	NO	NA	--	--	--
Other Use Requirements:									

Trade Name or Generic Name	Common Name (FRAC MOA)[1]	EPA Registration Number[2]	Tolerance Fruit (ppm)[3]	Days to Harvest	Field Posting Required[4]	REI Hr	EPCRA[5]		
							TPQ (lb a.i.)[6]		RQ (lb a.i.)[7]
							1	2	
ProCon-Z	Propiconazole (3)	34704-879	Nonbearing 1000 (oil) Fruit (group 10-10) 8.0	12 months	NO	24	--	--	--
Other Use Requirements: Do not apply more than 0.67 lb a.i. propiconazole/ac/season.									
ProPensity 1.3ME	Propiconazole (3)	60063-27	Nonbearing 1000 (oil) Fruit (group 10-10) 8.0	12 months	NO	24	--	--	--
Other Use Requirements: Do not apply more than 0.67 lb a.i. propiconazole/ac/season. Use up to 5.4 gal/ac/year.									
ProPhyt	Potassium phosphite (P 07)	42519-22-5905	Exempt	0	NO	4	--	--	--
Other Use Requirements: None									
Propi-Star EC	Propiconazole (3)	42750-211	Nonbearing 1000 (oil) Fruit (group 10-10) 8.0	12 months	NO	12	--	--	226 gal 100 lb naphthalene
Other Use Requirements: Do not apply more than 24 fl oz (0.67 lb a.i.) Propi-Star EC/ac/season.									
Propicon 3.6EC	Propiconazole (3)	87290-7	Nonbearing 1000 (oil) Fruit (group 10-10) 8.0	12 months	NO	12	--	--	--
Other Use Requirements: Do not apply more than 24 fl oz (0.67 lb a.i.) Propicon 3.6 EC/ac/season.									
Propiconazole 1.3 ME T&O	Propiconazole (3)	42750-252	Nonbearing 1000 (oil) Fruit (group 10-10) 8.0	12 months	NO	24	--	--	--
Other Use Requirements: Do not apply more than 24 fl oz (0.67 lb a.i.) Propicon 3.6 EC/ac/season.									
Propiconazole 3.6 EC	Propiconazole (3)	69361-40	Nonbearing 1000 (oil) Fruit (group 10-10) 8.0	12 months	NO	12	10,000	--	--
Other Use Requirements: Do not apply more than 24 fl oz (0.67 lb a.i.) Propiconazole 3.6 EC/ac/season.									
Propiconazole 14.3	Propiconazole (3)	53883-363 66222-41	Nonbearing 1000 (oil) Fruit (group 10-10) 8.0	12 months	NO	12	10,000	--	--
Other Use Requirements: Do not apply more than 24 fl oz (0.67 lb a.i.) Propiconazole 3.6 EC/ac/season.									

Trade Name or Generic Name	Common Name (FRAC MOA)[1]	EPA Registration Number[2]	Tolerance Fruit (ppm)[3]	Days to Harvest	Field Posting Required[4]	REI Hr	EPCRA[5]		
							TPQ (lb a.i.)[6]		RQ (lb a.i.)[7]
							1	2	
Propiconazole 14.3 Select	Propiconazole (3)	89442-17	Nonbearing 1000 (oil) Fruit (group 10-10) 8.0	12 months	NO	12	--	--	--
Other Use Requirements: Do not apply more than 24 fl oz (0.67 lb a.i.) Propiconazole 3.6 EC/ac/season.									
Propicure 3.6F	Propiconazole (3)	83222-18	Nonbearing 1000 (oil) Fruit (group 10-10) 8.0	12 months	NO	12	--	--	100 (Naphtha-lene)
Other Use Requirements: Do not apply more than 24 fl oz (0.67 lb a.i.) product/ac/season.									
Propiczone	Propiconazole (3)	83529-22-91026	Nonbearing 1000 (oil) Fruit (group 10-10) 8.0	12 months	NO	12	--	--	--
Other Use Requirements: Do not apply more than 24 fl oz (0.67 lb a.i.) product/ac/season.									
PropiMax EC	Propiconazole (3)	62719-346	Nonbearing 1000 (oil) Fruit (group 10-10) 8.0	12 months	NO	12	--	--	--
Other Use Requirements: Do not apply more than 24 fl oz (0.67 lb a.i.) PropiMax EC/ac/season.									
Propizol	Propiconazole (3)	74578-8	Nonbearing 1000 (oil) Fruit (group 10-10) 8.0	12 months	NO	24	--	--	--
Other Use Requirements: Do not apply more than 24 fl oz (0.67 lb a.i.) PropiMax EC/ac/season.									
Provysol	Mefentrifluconazole (3)	7969-411	2.0 (dried pulp) 15 (oil)	0	NO	12	--	--	--
Other Use Requirements: Do not apply more than 15 fl oz (0.39 a.i.)/ac/year.									
PVent	*Gliocladium catenulatum* strain J1446 (BM 02)	64137-13-70299	Exempt	0	NO	4	--	--	--
Other Use Requirements: None									
Pyrac 2EC	Pyraclostrobin (11)	87290-64	12.5 (dried pulp) 9.0 (oil) fruit (group 10) 2.0	0	NO	12	1000 (ethylene oxide)		1463528.9
Other Use Requirements: No more than 54 fl oz (0.88 lb a.i.)/acre/season. No more than 2 sequential applications.									

Trade Name or Generic Name	Common Name (FRAC MOA)[1]	EPA Registration Number[2]	Tolerance Fruit (ppm)[3]	Days to Harvest	Field Posting Required[4]	REI Hr	EPCRA[5]		
							TPQ (lb a.i.)[6]		RQ (lb a.i.)[7]
							1	2	
Quilt	Azoxystrobin (11) Propiconazole (3)	100-1178	A fruit (group 10-10) 15.0 A 20 (dried pulp) A 40 (oil) P Nonbearing P 1000 (oil) P Fruit (group 10-10) 8.0	12 months	NO	12	--	--	--
Other Use Requirements: Do not apply more than 82.5 fl oz Quilt/ac/year. Do not apply more than 0.68 lb a.i. propiconazole/ac/year. Do not apply more than 1.5 lb a.i. azoxystrobin/ac/season. Not for nursery use. No more than 3 applications per year.									
Rampart	Mono- and dipotassium salts of phosphorous acid (P 07)	34704-924	Exempt	0	NO	4	--	--	--
Other Use Requirements: Do not apply at intervals less than 3 days.									
ReCon 4 F	Metalaxyl (4)	91234-64	1.0 fruit, citrus 7.0 (oil) 7.0 (citrus pulp)	0	NO	48	10,000 lb	--	--
Other Use Requirements: Do not apply more than 3 gal (12 lb a.i.)/treated ac/year. Do not exceed 3 applications/year. Do not use in nurseries.									
Regalia PTO	*Reynoutria sachalinensis* extract (P 05)	84059-3-87865	Exempt	0	NO	4	--	--	--
Other Use Requirements: None									
Regulate Select	Metalaxyl (4)	89442-16	Nonbearing 1.0 fruit, citrus 7.0 (oil) 7.0 (citrus pulp)	12 months	NO	24	--	--	--
Other Use Requirements: Do not use in nurseries where stock is intended for commercial production.									
Reliant	Mono- and dipotassium salts of phosphorous acid (P 07)	83416-1	Exempt	0	NO	4	--	--	1000 potassium hydroxide
Other Use Requirements: None									
ReLoad	Mono- and dibasic sodium, and ammonium phosphites (P 07)	87865-1	Exempt	0	NO	12	--	--	--
Other Use Requirements: None									

Trade Name or Generic Name	Common Name (FRAC MOA)[1]	EPA Registration Number[2]	Tolerance Fruit (ppm)[3]	Days to Harvest	Field Posting Required[4]	REI Hr	EPCRA[5]		
							TPQ (lb a.i.)[6]		RQ (lb a.i.)[7]
							1	2	
Rendition	Peroxyacetic acid (NC) Hydrogen peroxide (NC)	68660-14-70051	P Exempt HP Exempt when ≤ 1% per application	0	YES	1	--	--	--
Other Use Requirements: None									
Resist 57	Mono- and dipotassium salts of phosphorous acid (P 07)	82940-1	Exempt	0	NO	4	--	--	--
Other Use Requirements: Do not apply at intervals less than 3 days. Do not use more than the highest rate/application.									
Reveille	Potassium phosphite (P 07)	42519-22-5905	Exempt	0	NO	4	--	--	--
Other Use Requirements: No more than 3 applications.									
Revus	Mandipropamid (40)	100-1254	0.70 (dried pulp) 15 (oil) 0.50 (fruit, group 10-10)	0	NO	4	--	--	--
Other Use Requirements: For field use, do not apply more than 16 fl oz (0.26 lb a.i.) of product/acre/season. In nurseries, do not apply more than 32 fl oz (0.52 lb a.i.) of product/ac/season.									
Ridomil Gold GR	Mefenoxam (4)	100-798	1.0 fruit, citrus 7.0 (oil) 7.0 (citrus pulp)	0	NO	48	--	--	>14,000
Other Use Requirements: Do not exceed the equivalent 6 lb a.i./ac of mefenoxam-containing products. Do not apply more than 240 lb/ac/year. Do not use in nurseries.									
Ridomil Gold SL	Mefenoxam (4)	100-1202	1.0 fruit, citrus 7.0 (oil) 7.0 (citrus pulp)	0	NO	48	--	--	>3,500 gal
Other Use Requirements: Do not exceed the equivalent 6 lb a.i./ac of mefenoxam-containing products. Do not use in nurseries.									
Root Shield AG Granules	*Trichoderma harzianum*, Rifai strain T-22 (BM 02)	68539-4 68539-3	Exempt	0	NO	AG 4 G 0	--	--	--
Other Use Requirements: Do not tank mix Root Shield AG with imazalil, propiconazole, tebuconazole, or triflumizole.									
Root Shield Plus Granules Plus WP	*Trichoderma harzianum* Rifai strain T-22 (BM 02) *T. virens* strain G-41 (BM 02)	68539-10 68539-9	Exempt	0	NO	G 0 WP 4	--	--	--
Other Use Requirements: None									
Root Shield WP	*Trichoderma harzianum*, Rifai strain KRL-AG2 (BM 02)	68539-7	Exempt	0	NO	0	--	--	--
Other Use Requirements: None									

Trade Name or Generic Name	Common Name (FRAC MOA)[1]	EPA Registration Number[2]	Tolerance Fruit (ppm)[3]	Days to Harvest	Field Posting Required[4]	REI Hr	EPCRA[5]		
							TPQ (lb a.i.)[6]		RQ (lb a.i.)[7]
							1	2	
Satori	Azoxystrobin (11)	34704-1068	Fruit (group 10-10) 15.0 20 (dried pulp) 40 (oil)	0	NO	4	--	--	--
Other Use Requirements: Do not apply more than 92.3 fl oz/ac/season for all uses or 1.5 lb a.i./ac/season. Not for nursery use.									
Serenade ASO MAX OPTI (Optimum) Soil	*Bacillus subtilis* strain QST 713 (44BM 02)	264-1152 264-1151 264-1160 264-1152	Exempt	0	NO	4	--	--	--
Other Use Requirements: None									
Serifel Biofungicide	*Bacillus amyloliquefaciens* MBI 600 (44BM 02)	71840-18	Exempt	0	NO	4	--	--	--
Other Use Requirements: None									
Shepherd	Propiconazole (3)	69117-3	Nonbearing 1000 (oil) Fruit (group 10-10) 8	12 months	NO	24	--	--	--
Other Use Requirements: Do not apply more than 5.4 gal (0.67 lb a.i.)/ac/season.									
Shield-Brite TBZ 500D 99WP	Thiabendazole (1)	64864-66 64864-68	15 (oil) 10 (fruit group 10)	PH[8]	NA	NA	--	--	--
Other Use Requirements: Postharvest only.									
Slant 41.8% EC	Propiconazole (3)	91234-25 91232-2-91234	Nonbearing 1000 (oil) Fruit (group 10-10) 8	12 months	NO	12	10,000 lb	--	--
Other Use Requirements: Do not apply more than 24 fl oz (0.67 lb a.i.)/ac/season.									
SNS-209 Organic Systemic Pest Control	Rosemary and Rosemary oil (NC)	NA	Exempt	0	NO	0	--	--	--
Other Use Requirements: None									
Sonata	*Bacillus pumilis* strain QST-2808 (44BM 02)	264-1153	Exempt	0	NO	4	--	--	--
Other Use Requirements: None									
SOPP Soap	Sodium Ortho-phenylphenate (NC)	64864-45	10	PH[8]	NA	NA	--	--	--

Trade Name or Generic Name	Common Name (FRAC MOA)[1]	EPA Registration Number[2]	Tolerance Fruit (ppm)[3]	Days to Harvest	Field Posting Required[4]	REI Hr	EPCRA[5]		
							TPQ (lb a.i.)[6]		RQ (lb a.i.)[7]
							1	2	
Other Use Requirements: Postharvest only.									
Stargus	*Bacillus amyloliquefaciens* (44BM 02)	84059-28	Exempt	0	NO	4	--	--	--
Other Use Requirements: None									
Strider	Propiconazole (3)	228-623	Nonbearing 1000 (oil) Fruit (group 10-10) 8	12 months	NO	24	--	--	--
Other Use Requirements: Do not apply more than 5.4 gal (0.67 lb a.i.)/ac/season.									
Subdue GR MAXX	Mefenoxam (4)	100-794 100-796	Nonbearing 1.0 fruit, citrus 7.0 (oil) 7.0 (citrus pulp)	12 months	NO	48	--	--	--
Other Use Requirements: Nonbearing. Do not exceed the equivalent 6 lb a.i./ac of mefenoxam-containing products. Do not use in greenhouse nursery stock intended for commercial use.									
Tenet WP	*Trichoderma asperellum* Strain ICC 012 (BM 02) *T. gamsii* strain ICC 080 (BM 02)	80289-9	Exempt	0	NO	1	--	--	--
Other Use Requirements: Not compatible with imazalil, dichloran, mancozeb, propiconazole, tenbuconazole, thiram, and triflumizole. Do not tank-mix or apply Tenet within 3 days before or after use of these products.									
Tetraban	Azoyxstrobin (11)	1381-267	Fruit (group 10-10) 15.0 20 (dried pulp) 40 (oil)	0	NO	4	--	--	--
Other Use Requirements: Do not apply more than 92.3 fl oz/ac/season for all uses or 1.5 lb a.i./ac/season.									
Tide Propiconazole 41.8EC	Propiconazole (3)	84229-11	Nonbearing 1000 (oil) Fruit (group 10-10) 8.0	12 months	NO	12	--	--	--
Other Use Requirements: Do not apply more than 24 fl oz (0.67 lb a.i.) PropiMax EC/ac/season.									
Tilt	Propiconazole (3)	100-617	Nonbearing 1000 (oil) Fruit (group 10-10) 8.0	12 months	NO	12	--	--	>1,000 gal
Other Use Requirements: Do not apply more than 0.67 lb a.i. (24 fl oz/ac/season) of Tilt.									

Trade Name or Generic Name	Common Name (FRAC MOA)[1]	EPA Registration Number[2]	Tolerance Fruit (ppm)[3]	Days to Harvest	Field Posting Required[4]	REI Hr	EPCRA[5] TPQ (lb a.i.)[6] 1	EPCRA[5] TPQ (lb a.i.)[6] 2	EPCRA[5] RQ (lb a.i.)[7]
Topaz	Propiconazole (3)	42750-211-1381	Nonbearing 1000 (oil) Fruit (group 10-10) 8.0	12 months	NO	12	--	--	226 gal
Other Use Requirements: Do not apply more than 24 fl oz (0.67 lb a.i.) PropiMax EC/ac/season.									
TREVO fungicide	Azoyxstrobin (11)	89167-39-89391 89168-41-89391	Fruit (group 10-10) 15.0 20 (dried pulp) 40 (oil)	0	NO	4	--	--	--
Other Use Requirements: Do not apply more than 92.3 fl oz/ac/season for all uses or 1.5 lb a.i./ac/season.									
Triathlon BA	*Bacillus amyloliquefaciens* strain D747 (44BM 02)	70051-107-59807	Exempt	0	NO	4	--	--	--
Other Use Requirements: None									
Trilogy	Neem oil extract (IRAC 18) (NC)	70051-2	Exempt	0	NO	4	--	--	--
Other Use Requirements: Do not apply while bees are actively foraging. Do not apply within 5 days of a sulfur application.									
TurfShield Plus WP	*Trichoderma harzianum* Rifai strain T-22 (BM 02) *Trichoderma virens* strain G-41 (BM 02)	68539-9	Exempt	0	NO	4	--	--	--
Other Use Requirements: Not compatible with imazalil, propiconazole, tenbuconazole, and triflumizole. Do not tank-mix or apply TurfShield within 3 days before or after use of these products.									
Ultra Flourish	Mefenoxam (4)	55146-73	1.0 fruit, citrus 7.0 (oil) 7.0 (citrus pulp)	0	NO	48	--	--	100 lb (Naph-thalene)
Other Use Requirements: Do not exceed the equivalent 6 lb a.i./ac (24 pints) of mefenoxam-containing products. No more than 3 applications/season.									
Vacciplant	Laminarin (P 04)	83941-2-66330	Exempt	0	NO	4	--	--	--
Other Use Requirements: None									
Veltyma	Pyraclostrobin (11) Mefentrifluconazole (3)	7969-409	P 12.5 (dried pulp) P 9.0 (oil) P Fruit (group 10-10) 2.0 M 2.0 (dried pulp) M 15 (oil)+++	0	NO	12	--	--	--
Other Use Requirements: Do not apply more than 30 fl oz (0.39 lb mefentrifluconazole and pyraclostrobin)/ac/year. Do not make more than 3 applications.									

Trade Name or Generic Name	Common Name (FRAC MOA)[1]	EPA Registration Number[2]	Tolerance Fruit (ppm)[3]	Days to Harvest	Field Posting Required[4]	REI Hr	EPCRA[5]		
							TPQ (lb a.i.)[6]		RQ (lb a.i.)[7]
							1	2	
Velum Prime	Fluopyram (7)	264-1078	1.0 fruit, (group 10-10) 8.0 (oil)	7	NO	12	--	--	--
Other Use Requirements: Do not exceed the equivalent 0.446 lb a.i./ac (13.7 fl oz) of fluopyram-containing products. Apply via chemigation.									
Willowood Azoxy 2SC	Azoyxstrobin (11)	87290-44	Fruit (group 10-10) 15.0 20 (dried pulp) 40 (oil)	0	NO	4	--	--	--
Other Use Requirements: Do not apply more than 92.3 fl oz/ac/season for all uses or 1.5 lb a.i./ac/season.									
Willowood Propicon 3.6EC	Propiconazole (3)	87290-7	Nonbearing 1000 (oil) Fruit (group 10-10) 8.0	12 months	NO	12	--	--	226 gal
Other Use Requirements: Do not apply more than 24 fl oz (0.67 lb a.i.)/ac/season.									
Willowood Pyrac 2EC	Pyraclostrobin (11)	87290-64	12.5 (dried pulp) 9.0 (oil) Fruit (group 10-10) 2.0	0	NO	12	1,000 lb Ethylene oxide	--	1463528.9 lb
Other Use Requirements: Do not apply more than 54 fl oz (0.88 lb a.i.)/ac/season.									

[1] Mode of action class for citrus pesticides from the Insecticide, Fungicide, and Herbicide Resistance Action Committees. Refer to ENY-624, *Pesticide Resistance and Resistance Management*, in the *2020–21 Florida Citrus Production Guide* for more details.
[2] Extracted from product labels, Code of Federal Regulations and other federal and state regulations.
[3] A letter before the number indicates to which common name the tolerance refers.
[4] Read product label for specific use precautions, especially Worker Protection Standards and environmental concerns.
[5] Emergency Planning and Community Right-To-Know Act. Information presented here is not intended to take the place of the actual regulation. Call the State Emergency Response Commission at 1-800-635-7179 for additional details.
[6] Threshold Planning Quantity. If the grower meets or exceeds this amount, notification must be made. Placard vehicle not a facility. (1 = active ingredient is a gas, is molten, is in solution, or is a fine powder; 2 = is a granular or other larger particle form.)
[7] The amount of active ingredient that when spilled or released requires reporting to authorities within a 15-minute time frame. Should be reported by telephone to 850-413-9919 or 800-320-0519.
[8] NA = not available.
[9] SL = See Label for use restrictions.
[10] Section 18 effective 12/31/2019–12/31/2020.
[11] Supplemental label expires 6/28/2020.

Table 6. Pesticides registered for use on Florida citrus—herbicides.

Trade Name or Generic Name	Common Name (HRAC MOA)[8]	EPA Registration Number[1]	Tolerance Fruit (ppm)	Days to Harvest	Field Posting Required[2]	REI Hr	EPCRA[3] TPQ (lb a.i.)[4] 1	EPCRA[3] TPQ (lb a.i.)[4] 2	EPCRA[3] RQ (lb a.i.)[5]
Aim EC	Carfentrazone-ethyl (E)	279-3241	0.1	3	NO	12	--	--	--
Other Use Requirements: None									
Alion	Indaziflam	264-1106	0.01	7	NO	12	--	--	--
Other Use Requirements: 24(c) SLN No. FL-110004; for application in citrus groves to trees established less than one year.									
Broadworks	mesotrione	100-1131	0.01	30	NO	12	--	--	--
Other Use Requirements: Do not exceed 6 fl oz/ac at the first application. Do not exceed 12 fl oz/ac or more than 3 applications within a 12-month period. Allow at least 5 months between applications at 6 fl oz/ac, and at least 6 weeks between applications of 6 fl oz/ac and subsequent applications at 3 fl oz/ac.									
Bromacil Hyvar X	Bromacil Bromacil (C1)	352-287	0.1	0	NO	12	--	--	--
Other Use Requirements: See Best Management Practice guidelines.									
Bromacil + Diuron Krovar I DF	Bromacil + Diuron (C1, C2)	352-505	0.1, 1	0	NO	12	--	--	--
Other Use Requirements: See Best Management Practice guidelines.									
Chateau SW	Flumioxazin	59639-99	0.02	3	NO	12	--	--	--
Other Use Requirements:									
Diuron	Diuron (C2)		NA[7]	0	NO	12	100	--	--
Direx 4L		66222-54							
Diuron 4L		19713-36 (Drexel)							
Diuron 4L		9779-329 (Winfield Solutions LLC)							
Diuron 4L		66222-54 (Mana)							
Diuron 4L		34704-854 (Loveland)							
Diuron 80		352-692							
Diuron 80		19713-274 (Drexel)							
Diuron 80DF		9779-318 (Agrisolutions)							
Diuron 80DF		66222-51 (Mana)							
Diuron 80 WDG		34704-648							
Karmex DF		66222-51							
Other Use Requirements: None									
Fusilade DX	Fluazifop-P-butyl (A)	100-1070		14 days	NO	12	--	--	--
Other Use Requirements: None									

Trade Name or Generic Name	Common Name (HRAC MOA)[8]	EPA Registration Number[1]	Tolerance Fruit (ppm)	Days to Harvest	Field Posting Required[2]	REI Hr	EPCRA[3]		
							TPQ (lb a.i.)[4]		RQ (lb a.i.)[5]
							1	2	
Glyphosate	Glyphosate (G)		0.5	1	NO	4 to 12*	--	--	--
Buccaneer		55467-10							
Buccaneer Plus		55467-9							
Credit Extra		71368-65				4 to 12*			
Durango		62719-517							
Durango DMA		62719-556							
Glyphomax		62719-323							
Glyphomax Plus		62719-322							
Honcho		524-445							
Honcho Plus		524-454							
Mad Dog		34704-889				4			
Mad Dog Plus		34704-890							
Ranger Pro		524-517							
Roundup PowerMax		524-549							
Roundup WeatherMax		524-537							
Touchdown HiTech		100-1182							
Other Use Requirements: None; *See labels for REI details.									
Goal	Oxyfluorfen (E)	(2.0 E) 62719-424	Nonbearing	12 months	NO	24	--	--	--
Other Use Requirements: None									
Landmaster II	Glyphosate + 2,4-D (G, O)	SLN FL 00-0004 524-376	5	7	NO	48	--	--	--
Other Use Requirements: See Florida State Statute SE-2.033 and supplemental labeling.									
Matrix Matrix FNV Matrix SG	Rimsulfuron	352-556 352-671 352-768	0.01	3	NO	4	--	--	--
Other Use Requirements: RESTRICTED PESTICIDE.[6]									
Paraquat dichloride	Paraquat dichloride (D)								
Gramoxon SL2.0		100-1431	0.05N	1	NO	24	10	10,000	1
Other Use Requirements: RESTRICTED PESTICIDE.[6]									

Trade Name or Generic Name	Common Name (HRAC MOA)[8]	EPA Registration Number[1]	Tolerance Fruit (ppm)	Days to Harvest	Field Posting Required[2]	REI Hr	EPCRA[3] TPQ (lb a.i.)[4] 1	EPCRA[3] TPQ (lb a.i.)[4] 2	EPCRA[3] RQ (lb a.i.)[5]
Pendimethalin	Pendimethalin (K1)								
Prowl H_2O		241-418		1 day	NO	24	--	--	--
Other Use Requirements: None									
Poast Plus	Sethoxydim (A)	7969-88	0.5	15	NO	12	--	--	--
Other Use Requirements: None									
Remedy Ultra	Triclopyr (O)	62719-552 SLN FL 080004	NA	NA	NO	Until dry	--	--	--
Rely 280	Glufosinate ammonium	264-829	0.15	14	NO	12	--	--	--
Other Use Requirements: None									
Simazine	Simazine (C1)		Grapefruit—0.25 Oranges—0.25	NA[7]	NO	12	--	--	--
Princep Caliber 90		100-603							
Princep 4L		100-526							
Simazine 4L		19713-60							
Simazine 4L		9779-296							
Simazine 4L		19713-60							
Simazine 4L		34704-687							
Simazine 90DF		19713-252							
Simazine 90DF		100-603-33270							
Simazine 90DF		9779-295							
Simazine 90DF		19713-252							
Simazine 90WDG		34704-686							
Sim-Trol 90DF		35915-12-60063							
Other Use Requirements: None									
Solicam	Norflurazon (F1)	100-849	0.2	30	NO	12	--	--	--
Other Use Requirements: None									
Surflan Oryzalin 4 A.S.	Oryzalin (K1)	(AS) 70506-43 66222-138	0.05	--	NO	24	--	--	--
Other Use Requirements: None									
Treevix	Saflufenacil	7969-276	0.03	1	NO	12	--	--	--
Other Use Requirements: None									

Trade Name or Generic Name	Common Name (HRAC MOA)[8]	EPA Registration Number[1]	Tolerance Fruit (ppm)	Days to Harvest	Field Posting Required[2]	REI Hr	EPCRA[3]		
							TPQ (lb a.i.)[4]		RQ (lb a.i.)[5]
							1	2	
Treflan HFP	Trifluralin (K1)	62719-250	0.05	--	NO	12	10	10,000	10

Other Use Requirements: None

[1] Extracted from product labels, Code of Federal Regulations and other federal and state regulations.
[2] Read product label for specific use precautions, especially Worker Protection Standards and environmental concerns.
[3] Emergency Planning and Community Right-To-Know Act. Information presented here is not intended to take the place of the actual regulation. Call the State Emergency Response Commission at 1-800-635-7179 for additional details.
[4] Threshold Planning Quantity. If the grower meets or exceeds this amount, notification must be made. Placard vehicle not a facility. (1 = active ingredient is a gas, is molten, is in solution, or is a fine powder; 2 = is a granular or other larger particle form.)
[5] The amount of active ingredient that when spilled or released requires reporting to authorities with a 15-minute time frame. Should be reported by telephone to 850-413-9919 or 800-320-0519.
[6] A certification license is required to purchase and apply or must be under the supervision of a licensee and only for those uses covered by the certified applicator's certification.
[7] NA = not available.
[8] Mode of action class for citrus pesticides from the Insecticide, Fungicide, and Herbicide Resistance Action Committees. Refer to ENY-624, *Pesticide Resistance and Resistance Management*, in the *2020–21 Florida Citrus Production Guide* for more details.

Table 7. Pesticides registered for use on Florida citrus—plant growth regulators and other products.

Trade Name or Generic Name	Common Name (Active Ingredients)	EPA Registration Number[1]	Tolerance Fruit (ppm)	Days to Harvest	Field Posting Required[2]	REI Hr	EPCRA[3] TPQ (lb a.i.)[4] 1	EPCRA[3] TPQ (lb a.i.)[4] 2	RQ (lb a.i.)[5]
Citrus Fix	2,4-Dichlorophenoxyacetic acid	5481-145	3	7	NO	12	--	--	--
Other Use Requirements: RESTRICTED PESTICIDE.[6]									
Ascend	Cytokinin + Gibberellic Acid + Indole-3-butyric Acid	9779-335 (SL)1381-253 (WSG)1381-254	Exempt	NA	NO	4			
Other Use Requirements: None									
Cytokin Bioregulator Concentrate	Cytokinin	90930-3	Exempt	NA	NO	4			
Other Use Requirements: None									
Cytoplex HMS	Cytokinin + Gibberellic Acid + Indole-3-butyric Acid	90930-6	Exempt	NA	NO	4			
Other Use Requirements: None									
Drexel Sprout-Stop	Potassium Salt of maleic hydrazide	19713-2	Nonbearing	--	NO	12			
Other Use Requirements: None									
Falgro	Gibberellic Acid	(20SP) 62097-3-82917 (4L) 62097-2-82917	Exempt	0	NO	4			
Other Use Requirements: None									
Gib Gro	Gibberellic Acid	(4 LS) 55146-62 (20%) 55146-53	Exempt	NA	NO	4	--	--	--
Other Use Requirements: None									
Hivol-44	2,4-Dichlorophenoxyacetic acid	5481-509	3	7	NO	12	--	--	--
Other Use Requirements: None									
Homobrassinolide	Homobrassinolide	69361-49	Exempt	15	NO	4			
Other Use Requirements: None									
Hormodin 3	Indole-3-butyric Acid	59807-3	Propagation	--	--	--			
Other Use Requirements: None									
InLine Soil Fumigant	Trans 1,3-dichloropropene + chloropicrin	62719-348	Replant	NA[8]	YES	5 days	0	10,000	0
Other Use Requirements: SL.[7] See label for geographic restrictions in Florida.									
KickStand PGR	Indole-3-butyric Acid	5905-540	Exempt	NA	NO	4			
Other Use Requirements: None									
K Salt Fruit Fix 200	1-Naphthaleneacetic acid	5481-414	0.1	150	NO	24	--	--	--
Other Use Requirements: None									

Trade Name or Generic Name	Common Name (Active Ingredients)	EPA Registration Number[1]	Tolerance Fruit (ppm)	Days to Harvest	Field Posting Required[2]	REI Hr	EPCRA[3] TPQ (lb a.i.)[4]		RQ (lb a.i.)[5]
							1	2	
N-Large	Gibberellic Acid	57538-18	Exempt	7	NO	12			
Other Use Requirements: None									
PGR IV	Gibberellic Acid + Indole-3-butyric Acid	51036-260	Nonbearing	--	NO	4			
Other Use Requirements: None									
Petroleum Oil	FC-412-66 FC-435-66 FC-455-88 470 oil	See Table 3	Exempt	0	NO	4	--	--	--
Other Use Requirements: See Sulfur (Table 2).									
ProGibb	Gibberellic acid	(4%) 73049-15 (40%) 73049-1 (LV)73049-498	Exempt	0	NO	4	--	--	--
Other Use Requirements: None									
Radiate	Cytokinin + Indole-3-butyric Acid	34704-909	Exempt	NA	NO	4			
Other Use Requirements: None									
Receptor	Cytokinin + Gibberellic Acid + Indole-3-butyric Acid	5905-594	Exempt	NA	NO	4			
Other Use Requirements: None									
Rhizopon AA #3	Indole-3-butyric Acid	63310-21	Propagation	--	NO	0			
Other Use Requirements: None									
Stimplex	Cytokinin	75287-3	Exempt	0	NO	4			
Other Use Requirements: None									
Stimulate Power	Cytokinin + Gibberellic Acid	57538-38	Exempt	NA	NO	4			
Other Use Requirements: None									
Stimulate Yield Enhancer	Cytokinin + Gibberellic Acid + Indole-3-butyric Acid	57538-13	Exempt	NA	NO	4			
Other Use Requirements: None									
Stimulate Fruit Thinner	Cytokinin + Gibberellic Acid	57538-36	Exempt	NA	NO	4			
Other Use Requirements: None									
Telone	Trans 1,3-dichloropropene (II, EC) or plus chloropicrin (C17, C35)	(II) 62719-32 (EC) 62719-321 (C17) 62719-12 (C35) 62719-302	Replant	NA[8]	YES	5 days	0	10,000	100
Other Use Requirements: SL.[7] See label for geographic restrictions in Florida.									
Validate	Cytokinin	34704-910	Exempt	40	NO	4			
Other Use Requirements: None									

Trade Name or Generic Name	Common Name (Active Ingredients)	EPA Registration Number[1]	Tolerance Fruit (ppm)	Days to Harvest	Field Posting Required[2]	REI Hr	EPCRA[3] TPQ (lb a.i.)[4]		RQ (lb a.i.)[5]
							1	2	
X-Cyte	Cytokinin	57538-15	Exempt	NA	NO	4			
Other Use Requirements: None									
Vapam HL	Metam-sodium (SMCD)	5481-468	Replant	NA[8]	YES	48	0	10,000	100
Other Use Requirements: SL[7]									

[1] Extracted from product labels, Code of Federal Regulations and other federal and state regulations.
[2] Read product label for specific use precautions, especially Worker Protection Standards and environmental concerns.
[3] Emergency Planning and Community Right-To-Know Act. Information presented here is not intended to take the place of the actual regulation. Call the State Emergency Response Commission at 1-800-635-7179 for additional details.
[4] Threshold Planning Quantity. If the grower meets or exceeds this amount, notification must be made. Placard vehicle not a facility. (1 = active ingredient is a gas, is molten, is in solution, or is a fine powder; 2 = is a granular or other larger particle form.)
[5] The amount of active ingredient that when spilled or released requires reporting to authorities with a 15-minute time frame. Should be reported by telephone to 850-413-9919 or 800-320-0519.
[6] A certification license is required to purchase and apply or must be under the supervision of a licensee and only for those uses covered by the certified applicator's certification.
[7] SL = See Label for use restrictions.
[8] NA = Not available.
[9] Postharvest use only.