

Best Management Practices for Soil-Applied Agricultural Chemicals¹

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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 time 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 (<http://ircitrusbmp.ifas.ufl.edu>; <http://Floridaagwaterpolicy.com>). In this state-sponsored, voluntary program, citrus growers are being encouraged to develop and adopt site-specific BMP plans for controlling agricultural 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 best management practices, including the following: integration of crop and pest management strategies (IPM), 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 also evaluated and corrected. In addition, a truly integrated strategy requires consideration of pesticide selection, when the choice exists, prior to application.

Pesticide selection should not be based only on cost effectiveness, but also on toxicity to non-target 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. 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.

¹ This document is HS-185, one of a series of the Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date: December 1995. Revised: September 2013. Visit the EDIS website at <http://edis.ifas.ufl.edu>. For a copy of this guide, request information on its availability at your county extension office.

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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 application should be delayed if heavy rainfall is imminent, and subsequent irrigations adjusted to account for rainfall amounts.

Most soil-borne pests are associated with citrus roots. For pesticide applications targeting soil-borne 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. Since 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 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 which promote excessive vegetative growth, such as over-watering 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 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 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 absorbed and thus less subject to leaching. K_{oc} values of several common soil applied agricultural chemicals are listed in University of Florida Soil and Water Science Department Circular 974. 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.

IRRIGATION

Agricultural chemicals are moved through the soil by both rain and irrigation. Hence, it is important to consider best management irrigation practices which minimize water movement below the root zone. Failure to irrigate properly may well 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.

It should also be recognized that excessive irrigation and rainfall can also promote population build-up 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 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 low soil organic matter content, irrigation schedules based on soil moisture deficits are likely to improve pest control and grove response to treatment by maximizing retention of toxic concentrations in the citrus tree root zone and prevent problems of environmental contamination.

Best management water use practices currently rely upon the use of accounting methods and/or the use of soil water sensors (e.g. tensiometers, capacitance probes, or other sensors) for determining when and how much irrigation water to apply during any single application. Irrigation based on tensiometers will likely require tensiometers 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 monitored to ensure that no water moves below the root zone. Irrigation by the budget method will require a computer and daily inputs of rainfall, irrigation, and evapotranspiration data. The set points for irrigation will be cumulatively based on daily depletion of available soil water throughout the profile and of tree growth stage.

The diameter and application rate to the wetted under canopy area, and the water-holding capacity of the soil will also be needed information for determining the duration of irrigation that will wet only to the appropriate root zone depth. Data on the water-holding capacity of citrus soils can be found in University of Florida, IFAS, publications: SL 193 Common Soils Used for Citrus Production in Florida; Circular 1127 Citrus Fertilizer Management on Calcareous Soils; Circular 1410 Fertigation Nutrient Sources and Application Considerations for Citrus, or in the soil survey report for each county. It is important to recognize that it is total volume of irrigation

water, and not necessarily duration or irrigation run time of the sprinklers which is important in driving the movement of chemicals through the soil profile. The length of time to irrigate will depend on the water-holding capacity of the soil and the amount of water depleted from the soil and microsprinkler application rate. Sprinkler application rates (volume) are therefore very important in determining how long to irrigate. 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 University of Florida, IFAS, publications: Circular 1406 Understanding Water Quality Parameters for Citrus Irrigation and Drainage Systems; Circular 1413 Control and Automation in Citrus Microirrigation Systems, Bulletin 265 Field Evaluation of Microirrigation Water Application Uniformity, and HS958 Management of Microsprinkler Systems for Florida Citrus.

In summary, the purpose of this document is to provide information that can help citrus growers and caretakers select and manage agricultural chemicals in ways which will minimize environmental impact. These BMPs must consider the soil properties of the application site and the mobility and toxicity of agrichemicals in soil, particularly with regard to rainfall and irrigation practices. With these considerations in mind, citrus growers can hopefully make better, more informed decisions regarding the chemicals that they use.