

2023–2024 Florida Citrus Production Guide: Best Management Practices for Soil-Applied Agricultural Chemicals¹

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Over 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 agencies emphasize the need to protect groundwater and all drinking water supplies and, in turn, have restricted the timing and use of certain widely used agricultural chemicals. As a result of these concerns and more stringent regulatory policies and best management practices (BMPs), growers will have to assume increasingly more responsibility for the crop management practices they choose: The fate of the environment depends, in part, on the agricultural chemicals they use. Specific BMPs are currently being implemented to optimize crop production and environmental protection for both ridge and Flatwoods citrus production; this state-sponsored, voluntary program encourages citrus growers 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 one to (1) monitor activities for the presence and abundance of pests within the grove, (2) determine whether pest population densities are high enough to cause economic loss, and (3) select 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.

Pesticide selection should be based not only on cost-effectiveness but also on mode of action rotation; consideration of the latter helps avoid resistance buildup, toxicity to

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nontarget species, and product solubility, persistence, and leaching potential of the pesticide in question. This consideration also requires regulating the irrigation schedule based on soil type, and other site characteristics. Various sources of information are available for identifying specific soil types and ideal irrigation schedules to help in 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 under-canopy coverage is of critical importance. Pesticide placement under the tree canopy targets the areas of highest fibrous root and pest density; by doing so, this placement can significantly improve overall pest control and minimize leaching. 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). Under-canopy weed growth may reduce pesticide effectiveness by interception or absorption of pesticide residues targeted for citrus roots or pests in the soil. Under-canopy weeds also interfere with microsprinkler operation and prevent uniform coverage of chemigated compounds. At the individual tree level, excessive irrigation, when 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. Organic matter is one of the most important soil characteristics in determining the leaching potentials of many agricultural chemicals. Rates of leaching are lower for soils with high organic matter content. Deep Ridge sands, low in organic matter (typically less than 1%), 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}): 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 irrigation management 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, *Phytophthora* spp., *Alternaria* spp., and various weeds. 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 under-canopy 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 water-use management 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 to determine how much irrigation water to apply per irrigation event and when to apply it. 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. The deeper tensiometer can be monitored to ensure that no water moves below the root zone. To irrigate on a budget, one needs a computer on which to input daily 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 water-holding capacity of the soil and the diameter and application rate to the wetted under-canopy area are necessary data to determine the duration of irrigation that would 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* (<http://ufdc.ufl.edu/IR00003134/00001>); Circular 1127, *Citrus Fertilizer Management on Calcareous Soils* (<https://edis.ifas.ufl.edu/ch086>); Circular 1410, *Fertigation Nutrient Sources and Application Considerations for Citrus* (<https://doi.org/10.32473/edis-ch185-2002>); or in the soil survey report for each county.

Total volume of irrigation water—not necessarily duration (irrigation run time) of the sprinklers—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* (<https://itc.tamu.edu/files/2018/05/CIR1406.pdf>); Circular 1413, *Control and Automation in Citrus Microirrigation Systems* (<https://doi.org/10.32473/edis-ch194-2002>); Bulletin 265, *Field Evaluation of Microirrigation Water Application Uniformity* (<https://edis.ifas.ufl.edu/ae094>); and HS958, *Management of Microsprinkler Systems for Florida Citrus* (<https://doi.org/10.32473/edis-hs204-2004>).