



**Water Quality/Quantity
Best Management Practices
for
Florida Vegetable
and
Agronomic Crops**

2015 Edition

FDACS-P-01266



Florida Department of Agriculture and Consumer Services
Adam H. Putnam, Commissioner





FLORIDA DEPARTMENT OF AGRICULTURE AND CONSUMER SERVICES COMMISSIONER ADAM H. PUTNAM

COMMENTS BY COMMISSIONER ADAM H. PUTNAM

Dear Agricultural Producers:

This revised manual, *Water Quality/Quantity Best Management Practices for Florida Vegetable and Agronomic Crops*, reflects the hard work of representatives of the industry; federal, state, and local government; and other stakeholders. The revision expands on the previous 2005 edition of the manual by incorporating practices for sugarcane, hay and silage production, and updates practices according to the type of production system.

While best management practices have been in place for many years in our state, their role in environmental protection was formally established in 1999 with the passage of the Florida Watershed Restoration Act. This legislation provides the framework for implementing Florida's Total Maximum Daily Load program, which sets water quality targets for impaired waters. It also identifies best management practices implementation as the means for agriculture to help meet those targets.

As Florida's population continues to increase, there are more impacts to and competition for Florida's limited water resources. All Floridians must take part in conserving and protecting these resources. This manual represents the industry's commitment to do just that.

As a native Floridian whose family has long been involved in agriculture, I want to thank all who participated with the Department in the development of this important manual. With the active support and participation of so many dedicated people, I am optimistic about the future of Florida's agricultural industry. I trust that you will join me in supporting this valuable water resource protection effort.

Sincerely,

A handwritten signature in black ink, appearing to read "Adam H. Putnam".

Adam H. Putnam
Commissioner of Agriculture

ACKNOWLEDGEMENTS

This statewide BMP manual for vegetable and agronomic crops clarifies and updates the practices in the original (2005) manual. The following is a list of individuals who participated in the manual revision. Each of these individuals and their organizations made important contributions to the process, and their work is sincerely appreciated.

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TABLE OF CONTENTS


INTRODUCTION.....	1
POTENTIAL WATER QUALITY IMPACTS ASSOCIATED WITH FARMING	4
KEYS TO POLLUTION PREVENTION	6
USER'S GUIDE TO BMP ENROLLMENT AND IMPLEMENTATION	7
Implementation Steps	7
BMP Implementation Follow-Up	8
BEST MANAGEMENT PRACTICES	9
1.0 Field and Bed Preparation	10
2.0 Nutrient and Irrigation Management	14
2.1 Plastic Mulch Production Systems	27
• Drip	
• Semi-Enclosed Seepage	
2.2 Bare Ground Production Systems	30
• Raised Bed	
• At-Grade	
2.3 Sugarcane Production Systems	34
• Organic and Sandy Soils	
2.4 Hay and Silage Production Systems	36
2.5 Protected Growing Systems	39
3.0 Irrigation System Maintenance	40
4.0 Sediment and Erosion Control Measures	45
5.0 Water Resources Protection	50
6.0 Stormwater Management	54
7.0 Integrated Pest Management	56
8.0 Recycling and Waste Management.....	60
APPENDICES.....	65
Appendix 1: Acronym List and Glossary.....	66
Appendix 2: Soil and Tissue Testing Information	68
Appendix 3: Effectiveness and Maintenance of Vegetative Filter Strips.....	70
Appendix 4: Soil Moisture Monitoring and Equipment Maintenance.....	72
Appendix 5: Special Nutrient Management Measures	75
Appendix 6: Incentive Programs for Qualifying Operations	77
Appendix 7: Example Record-Keeping Forms	79
Appendix 8: Contact Information	80
Appendix 9: Rule Chapter 5M-8, F.A.C.	81
Appendix 10: Notice of Intent to Implement Form and BMP Checklist	83
Appendix 11: Notice of Intent to Implement Form for EAA, C-139 and Western Basins Area	103

INTRODUCTION

Operations Intended to Use this Manual

In order to enroll in Florida Department of Agriculture and Consumer Services (FDACS) **Best Management Practices** (BMPs) under this manual, farms must produce vegetables, field crops, sugarcane, forage grasses grown for hay or silage production, or caladiums. This manual and BMP manuals for crops other than those listed above are available electronically at: <http://www.freshfromflorida.com/Business-Services/Water/Agricultural-Best-Management-Practices>.

Things to Keep in Mind as You Use this Manual

- Italicized words that appear in **bolded red** are defined in the glossary.
- Specific record-keeping requirements are noted using a “pencil mark” icon: 
- Each section provides a description of the BMPs along with related references. Some of the practices may not be applicable to all producers. With assistance from FDACS field staff and technicians, producers will identify the applicable BMPs, which are denoted by a check mark symbol (✓).

Overview of the Industry

The industry is extremely diverse and covers many geographic regions of the state. According to the 2012 Florida Agricultural Statistics Service data, Florida ranks second behind California in fresh market vegetable production, with approximately 237,000 acres of vegetables and a farm value exceeding \$2 billion in revenue. Agronomic crops, including sugarcane grown in South Florida and field crops grown primarily in North Florida, total approximately 986,000 acres.

Organic farming is a fairly well established sector of the industry. Organic crops are defined as product grown, packaged, and stored without the use of synthetic fertilizers, pesticides, plant growth regulators, or irradiation. To be a certified organic farm under Section 504.34, Florida Statutes, producers must meet specific standards. At the federal level, the National Organic Program develops, implements, and administers national production, handling, and labeling standards. For more information about the National Organic Program, go to: <http://www.ams.usda.gov/AMSV1.0/nop>.

Biofuel crop production is an emerging sector of the industry. Increasingly, as world crude oil prices rise, producers are experimenting with growing sugarcane, sorghum, switchgrass, corn, and other crops for biofuel feedstock. However, some of these new crops may require more irrigation and nutrient inputs than the crops previously grown, so producers should fully investigate all production requirements first.

Best Management Practices

BMPs are individual practices or combinations of practices that, based on research, field-testing, and expert review, have been determined to be the most effective and practicable means for maintaining or improving the water quality of surface and ground waters. BMPs typically are implemented in combination to prevent, reduce, or treat pollutant discharges offsite. BMPs must be based on sound science, be technically feasible, and be economically viable. For purposes of this manual, BMPs are denoted by a check mark symbol (✓).

BMPs and Water Quality

Studies conducted by the Environmental Protection Agency (EPA) indicate that nonpoint sources (both urban and agricultural) are the nation’s greatest contributors to water pollution. Much of the contribution is due to runoff draining into lakes, rivers, wetlands, estuaries, and ground water. It is good stewardship and makes good sense for producers to prevent or minimize these impacts by using BMPs. In fact, the Florida Legislature has established BMP implementation as the non-regulatory means for agricultural nonpoint sources to comply with state water quality standards. When you implement BMPs, you are also validating the Legislature’s support for this approach.

Total Maximum Daily Loads

Under the federal Clean Water Act and Florida law, the Florida Department of Environmental Protection (FDEP) must identify impaired surface waters and establish Total Maximum Daily Loads (TMDLs) for pollutants entering these waters. A TMDL establishes the maximum amount of a pollutant that can be discharged to a waterbody and still meet state water quality standards. Some pollutants for which TMDLs have been set include: total phosphorus, total nitrogen, total suspended solids, and fecal coliform bacteria.

FDEP may develop and adopt Basin Management Action Plans (BMAPs), which contain the activities that affected interests need to undertake to reduce point and nonpoint source pollutant loadings. In **watersheds** with adopted BMAPs, and in some other geographic areas, agricultural producers either must implement FDACS-adopted BMPs or conduct water quality monitoring prescribed by FDEP or the water management district (WMD).

Florida already has adopted a significant number of TMDLs, and many more waterbodies are listed for TMDL development. This list encompasses lakes, rivers, streams, springs, and estuarine systems. More information on listed waterbodies and adopted TMDLs is available at: <http://www.dep.state.fl.us/water/tmdl/index.htm>. To see a map of BMAP areas and learn more about BMAP development, go to: <http://www.dep.state.fl.us/water/watersheds/bmap.htm>. If you need help figuring out whether you are in a BMAP area, call (850) 617-1727, or e-mail AgBMPHelp@freshfrom-florida.com.

Benefits of Implementing BMPs

Before FDACS adopts BMPs, the FDEP reviews them and determines whether they will be effective in addressing water quality impacts from agricultural operations. Benefits to enrolling in and implementing FDACS-adopted BMPs include:

- A presumption of compliance with state water quality standards for the pollutants addressed by the BMPs. Even if additional numeric nutrient criteria become part of state standards, producers who enroll in and implement the BMPs still have the presumption of compliance.
- Release from the provisions of Section 376.307(5), Florida Statutes (F.S.), (fines for damages) for pollutants addressed by the BMPs.
- Technical assistance with BMP implementation.
- Eligibility for cost-share for certain BMPs (as available).
- The Florida Right to Farm Act generally prohibits local governments from regulating an agricultural activity that is addressed through rule-adopted BMPs that producers implement.
- Producers who implement FDACS-adopted BMPs might qualify for exemptions from WMD surface water permitting and/or satisfy other permitting requirements.

- Some BMPs increase production efficiency and reduce costs.
- BMP participation demonstrates agriculture's commitment to water resource protection, and maintains support for this approach to meeting water quality and conservation goals.

Implementation of BMPs does not excuse agricultural operations from complying with applicable permitting or other regulatory requirements.

Permit Exemptions

Some agricultural activities, especially those that alter on-site hydrology, may require an Environmental Resource Permit (ERP). Check with your WMD or FDACS before beginning construction of any stormwater management system to see whether a permit is needed, or whether the following exemptions apply:

- Under subsection 373.406(2), F.S., any person engaged in the occupation of agriculture may alter the topography of any tract of land for purposes consistent with the practice of agriculture. However, these activities may not be for the sole or predominant purpose of diverting or impeding surface waters, or adversely impacting wetlands. Agricultural activities that meet these criteria may be exempt from an ERP. If there is a documented dispute between a landowner and the WMD as to whether the exemption applies, either can request FDACS to make a binding determination.
- Under subsection 373.406(9), F.S., environmental restoration activities on agricultural lands that have minimal or insignificant impacts to water resources may also be exempt from an ERP, upon written request by the producer and written notification from FDEP or the WMD that the proposed activity qualifies for the exemption.
- Under subsection 373.406(13), F.S., upland, unconnected farm ponds up to 15 acres in size may be exempt as long as the average depth is less than 15 feet and they are located at least 50 feet from wetlands.

Even if an exemption applies, agricultural producers within a watershed with an adopted BMAP that addresses agricultural loadings either must implement FDACS-adopted BMPs or conduct water-quality monitoring prescribed by FDEP or the WMD.

Local Government Regulation

In general, nonresidential farm buildings are exempt from the Florida Building Code and associated county building codes, in accordance with sections 604.50 and 553.73, F.S. However, permits may still be required for construction or improvement of certain farm buildings, so it is important to check with your county building and permitting office before beginning construction.

The Florida Right to Farm Act (section 823.14, F.S.) provides that, with certain exceptions, a farm that has been in operation for one year or more and was

not a nuisance at the time of its established date of operation is not a public or private nuisance, if the farm conforms to generally accepted agricultural management practices. In addition, the Act provides that a local government may not adopt any ordinance, regulation, rule, or policy to limit an activity of a bona fide farm operation (with an agricultural land classification under s. 193.461, F.S.) if the activity is regulated through implemented BMPs adopted by FDEP, FDACS, or a WMD. Not all activities conducted on a farm are addressed by adopted BMPs, and some other exceptions apply, so it is important to research this beforehand.

POTENTIAL WATER QUALITY IMPACTS ASSOCIATED WITH FARMING

Most agronomic and vegetable crops are planted annually either from seeds or transplants, although vegetable crops are often multiple cropped on the same land in the same year. They generally have shallow fibrous root systems, may produce more than one crop per year, and receive larger amounts of fertilizer on an annual basis compared to other types of agriculture. Many operations use overhead, drip, and seepage irrigation to deliver water to crops. These combined factors create regional production and water quality challenges, as well as opportunities, depending upon site-specific factors.

Nutrients

Excess nitrogen and phosphorus are the most common causes of water quality impairments in Florida. These nutrients can enter surface waters through stormwater or irrigation runoff, or leach through soils into ground water.

The nitrogen form most abundant in natural surface waters is soluble organic nitrogen. In aerobic well-drained soils, nitrogen is usually transformed by bacteria to nitrate which is a plant-available form. Due to its high mobility, nitrate can also leach into ground water. Like nitrogen, phosphorus is another primary element necessary for growth of plants and animals. In terms of freshwater ecology, it tends to be the (growth) limiting nutrient, especially for lakes. Phosphorus is more effectively retained in the soil than nitrogen. However, phosphorus enters waterbodies attached to particulate matter via sediment transport or can be dissolved in water. In some soils, phosphorus is prone to leaching into ground water.

Excess Algal Growth

Algae are microscopic plants that are essential to aquatic systems. As a vital part of the food chain, algae provide the nutrition necessary to support aquatic animal life. Certain types of algae also provide habitat for aquatic organisms. However, high levels of nutrients in surface waters result in abnormal plant growth. The presence of excess algal blooms, noxious weeds, and too many floating aquatic plants can block sunlight necessary for photosynthesis by submerged aquatic plants. The mass die off and decomposition of these materials lowers the available dissolved oxygen, which can lead to fish kills.

Blue-green algae (*Cyanobacteria*) can become so abundant that they will cause a scum layer to form on the surface, shading the sunlight-dependent life below and disturbing the food chain. Livestock and pet deaths have been attributed to consumption of water with an abundance of Cyanobacteria, which produce toxins known to cause liver and nervous system effects in humans. Potential risks from recreational contact include skin, respiratory, and mucous membrane irritation.

Sedimentation

Sedimentation occurs when eroded soils are washed into surface waters, creating a buildup of solids on the bottom and suspended solids (turbidity) in the water column. Sedimentation impacts most commonly associated with agricultural operations come from the erosion of unprotected (non-vegetated) soils. Slope can further exacerbate this issue.

Sediment can fill in waterbodies, clog waterways, carry nutrients and other constituents, and affect water clarity. These effects combine to reduce fish, shellfish, and plant populations, and decrease the overall productivity of lakes, streams, estuaries, and coastal waters. Decreased penetration by sunlight can affect the feeding and breeding behaviors of fish, and the sediments can clog gills and cause irritation to the mucous membranes covering their eyes and scales. As the sediment settles, it can bury fish eggs. Recreational use may also decline because of reduced fish populations, less visibility, and reduced appeal of associated swimming areas.

Deposited sediment also reduces the flow capacity of ditches, streams, rivers, and navigation channels, which can result in more frequent maintenance dredging or farm field flooding. Nutrients and other contaminants such as pesticides can attach to sediments, and may have a negative water quality effect on downstream areas. Over time, they may be released from the sediment and become suspended in the water column.

Fecal Coliforms

Fecal coliforms from wildlife, uncomposted manure, improperly treated or applied *biosolids*, and septic tanks are another cause of water quality degradation. The likelihood of contamination is increased if manure or biosolids are applied to fields in excess of agronomic rates or under wet

weather conditions. The decomposition of fecal and other organic matter in water can lead to increased biological oxygen demand and lower dissolved oxygen levels. Fecal coliforms also can have serious human health impacts. As applicable, producers should follow Good Agricultural Practices, which address various food safety issues relating to microbial contamination.

KEYS TO POLLUTION PREVENTION

It is agriculture's responsibility to protect water quality and enhance water conservation by implementing BMPs. Implementing BMPs helps demonstrate the industry's commitment to protecting water resources, and garners support for this non-regulatory approach. Below are key guidelines.



Understand Water Quality Issues

Water quality includes chemical, biological, and physical characteristics. Elevated levels of phosphorus, nitrogen, sediment, bacteria, and organic material contribute to the degradation of water quality. The potential for discharges from agricultural operations to cause water quality problems varies, depending on soil type, slope, drainage features, nutrient management practices, and activities in or near **wetlands**, surface waters, or karst features. Farm management practices also affect an operation's impact on water quality. For more information on surface water quality, go to the following link: <http://lakewatch.ifas.ufl.edu/>.



Manage Nutrient Sources Properly

Managing nutrients carefully is critical to protecting water quality. Minimize the pollutants that leave your property by controlling the types of materials used on your operation. Nutrient-related pollutant discharges can come from excess use, inefficient placement, or poor application timing of commercial fertilizer, manure, and/or biosolids. An increasingly accepted and successful approach called the *4R Nutrient Stewardship Program* captures the key elements of effective nutrient management: Right Source – to ensure a balanced supply of essential nutrients, considering both naturally available sources and the characteristics of specific products, in plant available forms; Right Rate – based on soil nutrient supply and plant demand; Right Time – based on the dynamics of crop uptake, soil supply, nutrient loss risks, and field operation logistics; and Right Place – based on root-soil dynamics, nutrient movement, and soil variability within the field to maximize plant uptake and limit potential losses from the field. It is sound science in action. Successful use of the 4Rs also depends on proper water management. For more information, go to: <http://edis.ifas.ufl.edu/ss624> or www.nutrientstewardship.com.



Manage Irrigation and Drainage Carefully

Water is the carrier for nearly all pollutants. Managing irrigation inputs and drainage to keep moisture and fertilizer primarily in the root zone will reduce nutrient-related impacts. Irrigating in excess of the soil's water-holding capacity or excessive drainage will lead to increased runoff or leaching, and may lead to higher production costs or lower marketable yields.



Minimize the Potential for Erosion Impacts

Land clearing, culvert installation, road construction, ditch and canal maintenance, and cultivating short-term crops can expose soil and lead to erosion and increased pollutant loading risk. It is very important to apply soil conservation measures and special erosion control measures during these activities.



Minimize Impervious Areas

Some impervious areas (e.g., packing houses, parking and staging areas, etc.) are inevitable, but they should be constructed in a way to limit erosion or flooding problems.



Consider Production Region Geography

In the flatwoods production regions, many vegetables are cultivated on flat, sandy soils that have a **spodic horizon**. These soils typically are poorly drained and have high water tables. Because of these characteristics, and the fact that drainage ditches are usually needed to help remove excess water, there is an increased potential for discharge, especially during repeated rainfall events. In contrast, parts of the North Florida production region have deep, well-drained sands over unprotected limestone, known as **karst**. This type of geology is very vulnerable to leaching of nitrates to ground water and runoff into karst features and **sinkholes** that connect to the **aquifer**. Some other parts of this production region have steeper slopes and soils with higher clay content, making them more prone to erosion and sedimentation issues.

USER'S GUIDE TO BMP ENROLLMENT AND IMPLEMENTATION

The steps below will help you select which BMPs to implement to reduce or avoid water quality or water quantity impacts coming from your operation.

1. Identify your Location in the Watershed: In the Northern Everglades and in areas where FDEP has a basin management action plan in place, agricultural operations must implement applicable FDACS-adopted BMPs or monitor water quality. See www.dep.state.fl.us/water/watersheds/bmap.htm for more information, or call (850) 617-1727. Permit holders under the BMP program in Rule Chapter 40E-63, F.A.C., may elect to use that permit in lieu of the adopted BMPs in this manual.

2. Request On-farm Assistance with Enrollment: FDACS field staff or technicians will assist you with evaluating what BMPs are applicable to your operation and enrolling you in the BMP program, free of charge. To schedule an enrollment site visit, call (850) 617-1727, email AgBmpHelp@FreshFromFlorida.com, or contact a field person in your area (see **Appendix 8**).

3. Conduct an Inventory: The selection of BMPs begins with a basic inventory of the farm's natural features, which will help you determine how the operation of your farm may affect environmentally sensitive areas. **When developing the inventory, sketch your farm/facility, noting buildings, crop fields, and water sources.** Identify areas of particular concern that need to be addressed. These include streams, wetlands, springs, sinkholes, and poorly drained ponded areas, to name a few. You can use this list as a starting point to select the BMPs applicable to your farm. To help you conduct your inventory effectively, the following tools are available:

- Aerial photographs (<http://earth.google.com/index.html>, or other providers)
- USDA-NRCS soil survey maps (<http://websoil-survey.nrcs.usda.gov/app/>)
- USGS topographic maps (<http://topomaps.usgs.gov>)
- National Wetlands Inventory (<http://www.fws.gov/wetlands/data/index.html>)
- Historic rainfall records (<http://www.ncdc.noaa.gov/oa/ncdc.html>)

4. Select the Applicable BMPs: Carefully read sections 1.0 through 8.0 of this manual. With assistance from FDACS field staff or technicians, select all of the BMPs that are applicable to your operation and are technologically and economically feasible for you to implement. In Section 2.0 (Nutrient and Irrigation Management), make sure to locate the BMP category(s) relevant to your production system(s):

- **2.1** – Plastic Mulch Production Systems
- **2.2** – Bare Ground Production Systems
- **2.3** – Sugarcane Production Systems
- **2.4** – Hay and Silage Production Systems
- **2.5** – Protected Growing Systems

Record the applicable BMPs from all eight BMP sections on the checklist in **Appendix 10** of this manual. The checklist includes a column for you to schedule BMP implementation if a practice is not already in place.

Level I BMPs focus primarily on management actions, rather than structural practices. All producers are expected to implement the applicable Level I BMPs. In general, Level I BMPs do not require cost-share to implement, though there may be a few exceptions. To reiterate, depending on the location and specific conditions of the farm, not all of the Level I BMPs may be applicable to a particular site.

Level II and III BMPs address water quality risk features that require more attention. They may also require cost-share to implement. Producers may need to implement one or more of these BMPs based on site-specific needs identified by the assessment question(s) within the BMP sections of this manual. For initial implementation, some Level II BMPs may be delayed if the resource issue is addressed by the Level I practices.

It is advisable to consolidate your inventory and all your BMP decision-making, including the BMP Checklist, into a simple implementation plan, which will serve as a record of scheduled and completed BMPs, including operation and maintenance activities. A well thought-out, written plan enables managers and owners to schedule their activities and accomplish their objectives. Remember to keep the plan available and update it regularly. It will help you communicate with your employees,

your county extension agent, USDA-NRCS staff, or others.

5. File a Notice of Intent to Implement (NOI)


BMPs: In consultation with FDACS field staff or technicians, complete and submit to FDACS an NOI, contained in **Appendix 10** of this manual, along with the BMP checklist. Once received by FDACS, the NOI and checklist formally enroll your operation under the BMP program.

Alternative for growers holding 40E-63 permits: Complete and submit to FDACS an NOI, contained in **Appendix 11** of this manual, along with a copy of your permit. Once received by FDACS, the NOI formally enrolls your operation under the BMP program. Implementation of the applicable BMPs provides a presumption of compliance with state water quality standards for phosphorus and nitrogen. Implementation includes ongoing record keeping and maintenance of the BMPs.

6. Implement the BMPs: Implement all applicable Level I BMPs as soon as practicable, but no later than 18 months after submittal of the NOI. Implementation of the applicable BMPs provides a presumption of compliance with state water quality standards for the pollutants the BMPs address. Implementation includes ongoing record keeping and maintenance of the BMPs.

7. Keep Records on BMP Implementation:

FDACS rule requires record-keeping to document BMP implementation. Fertilizer application amounts and rainfall are two examples of record-keeping items. Record-keeping requirements are highlighted in the manual using this figure:

 All BMP records should be accurate, clear, and well-organized. You may develop your own record-keeping forms or use the ones provided in **Appendix 7**. You must retain the records for at least 5 years. However, it is desirable to retain records for as long as possible, to address any potential future legal issues. All documentation is subject to inspection. Confidential records should be labeled appropriately, in accordance with

chapters 812 and 815 F.S., or section 403.067 F.S. To learn more about the importance of record-keeping, a short instructional video is available at: <http://www.freshfromflorida.com/Media/Files/Agricultural-Water-Policy-Files/Best-Management-Practices/Vegetable-and-Agronomic-Crop-Videos/Video-1-Importance-of-Record-Keeping>.



Video 1: The Importance of Record-Keeping

BMP Implementation Follow-Up

FDACS has developed a BMP Implementation Assurance program to help evaluate how BMPs are being implemented, and to gather feedback on whether there are obstacles to using any of the practices. By program, FDACS mails surveys to enrollees, which contain questions about BMP-related activities on enrolled operations. In addition, FDACS staff members conduct site visits to enrolled operations to observe BMP implementation, provide assistance, and get more direct input from producers. The Implementation Assurance effort helps in:

- Documenting the level of participation in implementing agricultural BMPs.
- Identifying needs for education and implementation assistance.
- Reinforcing the importance of BMP implementation.
- Evaluating the effectiveness of FDACS BMP programs.
- Updating FDACS NOI records.

Your participation in these follow-up activities is vital to the continuing success of agricultural BMP programs in Florida.



BEST MANAGEMENT PRACTICES



1.0 FIELD AND BED PREPARATION

Field and Bed preparation involves planning and mechanical intervention to prepare land for planting a crop, and usually involves some amount of soil tillage and cultivation.

Fields, beds, and associated ditches are an integral part of farming. However, the alignment, length, and slope characteristics of a field/bed and the type of bed, all have an effect on the amount of stormwater runoff that is retained or discharged from a production field. Moreover, these variables also have a secondary effect on the amount of ambient water that can be beneficially used by the crop; and the amount of supplemental irrigation water that will be needed. Careful planning of the farm layout related to field, beds and principal drainage features will pay large dividends in the long term.

A well prepared planting bed is important for uniform stand establishment of crops. Most vegetable production areas in Florida use parallel rows of raised beds, while most field crop production areas are planted at-grade with little to no artificial drainage. Bed preparation and irrigation design are interrelated. For example, a low wide bed may result in poor lateral transfer of soil water, while a taller, narrower bed may facilitate more complete wetting of the soil in the root zone. Ultimately, the establishment of a uniform crop stand will maximize nutrient uptake and crop yield, and reduce

the potential for nutrient loss and soil erosion in excessively wet or dry areas.

Soil compaction can occur in any type of soil. Years of traffic, tillage and settling can cause soil particles to group together to fill in air spaces in the soil creating a “plow pan” below the root zone. When this happens, a hard layer is formed making it difficult for moisture and roots to penetrate the soil. Some soil types are more susceptible to compaction than others; but once a compaction layer is formed, and moisture and traffic continues, the compaction layer will continue to get denser and thicker. After long periods of drought, soil compaction can become worse. However, after soil moisture is replenished, the soil often returns to its normal physical condition. A penetrometer is a simple tool that uses downward pressure to determine soil compaction at different depths in the soil profile. It is normally equipped with a dial that is calibrated in pounds per square inch (PSI) of the base area of the cone shaped tip. Penetrometer interpretation should be based on visual observation of the plant’s root system, including consideration of whether root growth is restricted, soil moisture, and changes in soil density.

Producers should refer to USDA-NRCS Field Office Technical Guide Practice, Row Arrangement (Code 557) for more information; however, note that row lengths and orientations are generally limited by:

1. Erosion potential, based on slope and soil type;
2. Irrigation requirements, based on length of the drip laterals or the in-field irrigation ditches; and
3. Drainage requirements of the crop being grown.

Plastic mulch has many benefits and is used in most vegetable production systems; however, it can increase the potential for runoff. If plastic mulch is used during the rainy season, try to maintain the lowest water levels that are practical in ditches, ponds, and reservoirs to maximize the amount of water storage and minimize losses from runoff. Try to minimize the time between completion of farming and permanent removal of the mulch to reduce excessive runoff, particularly before the onset of the summer rainy season. Also, timely removal of plastic mulch from spring crops allows time for planting cover crops as soon as possible before the summer rainy season begins.

Contour Farming

Try to avoid intensive farming on fields that have excessive slopes/grades. Without alteration, these fields will most likely not produce a uniform crop, and will create stormwater and erosion problems instead.

Contour farming may be practical in some areas of North Florida. It involves the establishment of rows/furrows that follow the land's natural contours. It is most effective on fields with slopes between 2 and 10 percent, and in fields with plastic mulch. In terms of basic design, properly established contour lines are generally perpendicular to the primary direction of the slope, and connect points of nearly equal elevation. Runoff must be directed to stable outlets, such as grassed waterways, field borders, water and sediment control basins, or underground outlets that involve terraces or diversions. Remember to establish sod turn strips on sharp ridge points or other areas where contour row curvature becomes too sharp to keep machinery aligned with rows during field operations.

Contour farming increases water infiltration and reduces runoff rates. This practice is often used in conjunction with other practices (e.g., terraces, buffer strips or diversions) that are designed to control excessive runoff due to slope. It may be especially beneficial if your farm has been designated as having **highly erodible lands** which occur in parts of North Florida.

Drainage Ditches

Given the abundant rainfall and high water tables throughout much of the state, agricultural ditches are essential components and are the hydrologic "lifeblood" of many farming operations. They can range from field ditches to laterals and mains; and usually connect to larger canal systems in South Florida. Depending upon their configuration, ditches have an engineered limit or **conveyance capacity** that governs how much water the ditch can store or convey. An effective ditch network functions primarily to convey and distribute water without causing excessive erosion, water losses, and/or offsite degradation of water quality. Properly designed and constructed agricultural ditches are very important; however, equally important is the implementation of an ongoing maintenance program to ensure that the ditches will continue to function as designed.

When constructing open agricultural ditches, the size and form of the ditch must be considered. The size of the ditch will primarily depend upon the drainage characteristics of the land and the desired conveyance capacity of all ditches combined. Small open ditches are usually constructed with a v-ditcher or scraper. Large open ditches are generally built by qualified contractors who have the proper equipment.

Caution must be exercised when constructing ditch banks so that the ditch will remain open and not become filled by the banks caving in. In general, ditch bank side slopes in very sandy soils should be constructed at a minimum slope of 3 foot horizontal to 1 foot vertical or a 3:1 as depicted in **Figure 1**. In digging an open ditch, initially it is often not possible to achieve the desired slope in the beginning, so the ditch usually is dug deeper than designed so that as the banks settle, they will approximate the design grade. The excavated earth from a ditch is called spoil.

There are many factors that influence the flow of water in open ditches. One of the most important of these is the "cleanliness" of the ditch. Debris or rubbish, if allowed to accumulate in an open ditch, will decrease its capacity. Grass and weeds may also grow in open ditches to such an extent as to

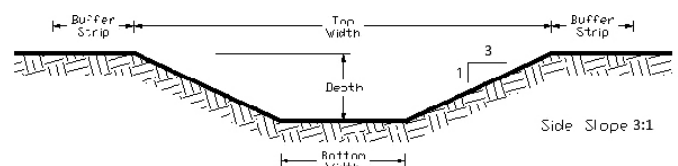


Figure 1

reduce the capacity of the ditch to less than half, so routine custodial maintenance of open ditches is very important. To learn more about the importance of proper ditch construction and maintenance, a short instructional video is available at: <http://www.freshfromflorida.com/Media/Files/Agricultural-Water-Policy-Files/Best-Management-Practices/Vegetable-and-Agronomic-Crop-Videos/Video-2-Ditch-Construction-and-Maintenance>.



In some cases, ditches may also function to deliver irrigation water to plants. Ditches are common on farms in the flat areas of Florida and are used for irrigation and drainage. It is normal design for ditch bottoms to be at lower elevation than the common water table. These ditches usually contain water all year. Many vegetable operations in South Florida use semi-enclosed seepage irrigation, where water is distributed from a header-pipe, and conveyed within the field through spigots that discharge into lateral ditches. This type of irrigation system is common on flatwoods soils that have a spodic horizon. The naturally high water table on these soils is raised to a level where water moves into the production bed by capillary action. Precise control of the water table is difficult to achieve with this system because of variables such as soil characteristics, topography, depth to water table, slope and spacing of water furrows, and a producer's irrigation schedule.

1.1 Field and Bed Preparation

Level I BMPs:

- ✓ 1. Plow down old crop residues well in advance of preparing for the next crop. Generally, a 6 week period between plowing down residues or a cover crop is recommended to allow adequate decay of the material. This does not apply to conservation tillage operations.
- ✓ 2. Use deep tillage to penetrate and break tillage pan layers in fields that are cultivated, as needed. Breaking compaction layers allows deeper root penetration to facilitate plant absorption of water and nutrients.
- ✓ 3. Use laser leveling to re-grade fields that historically have not drained well or that have correctable erosion issues. Re-grading can

improve water management and help conserve soil resources.

- ✓ 4. Evaluate field slope and proposed row length prior to farming a field. While drainage may improve as the slope/grade increases, it may also decrease in some areas as row length increases.
- ✓ 5. When preparing beds, the height of the bed should be no more than 12 inches; the bed width will depend on the crop and the number of rows per bed. New bed geometry research being conducted on plastic-mulched crops may change this guidance in the future.
- ✓ 6. Evaluate the use of contour farming and other soil conservation practices (e.g., grassed waterways, filter strips) to address drainage needs and anticipated erosion issues, especially when farming on significantly sloped fields in North Florida.

1.2 Drainage Ditches

Level I BMPs:

- ✓ 1. Construct drainage ditches based on water removal requirements for the particular crop and needed conveyance capacity, and ensure that ditch side slopes are constructed in accordance with the soil type and characteristics.
- ✓ 2. When using combination culvert/riser boards in ditches, remove only the number of boards necessary to achieve desired drainage.
- ✓ 3. Minimize sediment transport by designing and maintaining the ditches to slow water velocity in the main canal or in ditches near discharge structures.

References

1. UF-IFAS, Soil and Fertilizer Management for Vegetable Production in Florida, Publication CV101. <http://edis.ifas.ufl.edu/CV101>
2. EPA, National Management Measures for the Control of Nonpoint Pollution from Agriculture, EPA-841-B-03-004. http://water.epa.gov/polwaste/nps/agriculture/agmm_index.cfm
3. UF-IFAS, Manual Monitoring of Farm Water Tables, Publication 731.
4. USDA-NRCS Conservation Practice Standard Bedding, Code 310; Chiseling and Subsoiling, Code 324; Precision Land Forming, Code 462; Irrigation Land Leveling, Code 464; Row Arrangement, Code 557; Structure for Water Control, Code 587; Drainage Water Management, Code 554; Surface Drain-

age Field Ditch, Code 607. FOTG-Section IV. <http://www.nrcs.usda.gov/technical/efotg>

5. USDA-NRCS Conservation Practice Standard Field Border, Code 386; Riparian Herbaceous Cover, Code 390; Riparian Forest Buffer, Code 391; Filter Strip, Code 393; Grassed Waterway, Code 412; Stormwater Runoff Control, Code 570. FOTG-Section IV. <http://www.nrcs.usda.gov/technical/efotg>
6. ASABE, Design, Layout, Construction and Maintenance of Terrace Systems, Standard No. S268.4
7. UF-IFAS, Water Budgeting for High Water Table Soils. Publication 769.



2.0 NUTRIENT AND IRRIGATION MANAGEMENT

Nutrient management is control of the source, rate, placement, and timing of nutrient applications and soil amendments to ensure sufficient soil fertility for achieving realistic yield goals while minimizing impacts to water quality.

Irrigation Management involves selecting and maintaining the appropriate irrigation system for your crop; and adjusting irrigation methods, scheduling, and amounts to maximize irrigation application and crop water use efficiency based on monitoring soil, plant, and weather conditions.

Nutrient and irrigation management are linked and it is unlikely to have success in managing nutrients without paying close attention to irrigation management. The goal of a nutrient and irrigation management program is to produce an economically viable crop while making efficient use of the water resource and minimizing nutrient loss to the environment. To attain this goal, practices must be geared toward keeping nutrients in the root zone through the use of appropriate nutrient and irrigation sources and amounts, and proper management of those inputs. For example, excess irrigation may result in leaching nutrients (subsurface) beyond the root zone or in saturating soils and increasing (surface) runoff. On the other hand, inadequate soil moisture can prevent granular fertilizers from dissolving and reduce nutrient availability to crops. Even when approaching near-perfect conditions,

runoff and leaching will still occur due to natural rain events. This is true for seep irrigation systems that rely on a “mounded” water table, and for deep sandy soils that are more prone to leaching. Producers must work to minimize nutrient loss by focusing on the variables that they can control and manage.

Vegetable and agronomic crops are grown throughout Florida on widely different soil types and production systems. The main soil types consist of sandy soils (acidic or alkaline; deep or shallow, with or without a spodic layer), organic soils (histosols or “muck”), and the calcareous soils (rockland or marl) of south Miami-Dade County. Production systems range from dry-land farming to raised-bed plasticulture with drip irrigation. Nutrient and irrigation management practices must be adjusted to each of these production systems to ensure adequate productivity and minimize water quality and quantity impacts.

This section provides key nutrient and irrigation principles, followed by BMPs for five types of production systems. As discussed previously in the “User’s Guide,” producers should select only the BMPs based on their production system. If an operation uses the same NOI for more than one type of production system, make sure to carefully follow the Checklist in **Appendix 10** to guide your decision-making.



Figure 2

Basic Principles of Plant Nutrition

Principle 1: Supplying the Right Amount of Nutrients

Seventeen mineral elements are recognized as essential nutrients for plants. These are generally broken down into two categories, known as macro- and micro-nutrients. Carbon (C), hydrogen (H), and oxygen (O) are supplied by air and water, although some nitrogen (N) may be supplied by atmospheric deposition. Nitrogen, phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S) are the remaining macronutrients that are supplied from the soil and/or through the addition of supplemental fertilizer. Boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), Nickel (Ni), and zinc (Zn) are essential micronutrients. Although not considered essential for all plants, elements such as silicon (Si), sodium (Na) and cobalt (Co) have been proven to improve growth and health of many plants and are considered beneficial elements. The essential elements are important because: (1) agronomic and vegetable crops cannot complete their life cycle without adequate supplies of them; (2) typical deficiency symptoms appear (Figure 2) when an essential element is not available and disappear following timely application of the deficient element; and (3) each element has a metabolic role(s) that affects plant growth.

A study at the UF-IFAS Ft. Pierce Research and Education Center found that many South Florida mineral soils are deficient in Si. Si-rich amendments may significantly improve production and reduce nutrient losses. A recent UF-IFAS publication (SS-AGR-350) states that 25 percent of surveyed Florida sugarcane fields on organic soils had production losses of greater than 10 percent due to insufficient leaf Si content.

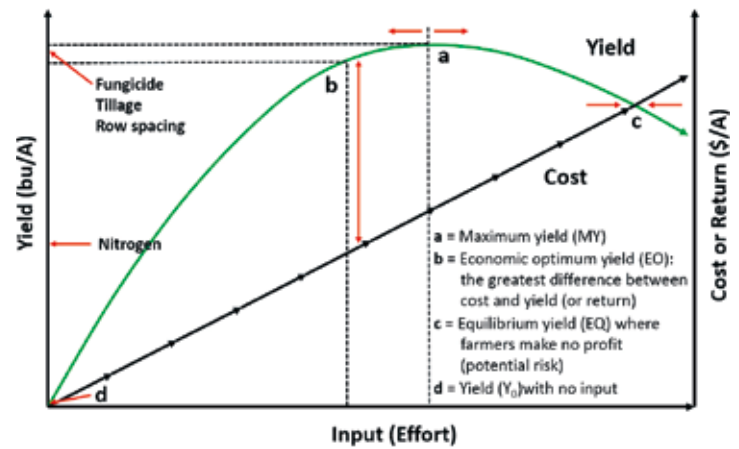


Figure 3

Principle 2: Diminishing Returns

On a hypothetical yield curve, it takes an increasing amount of nutrients to achieve the gain in yield or growth to a point. Ultimately, yield or growth will stop responding to increased nutrients, and may even decrease as noted in Figure 3. The proportional monetary return for each unit of fertilizer decreases as the fertilizer rate increases. The crop's fertilizer use efficiency also decreases, increasing the risk of nutrient losses to leaching and/or runoff. Published research has shown that, on average, approximately 30 to 55 percent of the applied N fertilizer is taken up and used by the crop. This uptake is known as the **fertilizer-nitrogen use efficiency**.

Principle 3: Fertilizer Timing

In general, small amounts of nutrients should be applied just before plant nutrient uptake occurs, but only a short time in advance of seeding or transplanting crops. This is particularly relevant in areas with sandy soils where low soil organic matter and low **cation exchange capacity** (CEC) mean that the soil will not hold positively charged nutrients or cations (like K⁺) very well. Although not generally considered a pollutant, leaching of K may result in negative economic consequences to the producer.

Soluble nutrients are usually more vulnerable to loss shortly after application, especially in pre-plant situations where they are incorporated into the bed. Environmental risk is reduced in production systems that apply small amounts of N fertilizer on a frequent basis (such as in drip irrigation or split applications). This is referred to as fertigation when the nutrients are applied through the irrigation system. Likewise, risk is reduced when most of the P fertilizer is banded near the root zone.

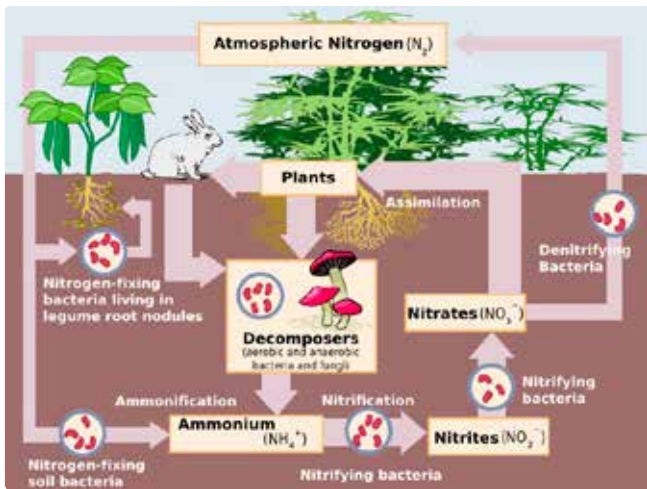


Figure 4

Soil Water Transformations: Nitrogen and Phosphorus Cycles

In an undisturbed ecosystem, essential plant elements may exist in different ionic forms, and undergo a series of transformations when they change from one form to another. Given the premise that no elements are created and/or destroyed, this series of transformations is called a cycle.

The Nitrogen Cycle

The N cycle, like other cycles, has absolute beginning and end, as shown in **Figure 4**. In theory, the cycle usually starts with N in soil organic matter, where it can be decomposed and converted into inorganic N forms by soil microorganisms (bacteria and fungi) in a process called mineralization. These specialized bacteria and fungi, also called decomposers, are generally present in the uppermost soil layers.

In the presence of oxygen, certain bacteria convert ammonium (NH_4^+) into nitrate (NO_3^-) through a process known as nitrification. Nitrate is very mobile in most soils and can be readily transported below the root zone and leached if not taken up by plant roots. In anaerobic (low-oxygen) soils, nitrate can be converted to nitrogen (N_2) gas or nitrous oxide (N_2O) gas; or in rare instances volatilized into ammonia (NH_3) gas. In sandy soils, the bottom of the root zone is typically 12 inches below the soil surface for shallow-rooted crops and 3 feet for the deepest-rooted crops (the actual rooting depth may be limited by the presence of soil compaction layers, water table, very acidic layers, or a spodic horizon). Because the available water-holding capacity of most sandy soils is typically 10 percent, the top 12 inches of soil can only hold about 1 inch of water. If more water is added, water will readily

move downward and can take mobile nutrients with it.

Nitrate not only affects surface waters such as springs, lakes, rivers and streams, but can also impact groundwater and other subsurface features. Unconfined karst geology is commonly found throughout North Florida, where a sand layer of variable thickness covers a limestone base, as depicted in **Figure 5**. Some areas of the state have a confining layer of clay between the sand and the limestone and this clay layer helps reduce the flow of contaminants to groundwater.

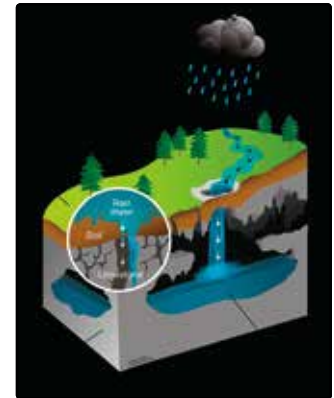


Figure 5

Through repeated wet/dry cycles, limestone can slowly dissolve to create sinkholes and other fissures, where nutrients and other pollutants can readily enter ground water, and later re-emerge through springs vents that form base flow to spring-fed rivers.

Nitrogen gas from the atmosphere can be converted and “fixed” in soil by specialized microorganisms, through a process called biological nitrogen fixation. Nitrogen gas can be fixed by free living soil bacteria. In agricultural systems, nitrogen fixation also occurs in legume plants that have nitrogen-fixing bacteria living within their root nodules. The main legume crops that are grown commercially in Florida are peanuts, snap beans, soybeans, southern peas, and perennial peanut forages. The environmental and economical benefit of growing legumes is a reduction in commercial N fertilizer inputs to make a crop.

At the “end” of the N cycle is the return of organic matter to the soil. Soil organic matter may originate from crop residue, incorporation of cover crops, and/or the addition of organic amendments such as compost, manure, or biosolids. In Florida, soil organic matter content often is very low in sandy or mineral soils, and is quickly mineralized. An exception to this is the muck soils of the Everglades Agricultural Area, where organic matter can exceed 10 percent and usually is considered to be high in N content.

The Phosphorus Cycle

The phosphorus cycle, as depicted in **Figure 6**, is much different from the N cycle. The three major

forms of P in mineral soils are organic P associated with humus, insoluble P, and plant-available P in soil solution. The most active form of P is the phosphate ion (PO_4^{3-}). Phosphorus is present in plants, manures, soil organic matter, and in mineral deposits such as rock or ore. When plant residues and other organic materials biodegrade, phosphate is released and slowly returned to the environment.

In soil, phosphate species exist as a soluble form in the soil solution, a labile (relatively soluble) form, or as an immobilized or insoluble form. The change (transformation state) between these three forms generally depends on microbiological reactions, soil chemistry, and soil pH. Unlike N which is highly mobile, P solubility is limited in most soils, and all of it may not be readily available for plant uptake depending on soil chemistry. Phosphorus adheres to mineral soil particles and clay components through a process known as **adsorption**. Further, P tends to build-up near the soil surface, making it readily available for transport via particulate matter in runoff. The exception to this is on coarse **uncoated sands**, predominant in areas of Central and South Florida, which have an extremely low ability to adsorb P because these sands have little Al and Fe coatings. In this case, it is especially important to manage P carefully, as these soils are very prone to leaching P. Uncoated soils series where P leaching may be a concern are listed in **Table 1**.

Table 1. Common Uncoated Soils Series

Archbold	EauGallie	Myakka	Ridgeland
Allanton	Eglin	Narcoosee	Satellite
Ankona	Estero	Nettles	St. Lucie
Basinger	Hallandale	Oldsmar	Smyrna
Broward	Hobe	Palm Beach	Valkaria
Canaveral	Immokalee	Pepper	Wabasso
Dade	Jonathan	Pomello	Wauchula
Deland	Lawnwood	Pomona	Waveland
Duette	Leon	Pompano	Zolfo

Key Nutrient Management Practices

4R Principles

The 4R nutrient management program helps producers achieve environmental protection while sustaining crop yield through proper nutrient management. The principles are the same globally, but their application depends on site-specific characteristics such as soils, cropping system, management techniques, and climate. The scientific principles of the 4R framework include:

Right Source – Ensure an adequate supply of essential nutrients in plant-available forms, considering commercial fertilizers and naturally available sources (green manure crops, livestock wastes, etc.) and the characteristics of specific fertilizer and nutrient products.

Right Rate – Assess fertilization needs and make decisions based on soil nutrient supply and plant demand. Rate is typically expressed as “pounds per acre” but in plastic mulch production the fertilizer is placed in the soil under the mulch where the “per acre expression” may cause misapplication of the correct rate due to differences in bed spacing. The “linear bed foot” method is used instead.

Right Time – Schedule fertilizer applications based on the dynamics of crop growth and nutrient demand during the growing season, soil supply, nutrient loss risks, and field operations.

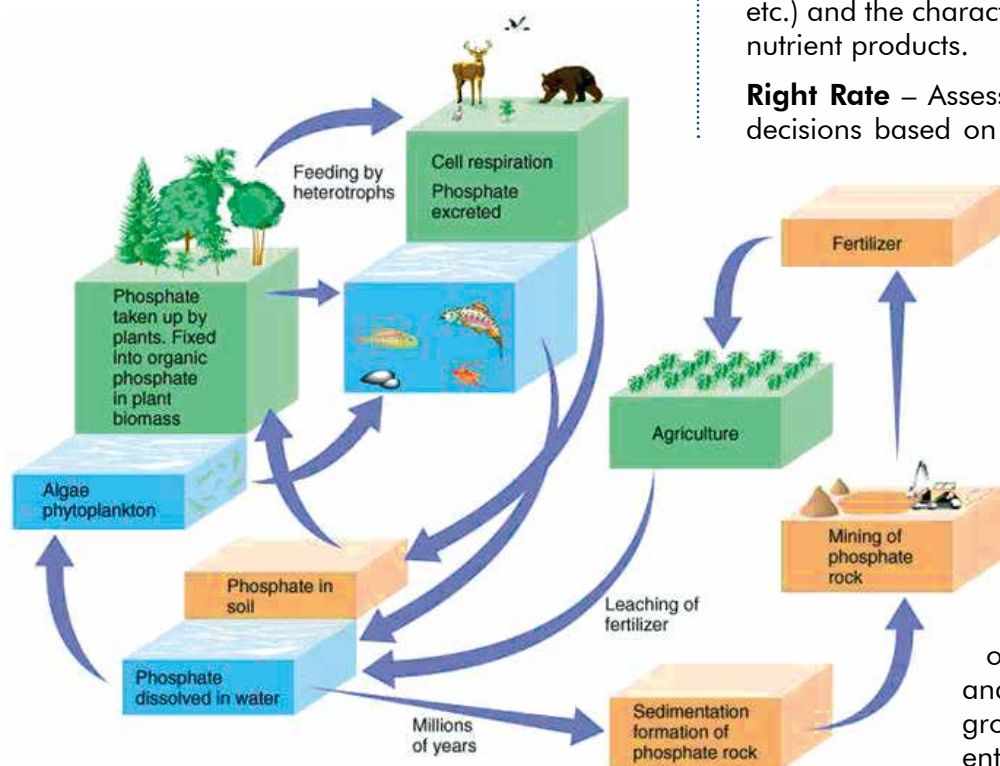


Figure 6

Right Place – Target nutrient applications in or very near to the root zone to maximize plant uptake and limit potential losses from the field.

Rate is only a part of a nutrient management program and the other 3 principles need to be combined appropriately with rate. The 4R nutrient management approach can help improve agricultural productivity and reduce nutrient losses, as:

- Optimizing nutrient management is simply good business in dealing with price increases for fertilizers and other inputs.
- Higher crop yields and quality resulting from improved soil and nutrient management have been well documented.
- Improved fertilizer efficiency increases the crop yield per acre for each unit of nutrient applied.
- More information on the 4Rs can be found in: <http://edis.ifas.ufl.edu/ss624>.

Successful implementation of the 4R principles requires appropriate management of irrigation and drainage. Nutrient leaching or surface runoff, regardless of the production system, is heavily influenced by irrigation amount, method, and timing, including rainfall. Effective nutrient and irrigation management combined keep the nutrients and water in the root zone and make them more available for crop uptake and less prone to being lost to the environment, and reduce operational costs.

Soil Test and Interpretation

The crop nutrient requirement is the total amount of nutrients derived from the soil plus fertilizer needed for optimal crop growth. Soil testing is a scientifically reliable method to determine the index (relative amount) of nutrients that are already in the soil. Annual soil testing is appropriate for many crops but not for all; for example, UF-IFAS recommends soil sampling for sugarcane prior to planting, which may be once every 3 to 5 years. When growing rotational crops, test the soil before planting each crop regardless of the prior crop. This would apply even if a soil test has been conducted in the previous year for the same or different crop.

Soil test results and interpretation provide soil pH information, and the indices of P, K, Ca, Mg, and micronutrients available and the amount of nutrients needed to meet a crop's total nutritional requirement. However, there is no soil test-based recommendation in Florida for N, due to its high rate of mineralization of organic matter and mobility in soil water. Soil tests for N in Florida do not have the

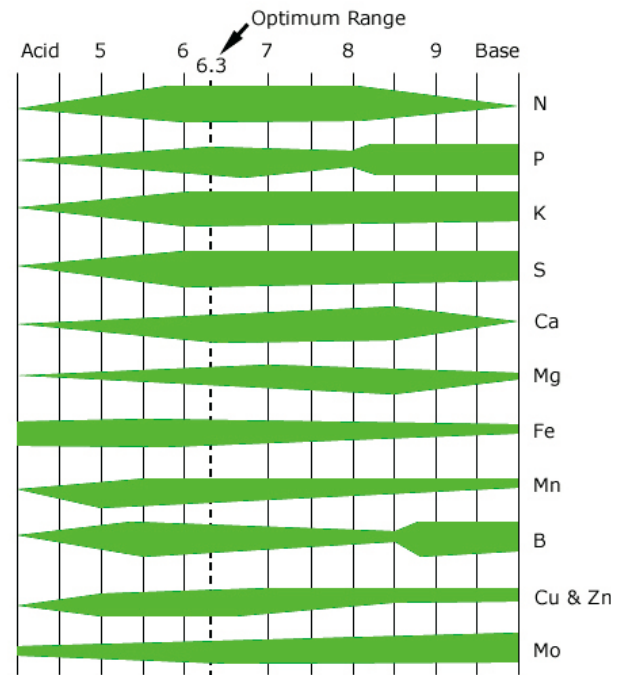


Figure 7

predictive capability as soil tests for other nutrients mentioned above. The selection of the appropriate laboratory method for P analysis depends primarily on the soil type. See: <http://edis.ifas.ufl.edu/ss621> and **Appendix 2** for more detail.

Soil pH is a very important chemical characteristic of the soil. For most vegetable crops, the target soil pH is between 6.0 and 6.5. Certain micronutrient deficiencies and toxicities may be corrected simply by adjusting the pH to the preferred range. Soil pH can be increased by the addition of lime, and reduced by the addition of powdered sulfur or other acidifying materials like ammonium fertilizer sources. Using dolomitic lime also supplies Mg in addition to Ca. The availability of many nutrients decreases with low soil pH, as indicated in **Figure 7**. Therefore, producers should regularly test their soils for pH, and maintain their soils in the optimum range for the desired crop. Always apply lime according to soil test results/recommendations.

A soil test may indicate the need for supplemental P. The addition of P when the soil test indicates low-P concentration helps to ensure a healthy crop by encouraging root growth, stalk strength, and resistance to root rot diseases. Most P fertilizer materials are in the inorganic or soluble form so they can be readily absorbed by plants. Unless starter fertilizer is warranted, producers should only apply P when supported by a calibrated soil test. The calibrated response to fertilizer for a specific crop and soil type is obtained through rate testing and statistical research. The BMP program recognizes the soil

test extraction methods (for P analysis) used by the UF-IFAS Extension Soils Testing Laboratories and, on a limited basis, methods used by other laboratories that base recommendations on calibrated soil tests for Florida crops.

All soil test results, whether conducted by a private or public laboratory, need to be interpreted appropriately before applying P fertilizer. Phosphorus fertilizer recommendations can come from a soil testing laboratory, UF-IFAS Extension Agent, Certified Crop Advisor, or other qualified professional as long as their P recommendations for a particular crop are based on a calibrated and correlated soil test, described in the following fact sheet: <http://edis.ifas.ufl.edu/ss622>. Phosphorus fertilizer recommendations must also be interpreted using the crop nutrient requirement method, not the build-up and maintenance method. Nitrogen recommendations need to be based on credible scientific research conducted on representative crops and soils. Credible research is defined to mean true scientific method involving hypotheses testing, replication, and statistical analysis, usually with peer-reviewed published results and conclusions. Research results and fertilizer recommendations from land-grant universities in the Southeastern United States generally meet these criteria. Some larger farms with in-house researchers may also conduct proprietary research which may qualify as well.

Tissue Test to Diagnose Plant Nutritional Status

Because of the mobility of some of the essential nutrients in soils, leaf tissue analysis is another tool that provides a good indication of plant nutrition and health for vegetables and row crops. Tissue analysis, used in conjunction with soil analysis, is a powerful tool to diagnose the overall effectiveness of a fertilization program. Soil testing alone does not always indicate season-long nutrient availabil-



Figure 8

ity to plants because it is just a snapshot of what is present at the time of sampling. The concentrations of nutrients inside plant tissue are the best indicators of crop nutritional status. In general, sufficient N content in most-recently matured whole leaves ranges between 2.5 and 6 percent of the dry weight. When N deficiency exists, plants are weak, grow slowly and produce low yield. Potential nutrient deficiencies can usually be detected with tissue analysis before visual symptoms appear.

The two main techniques available for monitoring plant nutritional status are dried plant parts and fresh leaf petiole-sap analysis. Laboratory analysis of dried plant parts consisting of the most-recently matured leaf is accurate but time consuming. Several leaf petiole-sap quick tests have been developed for several vegetables in Florida. These instruments can be used in the field, are useful in fine-tuning fertilization programs, but results can be variable. **Figure 8** demonstrates the use of handheld leaf tissue test equipment.

For more information on tissue testing and interpretation of results, see *Plant Tissue Analysis and Interpretation for Vegetable Crops in Florida* at: <http://edis.ifas.ufl.edu/ep081> or *Petiole Sap Testing for Vegetable Crops* at: <http://edis.ifas.ufl.edu/cv004>. To learn more about the benefits of soil and tissue testing, a short instructional video is available at: <http://www.freshfromflorida.com/Media/Files/Agricultural-Water-Policy-Files/Best-Management-Practices/Vegetable-and-Agronomic-Crop-Videos/Video-3-Benefits-of-Soil-and-Tissue-Testing>.



Calibration of Fertilizer Application Equipment

The benefits of soil and tissue testing in determining appropriate fertilization rates can be negated when the fertilizer application equipment is not properly calibrated in accordance with equipment and material specifications. Improperly calibrated fertilizer application equipment may result in excessive or insufficient fertilizer applied to the target crop. Consequently, crop yields may be drastically reduced and/or fertilizer materials wasted via over-application.

Calibration methods vary based on the type of fertilizer and fertilizer application equipment.

Calibration should be done in accordance with the manufacturer's recommendations, or whenever wear or damage is suspected to have changed the delivery rate. Many fertilizer spreaders come with catch pans to collect fertilizer over a known distance in order to calibrate output rates. For granular materials, it may be necessary to recalibrate whenever using a new material that has different particle density, size particles, or flow characteristics. Lastly, in order to maintain a completely uniform application rate of granular fertilizer and lime, try not to apply these materials if wind speeds exceed 5 mph.

For more information on calibration, see *Equipment Calibration Information Sheet* at: <http://www.extension.iastate.edu/Publications/NMEP9.pdf>.

Fertilizer Types and Application Methods

Fertilizers may be granular or liquid, soluble or timed-release (also known as slow-release or controlled-release). Conventional fertilizer products are water soluble, while controlled-release fertilizers (CRF) release nutrients under the combined action of heat, moisture, and microbes. One group of fertilizer products that is getting more attention because of the potential advantages for increasing nutrient use efficiency and reducing environmental nutrient loss is enhanced-efficiency fertilizers. While CRF is one example, the term also refers to other nitrogen fertilizer products that are treated with urease and/or nitrification inhibitors. Some of these products claim to reduce leaching and/or volatilization losses of nitrogen, especially on reduced-tillage operations where there is little to no opportunity to incorporate fertilizer product into the soil. Producers who are expanding their acreage with more nitrogen-dependent crops may want to investigate the use of these products. Tomato and pepper producers who grow a fall crop may want to use CRF due to the shorter growing period, which will more closely mimic the release characteristics of the product. Potato and watermelon producers who grow a spring crop may want to use CRF, or a blend of soluble and CRF. Research has shown that total N fertilizer amount for some vegetables can be reduced by using a CRF as the N source, so producers are encouraged to do their own trials.

Methods for granular fertilizer application include the broadcast method (granular fertilizer is applied over the entire field), the modified-broadcast method (granular fertilizer is applied only over the areas where raised beds will be formed), and the banding method (granular fertilizer is applied in bands near the root system). **Banding is the preferred granular application method for**

most vegetable and agronomic crops. Liquid fertilizers may be applied through aerial application, over-head irrigation systems, knifed (banded) in the row, or injected in drip-irrigation systems via fertigation (mostly for plasticulture).

Based on research, conversion of ammonium to nitrate is inhibited by cold soil conditions and/or recently fumigated beds. Therefore, 25 to 50 percent of applied N fertilizer should be in the nitrate form when these conditions are present. This allows for immediate plant uptake, while waiting on soil microorganisms to recover.

Dilute liquid fertilizers can also be targeted to the leaves of the plants rather than the soil. While most fertilizers are soil-applied, foliar fertilization consists of applying dilute fertilizer solutions directly to the plant leaf. However, plant leaf structure and waxy coatings may inhibit direct foliar nutrient absorption. In addition, evaporation may increase the concentration of the fertilizer solution and lead to leaf burn. Therefore, foliar fertilization is used mostly for the application of micronutrients. To learn more about fertilizer types and preferred methods of application, a short instructional video is available at: <http://www.freshfromflorida.com/Media/Files/Agricultural-Water-Policy-Files/Best-Management-Practices/Vegetable-and-Agronomic-Crop-Videos/Video-4-Fertilizer-Types-and-Preferred-Methods-of-Application>.



Video 4: Fertilizer Types and Preferred Methods of Application

Cover Crops

Cover crops are used to protect and improve soil conditions until the next crop is planted. They also improve soil structure and composition by adding valuable organic matter, increasing soil fertility, water holding capacity, and increasing long-term crop production through improved soil **tilth**. Certain cover crops may also be used to "scavenge" or trap some excess nutrients left in the soil after the primary crop is harvested. However, many cover crops are not adaptable to summer conditions and may not fit into crop rotation patterns, so do your research beforehand.

The use of cover crops can be a key component of nutrient management combined with conservation tillage systems. Legumes are increasingly popular cover crops. **Figure 9** illustrates the use of Blue

Lupin in a North Florida field. For certain parts of North Florida, center pivot irrigation systems used in conjunction with conservation tillage that includes a cover crop rotation may provide a considerable advantage in protecting soil and nutrient losses. Long term, this type of farming system increases soil permeability, water holding capacity, and may result in less irrigation when producing a cash crop.

The feasibility of using cover crops should be evaluated each year. **Table 2** lists legume, cereal and other cover crops particularly suited for use in the Southeastern U.S., as well as their advantages for compaction reduction, weed control, scavenging nutrients, etc. A good reference on cover crops can be found at: http://www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition.

Table 2. Cover Crops and Their Effectiveness

Crop Type	Scavenge N	Scavenge P	Erosion Control	Weed Control	Reduce Compaction
Legumes					
Austrian Pea	Fair	Fair	Excellent	Good	Fair
Iron Clay Cowpea	Fair	Good	Excellent	Excellent	Good
Crimson Clover	Good	Good	Excellent	Excellent	Fair
Hairy Vetch	Fair	Good	Good	Good	Fair
Lupin	Fair	Good	Good	Good	Good
Red Clover	Good	Excellent	Good	Excellent	Excellent
Sunn Hemp	Fair	Fair	Excellent	Excellent	Excellent
Velvet Bean	Good	Good	Excellent	Excellent	Good
White Clover	Fair	Fair	Excellent	Excellent	Fair
Cereals					
Oat	Excellent	Fair	Excellent	Excellent	Fair
Rye	Excellent	Excellent	Excellent	Excellent	Good
Ryegrass	Excellent	Good	Excellent	Excellent	Good
Sorghum-Sudan	Excellent	Good	Excellent	Excellent	Excellent
Winter Wheat	Excellent	Excellent	Excellent	Excellent	Good
Other					
Radish	Excellent	Excellent	Excellent	Excellent	Excellent
Buckwheat	Fair	Excellent	Fair	Excellent	Fair

Note: Table modified using USDA-ARS Fact Sheet 04a

Key Irrigation Management Practices

The goal of irrigation management is to keep both the irrigation water and the fertilizer in the crop root zone. Proper irrigation management is key



Figure 9

to proper nutrient management. This requires knowledge of the characteristics (particularly rooting depth) of the crop, so that water and fertilizer inputs can be precisely targeted and managed. It also requires knowledge of the primary soil type characteristics to determine how they influence the storage of water for the crop. To be successful at irrigation management, producers must readily adjust irrigation practices (such as scheduling) and amounts of water, based on soil, plant, and weather conditions.

Irrigation System Design and Installation

A typical irrigation system consists of water supply (e.g., pump), conveyance (e.g., pipes), application (e.g., drip orifice), and control mechanisms (e.g., soil moisture sensors). The predominant types of irrigation used to grow vegetable and agronomic crops in Florida are gravity and pressurized systems which are described below.

Gravity Systems

Seepage Irrigation Systems

Seepage systems distribute water by flow through the soil profile or over the soil surface. Because water is distributed by gravity flow, the uniformity of water application (and the associated irrigation application efficiency) is strongly dependent on the soil topography and hydraulic properties. Producers typically use precision land grading practices to minimize the effects of topography. However, soil characteristics are not readily changed, and losses of irrigation water due to lateral flow is highly dependent on the soil water status on surrounding land areas at the time that irrigation is practiced. As a result of these site-specific factors, water application efficiencies of seepage systems may vary widely in space and time, and are very site-specific.

Seepage irrigation artificially raises the water table. It is also a fundamental irrigation method for “top-down” irrigation crops, such as potatoes, that cannot tolerate saturated growing conditions. Surface ditch systems use field ditches which are called water furrows or lateral ditches.

Most of the sugarcane grown in South Florida and many of the vegetables are on seepage irrigation. Seepage irrigation distributes water by flow through the soil profile or over the soil surface. The uniformity of water application (and the associated irrigation application efficiency) is strongly dependent on the soil topography and hydraulic properties. Most of the Everglades Agricultural Area (EAA) is flat, and the field elevation is below the water level of the primary and secondary maintained canals. Irrigation water is let on the farm through control structures, usually by gravity and distributed via a network of canals and ditches that serve the dual purpose of irrigation and drainage.

Producers typically use precision land grading practices to minimize the effects of topography. However, soil characteristics are not readily changed, and losses of irrigation water due to lateral flow is highly dependent on the soil water status of surrounding land areas at the time of irrigation. Seepage irrigation systems can provide: added resource benefits when considering infiltration back into the relevant water storage system; aquifer recharge potential gained through the retention/detention of stormwater; the recycling of irrigation return flow; related environmental and operational factors such as the ability to maintain historical surface and



Figure 10

Many vegetable crops are irrigated using a modified type of seepage system. These systems convey water through pipes that discharge water to the field via spigots, in order to raise the water table below the crop. This system, shown in **Figure 10**, is used for many vegetable crops, but is very common in tomato and pepper production systems. Increasingly, semi-enclosed seepage irrigation systems are being used in combination with drip irrigation systems, to meet the crop’s water and nutrient needs; and to facilitate pre-plant fumigation. There are also hybrid systems now in use that can irrigate or drain a field. These are typically installed very similar to a conventional tile drain system. The system allows fields to be irrigated and drained using the same pipes and installation. By installing and managing the system properly, producers improve the control of moisture in their fields. In the irrigation process, water can be pumped back into the field via the perforated pipe system, directly watering crop roots. When drainage is required, the pump is shut down and the drainage outlet is opened. Effective management is particularly important when using this method, to ensure that the enhanced drainage does not increase offsite nutrient discharges.

Pressurized Irrigation Systems

These systems deliver water under pressure via closed pipelines and/or lateral pipes (see **Figure 11**) and use backflow-prevention devices. The most common pressurized systems used in the production of vegetable crops in Florida are drip, solid set sprinkler, and center-pivot. High-volume guns

are used less frequently. Subsurface drip irrigation is a relatively new technology being used more, and further information on this can be obtained at: <http://edis.ifas.ufl.edu/hs1217>.

Drip Irrigation

Drip irrigation involves a low-volume, low-pressure system and is generally considered a desirable option for bedded irrigation. The system consists of buried PVC pipe mains and sub-mains with ½" to ¾" polyethylene laterals. Water application is controlled by drip emitters, which are attached to the laterals or are an integral part of the system. Laterals may be on the ground surface, totally buried, or buried with emitters pointed to the surface. The output rate (usually 1 to 2 gallons/hour; or 25-40 gallons/hour per 100 linear feet) and number of emitters depends on bed size and plant-spacing requirements. Pressure-compensating emitters are preferred; however, if non-pressure compensating emitters are used, the system should be designed such that emitter pressures do not vary more than plus or minus 10 percent from the design operating pressure.

Plasticulture is a popular method of growing certain vegetables, including tomatoes, peppers, and melons. This production system consists of growing transplants on raised beds that are covered with plastic mulch. The plastic mulch helps to retain soil moisture and control weed growth. Water is delivered through a thin-walled drip irrigation tubing, or "tape," that has emitters at 12 to 24-inch intervals. To conserve water and to prevent leaching nutrients below the bed, UF-IFAS extension recommends limiting irrigation system run time to 30 minutes or less per irrigation event.



Figure 11

The tape is installed either on the ground surface directly under the mulch, or one to two inches below the ground surface. Usually, one or two rows of tape are installed per bed with a center to center spacing of five to six feet. The mulch and tape are generally used for one year, and then removed and discarded. Typically, farmers will also inject liquid fertilizer into the irrigation water.

Center Pivot or Linear Move

Center-pivot or linear-move systems typically have an end gun to reach corners of a field, which is usually equipped with an endgun shutoff to prevent water from being applied outside the target area. Soil type(s), soil slope, source water quality, and water supply should all be taken into account when selecting a sprinkler package for one of these systems. In general, the sprinkler package will be a small percentage (usually less than 10 percent) of the total system cost.

The most common sprinklers used on new systems are: reduced angle impact sprinklers (usually 6 degree), low-pressure sprinklers on top of the irrigation boom, and low-pressure drop nozzle retrofits. Each of these options uses less water than high-angle impact sprinklers on the top of the irrigation boom. Further water conservation savings can be generated by removing non-crop areas from irrigation; coordinating application amounts with variations in soil type and field topography; and, eliminating double application due to pivot overlap. Variable rate irrigation technology does this, and may include speed control, zone control, or both. It is particularly well suited to center pivot irrigation systems, and may reduce water use by an average of 15 percent. To maximize efficiency, the field's electrical conductivity may be mapped using Veris, DuelEM or similar equipment.

Traveling Gun

This term refers to either cable-tow or hard-hose traveling sprinkler systems. Travelers tend to have the poorest overall water-use efficiency among sprinkler alternatives. Their primary advantage is that they can be moved easily from field to field and are well suited to fields of irregular size and shape.

Regardless of the drive mechanism, new traveler systems should be equipped with hard-hose systems so that the sprinkler cart travels at a uniform speed from the beginning of the pull until the hose is fully wound onto the hose reel. Nozzle sizes on gun type travelers are typically ½ to 2 inches in diameter and require high operating pressures of 75 to

100 PSI at the gun for uniform distribution. Nozzle type (ring versus taper bore) should be selected to match irrigation application rates to soil infiltration rates. On heavy soils, guns should be operated in a 300 to 330 degree arc to minimize application rates. Trajectory angles on new systems should be less than 27 degrees to reduce the impact of wind.

Solid Set

Solid-set systems include both portable-pipe and buried systems. For maximum water savings, sprinklers should have a reduced angle below 23 degrees trajectory. A solid-set system should be designed to maintain adequate pressure and provide minimal overlap. Solid-set systems with automatic controllers are well suited for irrigating during non-peak evapotranspiration periods, although larger nozzles or additional system components may be needed to compensate for peak periods.

Irrigation system type and design depend on factors such as topography, soil type, crop type, water supply, and water quality. An irrigation system needs to be designed to meet a crop's peak water requirements. Irrigation system design requires in-depth technical knowledge, and should be handled by trained professionals, who use existing standards and criteria, as well as manufacturers' recommendations, to design the most appropriate irrigation system for a particular cropping system and location. For information about professionals who design and install irrigation systems, go to the *Florida Section of the American Society of Agricultural and Biological Engineers* at: <http://www.fl-asabe.org/>.

Irrigation Water Sources

Agricultural irrigation water sources can come from ground water, surface water, or other non-conventional sources. Depending on the aquifer's characteristics, ground water can contain high levels of minerals that can form scale, which may plug emitters. Dissolved salt concentrations greater than 1,200 micromhos per centimeter (an electrical conductivity measurement), or elevated chloride levels, can significantly stress plants, leading to low yield, leaf drop, dieback, and reduction in growth. Beans, carrots, okra, and strawberries are especially sensitive to saline water. This is an important consideration for irrigation systems that wet the plant canopy. Moreover, highly saline irrigation water that is allowed to run off may cause impacts to off-site water resources. Obtaining routine water

quality analyses will help you determine whether the water is appropriate to use on your crop.

Well water also may be vulnerable to iron and/or sulfur-reducing bacteria that can cause emitter plugging in drip irrigation systems. Chlorination (done before filtration) is the most common method for treating bacterial slimes, and should be considered for micro-irrigation systems. Surface water usually contains organic debris, algae, and other bacteria that present additional challenges. Algal cells and organic residues of algae can pass through irrigation system filters and form aggregates that can plug emitters. Because of this, the water must be filtered to prevent irrigation system plugging. When using surface water, consider chemically treating the water first to reduce microbial and algal growth. For more information on irrigation water source issues, see *Causes and Prevention of Emitter Plugging in Micro-Irrigation Systems* at: <http://edis.ifas.ufl.edu/AE032>.

Non-conventional irrigation water sources include irrigation tailwater and **reclaimed** water. Tailwater recovery systems may be particularly well-suited to plastic mulch production systems in Florida; these are addressed later in this chapter under section 2.1. Reclaimed water from municipal wastewater treatment plants is regulated under FDEP Rule Chapter 62-610, Florida Administrative Code. The N and P concentrations in tailwater, reclaimed water and/or unconfined production well water can be significant, so an analysis should be obtained before using it. Using tailwater or reclaimed water on certain vegetables may be subject to food safety requirements, whether by government regulation or contractual terms. For information on federal food safety rules, go to: www.fda.gov/Food/GuidanceRegulation/FSMA/default.htm. For information on food safety rules in Florida specific to tomatoes, go to: <http://www.freshfromflorida.com/Divisions-Offices/Fruit-and-Vegetables/Tomatoes>.

Crop Water Requirements and Irrigation Scheduling

Crop water requirements refer to the actual water needs for plant growth, taking into account **evapotranspiration** (ET). When irrigating, enough water should be applied only to wet the entire root zone. Irrigating too often encourages shallow rooting, increases soil compaction, leaches nutrients, and favors disease outbreaks.

Irrigation scheduling consists of determining when to start irrigating, at what intervals to irrigate, and

how long to irrigate. In order to develop an irrigation schedule, you should:

- Estimate irrigation water requirements.
- Adjust the estimate based on available soil moisture content, soil water tension, or historic or real-time ET and appropriate crop factors.
- Make further adjustments based on replenishment of soil moisture through rainfall.

Irrigation scheduling should be based on information such as: soil water holding capacity, potential ET rates; rainfall total, which can be determined by rain gauges and soil moisture equipment. ET rates can be obtained from the UF-IFAS Florida Automated Weather Network or FAWN, or by using your own weather station data. The observation of visual symptoms (e.g., wilting) coupled with irrigation technology will make you a better irrigation manager.

Irrigation system water loss rates are affected by sunlight, wind speed, relative humidity, and air temperatures. Water loss can be reduced by irrigating when conditions do not favor excessive evaporation, especially when overhead irrigation systems are used. It is recommended that overhead irrigation occur in the early morning hours before air temperatures rise and relative humidity drops, when crop type and planting season allow. Irrigating at this time also allows sufficient time for infiltration into the soil, and allows the plant canopy to dry, thereby reducing the chances of disease development.

Observation Wells

A water table observation well is an inexpensive management tool that can be used to provide a visual indication of surficial groundwater levels. This simple tool can be used to optimize soil moisture for crop production while minimizing water use and tailwater discharge. Observation wells, which often have color-coded bars to indicate the optimum water table levels, can also be used to prevent over-irrigation or over-drainage. They are especially useful in bedded row crop operations.

Soil Moisture Sensors

Soil moisture can be measured using commercially available portable soil moisture sensor devices. Specific zones of the field can be easily identified and managed when soil moisture sensing technology incorporates the power of global positioning systems (GPS) and geographic information systems (GIS) for producing maps.

Generally, there are two types of sensors used for irrigation scheduling: those that measure soil water potential (also called tension or suction); and those that measure volumetric water content directly. The latter have become more common in recent years due to a decrease in the cost of electronic components and increased reliability. These sensors will monitor the volumetric water content and more accurately guide irrigation management. However, a correct interpretation of the soil moisture readings is very important to assure proper irrigation management and avoid over-irrigation. Producers should familiarize themselves with these devices. See **Appendix 4** for further information. To learn more about the use of observation wells and soil moisture sensors, a short instructional video is available at: <http://www.freshfromflorida.com/Media/Files/Agricultural-Water-Policy-Files/Best-Management-Practices/Vegetable-and-Agronomic-Crop-Videos/Video-5-Use-of-Observation-Wells-and-Soil-Moisture-Sensors>.



Prior to implementing an irrigation schedule, the irrigation system should be evaluated to determine the system's rate of application per acre and other performance variables. Mobile Irrigation Labs (MILs) can help with this. There are a number of MILs strategically positioned around the state that will perform this service for free.

Irrigation Scheduling Support Systems

The Florida Automated Weather Network (FAWN) system maintains weather stations throughout the state. FAWN provides producers accurate, real-time weather data, which can be accessed via the internet or by phone. FAWN stations (**Figure 12**) measure air temperature, soil temperature, ET, wind speed and direction, rainfall, relative humidity and solar radiation. These parameters are critical to calculate supplemental irrigation requirements for your crop. FAWN also provides information on other irrigation tools. You can access this information at: <http://fawn.ifas.ufl.edu>.



Figure 12: Fawn tower

Special-Case Irrigation Measures

Plant Establishment

Most vegetable and agronomic crops are planted in the field using direct-seeding methods or by transplanting seedlings. Once the initial planting is done, it is critical that the crop has access to water to become properly established and to grow. It is important that the proper amount of irrigation water is available to establish sufficient soil moisture around the seedling or seed. This will help eliminate stress at this critical phase of its growth cycle.

A word of caution: many crops, such as strawberries, are irrigated using overhead sprinklers right after they are transplanted. This helps establish them and provides critical cooling, as they are planted in plastic mulch. Nonetheless, overwatering can result in excess runoff, leading to a loss of soluble nutrients and potential flood complaints from downstream landowners. One way to avoid this is to use “containerized” strawberry transplants with drip irrigation. This approach should result in little to no runoff, as compared to bare-root transplants. Another approach is to capture and reuse the establishment water runoff via a tailwater recovery pond.

Do not irrigate for crop establishment during or immediately after a storm event. Instead, allow infiltration to occur in order to determine soil moisture in fields more accurately prior to irrigating. Do not leave irrigation pumps unsupervised during crop establishment. This may lead to excess use and loss of irrigation water during that period.

Frost/Freeze Protection

Typical options for protecting vegetable crops from frost/freeze include seepage and sprinkler irriga-



Figure 13

tion, soil banking, and using synthetic row covers as illustrated in **Figure 13**. There are two types of temporary row covers: hoop-supported and floating. There are also two basic types of row cover materials: clear polyethylene and spun-bonded polyester or polypropylene, all of which are available in varying thicknesses, weights, widths, and lengths. Hoop-supported covers are sometimes referred to as low tunnels and generally cover a single row. Floating row covers lie directly over the crop and may cover multiple rows. The lightest covers are used primarily for insect exclusion while the heaviest covers are used for frost protection. In Florida, row covers have generally been used to protect tender crops from periodic freezes. Using an appropriate thickness cover can eliminate or reduce the need for irrigation during freezes. For more information on row covers, see *Row Covers for Commercial Vegetable Culture in Florida*, at: <http://edis.ifas.ufl.edu/cv201>.

Even with the advent of row covers, most producers still use irrigation water to protect sensitive crops. When doing so, the proper application and timing of water is critical. FAWN has online tools to help determine under what climatic conditions to use your irrigation system for frost and freeze protection (see <http://fawn.ifas.ufl.edu/tools/>). It is also important that you remember to comply with any frost/freeze protection provisions in your WMD consumptive use/water use permit. In 2013, FDACS unveiled a smart phone app that includes expanded weather stations and even more data. This will help producers make wise decisions during forecasted frost/freeze events. To use the app, go to: <http://fawn.ifas.ufl.edu/mffw/>. To learn more about frost/freeze protection measures coupled with the use of the smart phone app, a short instructional video is available at: <http://www.freshfromflorida.com/Media/Files/Agricultural-Water-Policy-Files/Best-Management-Practices/Vegetable-and-Agronomic-Crop-Videos/Video-6-Frost-Freeze-Protection-Measures-Coupled-with-the-Use-of-the-My-Florida-Farm-Weather-Smart-Phone-App>.



Video 6: Frost Freeze Protection Measures coupled with the use of the My Florida Farm Weather smart phone app

Drought

The National Drought Mitigation Center maintains a number of tools to assist producers in monitoring the intensity level of a drought. You can access these tools at: <http://droughtmonitor.unl.edu/>. As a general rule, producers should closely monitor soil moisture levels, and irrigate at night or at other times when the least amount of evaporative loss will occur. Irrigation frequency and duration should be based on rooting depth to provide adequate moisture to the crop root zone. As always, producers should contact their water management district to inquire about any water shortage requirements in effect.



Figure 14

2.1 Plastic Mulch Production Systems

Plastic mulch has been used commercially on vegetable production in Florida for more than fifty years, with the vast majority used in South and Southwest Florida on tomatoes, peppers, eggplants, strawberries, and cucurbits. Water, via drip irrigation tubing, and fertilizer via broadcasting, banding and/or fertigation is placed underneath plastic mulch on raised beds. However, in some cases, traditional semi-enclosed seep or overhead sprinkler irrigation systems (e.g., frost/freeze protection on strawberries) are also used in combination with plastic mulch production systems. There are also hybrid irrigation systems that use both drip and semi-enclosed seep.

When determining the fertilizer application rate for plastic mulch production systems, the calculation is based on the application method used. For

example, a 50 lbs N/acre broadcast rate means that 50 lbs of granular N are uniformly spread over a one-acre farm field. When liquid fertilizers are injected through a plastic mulch drip-irrigation system, the per-acre rate is less important than the rate per length of row under production. This is known as the linear bed-foot (LBF) system. The LBF system helps maintain a constant rate of fertilizer in the bed no matter what bed spacing variations exists. A schematic of this type of system is shown in **Figure 14**. For example, an injection of 14 lbs N/acre in a drip-irrigated tomato field with raised beds spaced six feet apart means that liquid fertilizer will be injected at a rate of 14 lbs N over 7,260 LBF of row ($43,560 \text{ sq. ft}/6 \text{ feet bed spacing} = 7,260$ linear feet of bed in one planted acre of tomato). Bed spacing will vary by vegetable commodity, so use **Table 3** to adjust the LBF calculation. Because liquid fertilizers are measured by volume and not weight, the nutrient concentration in the material (usually expressed in lbs/gal) need to be known.

For more information on calculating fertilizer rates using the linear bed-foot system, see *Calculating Recommended Fertilizer Rates for Vegetables Grown in Raised-Bed, Mulched Cultural Systems* at: <http://edis.ifas.ufl.edu/ss516>.

Tailwater Recovery

Tailwater recovery is often used with plastic mulch production systems, since these systems are more likely to generate runoff due to the impervious nature of plastic. The water that is captured is then pumped back into the irrigation system for reuse. In some cases, tailwater cannot be collected by gravity and must be collected via pumps. This may not be economically feasible, depending on

Table 3. Typical Bed Spacing

Crop	Typical Bed Spacing (ft)	Rows per Bed
Broccoli	6	2
Cabbage	6	2
Cauliflower	6	2
Cucumber	6	2
Eggplant	6	1
Lettuce	4	2
Muskmelon	5	1
Pepper	6	2
Squash	6	2
Strawberry	4	2
Tomato	6	1
Watermelon	8	1



Figure 15

the crop and the amount of irrigated acreage. Published research on a study conducted in Florida in soils with a spodic horizon shows that a one-inch rain event can raise the water table significantly underneath beds. This then results in less soil/water storage capacity, increasing the risk of runoff after the next rain event. Tailwater recovery ponds similar to those in **Figure 15** can mitigate this risk.


Use the following guidance when determining whether to implement tailwater recovery:

- Consider using tailwater recovery if you have a seepage or flood irrigation system, and site-specific conditions make it practicable.
- Locate them at the lowest point of elevation on your field, trying to avoid wetlands.
- Size them according to runoff volume and rates.
- Design them to maximize water use and minimize impacts to neighboring properties.
- In order to minimize disease risk when growing high-value crops, use chlorine or other approved disinfectants to treat tailwater for pathogens.
- Inquire about cost share and seek technical assistance.


Note: *The installation of tailwater recovery ponds may require an Environmental Resource Permit or other type of authorization, and may pose food safety issues, so producers should check with FDACS or their WMD before installing them.*

Plastic Mulch Production System BMPs


2.1.1 Plastic Mulch Nutrient Management Level I BMPs:

- ✓ 1.  Test soils on an annual basis prior to forming beds. Base P fertilization rate on soil test

results from a public or private laboratory that employs the standard testing methods used by the UF-IFAS Extension Soils Testing Laboratories. Refer to **Appendix 2** for guidance on accepted P extraction methods and sample collection. Keep a copy of all laboratory test results to track changes over time.

- ✓ 2. When determining the N, P, and K fertilization rates appropriate for your crops, consult UF-IFAS recommendations in the *Nutrient Management of Vegetable and Agronomic Row Crops Handbook (SP500)*, as revised, or other credible sources of information with published scientific support. Manage nutrients carefully, using the applicable BMPs in this section and section 2.1.2, to minimize offsite discharge and leaching.
- ✓ 3. Maintain and calibrate fertilizer application equipment.
- ✓ 4. Use the Linear Bed Foot (LBF) System to convert from lbs/acre to lbs/100 LBF, after determining the typical bed spacing using **Table 3**.
- ✓ 5. When using drip irrigation, incorporate all P, micronutrients, and up to 40 percent of the recommended amount for N and K in the bed, and apply the remaining N and K in recommended increments (via fertigation). The weekly N application may increase as the plant matures during its fruiting stage. For extended harvest periods, see the *Supplemental Fertilizer Application Guidance* below.
- ✓ 6. When using seep irrigation, incorporate all P, micronutrients, and up to 20 percent of the recommended amount for N and K in the bed, and apply the remaining N and K in narrow bands on the bed shoulders underneath the plastic.
- ✓ 7.  Use tissue test (leaf/petiole) results to: determine the need for supplemental fertilizer applications, evaluate the effectiveness of N, P, and K, fertilization programs, and diagnose micronutrient deficiencies. See *Supplemental Fertilizer Application Guidance* below. Keep a copy of all laboratory test results.
- ✓ 8. If growing two crops on the same plastic mulch within a 12-month period, take a representative soil sample in the bed, away from the residual fertilizer bands. Use either the drip irrigation system or a liquid fertilizer injection wheel to apply any additional fertilizer, based

on the second crop's nutrient requirement and soil test result.

- ✓ 9. Clean up and remove plastic as soon as practicable after the last harvest to help reduce runoff effects and disease incidence during the next cropping cycle.
- ✓ 10.  Keep records of all nutrient applications that contain N or P.


Supplemental Fertilizer Application Guidance for Plastic Mulch Systems

- Supplemental fertilizer application is allowed when the results of leaf tissue analysis and/or petiole sap-testing fall below the sufficiency range. For drip irrigation, the supplemental amount allowed is 1.5 to 2.0 lbs/acre/day for N or K₂O for one week. This is an additional 15 percent above the UF-IFAS recommended amount.
- Supplemental fertilizer application is allowed during extended fruiting and harvest periods. This occurs when weather or market conditions allow harvesting well beyond the growing period assumed when determining the fertilizer rate recommendation. Weekly leaf tissue analysis and/or petiole sap-testing are required to support extended crop harvest supplemental fertilizer application(s), which must be consistent with mature plant nutrient uptake.

Special Nutrient Management Measures for High-Rate Fertilizer Users:

If your answer to the following question is "yes," implement the management measure below.


Question: Not counting any extended harvest period applications under item 2 above, do you use more than 15% over the standard UF-IFAS fertilizer rate recommendation for N, but less than or equal to 30% on a per acre annual year basis?
 Yes No

- ✓ 11.  Work with FDACS field staff and/or UF-IFAS extension agents to implement one or more of the specific measures listed in **Appendix 5**, or similar approved measures, to mitigate the use of additional N inputs. Document the measures you will implement in the Comments section of the BMP checklist, and have staff help you develop a written action plan.

Additional High-Rate Fertilizer Management Measure:

If your answer to the following question is "yes," implement the additional management measure below.


Question: Not counting any extended harvest period applications under item 2 above, do you use more than 30% over the standard UF-IFAS fertilizer rate recommendation for N on a per acre annual year basis? Yes No

- ✓ 12.  After implementing the high-rate management measure above, consult with a professional engineer to ensure and document that most of the production area surface water runoff is retained onsite or treated before discharging. Another option is to begin converting your farm to drip irrigation, documenting the number of acres to be converted each year.

References

1. USDA-NRCS, Conservation Practice Standard Nutrient Management, Code 590. FOTG-Section IV. <http://www.nrcs.usda.gov/technical/efotg>
2. UF-IFAS, Nutrient Management of Vegetable and Agronomic Row Crops Handbook, Publication SP500. <http://edis.ifas.ufl.edu/ss639>
3. Virginia Tech, Protecting Water Quality Best Management Practices for Row Crops Grown on Plastic Mulch, Publication 442-756.
4. UF-IFAS, Commercial Vegetable Fertilization Principles. Publication SL319. <http://edis.ifas.ufl.edu/cv009>

2.1.2 Plastic Mulch Irrigation Management Level I BMPs:

- ✓ 1. Use available tools and data to assist in making irrigation decisions. Tools may include water table observation wells, on-site soil moisture sensors, crop water use information, and weather data. Real-time weather data is available through the FAWN website; or by installing your own on-site weather station.
- ✓ 2.  Install rain gauges on your operation and monitor them to schedule irrigation events. Larger rain events may contribute enough moisture underneath plastic mulch to substitute for the next irrigation event.
- ✓ 3. If one is available, get a Mobile Irrigation Lab evaluation to check the emission uniformity of the system. This will confirm that the main,

sub-main, and laterals are able to deliver proper pressure and flow to the drip tapes. This should be done every three to five years, even if the drip tapes are replaced annually. Make adjustments as needed.

- ✓ 4. During the first two weeks of crop establishment of transplanted seedlings, water frequently but carefully to prevent excessive runoff from occurring. This is very important if you also have and use overhead irrigation to acclimate the transplants.
- ✓ 5. Irrigate based on available water holding capacity in the soil root zone. When daily irrigation needs are greater than the available water holding capacity (during long, warm days) or when plants are flowering or developing fruit, splitting (pulsed) irrigation events into multiple daily applications will be of benefit.

To visualize the extent of water (and fertilizer) movement in your soil, contact your county extension agent to seek guidance on performing a dye test to determine the general extent of the wetted pattern directly underneath the emitter. To learn more about performing the dye test, a short instructional video is available at: <http://www.freshfromflorida.com/Media/Files/Agricultural-Water-Policy-Files/Best-Management-Practices/Vegetable-and-Agronomic-Crop-Videos/Video-7-Performing-a-Dye-Test-for-Irrigation-Management>.



Additional Level I BMPs For Plastic Mulch with Seepage Irrigation:

- ✓ 6. For frost/freeze protection, raise water tables by increasing water levels in irrigation canals and ditches.
- ✓ 7. Maintain the water table (saturated zone) at the lowest level necessary to reach plant rooting depths. Removable boards on water control structures can be an effective tool to manage the water table.
- ✓ 8. Install water table observation wells midway between ditches or water furrows at the anticipated high and low water-table elevations within each field. Inspect them periodically and make any needed repairs.

Level II BMPs:

If your answer to the following question is “yes,” implement the Level II BMP below.

Question: Do you double crop on plastic mulch in poorly drained soils using seepage irrigation, and discharge to surface waters? Yes No

- ✓ 9. Install tailwater recovery pond(s) to conserve water and re-circulate the dissolved nutrients on cropland. If this option is not technically or economically feasible, describe in the comments section of the BMP checklist an alternative means to address discharge issues.

References

1. USDA-NRCS, Conservation Practice Standard Irrigation Canal or Lateral, Code 320; Irrigation Pipeline, Code 430; Irrigation Reservoir, Code 436; Irrigation System Microirrigation, Code 441; Irrigation Tailwater Recovery, Code 447; Irrigation Water Management, Code 449. FOTG-Section IV. <http://www.nrcs.usda.gov/technical/efotg>
2. UF-IFAS, Management of Soil and Water for Vegetable Production in Southwest Florida, Publication SL-233. <http://edis.ifas.ufl.edu/ss452>
3. UF-IFAS, Principles and Practices of Irrigation Management for Vegetables. Publication AE260. <http://edis.ifas.ufl.edu/cv107>
4. Drip Irrigation: The BMP Era. An Integrated Approach to Water and Fertilizer Management for Vegetables Grown with Plasticulture. Publication HS917. <http://edis.ifas.ufl.edu/hs172>
5. Interpreting Dye Test Results for Improved Drip Irrigation Management for the Mulched Vegetable-Production Systems in South Florida. Publication AE506. <http://edis.ifas.ufl.edu/ae506>
6. EPA, National Management Measures for the Control of Nonpoint Pollution from Agriculture, Chapter 4F. EPA-841-B-03-004. http://water.epa.gov/polwaste/nps/agriculture/agmm_index.cfm

2.2 Bare Ground Production Systems

Vegetable crops such as potatoes, snap beans, southern peas, sweet potatoes, carrots, sweet corn, cucumbers for machine harvest, celery, radishes, certain lettuces, cabbage, and ornamental caladiums are routinely grown in non-mulched beds. Watermelons, eggplant, squash, zucchini, broccoli and pepper are grown periodically in bare ground systems. Bed preparation involves tillage where soil is prepared for planting a crop, usually by

several passes of mechanical equipment, resulting in a bed.

A well-prepared planting bed is important to establish plants. Most vegetable production areas in South Florida utilize parallel rows of raised bed systems, which help control erosion and improve on-farm water management. It is important to get a uniform crop stand as quickly as possible, in order to reduce erosion and moisture variability throughout the field. Engineering factors such as row length, bed height, bed layout, and irrigation system type must be carefully considered in that the design of one can dramatically affect the performance of the other.

In North Florida, many farms are planted with field or agronomic crops such as corn, peanuts and cotton, all of which are planted at grade without using raised beds. Conservation tillage techniques (e.g., strip till) may also be used to conserve moisture and soil resources. Furthermore, the water table is usually lower than that in South Florida, requiring little to no artificial drainage.

Legumes

Atmospheric N gas can be fixed in soil by specialized bacteria, through a process called nitrogen fixation. Part of the N fixed by leguminous crops is released in plant available forms as legume residues decompose. Some research has indicated that up to 140 pounds of N per acre may be available to the succeeding crop following a legume; however, this is highly variable and depends on how much of the legume crop was harvested and removed from the field, and how much stubble was left for incorporation into the soil. Producers should account for any “N credit” in succeeding crops.

The main legume crops that are grown commercially in Florida are peanuts, snap beans, soybeans, southern peas, and perennial peanut forages. Producers may use commercial inoculants, where a prepared culture of the proper strain of bacterium is applied to the legume seed or applied in the seed furrow at time of planting. For more information on commercial inoculants, see *Inoculation of Agronomic Crop Legumes* at: <http://edis.ifas.ufl.edu/aa126>.

Rotational Farming

Crop rotations benefit the soil via increased organic matter and improved soil tilth, and are the cornerstone of disease and nematode management. For example, if cotton is planted in the same field year after year, populations of the southern root-knot

nematode are likely to reach damaging levels. To combat this, peanuts are generally rotated (on a three to four year rotation schedule) with cotton crops as peanuts are not affected by the southern root-knot nematode and will significantly reduce re-colonization and damage in subsequent cotton production periods. Simply using pesticides such as nematicides and fungicides will not replace an effective crop rotation strategy.

Sod-based rotational farming is increasingly popular in parts of North Florida on farms with center pivot irrigation systems. It enables the produce to create discrete production “quadrants” whereby production areas are systematically rotated between animal, crop, and bahia forage grass systems. Doing so helps break disease cycles, increase soil organic matter and yield, decrease nitrate leaching, and provides permanent vegetative cover.

Some crops remove different amounts of certain nutrients. For example, a seed crop like corn will remove more P than cabbage. This can result in premature depletion of certain nutrients, creating an additional input expense. To learn more about the benefits of crop rotations and cover crops, a short instructional video is available at: <http://www.freshfromflorida.com/Media/Files/Agricultural-Water-Policy-Files/Best-Management-Practices/Vegetable-and-Agronomic-Crop-Videos/Video-8-Benefits-of-Crop-Rotations-and-Cover-Crops>.

Precision Agriculture

Many producers have readily embraced precision agriculture tools. A good example of this is through the use of a global positioning system (GPS) and associated navigation instrument (e.g., light-bar system) to guide field application equipment more precisely. **Figure 16** depicts a cab-mounted GPS and light-bar system. With this system, the skip and overlap rate between passes can be as low as 2 percent, where conventional foam markers only offer a skip/overlap reduction of around 10 per-



Figure 16



cent. This technology will prevent over-application of fertilizer or pesticide materials.

Precision agriculture also offers producers the ability to fertilize and lime on a grid basis, instead of fertilizing fields based on the “average” soil test value. With grid sampling and precision agriculture, bare ground producers can be more efficient with fertilizer and lime management.

For more information on this system, see *Precision Farming Tools: GPS Navigation* at: <http://www.pubs.ext.vt.edu/442/442-501/442-501.html>

Bare Ground Production System BMPs

2.2.1 Bare Ground Nutrient Management Level I BMPs:

- ✓ 1.  Test soils on an annual basis. Base P fertilization rate on soil test results from a public or private laboratory that employs the standard testing methods used by the UF-IFAS Extension Soils Testing Laboratories. Refer to **Appendix 2** for guidance on accepted P extraction methods and sample collection. Keep a copy of all laboratory test results to track changes over time.
- ✓ 2. When determining the N, P, and K fertilization rates appropriate for your crops, consult UF-IFAS recommendations in the *Nutrient Management of Vegetable and Agronomic Row Crops Handbook (SP500)*, as revised, or other credible sources of information with published scientific support. Manage nutrients carefully, using the applicable BMPs in this section and section 2.2.2, to minimize offsite discharge and leaching.
- ✓ 3. Maintain and calibrate fertilizer application equipment.
- ✓ 4. Use automated or manual shutoff valves on the fertilizer application equipment so that no fertilizer is applied in the turn row or other non-production areas.
- ✓ 5.  Keep records of all nutrient applications that contain N or P.

Additional Level I BMPs For Raised Beds:

- ✓ 6. Apply up to 40 percent of the N and K at planting or shortly after planting. Delay the first application based on the approximate number of days until germination (or cracking for potatoes), and the root system characteristics. P should be banded or injected, and

applied as close as possible to planting but no more than 10 days before.

- ✓ 7. Use the Linear Bed Foot (LBF) system to convert from lbs/acre to lbs/100 LBF, after determining the typical bed spacing using **Table 3**.
- ✓ 8. Apply the remaining fertilizer in split applications (or more frequently if fertigating) during the early part of the growing season, or according to specific crop needs.

Additional Level I BMPs For Field Crops Planted at Grade:

- ✓ 9. Apply all of the P and up to 30 percent of the N and K at planting or shortly after planting. Delay the first application based on the approximate number of days until germination (or cracking for potatoes), and the root system development characteristics. P should be applied as close as possible to planting but no more than 10 days before.
- ✓ 10. Apply additional fertilizer only after the root system has advanced into the inter-row area to maximize interception of available nutrients. Apply it in one or more applications during the early to middle part of the growing season, or according to specific crop needs.
- ✓ 11. If incorporating legumes/cover crops, compost, manure, or biosolids, or irrigating with reclaimed water, determine the N and P contribution by multiplying the average nutrient concentrations by the rate of material applied, and decrease N and P fertilization rates accordingly.
- ✓ 12. Consider incorporating a global positioning system (GPS) and associated navigation instrument (parallel-tracking device) to reduce overlap; grid map soil units to deliver fertilizer at a variable rate; or another precision agriculture technique, and describe it in the comments section of the BMP checklist.

Note: *If growing corn, keep in mind that there are lower N amounts recommended for non-irrigated corn. In general, maximum N uptake begins at the V6 growth stage (approximately 18 inches tall) and requires the most water during its ear development stage.*

Supplemental Fertilizer Application Guidance for bare ground production.

- Depending upon the stage of crop development, a single supplemental application of N and/or K

may be applied if rainfall exceeds 3 inches in 3 days, or 4 inches in 7 days. Apply up to 30 lbs of supplemental N/acre of planted cropland.

- A supplemental fertilizer application is allowed when the results of leaf tissue analysis and/or petiole sap-testing fall below the sufficiency ranges. Apply up to 30 lbs of supplemental N/acre within the affected crop production area.

Special Nutrient Management Measures for High-Rate Fertilizer Users:

If your answer to the following question is “yes,” implement the management measure below.

Question: Not counting any amount under the supplemental fertilizer application guidance above, do you use more than 10% over the standard UF-IFAS fertilizer rate recommendation for N, but less than or equal to 20% on a per acre annual year basis? Yes No

- ✓ 13. Work with FDACS field staff and/or UF-IFAS extension agents to implement one or more of the specific measures listed in **Appendix 5**, or similar approved measures, to mitigate the use of additional N inputs. Document the measures you will implement in the Comments section of the BMP checklist, and have staff help you develop a written action plan.

Additional High-Rate Fertilizer Management Measure:

If your answer to the following question is “yes,” implement the additional management measure below.

Question: Not counting any amount under the supplemental fertilizer application guidance above, do you use more than 20% over the standard UF-IFAS fertilizer rate recommendation for N on a per acre annual year basis? Yes No

- ✓ 14. After implementing the high-rate management measure above, begin converting your farm to either drip irrigation, or a high-efficiency, computer controlled, pivot irrigation system if your farm is in a karst area. Both speed and zone control variable rate application must be evaluated.

References


1. UF-IFAS, Nutrient Management of Vegetable and Agronomic Row Crops Handbook, Publication SP500. <http://edis.ifas.ufl.edu/ss639>

2. UF-IFAS, Description of Enhanced Efficiency Fertilizers for Use in Vegetable Production. Publication HS1247. <http://edis.ifas.ufl.edu/hs1247>
3. USDA-NRCS, Part 624, Water Table Control. Chapter 10. <http://directives.sc.egov.usda.gov/viewerFS.aspx?hid=21420>
4. USDA-NRCS, Cover Crops and Soil Health. Plant Materials Program. <http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/landuse/crops/?cid=stelprdb1077238>

2.2.2 Bare Ground Irrigation Management

Note: For bare ground operations that dry land farm and do not irrigate, skip the BMPs below and proceed to Section 3.

Level I BMPs:

- ✓ 1. Use available tools and data to assist in making irrigation decisions. Tools may include water table observation wells, on-site soil moisture sensors, crop water use information, and weather data. Real-time weather data is available through the FAWN website; or by installing your own on-site weather station. Agronomic or field crops grown in North Florida should follow the guidance in Reference 2 below.
- ✓ 2.  Install rain gauges on your operation and monitor them to help schedule irrigation events. Rain events of ¼ to ½ inch are usually sufficient to substitute for the next irrigation event.
- ✓ 3. If a Mobile Irrigation Lab is available, get an evaluation to check the distribution or emission uniformity and the conveyance efficiency of the irrigation system(s). This should be done every three to five years. Make adjustments as needed.
- ✓ 4. Do not irrigate beyond field capacity. It is important to leave a “reservoir” for unexpected rain to minimize nutrient leaching.
- ✓ 5. For center pivot irrigation systems, install low-pressure irrigation sprinklers with drops and speed and/or zone variable rate controls, if economically feasible.

Additional Level I BMPs For Seepage Irrigation:

- ✓ 6. For frost/freeze protection, raise water tables by increasing water levels in irrigation canals and ditches.

- ✓ **7.** Maintain the water table (saturated zone) at the lowest level necessary to reach plant rooting depths. Removable boards on water control structures can be an effective tool to manage the water table.
- ✓ **8.** Install water table observation wells midway between ditches or water furrows at the anticipated high and low water-table elevations within each field. Inspect them periodically for any needed repairs. Alternatively, use water table reference elevations for open seepage systems.

Producers should explore the use of a tailwater recovery system, especially if irrigation water is routinely discharging to surface waters. Cost-share assistance may be available.

Note: See *Appendix 7* for list of record-keeping requirements and example record-keeping forms.

References

1. USDA-NRCS, Conservation Practice Standard Irrigation Canal or Lateral, Code 320; Conservation Cover Crop, Code 327; Irrigation Pipeline, Code 430; Irrigation Reservoir, Code 436; Irrigation Sprinkler System, Code 442; Irrigation Systems, Surface and Subsurface, Code 443; Irrigation Tailwater Recovery, Code 447; Irrigation Water Management, Code 449. FOTG-Section IV. <http://www.nrcs.usda.gov/technical/efotg>
2. UF-IFAS, Crop Water Use and Irrigation Scheduling Guide for North Florida, Publication SL-288. <http://edis.ifas.ufl.edu/ss491>
3. UF-IFAS, Simple Water Level Indicator for Seepage Irrigation, Publication 1188.
4. Converting from Seepage Irrigation to Plasticulture for Vegetable Production: A Case Study. Publication HS1246. <http://edis.ifas.ufl.edu/pdf/HS/HS124600.pdf>

2.3 Sugarcane Production Systems

Historically, Florida had two muck farming regions: the Lake Apopka marsh area, north of Lake Apopka; and the Everglades Agricultural Area (EAA), a 700,000 acre area south of Lake Okeechobee. The 1996 Lake Apopka Restoration Act culminated in the buyout of the muck farms north of Lake Apopka, and has eliminated most of the farming there today. The 1994 Everglades Forever Act required mandatory BMPs and the EAA still flourishes as a prime sugarcane, winter vegetables, sod and rice production area.

In addition to the production of sugarcane on the muck soils of the EAA, sugarcane is also produced on mucky soils, sandy mucks, and sandy or mineral soils in Palm Beach, Hendry, Glades, Highlands, St. Lucie and Martin Counties (or other counties outside of the EAA boundaries).



Figure 17

Histosols, which are classified as a soil order by USDA soil taxonomists as represented in **Figure 17**, are highly organic soils composed primarily of muck, underlain by calcareous deposits. Muck soils in the EAA have very good water and nutrient holding capacities, but are prone to oxidation and soil subsidence, which increases the calcium concentration (from underlying lime rock) over time, and can raise soil pH. Too much calcium and/or incorrect soil pH can bind phosphate, making it less available to plants.

Sugarcane planting takes place from late August through January using sections of stalks from a donor plant, in a process called vegetative propagation. Conventional row spacing for commercial sugarcane production is 5-feet. Cane stalks have buds that sprout within two to three weeks, ultimately forming a dense stand of cane. After a field has been harvested the first time, a second crop of stalks, called a **ratoon**, grows from plant stubble. On average, three annual crops are harvested from the original cane before the field is replanted. Sometimes, fallow sugarcane fields are planted to another crop, such as rice, green beans, watermelons, peppers, or sweet corn to promote crop rotation.

Nutrient Management

Generally, no N fertilizer is recommended for sugarcane grown on deep muck soil. Sugarcane grown on sandy, sandy muck, shallow muck or mineral soils may require supplemental N fertilizer in multiple (split) applications. For muck soils, N deficiencies are rarely seen as the high organic N content is quickly mineralized into inorganic N which is readily available for plant uptake. A deficiency may appear if organic N cannot be mineralized under anaerobic conditions caused by floodwaters. For example, young sugarcane plants

grown on shallow muck during cool, wet periods have shown N-deficiency symptoms. In these instances, N fertilizer may be applied.

P is likely to be deficient in both muck and mineral soils in South Florida. Careful control of available P levels is essential for reasonable yields of sugarcane and sucrose. P deficiency is much more common in ratoon crops, and deficiency symptoms tend to increase with crop age. For more detailed information, see *Nutritional Requirements for Florida Sugarcane* at: <http://edis.ifas.ufl.edu/sc028>.

Organic muck soils are highly buffered against pH change, and tend to be neutral to alkaline. Lowering the soil pH of organic soils can be accomplished with sulfur applied in the furrow, and may be needed when pH is greater than 6.6 which can trigger micronutrient deficiencies. Some sandy soils have lower than optimum surface soil pH, and liming of soils with pH of 5.5 or lower may result in more adequate nutrition and yield increase.


Irrigation Management


Frequency and depth of irrigation will vary with sugarcane growth periods. During the establishment period, including emergence and establishment of young seedlings, light, frequent irrigation applications are recommended. During the early vegetative period, tillering (secondary sprouts formed from underground buds) is in direct proportion to the frequency of irrigation. During stem elongation and early yield formation, the irrigation interval can be extended but the amount should be increased. The response of sugarcane to irrigation is greater during the vegetative and early yield formation periods than during the later part of the yield formation period, when active leaf area is declining and the crop is less able to respond to sunshine. During the ripening period, irrigation intervals are extended or irrigation is stopped when it is necessary to bring the crop to maturity by reducing the rate of vegetative growth, thus dehydrating the cane and forcing the conversion of total sugars to recoverable sucrose. During the yield formation period, frequent irrigation leads to flowering, which reduces sugar production.

Rooting depth varies with soil type and irrigation regime, but the active root zone for water uptake is generally limited to the upper soil profile. With growing season ET averaging between 5 to 6 millimeters/day, the depletion level during the vegetative and yield formation period can be 65 percent of the total available water without having any serious effects on yields.


Seepage irrigation is commonly used and is particularly effective in the EAA. Water must be pumped out of sugarcane fields when rainfall is excessive, and fields are irrigated by allowing the water to flow back into the same ditches that are used for drainage. Water then readily seeps from lateral field ditches throughout the field, generally flowing on top of the underlying limestone bedrock, providing irrigation of the soils via capillary action. Because of geology and the need to drain and irrigate with the same ditch, it is common for ditch bottoms to be below the natural water table of the farm.

2.3.1 Sugarcane Nutrient Management Level I BMPs:

- ✓ 1.  Test soils prior to planting cane. Base P fertilization rate on soil test results from a public or private laboratory that employs the standard testing methods used by the UF-IFAS Extension Soils Testing Laboratories, or alternate test methods that have a calibrated crop response. Refer to **Appendix 2** for guidance on P extraction methods and sample collection. Keep a copy of all laboratory test results to track changes over time. Band or air-duct all P as a pre-plant application.
- ✓ 2. Repeat the application of P fertilizer every year after harvesting. The rates should follow the calibration curve according to first, second, and third ratoon and the soil test done prior to planting.
- ✓ 3. Maintain and calibrate fertilizer application equipment.
- ✓ 4. No N fertilizer is recommended for sugarcane grown on deeper muck soils. However, young sugarcane plants in any soils that have been exposed to anaerobic conditions caused by excessive rainfall or floodwaters may require N fertilizer.
- ✓ 5. For sandy, sandy muck, shallow muck, or mineral soils, apply N fertilizer in accordance with UF-IFAS recommendations in the *Nutrient Management of Vegetable and Agronomic Row Crops Handbook (SP 500)*, as revised, or other credible sources of information. Do not apply more than 50 lbs of soluble N/acre in any single application. For mucky sands and/or sandy mucks, apply less than the recommended annual rate for sandy soils. Manage nutrients carefully, using the applicable BMPs in this section and section 2.3.2, to minimize offsite discharge and leaching.

- ✓ 6. Incorporate fallow flooding into the rotation cycle for non-production sugarcane fields in organic muck soils, if feasible, to prevent soil subsidence and oxidation.
- ✓ 7.  Keep records of all nutrient applications that contain N or P.

2.3.2 Sugarcane Irrigation Management Level I BMPs:

- ✓ 1. Use available tools and data to assist in making irrigation decisions. Tools may include water level observation, removable soil moisture sensors, crop water use information, and/or weather data. Real-time weather data is available through the FAWN website; or by installing your own on-site weather station.
- ✓ 2.  Install rain gauges on your operation and monitor them to help schedule irrigation events. Rain events of ¼ to ½ inch are usually sufficient to substitute for the next irrigation event.
- ✓ 3. Irrigate up to field capacity and not beyond.
- ✓ 4. Maintain the water table at the lowest level necessary to reach sugarcane rooting depths. Removable boards on water control structures can be an effective tool to manage the water table.
- ✓ 5. If fields are flooded temporarily, monitor the water levels and berms for integrity.
- ✓ 6. For frost/freeze protection, raise water tables by increasing water levels in irrigation canals and ditches.

Note: See **Appendix 7** for list of record-keeping requirements and example record-keeping forms.

References

1. UF-IFAS, Nutritional Requirements for Florida Sugarcane, Publication SS-AGR-228. <http://edis.ifas.ufl.edu/sc028>
2. UF-IFAS, Nutrient Requirements for Sugarcane Production on Florida Muck Soils, Publication SS-AGR-226. <http://edis.ifas.ufl.edu/sc026>
3. UF-IFAS, Nutrient Management of Vegetable and Agronomic Row Crops Handbook, Publication SP500. <http://edis.ifas.ufl.edu/ss639>
4. UF-IFAS, Phosphorus Fertilizer Recommendations for Sugarcane Production on Florida Organic Soils, Publication SS-AGR-348. <http://edis.ifas.ufl.edu/sc091>

5. UF-IFAS, Sugarcane Production in Southwest Florida: Mineral soils and Amendments Publication SL 230. <http://edis.ifas.ufl.edu/sc073>
6. UF-IFAS, Efficiencies of Florida Agricultural Irrigation Systems, Bulletin 247.

2.4 Hay and Silage Production Systems

There are millions of acres of grazing land in the state of Florida. It varies from forested range in the northern region to planted pastures in the southern region. Besides supporting cow/calf operations, some of these pastures are also used for hay/silage production. In some parts of the state, such as in the Suwannee River valley, many fields are exclusively planted and managed for hay/silage (collectively referred to as forage) production.

Warm-season perennial grasses provide the bulk of hay production in Florida. Bermudagrass, stargrass, and bahiagrass dominate, primarily because they thrive in warmer weather, which can be six to eight months of the year depending on the location. However, the cool-season grasses generally are higher in quality (digestibility). Grown primarily in North Florida, the cool-season grasses include small grains (rye, wheat, oats, and triticale) and annual ryegrass. Legumes, such as perennial peanut or clover, also may be used for hay production. Some producers also plant summer annual grasses, such as corn, sorghum, and millet, for silage to supplement animal feedstock.

Maturity stage at harvest is the most important factor determining quality, as forage quality usually declines with advancing maturity. **Table 4** provides guidance for the recommended harvest stages for various types of hay.

Nutrient Management

Balanced fertilization is necessary to achieve efficient growth, adequate root development, and cold hardiness of forages. As in other crops, the main nutrients required are N, P, and K, and in lesser amounts secondary nutrients and micronutrients. N is the nutrient that forages use in higher quantities as a building block for amino acids and proteins for growth, and adding N often results in improved forage nutritive value by increasing the crude protein content. Phosphorus is native in many Florida soils but it may be deficient in some. Many forage crops extract enough P from the subsoil even when levels in the surface are low. Potassium, like N, is also mobile in sandy soils and applications are typically required as are calcium, magnesium, sulfur, and some micronutrients.

Table 4. Recommended Stages to Harvest Hay Crops

Plant	Time of Harvest
Alfalfa	Bud stage for first cutting, one-tenth bloom for later cuttings
Bahiagrass	10 to 12-inch height
Bermudagrass	15 to 18-inch height
Clovers	Early bloom
Oats, Barley, Wheat	Boot to early head stage
Perennial Peanut	12 to 14-inch height
Soybean or Cowpea	Mid to full bloom
Sorghum-Sudangrass	30 to 40-inch height
Hermathria	Between 4 and 6 weeks

The amount of fertilizer to apply will depend on how the forage is used. To achieve the potential production used in a typical hay system (5 to 8 tons/acre), the required amounts of nutrients cannot be supplied by the soil alone. This is especially true with multiple cuttings. If the production system includes a mix of legumes that fix N, there will be some contribution of N but usually no more than about 30 to 40 lbs N/acre. Producers should follow the fertilization recommendations in *Nutrient Management of Vegetable and Agronomic Row Crops Handbook* at: <http://edis.ifas.ufl.edu/ss639>.

Special Water Quality Considerations

Due to their high yield and tissue nutrient concentration, forages can reduce excess soil nutrients (such as N or P) when they are harvested for hay, silage, or used as greenchop. Given their extensive root systems, forages not only efficiently extract nutrients, but also minimize soil compaction and erosion by water and wind.

Sometimes, irrigation of forage crops is used to manage wastewater from dairy operations or municipal water treatment facilities. Under either of these scenarios, multiple cropping systems should be used to maximize the removal of residual soil nutrients. Also, careful nutrient management planning is needed to ensure that crops are fertilized at the proper agronomic rate.

Irrigation Management

Irrigation of forage crops grown for hay or silage is common, due to sandy soils, uneven distribution of rainfall, and multiple yearly harvests. In Florida,

there are approximately 196,000 acres of silage and hay crops under irrigation. The irrigation systems most commonly used are center-pivot and lateral-move equipment, which are permanent self-propelled systems. Portable and large traveling-gun systems are sometimes used.

Average water use for bermudagrass irrigation ranges from 0.12 inches to: 0.16 inches/day in March; 0.18 inches/day in May, June, and July; 0.16 inches/day in August; and 0.14 inches/day in September. Producers should educate themselves on their particular forage crop's water use requirement to ensure that the proper amount of water is applied during each irrigation event.

Harvesting and Storage

Certain forages are harvested, stored, and later fed to livestock as silage. Crops such as corn and sorghum are particularly well-suited to harvesting as silage because of their high energy value and the fact that their thick stalks delay drying. Once harvested, silage is stored in a silo (absence of air, low pH) and preserved by naturally occurring acids until it is used as feed.

Bermudagrass and bahiagrass are usually harvested as hay and, in North Florida, may be cut and harvested up to four times per year. Hay baled at too high a moisture level will generate excessive heat and can even catch on fire. Further, hay stored outside for a prolonged period of time may result in leaf shatter, dry matter loss, and reduced forage quality due to rain. To offset this effect, hay bales should be stored under roof as in **Figure 18**, or, if stored outside, oriented in north-south rows to get more exposure to sunlight.

Major losses in forage quality generally occur due to poor storage and feeding techniques. Ultimately, a reduction in quality increases the level of animal refusal during feeding, and will require additional feed supplementation to offset the animal's nutritional requirements. For more information about silage management, go to: <https://www.pioneer.com/home/site/us/livestock-feed-nutrition/>.

Accurate laboratory testing of feed and forage will provide the information needed to formulate animal feeding rations; and provides a basis for commercial hay sales. For more information about forage quality, sample collection and laboratory analysis, see the publication, *Understanding and Improving Forage Quality* at:



http://extension.uga.edu/publications/files/pdf/B%201425_1.pdf.




Figure 18

Hay and Silage Production System BMPs

2.4.1 Hay and Silage Nutrient Management Level I BMPs:

- ✓ 1.  For established stands of hay, take soil samples during the dormant season and test them on an annual basis. Base P fertilization rate on soil test results from a public or private lab that employs the standard testing methods used by the UF-IFAS Extension Soils Testing Laboratories. Refer to **Appendix 2** for guidance on accepted P extraction methods and sample collection. Keep a copy of all laboratory test results to track changes over time.
- ✓ 2. Maintain and calibrate fertilizer application equipment.
- ✓ 3. Fertilize perennial grasses for hay crops in the spring as soon as the crop starts growing. Apply up to 80 lbs N/acre/cutting, and all of the recommended P and K in early spring. Reduce the N accordingly, after the next-to-last cutting in the fall.
- ✓ 4. Begin spring harvest (first cutting) of hay when the grass reaches the recommended height(s) listed in **Table 4**.
- ✓ 5. For producers growing annual silage or other forages, consult UF-IFAS recommendations in the *Nutrient Management of Vegetable and Agronomic Row Crops Handbook (SP 500)*, as revised.
- ✓ 6.  Keep records of all nutrient applications that contain N or P.

2.4.2 Hay and Silage Irrigation Management Level I BMPs:

- ✓ 1. Use available tools and data to assist in making irrigation decisions. Tools may include water table observation wells, on-site soil moisture sensors, crop water use information, and weather data. Real-time weather data is available through the FAWN website; or by installing your own on-site weather station.
- ✓ 2.  Install rain gauges on your operation and monitor them to help schedule irrigation events. Rain events of ¼ to ½ inch are usually sufficient to substitute for the next irrigation event.
- ✓ 3. If a Mobile Irrigation Lab is available, get an evaluation to check the distribution (sprinkler) or emission uniformity and the conveyance efficiency of the irrigation system(s). This should be done every three to five years. Make adjustments as needed.
- ✓ 4. Do not irrigate beyond field capacity.

Note: See **Appendix 7** for list of record-keeping requirements and example record-keeping forms.

References

1. UF-IFAS, Forages of Florida website. http://edis.ifas.ufl.edu/topic_book_florida_forage_handbook
2. UF-IFAS, Silage Harvesting Equipment, Publication DS53. <http://edis.ifas.ufl.edu/ag180>
3. UF-IFAS, Bahiagrass: A Quick Reference, Publication AG271. <http://edis.ifas.ufl.edu/AG271>
4. UF-IFAS, Bermudagrass: A Quick Reference, Publication SSAGR264. <http://edis.ifas.ufl.edu/AG272>
5. UF-IFAS, Standardized Fertilization Recommendations for Agronomic Crops. Publication SL-129. <http://edis.ifas.ufl.edu/SS163>
6. UF-IFAS, Fertilizing and Liming Forage Crops, Publication AG179. <http://edis.ifas.ufl.edu/AG179>

2.5 Protected Growing Systems

Protected growing systems include greenhouses and high tunnels that modify the environment to enhance crop yield, fruit quality, frost protection, and potentially reduce the use of pesticides via insect exclusion.

Greenhouses

These permanent systems involve growing crops in an enclosed environment that usually require automated environmental control systems, ventilation, glazing materials, and skilled labor. The greenhouse structure may be a stand-alone facility or multiple greenhouses connected by gutters. The production system is usually a soilless one that incorporates a drip irrigation system and a leachate collection system, if applicable.

For more information, see *Florida Greenhouse Vegetable Production Handbook (Volumes 1-3)* at: <http://edis.ifas.ufl.edu/cv255>.

High tunnels

High tunnels are unheated, non-automated, plastic-covered non-permanent structures covering multiple crop rows. They range from 6 feet or higher with passive ventilation through roll-up side or end walls. Crops can be grown in plastic mulch, bare soil, or soilless media and are irrigated and fertilized through low-volume irrigation. The primary benefit of high tunnels is early maturity and faster ripening, along with improved disease control. Producers should consider using tailwater recovery/reuse with high tunnels to handle increased runoff. For more information on high tunnels, see *Protected Culture for Vegetable and Small Fruit Crops: High Tunnels for Strawberry Production in Florida*, at: <http://edis.ifas.ufl.edu/hs407>.

Hydroponics

Hydroponics is a form of plant culture using a nutrient solution in either a liquid culture or in a soilless media culture. There are basically three types of liquid culture hydroponic systems: (1) static aerated nutrient solution; (2) nutrient film technique (NFT); and, (3) aeroponics.

2.5.1 Protected Growing System BMPs Level I BMPs:

- ✓ 1. Follow all applicable BMPs in this manual.
- ✓ 2. Use gutters or other means to convey roof runoff water to an onsite catchment pond for evaporation or reuse.
- ✓ 3. Consider installing a nutrient leachate collection system and conveying leachate outside the greenhouse for use on another crop (nursery plants, turfgrass, hay field, etc.) or convey leachate to a constructed treatment wetland.

Note: After collecting it in a leachate collection system, you can treat the wastewater by using it on an actively growing crop or other vegetated area outside of the greenhouse. Another option for treating hydroponic wastewater is to construct a passive wetland system. Guidance on this and other treatment options can be found in *Managing Waste Water from Intensive Horticulture: A Wetland System* at: http://www.dpi.nsw.gov.au/___data/assets/pdf_file/0005/119372/horticulture-waste-water-wetland-system-eng.pdf.



3.0 IRRIGATION SYSTEM MAINTENANCE

Irrigation System maintenance involves keeping the irrigation system components in peak operating condition, enabling the system to perform according to manufacturer's recommendations.

The importance of irrigation system maintenance cannot be overstated. Even the best-designed, most-efficient irrigation system will perform poorly if its components are not properly maintained over time. The benefits of maintaining irrigation systems in good working condition include water conservation, uniform plant growth and production, reduced energy consumption, and lower long-term operation and maintenance costs.

Irrigation System Maintenance

Maintenance is necessary on any irrigation system to keep the system operating at peak efficiency according to manufacturer's recommendations. Maintenance is also important on pumping plant motors and other associated components.

Irrigation system maintenance involves calibration, preventive maintenance, corrective maintenance, and record keeping. All farms should follow an ongoing, well-documented maintenance program that includes periodic calibration of each irrigation system and associated water meter(s) to help ensure that the correct amount of water is delivered. Visual

inspections should be conducted regularly to identify any necessary repairs or corrective actions. A Mobile Irrigation Lab (MIL) may be available in your area to perform irrigation system evaluations and recommend system improvements free of charge.

For traditional open-ditch seepage irrigation systems, water control structures (such as risers and culverts) should be kept clean and operational. Maintenance of semi-closed seepage irrigation systems includes operational checks of pumping plants (pump and engine/motor), and maintaining



Figure 19

all pipes, spigots, and valves in good working order. Maintenance of pressurized pipe systems includes operational checks of pumping plants, valves, irrigation emitters, and maintenance of irrigation lines through chlorination/acidification and flushing as in **Figure 19**. Malfunctioning or worn-out emitters or nozzles need to be replaced with similar ones that have the same flow and pressure characteristics. For micro-irrigation systems, **sequestering agents** are commercially available to help prevent plugging caused by scale deposition. For center pivot systems, a variable speed drive device may be beneficial if you have multiple pivots and/or irrigate different crops from the same pumps.

Tracking Irrigation System Performance

It is very important to measure the amount of water that is actually delivered through the irrigation system, via a water meter or another calibrated flow measurement device. Knowing the flow and total volume applied to your crop will help you determine how well your irrigation system and irrigation schedule are working. Keep in mind that totalizing water meters have impellers that can wear out over time, and can therefore give incorrect readings. To deal with this issue, most MILs have non-intrusive ultrasonic flow meters that can be used to validate the reliability of existing flow meters.

It is also a good idea to install permanent pressure gauges (with valve in between pipe and gauge) at various locations in the irrigation line itself. Use the gauges to perform routine pressure checks to ensure that no significant pressure losses are occurring. If so, it may affect the output of water to that portion of the field.

For specific reporting and measuring requirements, follow the consumptive water use permit issued by the water management district.

Pumping Plant Efficiency

In Florida, many farms use stationary internal combustion engines that run on diesel fuel to run large, turbine pumps that draw water from the aquifer and deliver it to the irrigation system under pressure. Some farms in north Florida use electric motors which also coincide with the high use of center pivot irrigation systems. Pumping plant efficiency (PPE) is based on the combined effect of engine/motor efficiency and pump efficiency ratings. In general, PPE using electric motors can average as high as 70 percent, while PPE using diesel engines can average as low as 25 percent; however, there are many management and maintenance variables that can affect these numbers.

PPE is important and should be combined with a design review that has a goal to accomplish pumping using minimum power. This review will study and minimize anything that adds head to the pump. This extends to selecting the least-cost viable power source.

A turbine pump has three main parts: the gear head, the pump bowl, and the discharge column. A shaft from the gear head to the pump bowl drives the impeller. The bowl is placed beneath the water surface, and has a screen to keep coarse sand and gravel from entering the pump. There are also stationary guide vanes surrounding the impeller that provide a more uniform distribution of pressure.

Seasonal fluctuations in the water table should be determined prior to installing the pump so that the bowls can be placed below the anticipated draw-down point. In locations where fluctuations are apt to occur and a constant discharge rate over the pumping range is needed, a power unit with variable speeds should be considered. Variable speed electric motors are more suited to this application.

A right-angle gear drive is the most dependable and efficient method of transmitting power from an engine/motor to a turbine pump. Correct alignment is critical between the pump and the power unit; and, the pump must also be correctly aligned in the well casing so that no part of the pump assembly touches the well casing. This is important because vibration in the pump assembly may damage the well casing. Finally, the pump, engine/motor, and fuel tank (if applicable) should be mounted on a firm foundation so that proper alignment points are maintained. A concrete foundation with a berm provides the most permanent and trouble-free installation.

Regardless of the power source, pumping costs are an item that producers have some degree of control over. Pumping costs often are higher than they need be for two reasons: 1) more water is pumped than is necessary and, 2) the pumping plant itself operates inefficiently. To learn more about pumping plant efficiency variables, a short instructional video is available at: <http://www.freshfromflorida.com/Media/Files/Agricultural-Water-Policy-Files/Best-Management-Practices/Vegetable-and-Agronomic-Crop-Videos/Video-9-Pumping-Plant-Efficiency-Variables>.



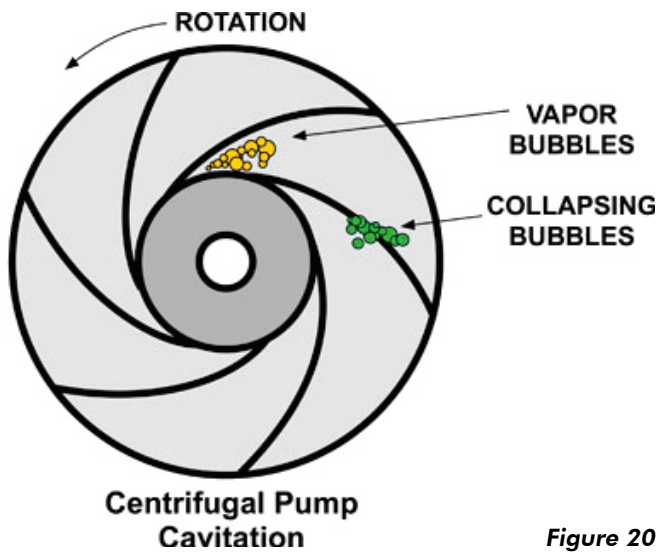


Figure 20

Some of the more common causes of low PPE are:

1. **Impellers that are out of adjustment.** This is the easiest and least expensive problem to correct; however, to avoid pump damage, only experienced pump professionals should attempt to make impeller adjustments.
2. **Pump bowls designed for a higher pumping rate.** This is a pumping rate in excess of what the well can supply, and is one of the most common reasons for poor PPE. Declining water tables can also reduce well yield causing a pump to cavitate (resulting in vibration and noise) because it is being forced to operate at a lower flow rate and higher lift than that for which it was designed. In this case, an increased PPE can only be achieved by replacing the bowls with ones that meet the proper specifications.
3. **Damaged impellers.** Three common causes of impeller damage are cavitation, sand pumping (due to well filter failure or design problems), and improper impeller adjustment. Sometimes only the impellers need to be changed, but more often the permanent solution is to replace the entire bowl assembly.
4. **Incorrect power unit selection.** This is a common cause of low PPE, and is much more important for engines than for electric motors. Incorrect engine selection is a major cause of low efficiencies. If undersized, operating speeds of smaller engines are increased so that they will produce adequate power. As a result, they wear out rapidly and require much more fuel.
5. **Failure to perform required maintenance.** Tune-ups are critical in engine-driven pumping plants. Electric motors, on the other hand, usu-

ally are more maintenance-free. Monitoring the pumping unit pressure head and flow discharge are critical to assure proper operation and a longer unit life span. This is discussed in more detail later.

6. **Differences in operating conditions.** Finally, a change in operating conditions from those for which a pumping plant was designed will result in a drop in efficiency. Three common situations that result in increased pumping lifts and total discharge head pressure are: 1) a drop in water table elevation, 2) converting from open discharge to a closed pipeline system, and/or 3) a reduction in operating pressure when center pivot sprinklers are converted from high to low pressure to save water and energy. The pump may operate less efficiently and cavitate under this scenario. **Figure 20** helps explain this further.

For more information about this topic, including remedies for the above conditions, go to: <http://www.ext.colostate.edu/pubs/crops/04712.html>.

In summary, most irrigation pumping plants have excessive operating costs because they are often in need of repair, poorly matched to the pumping load, or incorrectly plumbed using more power or fuel than they should. In 2013, NRCS developed a new conservation practice standard, Code 374, known as the Farmstead Energy Improvements. It is for the express purpose of developing and implementing improvements to reduce or improve the efficiency of on-farm energy use. Producers who are contemplating energy efficient upgrades on their farm should consult this standard before proceeding.

Understanding Pump Curve Numbers

For maximum efficiency, it is important to operate in the “sweet spot” of a pump curve. An example illustration of a manufacturer’s pump curve is shown in **Figure 21**. To do so, you must obtain the operating pressure (expressed as total dynamic head) and system capacity (flow rate, usually expressed in GPM), and then use pump characteristic curves to operate the system to its maximum efficiency. Most pump manufacturers provide characteristic curves or graphs for their pumps. These curves show the relationship between head, horsepower, capacity, and efficiency.

To go one step further, and incorporate pumping costs requires that a comprehensive pump evaluation be done. It involves measuring several operating characteristics of the pump. These include:

- Depth to water before pumping (static water level).
- Depth to water during pumping (dynamic water level or static pumping level).
- Pump total dynamic head.
- Pump flow rate, and.
- Rate of electrical energy or fuel consumption.

From these measurements, both the water horsepower (rate of useful work done by the pump) and input horsepower (rate of energy used by the motor or engine) can be calculated. Overall PPE is expressed mathematically as the water horsepower divided by the input horsepower. Producers who want to go this extra step should get help from qualified professionals, as various formulas must first be solved to ascertain whether repair or replacement of pumping plant equipment is needed.

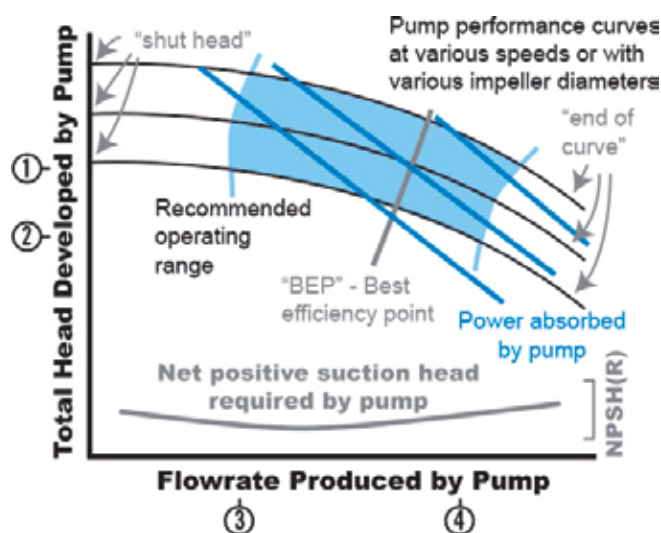


Figure 21

Irrigation System Maintenance BMPs

3.1 Pressurized Irrigation Systems

Level I BMPs:

- ✓ 1. On a periodic basis, examine sprinkler nozzles or emitters for wear and malfunction, and replace them as necessary.
- ✓ 2. If PVC pipes are exposed, re-paint/treat them if the treatment material has worn out; and install or repair impact protection posts, if applicable.
- ✓ 3. Clean and maintain filtration equipment so it will operate within the recommended pressure range.
- ✓ 4. Flush irrigation lines regularly to prevent emitter clogging. To reduce sediment build up,

make flushing part of a regular maintenance schedule. If fertigating, flush all fertilizer from the lateral lines before shutting down the irrigation system to prevent microbial growth.

- ✓ 5. Test irrigation source water quality annually to detect issues with water chemistry that may result in irrigation system plugging or affect plant health.
- ✓ 6. Ensure that totalizing flow meters are calibrated every 8 years, using proper equipment, such as non-intrusive ultrasonic flow meters. An exception to this is if other calibration or reporting requirements are set forth as part of a water management consumptive use permit.

If you find that there are significant (psi) differences across the irrigation laterals, or across any main pipe, you can use pressure-compensating emitters or valves to correct the problem.

3.2 Non-pressurized (Seepage) Irrigation Systems

Level I BMPs:

- ✓ 1. Clean debris and control undesirable aquatic vegetation in irrigation ditches and canals, to maintain water flow and direction.
- ✓ 2. Keep water-level-control structures (such as culverts and risers) in irrigation ditches in good working order.
- ✓ 3. Maintain irrigation swales/furrows at the correct slope, so that water is applied evenly along the field.
- ✓ 4. Use a culvert and screw gate or similar device for the irrigation system, where possible, to conserve water.

3.3 Pumping Plant

Level I BMPs:

- ✓ 1. Ensure that the pump, engine/motor, and fuel tank (if applicable) are mounted on a firm foundation, and that all engine/pump/shaft alignment points are correct and within manufacturer's specifications.
- ✓ 2. Obtain the operating pressure (total dynamic head) and system capacity (flow rate in GPM), and then use the specific pump manufacturer characteristic curve to operate the unit to maintain efficiency based on field conditions.
- ✓ 3. For diesel engines older than twenty years, have a comprehensive evaluation done by a

professional to determine the pumping plant efficiency.

References

1. UF-IFAS, Evaporation Loss During Sprinkler Irrigation, Publication 290. <http://edis.ifas.ufl.edu/pdffiles/AE/AE04800.pdf>
2. UF-IFAS, Causes and Prevention of Emitter Plugging in Micro-Irrigation Systems, Publication 258. <http://edis.ifas.ufl.edu/ae032>
3. UF-IFAS, Principals of Micro-Irrigation, Publication AE70
4. UF-IFAS, Potential Impacts of Improper Irrigation System Design. Publication AE73. <http://edis.ifas.ufl.edu/ae027>
5. USDA-NRCS, National Engineering Handbook, Chapter 8, Irrigation Pumping Plants
6. USDA-NRCS, Irrigation Systems, Surface and Sub-surface, Code 443. FOTG-Section IV. <http://www.nrcs.usda.gov/technical/efotg/>.



4.0 SEDIMENT AND EROSION CONTROL MEASURES

Sediment and Erosion Control Measures are permanent or temporary practices to prevent sediment loss from fields, slow water flow, or trap and collect debris and sediments in runoff water.

The 1982 USDA National Resources Inventory (NRI) showed an annual soil erosion rate on cropland of 3.05 billion tons, due to water and wind. According to the 2010 NRI, soil erosion on cropland dropped 41 percent between 1982 and 2010. Water (sheet and rill) erosion decreased from 1.67 billion tons per year to 982 million tons per year, and erosion due to wind decreased from 1.38 billion to 740 million tons per year. While much of this decline may be due to improved farming practices, there also was a decrease in cropland acres during the same time period.

More than half of all cropland erosion occurs in the Corn Belt and the Northern Plains production regions. However, even with its relatively flat topography, Florida is not immune to erosion-related impacts, especially in the Panhandle region.

Physical Processes of Erosion

Erosion occurs because of two basic processes: detachment and transport. A soil colloid broken into smaller particles (detachment) makes it easier for gravity, water, or wind to move the particles somewhere else (transport).

Soil Characteristics

Soil is not a homogeneous substance but a mix of sand, silt, and clay. Sands have the largest particle diameter, and clays the smallest. The particles may be either highly consolidated, with very few pores, or loosely consolidated, with over 50 percent of the soil volume comprised of pore space. Soils with more solids than open space are more compacted, less porous. Lower soil porosity decreases infiltration and percolation, which may be detrimental to plant growth and may increase runoff.

An important element affecting sediment transport potential is the composition of soil particles. The sediment-delivery ratio for sandy soils normally is low, as sand particles rarely are transported very far from their point of origin. By contrast, clay soils usually have a high sediment-delivery ratio, since



Figure 22

clays typically remain suspended in the water column for a longer period, regardless of flow velocity. **Figure 22** shows the effects of center-pivot irrigation wheels creating “ruts” on clay soils with some slope.

Sediment becomes “enriched” as it flows to a waterway, meaning that it contains a higher proportion of clays and other fine particles than does the soil from which it originates. The primary characteristics that determine how fast suspended solids (soil) settle are density, size and shape. Large particles settle faster than smaller ones of the same density, and spherical particles settle faster than flat ones.

Water and Wind Erosion

Most erosion is water-induced. Two inches of rain falling on a single acre is equivalent to more than 225 tons of water. The water that does not infiltrate into the soil remains on the surface and moves down slope, taking with it soil particles and attached chemicals and nutrients. Agricultural activities can accelerate natural erosion processes by increasing stormwater runoff from impervious or compacted areas, and/or excessive irrigation that saturates the upper soil profile.

In Florida, water erosion in agricultural areas primarily occurs as sheet erosion, a process in which soil particles are moved across the surface by sheet flow, often a result of stormwater runoff. Sheet erosion can remove the topsoil layer, which reduces overall soil fertility. Rill erosion occurs as water flow increases and concentrates in small channels, or rills. The rills usually are only a fraction of an inch deep, and can be removed during mechanical tillage. Nevertheless, rill erosion can remove substantial amounts of soil by allowing water to move faster within narrow channels, thereby increasing its

scouring action. Sheet and rill erosion carry finer, smaller soil particles that generally contain higher proportions of nutrients and pesticides. Rills can enlarge into gully erosion, which can be difficult to control and can render parts of a field worthless. Waterways can also be affected through stream-bank erosion whereby the waterway channel may erode or the banks may be undercut and cave-in, particularly during higher than normal flows.

Wind can erode and transport soil particles of various sizes, negatively affecting farmland and nearby waterbodies. However, most wind-borne particles are composed of silt and clay. Wind erosion is less of a problem in Florida because of the predominance of sandy soils. Typically, wind erosion occurs when wind velocity exceeds 12 mph (measured one foot above the ground) on soils with little to no vegetative cover.

Erosion and Sediment Control Strategies

Five key factors that affect soil loss rates are rainfall intensity and duration, soil erodibility, field topography, vegetative cover, and tillage practices. The primary strategies for controlling erosion and sedimentation impacts involve reducing soil detachment, reducing sediment transport, and trapping sediment before it reaches a waterbody. Keep in mind that it is not possible to prevent all erosion, but it can be reduced to tolerable rates. In terms of crop production, tolerable soil loss is the maximum rate of soil erosion that will permit long-term maintenance of soil productivity.

Sediment Transport and Trapping Control Measures

Sediment transport can be reduced in several ways. Vegetative cover slows runoff, increases infiltration, reduces wind velocity, and traps sediment. Reductions in slope length and steepness reduce runoff velocity, thereby reducing sediment transport as well. Terraces and diversions are common techniques for reducing slope length. Runoff can be slowed or even stopped by placing furrows perpendicular to the slope, and through implementing practices, such as contour farming, which create discrete collection basins to slow runoff and settle sediment particles. Wind-induced erosion can be reduced by decreasing the distance across a field that is exposed to the wind, or by creating soil ridges or other wind barriers.

The following are some practices used to reduce sediment transport, excerpted from the USDA-NRCS, Field Office Technical Guide:

- **Contour farming (Code 330):** Farming sloping land in such a way that preparing land, planting, and cultivating are done on the contour. This includes following established grades of terraces or diversions.
- **Contour strip cropping (Code 585):** Growing crops in a systematic arrangement of strips or bands on the contour to reduce water erosion. The crops are arranged so that a strip of grass or close-growing crop is alternated with a strip of clean-tilled crop or fallow or a strip of grass is alternated with a close-growing crop.
- **Field windbreak (Code 392):** Establishment of plants in or adjacent to a field as a barrier to wind.
- **Herbaceous wind barriers (Code 442A):** Herbaceous vegetation established in rows or narrow strips across the prevailing wind direction.
- **Grassed waterway (Code 412):** A natural or constructed channel that is shaped or graded to required dimensions and established in suitable vegetation for the stable conveyance of runoff.

Additional practices used to reduce sediment transport include:

- **Level fields** – A systematic maintenance program to level fields that promotes uniform drainage, thus helping to reduce erosion.
- **Use of cover crops** – A systematic program of utilizing full field cover plants.
- **Fallow flooding** – May be used to protect the soil from wind exposure and oxidation of organic matter.
- **Use of vegetation to stabilize ditch and canal banks** – Planting vegetation or maintaining existing vegetation in a strip along ditch and canal banks to trap sediments.
- **Ditch bank berms** – Placing dug materials along top of ditch banks, covering with organic soil, and promoting vegetative cover.
- **Grassed field ditch connections to laterals** – Using grass as a soil stabilizer at the point of field ditch connections to lateral canals.
- **Flexible plastic pipe in field ditch connections to laterals** – Using pipe to connect field ditches to laterals canals to reduce erosion at intersection.

- **Sediment sump in field ditches** – Creating and maintaining sumps to trap sediment at field ditch connections to lateral canals.
- **Field ditch culverts** – Placing and maintaining culverts above the bottoms of field ditches at connection to lateral canals.
- **Slow field ditch drainage near discharge pumps** – Placing and maintaining culverts with risers and boards on laterals and/or field ditch connections near farm discharge pumps.
- **Sediment traps near discharge pumps** – Constructing and maintaining sediment traps by placing rock barriers or widening section of canal near farm discharge pumps.
- **Sediment sumps near discharge pumps** – Constructing and maintaining sediment sumps in canal bottoms near farm discharge pumps to trap bottom sediments (This is different than the dug-out area when setting the pump).
- **Systematic canal cleaning program** – Cleaning all canals and farm ditches regularly through a systematic management plan to remove sediments, thus preventing off-site discharge.
- **Floating barriers at pump stations** – Reducing debris (P source) leaving the site by installing debris barriers at discharge locations.

Conservation Tillage

Conservation tillage is the practice of managing the amount, orientation, and distribution of crop and other plant residues on the soil surface, while continuing to grow crops in the residue. Conservation tillage may involve several types of tillage practices or techniques that are designed to maintain crop residue. These practices help reduce soil erosion, which is especially important on soils that meet the NRCS criteria for “highly erodible”. Conservation tillage also helps conserve soil moisture and provides wildlife habitat benefits. The more common types of conservation tillage used in Florida are strip-till and no-till.

Strip-till is used increasingly in North Florida on cotton, corn, soybeans, and to a lesser degree on peanuts. When strip-till is used in a production system, producers must not disturb more than one-third of the row width during seedbed preparation and planting activities. Exceeding this threshold may jeopardize cost-share reimbursement provided by NRCS.

Furrow Diking

Furrow diking is a tillage system in which soils are plowed into ridge-like barriers within furrows that run alongside row crops. The ridges hold irrigation and rain water in the furrows, allowing it to soak into the soil instead of running off. **Figure 23** shows a freshly furrow-diked peanut field. Furrow dikes normally last one season. Producers practicing conservation tillage also can use furrow diking, since the paddles used to create the ridges will not disturb the area where the crops are planted. The primary environmental benefits of furrow diking include water conservation and erosion control.

A recent USDA-ARS study in Tifton, Georgia, found that using furrow diking on cotton fields during a moderate drought saved farmers one inch of irrigation water



Figure 23: Furrow Dike

per acre, reduced runoff by 28 percent, and curbed soil erosion. The next year, when drought conditions were more severe, it saved five inches of irrigation water per acre. Another study compared crop yields, water needs, and the effects of different irrigation rates for furrow-diked cotton to those for traditionally tilled cotton. The study found that in one of three years, producers could reduce the irrigation rate by one-third and still achieve the same yield as a traditional cropping system.

Groundwater Protection

Karst topography, where sediment and sediment-borne pollutants can enter groundwater through direct underground links (caves, conduits, sinks), is a concern in certain parts of the state. The affected water can re-emerge through a spring vent and can reduce surface water clarity and create turbidity.

Sediment and Erosion Control BMPs

4.1 Road Construction and Maintenance

Minimize the amount of vegetation that is cleared when constructing roads, buildings, etc. When protection is needed, use silt fences during construction activities. They must be properly trenched in, backfilled, and compacted in accordance with the Florida Stormwater, Erosion, and Sediment Control Inspector's Manual referenced below.

Level I BMPs:


- ✓ 1. Stabilize access roads that cross streams and creeks, using rock crossings, culverts, or bridges.
- ✓ 2. Maintain vegetative cover on road banks.
- ✓ 3. When constructing above-grade access roads, locate the road(s) a minimum of 25 feet from regulated wetlands.

References

1. Farming for Clean Water in South Carolina: A Handbook of Conservation Practices, <http://www.epa.gov/owow/nps/bestnpsdocs.html#agriculture>
2. FDEP, The Florida Stormwater, Erosion, and Sediment Control Inspector's Manual. <http://www.dep.state.fl.us/water/nonpoint/docs/erosion/erosion-inspectors-manual.pdf>
3. EPA, National Management Measures for the Control of Nonpoint Pollution from Agriculture, EPA Document No. 841B03004. <http://www.epa.gov/nps/agmm/>
4. USDA-NRCS, Conservation Practice Standard Access Road, Code 560. FOTG-Section IV. <http://www.nrcs.usda.gov/technical/efotg>

4.2 Ditch Maintenance

Level I BMPs:

- ✓ 1. Maintain permanent vegetative cover on ditch banks.
- ✓ 2. Protect ditch banks from erosion in areas subject to high water velocities, using **rip-rap**, concrete, headwalls, or other buffering materials.
- ✓ 3. Keep all control structures free from obstructions.
- ✓ 4.  Do not remove sediments below the ditch's original invert elevation, which can be determined by permit drawings, basic survey drawings, and/or changes in soil characteristics and color. Keep drawings of the design cross-sectional area for future reference.

Level II BMPs:

If your answer to the following question is "yes," implement the Level II below, whichever one is more appropriate.

Question: Under average hydrologic conditions, have you observed a sand bar where your drain-

age ditches/canals meet, or at a point downstream where runoff exits your property? Yes No

- ✓ 5. Install check dams in drainage ditches, perpendicular to the direction of flow and downstream of the area contributing the sediment. Check dams can be created using a variety of materials such as rock, rip rap, or sand bags.
- ✓ 6. Install sediment traps within the water conveyance system. Clean out traps periodically, as sediments will accumulate over time. If you are experiencing recurring erosion problems, install a flashboard riser water control at the sediment trap outlet.

References

1. USDA-NRCS, Irrigation Field Ditch, Code 388; Surface Drainage-Field Ditch, Code 607, and Surface Drainage-Main or Lateral, Code 608, FTOG Section IV. <http://www.nrcs.usda.gov/technical/efotg>
2. American Society of Agronomy: Drainage for Agriculture. <http://www.agronomy.org>
3. USDA-NRCS, Sediment Basin, Code 350; Structure for Water Control, Code 587; and Water and Sediment Control Basin, Code 587, FOTG Section IV. <http://www.nrcs.usda.gov/technical/efotg>
4. USDA Planning and Design Manual for the Control of Erosion, Sediment, and Stormwater

4.3 In-Field Erosion Control

Level I BMPs:

- ✓ 1. If a farm field discharges sediments offsite or directly to a waterbody, install and maintain filter strips, sediment basins, or similar measures.
- ✓ 2. As needed, apply mulch on steep non-production areas to provide temporary erosion control until plants establish. Select non-invasive plants or a seeding mixture to provide short-term and long-term vegetative cover.

- ✓ 3. Use a combination of vegetative cover (e.g., rye, millet) and/or geo-fabric material to stabilize the ground at the downstream side of plastic mulch rows.
- ✓ 4. For plastic mulch production systems, install plastic-covered spill ways where cross ditches flow into lateral ditches.
- ✓ 5. Use a conservation practice to protect soils during non-production or fallow periods.

Level II BMPs:

If your answer to the following question is "yes," implement the Level II BMP below.

Question: Do you have highly-erodible soils and grow a commodity that doesn't require clean tillage of the entire field prior to planting? Yes No

- ✓ 6. Contact NRCS or FDACS for technical assistance in implementing conservation tillage.

Level III BMPs:

If your answer to the following question is "yes," implement the Level III BMP below.

Question: Do you have highly-erodible soils and very limited success using conservation tillage, contour planting, or critical area planting for recurring erosion problems? Yes No

- ✓ 7. Contact NRCS or FDACS for technical assistance and to inquire about possible cost-share in implementing diversions and terrace control.

References

1. USDA-NRCS, Heavy Use Protection, Code 561. FOTG Section IV, <http://www.nrcs.usda.gov/technical/efotg>
1. LSU, Agronomic Crops Best Management Practices. Publication 2807. <http://www.lsuagcenter.com/en/communications/publications/Publications+Catalog/Crops+and+Livestock/Best+Management+Practices/>



5.0 WATER RESOURCES PROTECTION

Water resources are distinct hydrologic features, including wetlands, springs, lakes, streams, and aquifers.

Wetlands and Springs

Wetlands and springs are important components of Florida's water resources. Wetlands often serve as spawning areas and nurseries for many species of fish and wildlife, perform important flood-storage roles, cycle nutrients in runoff water, contribute moisture to the hydrologic cycle, and add plant and animal diversity. They also can provide limited grazing for animals. Wetlands and springs offer valuable recreational opportunities for the public and can be an economic benefit to the surrounding communities.

Wetlands

Under Florida Law, wetlands are areas inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils. Florida wetlands generally include swamps, marshes, bayheads, bogs, cypress domes and strands, sloughs, wet prairies, riverine swamps, hydric seepage slopes, tidal marshes,

mangrove swamps and other similar areas. Florida wetlands generally do not include longleaf or slash pine flatwoods with an understory dominated by saw palmetto.

Chapter 62-340, Florida Administrative Code, entitled *Delineation of the Landward Extent of Wetlands and Surface Waters*, contains the methodology that all state and local governments in Florida must use to determine the boundary between wetlands and uplands and other surface waters. The NRCS uses the USACOE Wetland Delineation and National Food Security Act manuals to determine wetlands boundaries on agricultural lands. In most cases, both state and federal methodologies produce the same or nearly the same determinations.

Springs

The Florida Geological Survey defines springs as a point where underground water emerges to the earth's surface. Springs flow naturally from underlying aquifers and are classified based on their magnitude, or amount of flow coming from the spring vent. Springs and spring runs attract wildlife, provide over-wintering habitat for endangered manatees, contain unique biological communities, and are important archeological sites.

The area within ground water and surface water basins that contributes to the flow of a spring is a spring's recharge basin, also called "springshed," as depicted in **Figure 24**. This area may extend for miles from the spring, and the size of the area may fluctuate as a result of underground water levels. First magnitude springs discharge 64.6 million gallons per day (MGD) or more; second magnitude springs discharge from 6.46 to 64.6 MGD. FDEP works with water management districts and local stakeholders to define the major ground water contributing areas for springs that have been identified as impaired. Measures to help restore springs water quality in these areas are included in the relevant basin management action plans adopted by FDEP.



Figure 24

Rivers and Streams

Rivers and streams are naturally flowing watercourses. There are approximately 51,000 miles of rivers and streams in Florida, generally classified as sand-bottom, calcareous, swamp and bog, alluvial, or spring-fed systems. Three measurable components contribute to stream flow: base flow, interflow, and surface runoff. Surface runoff is most affected by rainfall (stormwater runoff), and contributes most to peak flow. Rivers and streams readily can transport pollutants received in stormwater runoff to wetlands, lakes, estuaries, and other waterbodies. Consequently, it is important to minimize runoff to rivers and streams.

Conservation Buffers

Conservation buffers are permanently vegetated, non-cultivated areas established to retain water and soil onsite to help reduce pollutants in surface water runoff. They include production field area borders, filter strips, grassed waterways, and **riparian** buffers, and are particularly effective in providing water quality treatment near sensitive areas.

- **Borders** are strips of permanent vegetation, either natural or planted, at the edge or perimeter of field production areas. They help reduce erosion from wind and water and protect soil structure and water quality, and may provide wildlife habitat.

- **Filter strips and grassed waterways** are areas of permanent vegetation between production areas that drain to natural waterbodies or other low areas. Their main purpose is to decrease the velocity of runoff water and remove sediment particles. For more information on filter strip site location, establishment, and maintenance, see **Appendix 3**.
- **Riparian buffers** can be forested or herbaceous areas located adjacent to streams, which help reduce amounts of sediment, organic material, nutrients, and pesticides in surface water sheetflow. Riparian buffers are most effective on sloped lands next to streams.

Conservation buffers should be inspected periodically, and restored as needed to maintain their intended purpose. Ensure that applications of fertilizers, pesticides, or other chemicals do not compromise the intended purpose of the buffer. As necessary, use prescribed burns in accordance with Florida Forest Service guidelines, to maintain native vegetation and discourage the establishment of nuisance vegetation. When practicable, use native vegetation to establish conservation buffers.

Aquifer Protection

With the majority of Florida's water supply originating from underground sources (aquifers), it is extremely important for agricultural operations to protect wellheads from contamination. Successful wellhead protection includes complying with regulatory requirements and using common-sense measures (**Figure 25**) with regard to well placement and agricultural practices near wells. For existing wells, minimize or carefully conduct any activities that are near the wellhead to reduce the risk for contamination. For new-well construction, the initial focus should be on well location and sound well-construction practices, followed

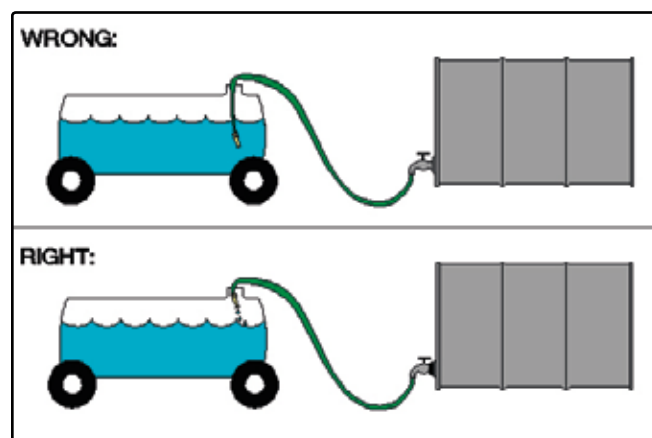


Figure 25

by proper maintenance. To learn more about wellhead and other aquifer protection measures, a short instructional video is available at: <http://www.freshfromflorida.com/Media/Files/Agricultural-Water-Policy-Files/Best-Management-Practices/Vegetable-and-Agronomic-Crop-Videos/Video-10-Wellhead-and-Other-Aquifer-Protection-Measures>.



Water Resources Protection BMPs

5.1 Wetlands Protection

Do not dredge or fill in wetlands unless permitted or exempt. Consulting with the WMD and the NRCS is recommended prior to conducting activities in or near wetlands to ensure that you are complying with any permitting or NRCS program eligibility requirements.

Minimize adverse water quality impacts to receiving wetlands by progressively applying measures until the problem is adequately addressed. Practices such as filter strips, conservation buffers, swales, or holding water on-site may preclude the need for more aggressive treatment measures.

Note: Use an NRCS county soil survey map to help identify the location of wetlands, hydric soils, or frequently flooded areas. If you do not have an ERP (which provides a wetlands delineation), seek technical assistance to determine the landward boundary of wetlands on your operation.

- ✓ 1. Install and/or maintain a minimum 35-foot, non-fertilized **vegetated buffer** upland of the landward jurisdictional boundary of all wetlands and lakes, unless you have an existing WMD permit (e.g., ERP, or management and storage of surface waters permit) that specifies a different buffer. For lakes that have an adopted TMDL for nutrients, expand the buffer to 50-feet.
- ✓ 2. For existing operations that are unable to meet the vegetated buffers specified above, submit to FDACS a written description of the alternative measures you will take to protect the wetlands from water quality impacts (Use the comments section at the end of the BMP checklist).

When broadcast applying fertilizer near a wetlands buffer, ensure that the fertilizer does not land inside the buffer.

References

1. NRCS, Wetland Enhancement, Code 659; Nutrient Management, Code 590, FOTG-Section IV. www.nrcs.usda.gov/technical/efotg
2. EPA, National Management Measures for the Control of Nonpoint Pollution from Agriculture. <https://www.epa.gov/nps/national-management-measures-control-nonpoint-source-pollution-agriculture>
3. FDEP, Delineation of the Landward Extent of Wetlands and Surface Waters Rule, Chapter 62-340, F.A.C. <http://www.dep.state.fl.us/legal/Rules/rulelist.htm>

5.2 Streams Protection

Level I BMPs:

- ✓ 1. Install and/or maintain a riparian buffer along **perennial streams** on production areas that exceed 1-percent slope and discharge directly to the streams. Contact FDACS, NRCS, or an NRCS-approved Technical Service Provider for assistance in properly designing the riparian buffer.
- ✓ 2. Locate and size any stream crossings to minimize impacts to riparian buffer vegetation and function and to maintain natural flows.

References

1. USDA-NRCS Field Border, Code 386; Riparian Herbaceous Cover, Code 390; Riparian Forest Buffer, Code 391; Filter Strip, Code 393; Grassed Waterway, Code 412; and Stream Crossing, Code 578. FOTG-Section IV. www.nrcs.usda.gov/technical/efotg
2. UF-IFAS, Best Management Practices (BMPs): Perimeter Borders. Publication AE439. <http://edis.ifas.ufl.edu/ae439>

5.3 Protection for First- and Second-Magnitude Spring Recharge Basins

Level I BMPs:

- ✓ 1. Install and/or maintain a 100-foot non-fertilized vegetated buffer upland of the landward boundary of springs and spring runs.
- ✓ 2. Install and/or maintain a 50-foot non-fertilized vegetated buffer around sinkholes or other visible karst features.
- ✓ 3. Do not exceed the UF-IFAS recommended fertilizer rate for N and P, including any contributions from irrigation sources.

- ✓ 4. If you have a sinkhole on your property, never use it to dispose of any materials, including pesticide containers.

References

1. FDEP. Protecting Florida's Springs, Land Use Planning Strategies and Best Management Practices www.dep.state.fl.us/springs/reports/files/springs-manual_2002.pdf.


5.4 Well Operation and Protection

When installing a new well, contact your WMD to see whether the well requires a construction and/or consumptive use permit. Use a Florida-licensed water well contractor, and drill new wells according to local government code and WMD well-construction permit requirements. Potable (drinking) water wells are regulated by Chapter 62-521, F.A.C., and must follow the requirements of that rule.

Locate new wells up-gradient as far as possible from likely pollutant sources, such as petroleum storage tanks, septic tanks, chemical mixing areas, or fertilizer storage facilities.

Level I BMPs:

- ✓ 1. If injecting fertilizer or chemicals, use back-flow-prevention devices at the wellhead to prevent contamination of the water source.

- ✓ 2. Inspect wellheads and pads at least annually for leaks or cracks, and make any necessary repairs.
- ✓ 3. If in the Homestead area, use the criteria in the *Handbook for the Voluntary Retrofit of Open, Uncased Agricultural Wells* to address open bore wells to ensure that the Biscayne aquifer is protected.
- ✓ 4.  Maintain records of new well construction and any modifications to existing wells.

References

1. USDA-NRCS Water Well, Code 642; Well Decommissioning, Code 351; Well Plugging, Code 755. FOTG-Section IV. www.nrcs.usda.gov/technical/efotg
1. FDEP, Water Well Permitting and Construction Requirements Rule, Chapter 62-532, F.A.C. <http://www.dep.state.fl.us/legal/Rules/rulelist.htm>
2. Florida Water Permits. <http://flwaterpermits.com/>
3. DERM, Handbook for the Voluntary Retrofit of Open, Uncased Agricultural Wells.

Note: See *Appendix 7* for list of record-keeping requirements and example record-keeping forms.



6.0 STORMWATER MANAGEMENT

Stormwater management is the on-site management of rainfall and associated runoff through the use of nonstructural and structural BMPs to provide flood protection and water quality protection.

Alteration of the land (e.g., construction of impervious surfaces such as roads, driveways, parking lots, large numbers of greenhouses, and other agricultural structures) increases the potential for stormwater runoff. Lack of appropriate stormwater management can lead to on-site and off-site flooding, increased pollutant loading to surface and ground waters, and erosion and sedimentation.

Construction of complex stormwater management systems with drainage pumps and outfall structures may alter on-site hydrology, and therefore may require an ERP or other WMD surface water management permit. Check with your WMD before beginning construction of any stormwater management system.

There may be individual circumstances that create the need for specific stormwater management practices. Some operations may already have a WMD surface water management permit that contains on-site stormwater management requirements. However, if stormwater problems exist that are not addressed by a WMD permit, it is important to develop and implement a stormwater

management plan suited to the operation's unique circumstances.

Stormwater BMPs

6.1 Stormwater Conveyance Systems

Level I BMPs:

- ✓ 1. Install gutters and downspouts on all buildings adjacent to production areas, and divert stormwater away from the production area toward vegetated areas. When not detrimental to crop health, collect and use this water for irrigation.
- ✓ 2. Operate and maintain all stormwater management conveyances (swales, ditches, and canals) to ensure that they operate as designed.
- ✓ 3. If you have an existing operation that does not have a WMD surface water permit and has a history of downstream flooding issues, develop and implement a written stormwater management plan that provides specific responses to various types and levels of rainfall, as feasible. The goal of the plan should be a reduction in volume of off-site discharge. Evaluate the plan's effectiveness, and make adjustments as needed.
- ✓ 4. If the total impervious area of your operation (e.g., asphalt or concrete roads/parking lots,

roofs, greenhouses) exceeds 10 percent of the total land area, have a site-specific evaluation performed to determine whether off-site stormwater runoff is an issue. USDA-NRCS may be able to perform this at no cost.

In developing a stormwater management plan:

- Contact your local NRCS District Conservationist to obtain information about the soil types for the proposed or existing farm location. The District Conservationist can identify soil types that are historically prone to flooding or standing water. Evaluate the storage capacity, size, and elevations of existing ditches, ponds, creeks, rivers, and wetlands, and the size, layout, and elevations of the fields. You should also contact your county or water management district to obtain maps (FEMA, FIRM) or other information related to flooding issues at the proposed or existing location. You can access this information via the web at: www.fema.gov/hazard/map/firm.shtm.
- Consult with a public or private agricultural engineer to discuss your stormwater management needs and considerations, especially if you are on poorly drained lands. Find an engineer qualified to provide an appropriate stormwater runoff analysis for your site.

- Determine the maximum storm size for which you want to provide flood protection. The flood control design storm addressed by WMD ERP regulations varies from a 25-year, 24-hour storm to a 100-year, 3-day storm. For example, a 25-year, 24-hour storm produces from 8 to 10 inches of rainfall in a 24-hour period. Generally, the larger the design storm event used, the more extensive the stormwater management system needs to be. Factors that will affect this decision include land availability, the existence of internal natural features such as creeks, rivers, ponds, or wetlands, the potential to flood downstream property owners, and costs.
- Include both nonstructural BMPs and structural BMPs, as needed.

References

1. USDA-NRCS, Runoff Management System Code 570, FOTG-Section IV. www.nrcs.usda.gov/technical/efotg
2. Water Management Districts, ERP Stormwater Quality Applicant's Handbook.
3. ANSI/ASAE, Design and Construction of Surface Drainage Systems on Agricultural Lands in Humid Areas, EP302.4. www.asabe.org/standards/index.html



7.0 INTEGRATED PEST MANAGEMENT

Integrated Pest Management (IPM) combines the monitoring of pest and environmental conditions with the judicious use of cultural, biological, physical, and chemical controls to manage pest problems.

Under Florida law (section 482.021, F.S.), IPM is defined as: ...“the selection, integration, and implementation of multiple pest control techniques based on predictable economic, ecological, and sociological consequences, making maximum use of naturally occurring pest controls, such as weather, disease agents, and parasitoids, using various biological, physical, chemical, and habitat modification methods of control, and using artificial controls only as required to keep particular pests from surpassing intolerable population levels predetermined from an accurate assessment of the pest damage potential and the ecological, sociological, and economic cost of other control measures.”

The basic steps of an IPM program are as follows:

- Identify key pests (scouting).
- Determine the pest’s life cycle and which stage of the life cycle to target (for an insect pest, whether it is the egg, larva/nymph, pupa, or adult stage).
- Determine if the numbers of correctly identified pest insects have reached the economic or action threshold before considering control measures.
- Decide which pest management practices are appropriate, and implement associated corrective actions. Use cultural, biological, and physical methods to prevent problems from occurring (for example, prepare the site and select resistant

plant cultivars), and/or reduce pest habitat (for example, practice good sanitation). Consider all of the cultural, biological, and physical control measures available and appropriate before moving to a chemical control method for preventing and controlling pest infestations.

- Direct the control where the pest lives or feeds. Use properly timed preventive chemical applications only when your experience indicates that they are likely to control the target pest effectively, while minimizing the economic and environmental costs.

Scouting

Scouting is the most important element of a successful IPM program. It involves monitoring pest presence and development throughout the growing season. By observing plant conditions regularly and noting which pests are present, an informed decision can be made regarding severity of crop damage and what pest control method is necessary. It is essential to record the results of scouting to develop historical information, document patterns of pest activity, and document the treatment’s success or failure.

Cultural Controls

Pests may be managed through preventing or avoiding all together, pests from reaching economically significant levels. Producers can accomplish this in a large part by using cultural tactics that are often the most inexpensive and effective measures

one can choose. Cultural tactics include rotation, selecting plant varieties that have natural resistance to specific pests, scheduling planting dates and irrigation applications that would make the environment unfavorable for the establishment of an economically significant pest population. Producers should practice strict sanitation, and planting stock should be disease-free.

Biological Controls

Biological controls utilize organisms that prey or parasitize pests. Biological controls involve the use of natural enemies to control, suppress, or the active manipulation of antagonistic organisms to reduce pest population densities to acceptable levels. Natural enemies help to reduce the amount of pesticides needed to control pests, thus protecting water quality and reducing production costs. Biological control techniques should be tailored to the pest's life cycle, availability of effective predators and parasites, environmental conditions, and historical data. An example of biological control of boll weevil on cotton is shown in **Figure 26**.



Figure 26

Physical Controls

Physical methods generally are used to deter, trap, destroy, or provide barriers to pests. The EPA regulates various mechanical devices and allows their use to minimize or prevent negative impacts from nuisance pests. EPA refers to these as "pest control devices." A product is a pest control device if it uses only physical or mechanical means to trap, destroy, repel, or mitigate any pest and does not include any pesticidal substance or mixture of substances.

Pest control devices alone are not required to be registered with EPA. However, if a device and a pesticide product are packaged together, the combined product is a pesticide product subject to registration requirements. For more information, refer to: www.epa.gov/pesticides/factsheets/devices.htm.

Sensory Devices

Scare tactics generally include audible and visual sensory devices. Visual deterrents such as whirlers,

streamers, scare-eye balloons, lasers, reflectors, and predator models are seldom effective if used alone. Their efficacy is increased if supplemented with sound devices such as alarms, recorded (bird) distress calls, or fireworks (which includes exploders and propane cannons). In Florida, fireworks are governed by Chapter 791, F.S.

The Occupational Safety and Health Administration regulates allowable exposure times for sound, and has determined that it is safe for humans to listen to a 100-decibel sound for up to two hours a day. High-decibel sound devices for nuisance animal control usually consist of bio-acoustics, acoustics, ultrasonics, and propane cannons.

For sound devices to be effective in deterring nuisance birds, they must be managed according to the habits and characteristics of the nuisance bird species. In general, best results are obtained when sounds are presented at random intervals, a range of different sounds is used, the sound source is moved frequently, and sounds are supported by other methods, such as distress calls and/or visual deterrents. Otherwise, birds will usually become accustomed to these devices. Go to: <http://icwdm.org/handbook/birds/Dispersal.asp> for more information about bird behavior and related dispersal techniques.

Note: When planning to use high-decibel sound devices, especially propane cannons, producers should first communicate with and inform adjacent (residential) neighbors as to the reasons for using the devices. Producers using high-decibel sound devices on lands classified as agriculture pursuant to section 193.461, F.S., which are adjacent to residential areas, must employ the following measures to mitigate the disturbance to neighbors.

- Only use sound devices when bird predation has been corroborated.
- Start control no sooner than 15 days before the crop ripens.
- Use electronic timers or sensors to activate devices during peak feeding times.
- Shut off devices 30 minutes after sunset; do not resume activities sooner than 30 minutes before sunrise.
- Use the devices in accordance with manufacturers' recommendations, paying particular attention to the recommended number of devices per acre.
- Alternate or relocate devices at least every 4 days to avoid habituation.

- If using propane cannons:
 - When using hay bales placed directly behind the cannon to muffle the sound, devices can be located within 300 feet from the nearest residence. Otherwise, locate them no closer than 450 feet from the nearest residence.
 - If the device is adjustable, use the lowest decibel-level setting effective in controlling pests.
 - Set each cannon's blast intervals to not less than three minutes apart. If using more than one cannon in the vicinity of residential areas, increase the blast intervals so that sequential firing of multiple cannons meets this restriction as much as possible.
 - Aim the devices away from adjacent residences. Employ directional noise baffle barriers if feedback from neighbors warrants.
 - Ensure that propane tank valves do not leak, causing inadvertent blasts.
 - Regularly monitor bird activity to ensure the cannon's effectiveness.

Chemical Controls

Chemical methods involve the use of chemical pesticides, including some repellants. The EPA and FDACS regulate the use of pesticides in Florida. The term pesticide is defined by EPA as any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Chemical control involves the use of pesticides, as necessary. Factors that influence the selection of chemical controls in Florida include:

- The product's registration status within Florida and labeling requirements.
- The effectiveness of the product against the target pest.
- The potential risk of a particular pesticide to beneficial organisms (e.g., honey bees).
- The product's cost effectiveness.
- The potential hazards to applicators, bystanders (e.g., residents, nearby businesses) and the environment (i.e., non-target organisms, water quality).

Choosing the proper pesticide requires familiarity with product labels and performance. **Always follow the label directions.** The label is the single most important document in determining the correct use of a pesticide. State and federal pesticide

laws require strict adherence to label directions. Free mobile apps have been developed by Clemson University to help accurately calibrate pesticide spray application equipment; and to calculate the amount of product mix needed. You can access these at: <http://www.clemson.edu/extension/mobile-apps/>.

Restricted Use Pesticides

Certain pesticides are classified as **Restricted Use Pesticides** (RUPs). Florida Pesticide Law (Chapter 487, F.S.) requires licensed applicators to keep records of all RUP use. Pursuant to Rule 5E-9.032, F.A.C., information on RUPs must be recorded within two working days of the application and maintained for two years from the application date. For additional information, contact your County Extension Agent or the Division of Agricultural Environmental Services of the Florida Department of Agriculture and Consumer Services at: <http://www.freshfromflorida.com/Divisions-Offices/Agricultural-Environmental-Services>.

Record Keeping

Proper records of all pesticide applications must be kept according to state and federal requirements. These records help to establish proof of proper use, facilitate the comparison of results of different applications, or find the cause of an error.

Pest Management BMPs

Practice IPM and use all pesticides in accordance with the label. Rinse, recycle, or dispose of empty pesticide containers following federal, state, and local regulations. When applying a pesticide close to a stream, canal, pond, or other waterbody, choose a pesticide with an active ingredient that has a low toxicity to aquatic organisms.

7.1 Pesticide Storage and Mixing Level I BMPs:

- ✓ **1.** Store pesticides in an enclosed, roofed structure with an impervious floor and lockable door, at least 100 feet from wells, wetlands or other waterbodies, and sinkholes.
- ✓ **2.** When practicable, construct a permanent mix/load facility with an impermeable surface, and locate it at least 100 feet from wells, wetlands or other waterbodies, and sinkholes.
- ✓ **3.** Where permanent facilities are not practicable, use portable mix/load stations or conduct any field mix/load activities at random locations in the field; use nurse tanks if applicable.

- ✓ 4. Use a check valve or air gap separation to prevent backflow into the tank or water source when filling a sprayer.

7.2 Aquatic Plant Management

Level I BMPs:

- ✓ 1. Use barriers, traps, screen devices and/or debris baffles to control floating aquatic weeds.
- ✓ 2. Use biological control agents or herbicides registered and labeled for aquatic applications, when chemical control is warranted.

References

1. FDACS/FDEP, Best Management Practices for Agrichemical Handling and Farm Equipment Maintenance Manual. www.floridaagwaterpolicy.com/BestManagementPractices.html

2. UF-IFAS, Integrated Pest Management Program. <http://ipm.ifas.ufl.edu/>
3. Southern Region Integrated Pest Management Center. www.sripmc.org/
4. UF-IFAS, Protecting Water Resources from Agricultural Pesticides, Publication PI-1. <http://edis.ifas.ufl.edu/PI001>
5. NRCS, Agrichemical Handling Facility, Code 309; Pest Management, Code 595. FOTG-Section IV. www.nrcs.usda.gov/technical/efotg
6. UF-IFAS, BMP: Ribbon Barriers, Publication ABE 383. <http://edis.ifas.ufl.edu/ae432>
7. UF-IFAS, Florida Crop/Pest Management Profile: Aquatic Weeds. Publication PI-138. <http://edis.ifas.ufl.edu/pi175>



8.0 RECYCLING AND WASTE MANAGEMENT

Waste Stream Management involves other environmental, health and safety issues that farms typically encounter.

Farm maintenance areas are sites where pesticides are mixed and loaded into application equipment; tractors and other pieces of farm equipment are serviced; or pesticides, fuel, fertilizer, and cleaning solvents are stored. These are areas of the farm where accidental pollution of soil, surface water, or ground water is most likely to occur. Contamination can occur when pesticides, lubricants, solvents, or other chemicals are spilled, rinse water from container or equipment cleaning is dumped on the ground or discharged into surface water, or improperly cleaned containers are stockpiled or buried. Proper management of farm maintenance areas is an important part of responsible chemical and pesticide use. Proper handling and disposal practices at these sites can help avoid serious environmental problems, protect the farm's water supply, reduce exposure of the owner to legal liability for contamination and cleanup (including fines), and foster a good public image for agriculture.

Use the guiding principles below in farm maintenance areas to help prevent contamination:

- **Isolate** all potential contaminants from soil and water.

- **Do not discharge** any waste material onto the ground or into surface waterbodies.
- **Conserve** resources to maximize efficient use of irrigation, fertilizers, and pesticides.

Try to eliminate the discharge of materials such as equipment wash water to ground or surface waters. Surface water contamination can occur directly through spills or releases to a lake or canal, or indirectly through stormwater drains, field ditches, or swales. Discharge to ground water may occur by percolation through highly permeable soils from repeated activity at a single location, or by flow into sinkholes, improperly constructed wells or other direct conduits to ground water.

Fertilizers

If not handled properly, fertilizers can be a significant source of water pollution. The nutrients in fertilizers can lead to algal blooms and stimulate growth of noxious plants in lakes and streams.

Nitrate is a special health concern because excessive levels in drinking water can cause methemoglobinemia (blue baby syndrome) in infants. Case studies show that the likelihood of this condition increases rapidly when water contains nitrate-N above 20 parts per million. Because of the

extensive interconnection of Florida's aquifers and surface waters, Florida requires that all potable ground waters meet federal drinking water standards. For nitrate-N, federal and state regulations set this standard at 10 parts per million. Extremely shallow wells (less than 50 feet), and old wells that may have faulty casings, are at the highest risk for nitrate contamination.

Storage

Always store nitrogen based fertilizers separately from solvents, fuels, and pesticides since many fertilizers are oxidants and can accelerate a fire. Ideally, fertilizer should be protected from rainfall, and stored in a concrete building with a flame-resistant roof. Storage of dry bulk materials on a concrete or asphalt pad may be acceptable if the pad is adequately protected from rainfall and from water flowing across the pad. Secondary containment of stationary liquid fertilizer tanks containing greater than 80 percent nutrients or phosphoric acid is required per FDEP Chapter 62-762, F.A.C. Even where not required, the use of secondary containment is a sound practice.

Loading and Spill Containment

Load fertilizer into application equipment away from wells or surface waterbodies. A concrete or asphalt pad with rainfall protection is ideal, as this permits easy recovery of spilled material. If this is not feasible, loading at random locations in the field can prevent a buildup of nutrients in one location. Do not load fertilizers on a dedicated pesticide chemical mixing center because of the potential for cross-contamination. Fertilizers contaminated with pesticides may cause crop damage or generate hazardous wastes. Clean up spilled material immediately. Collected material may be applied as fertilizer.

Solvents and Degreasers

The routine release of even small amounts of solvents can result in serious environmental and liability consequences due to the accumulation of contaminants in soil or ground water. As little as 25 gallons per month of used solvent disposal can qualify you as a "small quantity generator" of hazardous waste, thus triggering reporting requirements. Whenever practical, replace solvent baths with re-circulating water-based washing units (which resemble heavy duty dishwashers). Soap and water or other water-based cleaners often are as effective as solvent-based ones. Blowing off equipment with compressed air instead of washing

with water often is easier on hydraulic seals and can lead to fewer oil leaks. Minimize the need for storage by carefully planning and ordering chemicals only as they are needed. Store solvents and degreasers in lockable metal cabinets in an area away from ignition sources (e.g. welding areas, grinders) and provide adequate ventilation. Many are toxic and highly flammable. Never store them with pesticides or fertilizers or in areas where smoking is allowed. Keep solvent containers covered to reduce volatile organic compound emissions and fire hazards. Keep an inventory of the solvents stored and the Safety Data Sheets and emergency response equipment on the premises near the storage area, but not inside the area itself, since it may not be available when needed most.

Use and Disposal

Always wear the appropriate personal protective equipment (PPE), especially eye protection, when working with solvents. Never allow solvents to drain onto pavement or soil, or discharge into waterbodies, wetlands, storm drains, sewers or septic systems, even in small amounts. Solvents and degreasers should be used over a collection basin or pad that can collect all used material. Most solvents can be filtered and reused many times. Store the collected material in marked containers until it can be recycled or legally disposed.

Private firms provide solvent wash basins that drain into recovery drums and a pick-up service to recycle or properly dispose of the drum contents. Collect used solvents and degreasers, place them into containers marked with the contents and the date, and then have them picked up by a service that will properly recycle or dispose these materials. Never mix used oil or other liquid material with the used solvents. Use only licensed contractors when disposing of spent material offsite.

Paint

Paints, stains, or other finishing materials may be either oil-based or latex. The best method of disposal for empty latex paint cans is to allow the can to fully dry and then dispose of it as solid waste. Unused latex paints can be mixed together, re-tinted, and used. Charitable housing groups will often accept unused latex paint.

Oil and solvent based coatings which cannot be used should be disposed as hazardous waste, so check with your county for disposal options. However, most empty cans may be allowed to fully dry and then disposed of as solid waste.

Used Oil, Antifreeze, and Lead-Acid Batteries

Collect used oil, oil filters, and antifreeze in separate marked containers and recycle. In Florida, recycling is the only legal option for handling used oil. Oil filters should be drained into a container (puncturing and crushing helps speed drainage) and taken to the place that recycles your used oil. Many gas stations or auto lube shops will accept small amounts (including oil filters) from individuals. Do not mix used oil with used antifreeze or sludge from used solvents. Antifreeze must be recycled or disposed as a hazardous waste. Commercial services are available to collect this material.

Lead-acid storage batteries are classified as hazardous wastes unless they are recycled. All lead-acid battery retailers are required by law to accept returned batteries for recycling. Make sure all caps are in place to contain the acid. Store used batteries on an impervious surface and under cover.

Gasoline and Diesel Fuel

Design and manage fuel dispensing areas to prevent soil and water contamination. Place fuel pumps on concrete or asphalt surfaces. Fuel pumps with automatic shut off mechanisms reduce the potential for overflow and spillage during fueling. Do not locate the pumps where a spill or leak would cause fuel to flow onto the ground or into a storm drain or surface waterbody.

Stationary fuel storage tanks should be in compliance with FDEP storage tank regulations (Chapter 62-761, F.A.C. for underground tanks and 62-762, F.A.C. for aboveground tanks) and EPA Oil Spill Prevention, Control, and Countermeasure rule at: www.epa.gov/osweroel/content/spcc/spcc_ag.htm. In general, underground tanks with volumes over 110 gallons and above-ground tanks with volumes over 550 gallons must be registered and located within secondary containment systems (**Figure 27**) unless of double-wall construction.



Figure 27

While containment is not usually required for smaller tanks, it is still a good practice.

The water to be discharged from secondary containment must be checked for contamination. This can be done by looking for an oil sheen, observing any smell of fuel or oil, or through the use of commercially available test kits. Never discharge to the environment any water that is contaminated. If the water is not contaminated, it can be reused, or safely discharged.

General Equipment Cleaning

Clippings and dust removed from machinery should be handled separately from other waste materials and equipment wash water. Many manufacturers now recommend the use of compressed air to blow off equipment. This is less harmful to the equipment's hydraulic seals, eliminates wash water, and produces dry material that is easy to handle.

Wash equipment over a concrete or asphalt pad that allows water to be collected, or to run off onto grass or soil, but not into a surface waterbody or canal. After the residue dries on the pad, it can be collected and composted or spread in the field. To keep crop residue and other debris from becoming contaminated with pesticide, do not conduct such operations on a pesticide mixing and loading pad.

Minimize the use of detergents. Use only biodegradable non-phosphate detergents. The amount of water used to clean equipment can be minimized by using spray nozzles that generate high pressure streams of water at low volumes.

Wash water generated from the general washing of equipment, other than pesticide application equipment, may not have to be collected. This wash water must not, however, be discharged to surface or ground water either directly or through ditches, storm drains or canals. For regular wash down of ordinary field equipment, allow the wash water to flow to a grassed retention area or swale. Do not allow any wash water to flow directly into surface waters or to a septic system.

Pesticide Application Equipment Washwater

Wash water from pesticide application equipment must be managed properly since it will contain pesticide residues. Wash the outside of the equipment at random spots in the field using water from a nurse tank. Clean the tires and particularly dirty areas of the equipment exterior prior to bringing it into the pad area. These practices prevent

unwanted dirt from getting on the mix/load pad and sump or from being recycled into the sprayer. Avoid conducting washing in the vicinity of wells or surface waterbodies. For intensive centralized or urban operations, it may be necessary to discharge the wash water to a FDEP permitted treatment facility.

The inside of the pesticide application equipment should be washed on the mix/load pad. The rinsate may be applied as a pesticide (preferred) or stored for use as make-up water for the next compatible application. Otherwise it must be treated as a (potentially hazardous) waste. After washing the equipment and before an incompatible product is handled, the sump should be cleaned of any liquid and sediment.

Recycling and Industrial Waste Management BMPs

8.1 Waste Reduction BMPs

Level I BMPs:

- ✓ 1. Store fertilizers in an enclosed, roofed structure with an impervious floor and lockable door, at least 100 feet from wetlands, waterbodies, or sinkholes.
- ✓ 2. Recycle used oil, solvent bath waste, and antifreeze using appropriate means.
- ✓ 3. Ensure that all regulated petroleum storage tanks are registered, and meet the requirements of FDEP rule for secondary containment.

References

1. USDA-NRCS Conservation Practice On-Farm Secondary Containment Facility, Code 319 FOTG-Section IV. www.nrcs.usda.gov/technical/efotg

APPENDICES

APPENDIX I: ACRONYM LIST AND GLOSSARY

Adsorption: The process by which chemicals are held on the surface of a mineral or soil particle.

Aquifer: Soil or rock formation that contains groundwater and serves as a source of water that can be pumped to the surface.

Best Management Practices (BMPs): A practice or combination of practices based on research, field-testing, and expert review, to be the most effective and practicable on-location means, including economic and technological considerations, for improving water quality in agricultural and urban discharges. Best management practices for agricultural discharges shall reflect a balance between water quality improvements and agricultural productivity.

Biosolids: Solid, semisolid, or liquid residue generated during the treatment of domestic wastewater in a domestic wastewater treatment facility.

BMAP: Basin Management Action Plan.

Ca: Calcium.

Cation Exchange Capacity: The sum total of exchangeable cations that a soil can adsorb expressed in milliequivalents per 100 grams of soil, clay, or organic colloid.

Conveyance Capacity: The amount of flow (expressed in cubic feet per second) that a ditch/canal can carry based on its size, shape, slope, and smoothness.

CREP: Conservation Reserve Enhancement Program.

CRP: Conservation Reserve Program.

CSP: Conservation Security Program.

CRF: Controlled Release Fertilizer.

Cu: Copper.

Cyanobacteria: Also known as blue-green bacteria, which produce their energy through photosynthesis. Certain Cyanobacteria produce cyanotoxins that can be toxic to animals and humans.

ECP: Emergency Conservation Program.

EDIS: Electronic Document Information System.

EPA: Environmental Protection Agency.

EQIP: Environmental Quality Incentives Program.

ERP: Environmental Resource Permit.

ESTL: Extension Soils Testing Laboratory.

Evapotranspiration (ET): The combined loss of water through evaporation from plants and soil and emission of water vapor (transpiration) through plant leaf openings (stomata).

F.A.C.: Florida Administrative Code.

FAWN: Florida Automated Weather Network.

FDACS: Florida Department of Agriculture and Consumer Services.

FDEP: Florida Department of Environmental Protection.

Fertilizer Nitrogen Use Efficiency: A term used to indicate the ratio between the amount of fertilizer N removed from the field by a crop compared to the amount of fertilizer N applied.

FFWCC: Florida Fish and Wildlife Conservation Commission.

Field Capacity: The amount of soil water remaining in soil after the free water has drained through the profile.

FOTG: Field Office Technical Guide.

F.S.: Florida Statutes.

FSA: Farm Services Agency.

GPS: Global Positioning System.

Highly Erodible Lands: Soils that have an Erodibility Index of 8 or greater based on slope and steepness combination, given the soil characteristics and rainfall in the area. The lists for each county in Florida can be found in the NRCS FOTG Section II.A.5.

IPM: Integrated Pest Management.

Karst: Landforms or terrain caused by the dissolution of soluble rock (limestone or dolostone) characterized by springs, sinkholes, and caves.

Mg: Magnesium.

MGD: Million Gallons Per Day.

MIL: Mobile Irrigation Lab.

N-P-K: Nitrogen, Phosphorus and Potassium.

NOI: Notice of Intent.

NRCS: Natural Resources Conservation Service.

Perennial Streams: Streams or rivers that flow in a well-defined channel throughout most of the year under typical climatic conditions.

PPM: Parts Per Million.

PVC: Poly Vinyl Chloride.

Ratoon: A new shoot or sprout springing from the base of a crop plant, especially sugar cane, after harvesting.

Reclaimed Water: Water that has received at least secondary treatment and basic disinfection and is reused after flowing out of a domestic wastewater treatment facility.

Restricted Use Pesticides (RUPs): Pesticides registered by EPA that may only be applied by or under the direct supervision of trained and certified applicators.

Rip Rap: Large, loose angular stones or clean concrete debris that serve as a permanent erosion-resistant feature.

Riparian: Vegetated areas along a watercourse through which materials and water pass. Riparian areas characteristically have a high water table and are subject to periodic flooding and influence from the adjacent watercourse.

Sequestering Agents: A chemical compound used to tie up undesirable ions, keep them in solution, and eliminate or reduce their effects.

SFWMD: South Florida Water Management District.

Sinkhole: For the purposes of this manual, a sinkhole is an opening in the ground resulting from the collapse of overlying soil, sediment, or rock into underground voids created by the dissolution of limestone or dolostone.

Spodic Horizon: A subsurface soil layer characterized by organic matter, aluminum and iron. In Florida, these soils are common in poorly drained flatwoods.

SWCD: Soil and Water Conservation District.

TDS: Total Dissolved Solids.

Tilth: The physical condition of soil, primarily as a result of tillage.

TMDL: Total Maximum Daily Load.

UF-IFAS: University of Florida, Institute of Food and Agricultural Sciences.

Uncoated sands: Sand particles that lack clay and organic matter coating, and have poor water and nutrient holding capacities.

USACOE: United States Army Corps of Engineers

USGS: United States Geological Survey.

Vegetated Buffer: An area covered with vegetation suitable for nutrient uptake and soil stabilization, located between a production area and a receiving water or wetland.

Watershed: Drainage basin or region of land where water drains downhill into a specified body of water.

Wetlands: As defined in section 373.019(27), F.S., wetlands means those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils. Soils present in wetlands generally are classified as hydric or alluvial, or possess characteristics that are associated with reducing soil conditions. The prevalent vegetation in wetlands generally consists of facultative or obligate hydrophytic macrophytes that are typically adapted to areas having soil conditions described above.

WHIP: Wildlife Habitat Incentives Program.

WMDs: Water Management Districts.

WRP: Wetland Reserve Program.

APPENDIX 2: SOIL AND TISSUE TESTING INFORMATION

Soil Testing

The soil testing process comprises the four major steps described below, which must be conducted properly to achieve reliable results:

Step 1: Soil Sample Collection

The soil sample submitted to the laboratory must represent as accurately as possible the field from which it is taken, otherwise the recommendations may be inadequate or inaccurate. Generally, a sample should be a composite of subsamples taken of the upper six to twelve inches from 10 to 20 spots in a given area. Samples collected from areas that are not typical of the site should be avoided or submitted separately. Composite samples including anomalous areas in the field can result in over- or under-applying nutrients. It is a good idea to consolidate samples from areas that are managed similarly (management zones). If using one of the UF-IFAS Extension Soils Testing Laboratories, consult the UF-IFAS Soil Testing page, at: http://edis.ifas.ufl.edu/topic_soil_testing, for further information and to obtain the appropriate soil test sheet. Similar information and forms should be obtained prior to submitting soil samples to other qualified soil testing laboratories.

Step 2: Sample Analysis

For accurate fertilizer recommendations, the chemical extraction and testing procedures used by the laboratory must be correlated to plant growth and nutrient uptake. Soil samples are received by the laboratory then homogenized through grinding and/or sieving. The laboratory takes a precise amount of the mixed sample, by volume or weight and adds an extractant solution appropriate for the nutrient and the soil type being analyzed. The following are standard extraction methods used at the UF-IFAS Extension Soils Testing Laboratories (ESTL) and/or most private laboratories for different soil types in Florida:

1. Mehlich-3 extraction – Used on all mineral or organic soils over most pH levels.
2. AB-DTPA extraction – Used on alkaline (calcareous) soils with a pH of 7.4 and above.
3. Water extraction – Used for extraction of P on organic soils.

4. Acetic acid extraction – Used on organic soils for extraction of K, Mg, Ca, Si, and Na.
5. Bray 1 or Bray 2 extraction – Used for extraction of P on organic and mineral soils.
6. Ammonium acetate extraction – Used for extraction of P, K, Mg, Ca, Si on mineral soils.

Note: Before submitting soil samples to a private laboratory, it is important to know what extraction procedures will be used, as the soil testing BMP in this manual requires the standardized procedures used by the ESTLs. Also note that the ESTLs do not offer a soil test for N because there is no reliable test for plant-available N under Florida conditions. Nitrogen recommendations are based on crop nutrient requirements based on extensive research. More information regarding the procedures used at the UF-IFAS ESTL in Gainesville can be found in the extension publication, Circular 1248, at: <http://edis.ifas.ufl.edu/ss312>.

Step 3: Interpreting Test Results

Soil testing laboratories usually offer interpretation of the soil test results, i.e., nutrient application recommendations. Recommendations must be based on soil test-crop response trials and field calibration of the test results using optimum economic yields. This practice is referred to as the crop nutrient requirement method of interpretation.

The results are usually categorized in ranges from “low” to “high.” Yield increases resulting from added nutrients are usually not obtained once the test results are interpreted as “High.” The soil extraction methods differ largely by soil type and pH, so the interpretations should be specific to the soil type.

Step 4: Using the Results

Nutrient recommendations from soil test results are based on the optimum economic crop response to an added nutrient to the soil. If properly interpreted, most soil testing laboratories also provide information to assist the producer in making determinations about fertilizer rate, source, placement, and timing of application. When producers receive a soil test report and appropriate recommendations, they must make sound decisions about fertilizer source, rate, scheduling, and placement, within practical

and economic constraints. The law of diminishing returns must be considered in developing and using the recommendation. To reiterate, if the test results are interpreted as 'High' for a particular nutrient, there will be no fertilizer amount recommendation for that nutrient.

Tissue Testing

Tissue testing is the analysis and diagnosis of the plant's nutritional status based on its chemical composition. It is commonly performed on dried leaves, with results compared to recommended nutrient ranges. For certain vegetables, the petiole sap test literature values are fairly well correlated with crop response and a good alternative for a quick test of the nitrate-N and K concentration. Petiole sap testing can help growers monitor N and K nutrient status and make adjustments in fertilizer applications. Plant sap testing should not be thought of as a replacement for good whole leaf testing. Producers are encouraged to contact their local extension agent or a Certified Crop Advisor before embarking on a tissue testing regimen.

Quality Control

All accredited public and private laboratories must adhere to Standard Operating Procedures and a Quality Assurance and Quality Control (QA/QC) protocol. The laboratories QA/QC reports should demonstrate reasonable repeatability in the results

they report to the producer. It is appropriate for the producer to include duplicate (split) samples of the same composite soil to validate the soil sampling methodology.

References

1. Hochmuth, G., R. Mylavarapu, and E. Hanlon. 2014. Soil testing for plant available nutrients – what is it and why do we do it? <http://edis.ifas.ufl.edu/ss621>
2. Mylavarapu, R.S. and E.D. Kennelley. 2002. UF/IFAS Extension Soil Testing Laboratory Analytical Procedures and Training Manual. Soil and Water Science, Circular 1248, Cooperative Extension Service, UF-IFAS. <http://edis.ifas.ufl.edu/SS312>.
3. Hochmuth, G., R. Mylavarapu, and E. Hanlon. 2014. Fertilizer recommendation philosophies. <http://edis.ifas.ufl.edu/ss623>.
4. Hanlon, E.A. 2001. Procedures used by state soil testing laboratories in the southern region of the united states. Southern cooperative series bulletin # 190C ISBN; 1-58161-191-9.
5. Bray, R.H. and L.T. Kurtz. 1945. Determination of total, organic and available forms of phosphorus in soils. SS59:39-45.
6. Chapman, H.D. 1965. Cation-exchange capacity. In: C.A.Black (ed.). Methods of soil analysis-Chemical and microbiological property. Agronomy (1965):891-904.

APPENDIX 3: EFFECTIVENESS AND MAINTENANCE OF VEGETATIVE FILTER STRIPS

A. Site Eligibility

1. Vegetative filter strips (VFS) are effective for water quality improvement only if the flow across the VFS is shallow and the VFS is not submerged. Vegetative filter strips should not be installed on fields with significant concentrated flow across the proposed VFS areas.
2. VFS should be located only within areas characterized by shallow sheet flow which are upslope of natural or man-made channels.
3. VFS should not be installed in areas higher than the fields they are intended to protect.
4. Large fields with significant natural drainageways or grassed waterways are acceptable for VFS only if they are installed on both sides of internal field drainageways. This will allow pollutants to be trapped before they can enter the drainageways.
5. VFS are inappropriate for fields in continuous forage or pasture because the field is already protected from excessive sediment and nutrient loss.

B. Vegetative Filter Strip Establishment

1. The type(s) of vegetation and seeding rates used in VFS should be appropriate for local soil and climatic conditions and approved for use in the designated area. Grasses and legumes or combinations thereof are the most effective for erosion control and water quality improvement because of their dense growth, resistance to overland flow and filtering ability. Shrub and wildlife strips should not be permitted because they are relatively ineffective for water quality improvement when compared to grass and legume VFS.
2. Trees, stumps, brush and similar materials should be removed from the proposed filter strip to avoid interference with proper VFS operation and maintenance.
3. The VFS area should be limed and fertilized according to soil test recommendations with subsequent incorporation into the top 3 to 6 inches of soil as part of seedbed preparation.
4. Vegetation should be planted during optimum seeding times on firm, moist seedbeds. If site

conditions are unfavorable at planting, mulch material should be applied immediately after seeding. Mulching is recommended to minimize rill development during VFS establishment.

5. Some sites may require limited grading to correct slope problems within the strip such as gullies or high areas within or immediately downslope of the filter. This is not economically feasible for sites with severe topographic limitations.
6. At sites where there may be significant flow along or parallel to the filter, shallow berms or terraces may need to be constructed perpendicular to the filter at 50-foot to 100-foot intervals to intercept runoff and force the flow through the VFS before it can concentrate further.
7. VFS should be a minimum of 20-feet in width at the time of establishment. In steeper areas with poorly drained soils, minimum VFS width should be determined with design equations or according to approved local specifications.

C. Maintenance Practices

1. VFS should be mowed and the residue harvested a minimum of 2 to 3 times per year to promote thick vegetation with optimum pollutant-removal capabilities.
2. VFS should be limed and fertilized annually along with the rest of the field according to soil test recommendations.
3. Caution should be used when applying herbicides to VFS or adjacent fields for weed control. If herbicides are applied to fields, sprayers should be turned off before crossing VFS or using them for turn rows.
4. VFS should not be used for roadways because roadways change flow patterns which can lead to concentrated flow problems. If a VFS must be used for a roadway then the VFS should be 8 to 10 feet wider than normal and the roadway should be located on the downslope side of the filter so that field runoff will be filtered before it can concentrate in the disturbed roadway area.
5. Cattle should be excluded from VFS at all times but especially during periods when soils are moist and VFS are most susceptible to damage from hooves.

6. VFS should be inspected for stand establishment after planting and if stand is inadequate, the area should be re-fertilized and overseeded.
 7. VFS should be inspected regularly for damage caused by tillage operations, misapplication of herbicides, gully erosion, sediment inundation, etc., and repaired as soon as possible.
 8. VFS that have accumulated sufficient sediment so that they are higher than adjacent fields should be plowed out, disked and graded if necessary
- |
9. Care must be taken during all tillage operations to avoid tilling into VFS and reducing its effective width. If moldboard plowing is practiced, the last plow pass should turn soil towards the filter and the disturbed area next to the filter should be carefully disked to minimize gully formation and other flow problems.

Adapted from Bulletin 153, Long-Term Effectiveness and Maintenance of Vegetative Filter Strips, T.A. Dillaha. Virginia Polytechnic Institute.

APPENDIX 4: SOIL MOISTURE MONITORING AND EQUIPMENT MAINTENANCE

Monitoring Concepts

Successful producers understand soil moisture similar to the way a pilot can fly in good weather by visual flight rules rather than on instruments alone. However, the addition of instruments in both cases allows the operator to perform the job much more accurately. Given the high cost of energy and fertilizer along with decreasing availability of fresh water, precision irrigation through soil moisture monitoring produces a quality crop and saves money, water, fuel, fertilizer, and time. The latest soil moisture monitoring equipment provides producers real-time, understandable information on crop water requirements at the root zone, with the data transmitted to a computer, tablet or smart phone. While tensiometers are still used, a variety of new equipment exists that will provide accurate soil moisture measurements. A detailed discussion of these technologies, including relative costs, can be found at UF-IFAS Bulletin 343 *Field Devices for Monitoring Soil Water Content* at: <http://edis.ifas.ufl.edu/ae266>.

While soil types and crops vary, the science of trying to maintain the correct amount of available water for the plant does not. Experienced producers generally know when to irrigate based on plant and soil characteristics. Knowing when to stop irrigating is more difficult as the plant initially responds to correct amounts of irrigation as it does to 50 percent more water than it needs.

The question “what is field capacity” is the same as asking “how much water is enough?” Field capacity is the amount of water the soil will hold after drainage by gravity. The terms associated with each level of soil moisture are described below. For any soil, there is a combination of solid soil matrix (sand, silt, clay, and organic matter), air, and water.

1. **Permanent Wilting Point** – At permanent wilting point, there is no plant available water. There is some water in the space between mineral particles but the plant roots are unable to extract water from the soils.
2. **Field Capacity** – At field capacity, the maximum amount of water can be held within the root zone after drainage. Water is held to soil particles mainly by surface attraction and restricted void space. The percentage of water held in a soil at

field capacity varies and generally increases as soil grain size decreases (from gravel to sand to silt to clay). For instance, quartz sand may have a field capacity of 10 percent while a clay soil can have a field capacity over 30 percent.

3. **Saturation** – At saturation, the void space between soil particles is completely filled with water. The capacity of the soil to hold water in the root zone is exceeded and water drains below the root zone.

Apart from visual inspection of the plant and soil, a number of methods are available to either estimate or measure soil moisture content. The Florida Automated Weather Network (FAWN) provides data to allow calculations of evapotranspiration (ET). This method estimates crop irrigation requirements based on environmental conditions at or near the farm. It is probably the lowest cost option available for irrigation scheduling. While it provides a good methodology for scheduling, information on crop soil moisture content is not available so assumptions must be made regarding effectiveness of irrigation and rainfall.

Precision Irrigation with Soil Moisture Monitoring

Time Domain Reflectometry or TDR is one of the more popular and cost-effective types of sensors. It measures a characteristic of air, soil and water referred to as permittivity. The permittivity of a substance controls how an electric field is established. Measuring the time it takes to establish a stable electric field can be converted to a percentage of moisture in soil. Capacitance-based soil moisture sensors are another popular type of sensor, and operate similar to TDRs.

Sensor placement is based on a number of factors that include crop type, soil classification, extent of root zone, and irrigation system efficiency. Operations with well-designed, more efficient irrigation systems require fewer data collection stations. Sensors report to data loggers which convert the readings to soil moisture content, store data, and transmit it via radio or cellular modem. Loggers that lack automated transmission capabilities also can be obtained. These loggers are less expensive but still hold a very large amount of data. They

can be accessed in the field with a laptop or other recording device.

Data loggers usually have multiple ports that allow for multiple sensors to be connected, recorded and transmitted. In addition to soil moisture sensors, the loggers can also collect rainfall, temperature, wind speed and direction, and other parameters. Pressure sensors can also be attached to irrigation supply lines to accurately track the amount of time the irrigation system operated.

Prior to installation of sensors and data loggers, the farming area must be scouted so that key information can be collected on crop root system characteristics, soil types and irrigation distribution factors. A point is selected within the irrigated area that is representative of either: 1) average conditions if the irrigation system is efficient; or, 2) a point in the system that receives lower amounts of irrigated water if the system is inefficient. Using the latter case insures that sufficient water reaches the weakest parts of the irrigated system.

Soil moisture sensors are placed within and sometimes below the root zone of the crop. The sensor placed in the root zone shows soil moisture content or plant available water at a frequency specified by the producer. If the root zone covers a large vertical area, more than one sensor may be needed to show how a given irrigation or rainfall event penetrates the full extent of the root zone. Using rainfall as an example, producers want to know the difference between rainfall and effective rainfall. A half-inch of rainfall during a 24 hour period has a completely different effect on crops if it falls on dry soil versus moist soil. It has a different effect if it falls in several different events versus one. The extent of canopy closure has an influence on the effectiveness of rainfall as well. Instead of calculating or estimating effective rainfall, soil moisture monitoring shows the producer what a given rainfall amount actually does to soil moisture in the root zone.

Use of Soil Moisture Monitoring Hardware and Software for Irrigation Management

Figure 28 shows the output that the producer sees using soil moisture monitoring software. The light blue band shown in the figure is the optimum soil moisture range for this crop. This colored band is initially set to a conservative range of soil moisture conditions, and then fine-tuned as field capacity is determined through multiple irrigation events. The top of the band is typically set near field capacity and the bottom is set to the fraction of soil water

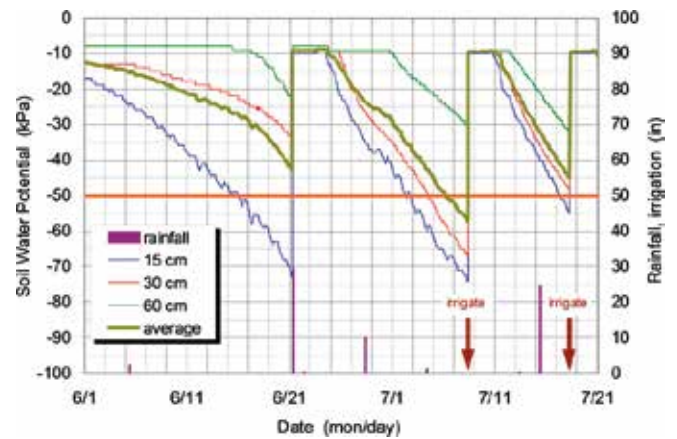


Figure 28

depletion desired for the crop, always remaining above the permanent wilting point.

The thin blue line within the band shows soil moisture in the root zone of the crop. The labels shown in the figure are notes that can be added by the producer to track activities – in this case, the length of irrigation events. The green bars show irrigation times and dates graphically, but clicking the “table” button at the top will show a listing of exact minutes irrigated during a day, week, month or any specified time period.

In this example, the producer irrigated for 534 minutes on May 8th. You will note that soil moisture exceeded 25 percent and was near full saturation after nearly 9 hours of irrigation. The response of the lower sensor, installed below the root zone, can be seen on the graph below the light blue band. It shows an increase in soil moisture from the May 8th irrigation event. Ideally, irrigation should be adjusted so the applied water wets the root zone but does not significantly affect the soil sensor below the root zone. The producer successively reduced the amount of water applied through the month of May with the last event on the 23rd lasting 171 minutes. The root zone sensor still shows a strong response with no observable response in the lower sensor below the root zone. The producer reduced his irrigation time from almost 9 hours to below 3 hours – providing ample water to the crop, with only one-third of the water and diesel fuel previously used.

Maintenance of Monitoring Equipment

Row crop cultivation and management practices present unique challenges with regard to the installation and maintenance of soil-sensor networks. A careful evaluation of the field management practices will reduce the potential for damage during installation and minimize maintenance require-

ments. Common practices that have a bearing on soil moisture monitoring systems use include:

Land Preparation – Row crops are rotated as often as once a year. Rotation necessitates removal of sensor networks for land preparation. Before installing a sensor network, consider the methods of removal. A well-marked sensor location and clear installation documentation record are key. Know where sensors are relative to other landmarks. Handheld GPS devices simplify marking the general location, but permanent markers such as flags or poles will pinpoint the location very accurately and allow you to effectively remove sensors without causing damage.

Planting – The width of planter machinery often determines the width of tillage or spray equipment that will pass through the crop area. Locate gaps where equipment can be installed away from tractor tire runs and equipment. Always place a marker at the end of the row containing a sensor network. This serves as an early warning to look for equipment.

Irrigation – Irrigation systems for row crops come in a variety of forms. Before mounting rain gauges or data logging hardware, consider the height of sprinkler nozzles and irrigation machinery that may pass overhead. Wetting patterns are important for soil sensor location, especially if the pattern is not uniform or other alterations such as wheel tracks, field edges, pivot stops, etc., change the field drainage.

Spraying – Locating installations in a “Guess Row” will facilitate working around the sensor network with sprayers and cultivation machinery. If cultivation tools penetrate the soil surface, sensors should be installed in-line with the plants, or deep enough

to avoid being caught by soil shanks. If desired, the data logger may be installed on a pole that can be lowered down or quickly removed to allow a sprayer boom to pass overhead. Data loggers can also be installed at a height below the level of cultivation but this will largely depend on the crop height.

Harvest – Some crops have multiple harvest times throughout the year. In this instance, the data logging system can be removed, or placed below ground temporarily to avoid damage. Sprinkler boxes make an inexpensive below ground enclosure to protect equipment during harvest. Sensor wires and posts can be run through the box in such a way that you can continue to collect data even when the unit is below ground. The primary concern when equipment is below ground is to prevent water from flooding the sprinkler box, so limit this period as much as possible. If the crop is expected to reach a significant height, install a marker pole that extends above the crop canopy for later identification and quick servicing.

Post-season maintenance – For annual crops, the ground will eventually have to be tilled. Hopefully, the system has been installed in a way that it can be easily identified and removed. In addition, be sure to place equipment in a dry place for storage until it is needed again. Power sources and connections should be checked seasonally. For the equipment shown, AA batteries are customarily replaced as needed and shown on the software battery indicator. Other sensor types use wet-cell batteries and solar panels. In this case, the panels should be kept clean and inspected for damage. Rain gauges should be inspected and cleaned periodically to allow for unimpeded flow of precipitation through the gauge.

Content prepared with the assistance of Water and Earth Sciences, Inc., Lake Wales, Florida.

APPENDIX 5: SPECIAL NUTRIENT MANAGEMENT MEASURES

The list that follows is not all-inclusive. However, it contains specific measures that producers can take to comply with the special nutrient management measures in Chapter 2 of this manual. Use one or more of these, or similar measures, to ensure proper management of fertilizer inputs. Essentially, they address source, placement, and scheduling of fertilizer applications. In the “Comments” section of the BMP checklist, document these and/or the other measures you will implement.

Producers are required to work with FDACS field staff and/or UF-IFAS extension agents to develop a written action plan that will prescribe and document implementation of a combination of the practices below. The action plan will outline how the producer will ultimately comply with the UF-IFAS recommended fertilizer rate(s). Other qualified professionals such as a Certified Crop Advisor (CCA) may also provide technical assistance. Producers should work with a CCA that has a 4R Nutrient Management Specialist designation, if one exists in their area.

The goal of the plan is to achieve UF-IFAS recommended fertilizer rate(s) on the farm within five years. As part of this effort, producers are required to implement one or more of the measures below and should conduct on-farm trials (side-by-side comparisons) in comparison with current practices, collect data, and review the results. The data, which includes fertilization and irrigation records, may be subject to annual review by FDACS staff.

After five years from the date of the Notice of Intent, if fertilization rates still exceed the threshold for *special nutrient management measures for high-rate fertilizer users* in Chapter 2, a loss of the presumption of compliance may result.

Use Alternative Fertilizer and Irrigation Techniques

Transitioning to proven alternatives may take some time. Most producers are inquisitive by nature, but are skeptical until they see the bottom line. The use of controlled-release fertilizers (CRF) may be appropriate for certain crops. Experimentation on a small amount of acreage is a good way to monitor the effectiveness and reliability of CRF when replacing or combining it with existing soluble nitrogen fertilizer sources.

Use soil moisture monitoring technologies and a blue-dye leaching test to observe and document where the water is located in relation to the root zone. Doing so will show you the visual extent of nutrient leaching of mobile nutrients (N and K) which will generally coincide with the wetting front. Contact FDACS staff or an IFAS agent for assistance with this test. Use the test results to adjust fertilizer source, timing and placement, along with irrigation management to reduce water and nutrient movement below the crop root zone.

Increasing the number of split applications (especially for N) is another proven alternative. Fertigating, knifing, injection wheels, etc., will facilitate split applications of fertilizer materials, and will allow the nutrients in soil solution to become more proportionally available to the plant to maximize crop nutrient uptake.

Double Crop or use Cover Crops to Scavenge Nutrients

Often, in plasticulture production systems, residual nutrients remain in the bed after the main crop is harvested and terminated, especially if excessive rates of fertilization were applied. The risk of losing these nutrients to the environment is significantly reduced if a second cash crop or cover crop requiring less N than the first crop is planted in the same field. Double cropping using transplants as depicted in **Figure 29** may provide an advantage when trying to scavenge excess nutrients. Transplants already have a primary root system that will quickly expand and scavenge the available residual nutrients.



Figure 29

Incorporate Tailwater Recovery

Tailwater recovery can reduce the annual average irrigation amount from ground or surface water sources by 10 percent or more. Thus, it not only conserves water, but allows producers to “pick up” and recycle water-soluble nutrients via the irrigation system. Cost share may be available to help offset construction costs for tailwater pond(s) and appurtenances. Strategic installation of a tailwater recovery pond(s) establishes permanent infrastructure to use season after season. It is important to remember to account for the N and P in tailwater, and to reduce the fertilizer input accordingly.

APPENDIX 6:

INCENTIVE PROGRAMS FOR QUALIFYING OPERATIONS

Implementation of Best Management Practices can reduce non-point sources of pollution, conserve valuable soil and water resources, and improve water quality. The implementation of these management practices can also be expensive and, in some cases, may not be economically feasible for agricultural producers. To reduce the financial burden associated with the implementation of selected practices, several voluntary cost-share programs have been established. These programs are designed to conserve soil and water resources and improve water quality in the receiving watercourse. The narrative below is intended to provide basic information regarding the primary federal, state, and regional cost-share programs. Sources of additional information have also been included, and producers are encouraged to contact the identified agencies or organizations for current information about each program.

I. Programs Administered by USDA – Farm Services Agency (FSA)

Conservation Reserve Program (CRP): This program encourages producers to convert highly erodible cropland or other environmentally sensitive lands to vegetative cover including grasses and/or trees. This land use conversion is designed to improve sediment control and provide additional wildlife habitat. Program participants receive annual rental payments for the term of the contract in addition to cost share payments for the establishment of vegetative cover. CRP generally applies to highly erodible lands and is more applicable to North Florida.

Conservation Reserve Enhancement Program (CREP): CREP uses a combination of federal and state resources to address agricultural resource problems in specific geographic regions. This program (which is not limited to highly erodible lands) is designed to improve water quality, minimize erosion, and improve wildlife habitat in geographic regions that have been adversely impacted by agricultural activities.

Emergency Conservation Program (ECP): The ECP provides financial assistance to producers and operators for the restoration of lands on which normal agricultural operations have been impeded by natural disasters. More specifically, ECP funds are available for restoring permanent fences, terraces,

diversions, irrigation systems, and other conservation installations. The program also provides funds for emergency water conservation measures during periods of severe drought.

For further information on CRP and CREP, including eligibility criteria, please contact your local USDA Service Center. Information is also available on the Internet at www.fsa.usda.gov.

II. Programs Administered by NRCS

Conservation Plans

Conservation planning is a natural resource problem-solving and management process, with the goal of sustaining natural resources. Conservation Plans include strategies to maintain or improve yields, while also protecting soil, water, air, plant, animal, and human resources. They are particularly well-suited to livestock operations and farming operations that produce multiple commodities. Conservation Plans are developed in accordance with the NRCS FOTG. Assistance in developing a plan can be obtained through the local Soil and Water Conservation District (SWCD), the NRCS, the Cooperative Extension Service, and private consultants who function as technical service providers. However, the decisions included in the Conservation Plan are the responsibility of the owner or manager of the farm. Conservation Plans are usually required to receive cost share for any of the programs described below.

Environmental Quality Incentives Program (EQIP): EQIP provides financial assistance for the implementation of selected management practices. Eligibility for the program requires that the farm have a NRCS-approved conservation plan. Practices eligible for EQIP cost share are designed to improve and maintain the health of natural resources and include cross-fences, water control structures, brush management, prescribed burning, nutrient management and other erosion control measures.

Conservation Security Program (CSP): CSP is a voluntary conservation program that supports ongoing stewardship on private lands. It rewards farmers and operators who are meeting the highest standards of conservation and environmental management. Its mission is to promote the conser-

vation and improvement of soil, water, air, energy, plant and animal life.

Wetlands Reserve Program (WRP): WRP is a voluntary program designed to restore wetlands. Program participants can establish easements (30-year or perpetual) or enter into restoration cost-share agreements. In exchange for establishing a permanent easement, the landowner usually receives payment up to the agricultural value of the land and 100 percent of the wetland restoration cost. Under the 30-year easement, land and restoration payments are generally reduced to 75 percent of the perpetual easement amounts. In exchange for the payments received, landowners agree to land use limitations and agree to provide wetland restoration and protection.

Wildlife Habit Incentives Program (WHIP): The Wildlife Habitat Incentives Program provides financial incentives for the development of fish and wildlife habitat on private lands. Program eligibility requires that landowners develop and implement a Wildlife Habitat Development Plan. Participants enter multiyear (5 to 10 year) agreements with NRCS.

For further information on these programs, including eligibility criteria, please contact your local USDA Service Center. Information is also available on the Internet at the following web site: www.nrcs.usda.gov.


III. Programs Administered by State and Regional Entities

Office of Agricultural Water Policy: To assist nursery producers in the implementation of BMPs, the Florida Department of Agriculture and Consumer Services/Office of Agricultural Water Policy contracts with several of the state's Soil and Water Conservation Districts and Resource Conservation and Development Councils to provide cost share, as funding is available.

Water Management District Cost-Share Programs: Some of the WMDs may have agricultural cost-share programs in place for eligible producers.

For further information on these programs, including eligibility criteria, please contact your soil and water conservation district, your WMD, or FDACS. Information and links to other sites are also available on the Internet at the following web site: <http://www.freshfromflorida.com/Divisions-Offices/Agricultural-Water-Policy>.

APPENDIX 7: EXAMPLE RECORD-KEEPING FORMS

Keeping records aids in operating and maintaining BMPs. To reiterate, BMPs that have a pencil icon  require records to be kept for a minimum of five years.

You may maintain your records as hard copies or in an electronic format, depending on your preference. Below is an example of a set of record-keeping forms. You may use these tables, develop your own, or choose commercially available record-keeping software suited to your operation.

Soil Sample Records (Retain all Lab Results)				
Sample Date	Field Location	# of Samples	Name of Lab	Records Location

Tissue Sample Records (Retain all Lab Results)				
Sample Date	Field Location	# of Samples	Name of Lab	Records Location

Fertilization Records (Retain all Receipts)								
Field Name					Production Acreage		Year	
Brand	Application method	Grade N-P ₂ O ₅ -K ₂ O	% CRN	% CRP ₂ O ₅	Amount of fertilizer applied (lbs/total production acreage)	Amount of fertilizer applied (lbs/acre)	Total N applied (lbs/acre)	Total P ₂ O ₅ applied (lbs/acre)

Rainfall (inches)											
Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.

Well Records					
Location	Year Constructed	Constructed By	Last Modified	Modified By	Records Location

APPENDIX 8: CONTACT INFORMATION

Emergency Information

Emergency Reporting Numbers	24 hours	
State Warning Point <i>Division of Emergency Management – contact in case of oil or hazardous substance spill</i>	Toll-Free	1-800-320-0519
Emergency Information and Follow-Up Numbers	Monday - Friday	
State Warning Point Information Line	8:00 am - 5:00 pm	(850) 413-9900
DEP Emergency Response	8:00 am - 5:00 pm	(850) 245-2010
State Emergency Response Commission <i>For follow-up reporting only</i>	Toll-Free	1-800-635-7179

Non-Emergency Information

Florida State Agency Numbers

Toll Free

Department of Agriculture and Consumer Services	www.freshfromflorida.com	
Office of Agricultural Water Policy	(850) 617-1727	
Division of Agricultural and Environmental Services	(850) 617-7900	
Bureau of Pesticides	(850) 617-7917	
Bureau of Compliance Monitoring	(850) 617-7850	
Department of Environmental Protection	www.dep.state.fl.us	
Non-point Source Management Section	(850) 245-2836	
Hazardous Waste Management Section	(850) 245-8707	
Northwest District Office (Pensacola)	(850) 595-8300	
Northeast District Office (Jacksonville)	(904) 256-1700	
Central District Office (Orlando)	(407) 897-4100	
Southeast District Office (West Palm)	(561) 681-6600	
Southwest District Office (Tampa)	(813) 632-7600	
South District Office (Ft. Myers)	(239) 344-5600	
Water Management Districts	www.flwaterpermits.com	
Northwest Florida (Tallahassee)	(850) 539-5999	
Suwannee River (Live Oak)	(386) 362-1001 1-800-226-1066
St. Johns River (Palatka)	(904) 329-4500 1-800-451-7106
Southwest Florida (Brooksville)	(352) 796-7211 1-800-423-1476
South Florida (West Palm)	(561) 686-8800 1-800-432-2045
<u>Other Helpful Numbers – Main offices</u>		
NRCS – Florida Office (Gainesville)	(352) 338-9500	
UF/IFAS Extension Administration	(352) 392-1761	
Association of Florida Conservation Districts <i>Soil and Water Conservation Districts</i>	(407) 321-8212	

APPENDIX 9: RULE CHAPTER 5M-8, F.A.C.

5M-8.001 Purpose

Rulemaking Authority 403.067(7)(c)2, FS. Law Implemented 403.067(7)(c)2, FS. History—New 2-8-06, Repealed _____.

5M-8.002 Documents Incorporated by Reference

The following documents are hereby adopted and incorporated by reference. Copies of the documents may be obtained from the Florida Department of Agriculture and Consumer Services (FDACS), Office of Agricultural Water Policy, Mayo Building, 407 South Calhoun Street, Tallahassee, Florida 32399 or online as indicated.

- (1) Water Quality/Quantity Best Management Practices for Florida Vegetable and Agronomic Crops (Edition 2015, FDACS-P-01268) accessed online at <https://www.flrules.org/gateway/ChapterHome.asp?Chapter=5m-8>.
- (2) University of Florida Nutrient Management of Vegetable and Agronomic Row Crops Handbook (February 2015, SP500) accessed online at <https://www.flrules.org/gateway/ChapterHome.asp?Chapter=5m-8>.
- (3) Dade County Department of Environmental Resources Management document Handbook for the Voluntary Retrofit of Open, Uncased Agricultural Wells (1997) accessed online at <https://www.flrules.org/gateway/ChapterHome.asp?Chapter=5m-8>.
- (4) Notice of Intent to Implement Water Quality/Quantity Best Management Practices for Florida Vegetable and Agronomic Crops (2015), FDACS-01351, Rev. 3/15, accessed online at <https://www.flrules.org/gateway/ChapterHome.asp?Chapter=5m-8>.
- (5) Notice of Intent to Implement Best Management Practices for Everglades Agricultural Area or C-139 and Western Basins Area, FDACS-01445, Rev. 2/15, accessed online at <https://www.flrules.org/gateway/ChapterHome.asp?Chapter=5m-8>.

Rulemaking Authority 403.067(7)(c)2, FS., 570.07(10) and (23), FS. Law Implemented 403.067(7)(c)2, FS. History—New 2-8-06, Amended _____.

5M-8.003 Presumption of Compliance.

Pursuant to Section 403.067(7)(c)3., F.S., implementation of best management practices (BMPs), in accordance with this rule chapter, that have been verified by the Florida Department of Environmental Protection as effective in reducing pollutants addressed by the practices, provides a presumption of compliance with state water quality standards and release from the provisions of Section 376.307(5), F.S., for those pollutants. In order to qualify for a presumption of compliance and release from Section 376.307(5), F.S., the applicant must:

- (1) Submit the Notice of Intent to Implement:
 - (a) As provided in Rule 5M-8.004, F.A.C., that identifies the applicable BMPs; or
 - (b) If the property is located in the Everglades Agricultural Area or C-139 Western Basins Area, submit the Notice of Intent to Implement as provided in Rule 5M-8.005, F.A.C.;
- (2) Implement all applicable BMPs in accordance with the requirements in Rule 5M-8.004, F.A.C., or Rule 5M-8.005, F.A.C.;
- (3) Implement all applicable BMPs no later than 18 months after submittal of the NOI; and
- (4) Maintain documentation, in accordance with Rule 5M-8.006, F.A.C., to verify the implementation and maintenance of the identified BMPs.
- (5) The presumption of compliance applies only to phosphorus and nitrogen for producers within the Everglades Agricultural Area or C-139 and Western Basins Area.

Rulemaking Authority 403.067(7)(c)2, FS., 570.07(10) and (23), FS. Law Implemented 403.067(7)(c)2, FS. History—New 2-8-06, Amended _____.

5M-8.004 Notice of Intent to Implement Water Quality/Quantity Best Management Practices for Florida Vegetable and Agronomic Crops

- (1) A Notice of Intent (NOI) to Implement Water Quality/Quantity Best Management Practices for Florida Vegetable and Agronomic Crops (2015), FDACS-01351, Rev. 3/15, as incorporated in Rule 5M-8.002, F.A.C., and the required supporting documentation as described on the NOI form shall be submitted to the Florida Department of Agriculture and Consumer Services, Office of Agricultural Water Policy, Mayo Building, 407 South Calhoun Street, Tallahassee, Florida 32399.
- (2) A BMP checklist with a schedule for implementation, as contained in the manual incorporated in Rule 5M-8.002(1), F.A.C., must be submitted with the NOI. The applicant shall select the applicable BMPs by following the instructions in the manual.
- (3) Once the NOI is filed, the applicant is eligible to apply for cost-share assistance with BMP implementation.

Rulemaking Authority 403.067(7)(c)2, FS., 570.07(10) and (23), FS. Law Implemented 403.067(7)(c)2, FS. History—New 2-8-06, Amended 5-23-07, _____.

5M-8.005 Notice of Intent to Implement Best Management Practices for Everglades Agricultural Area or C-139 and Western Basins Area

- (1) A Notice of Intent (NOI) to Implement BMPs for Everglades Agricultural Area or C-139 and Western Basins Area, FDACS-01445, Rev. 2/15, as incorporated in Rule 5M-8.002, F.A.C., and supporting documentation shall be submitted to the Florida Department of Agriculture and Consumer Services, Office of Agricultural Water Policy, Mayo Building, 407 South Calhoun Street, Tallahassee, Florida 32399.
- (2) A copy of the 40E-63, F.A.C., permit must be submitted with the NOI.
- (3) Once the NOI is filed, the applicant is eligible to apply for cost-share assistance with BMP implementation.

Rulemaking Authority 403.067(7)(c)2, FS., 570.07(10) and (23), FS. Law Implemented 403.067(7)(c)2, FS. History—New 2-8-06, Amended 5-23-07, _____.

5M-8.006 Record Keeping

BMP participants must keep records for a period of at least five years after they are generated to document implementation and maintenance of the practices identified in the manual incorporated by reference in Rule 5M-8.002(1), F.A.C., and in the Notice of Intent to Implement. All documentation is subject to inspection.

Rulemaking Authority 403.067(7)(c)2, FS., 570.07(10) and (23), FS. Law Implemented 403.067(7)(c)2, FS. History—New.

5M-8.007 Previously Submitted Notices of Intent to Implement

In order to retain a presumption of compliance with state water quality standards:

- (1) Producers who are not described in sections (2) or (3) below who submitted a Notice of Intent to Implement Best Management Practices prior to the effective date of this rule must:
 - (a) Within two years of the effective date of this rule, submit a new NOI and BMP checklist in accordance with Rule 5M-8.004, F.A.C., and
 - (b) Implement the selected BMPs on the checklist submitted to the Department .
- (2) Producers who are not described in section (3) below who submitted a Notice of Intent to Implement Best Management Practices prior to the effective date of this rule and that have a Water Management District-permitted, operational retention/detention stormwater management system that treats the production runoff water must:
 - (a) Within four years of the effective date of this rule, submit a new NOI and BMP checklist in accordance with Rule 5M-8.004, F.A.C., and
 - (b) Implement the selected BMPs on the checklist in accordance with Rule 5M-8.004, F.A.C.
- (3) Producers described below who, prior to the effective date of this rule, submitted a Notice of Intent to Implement Best Management Practices shall be subject to the manual incorporated by reference in Rule 5M-8.002(1), F.A.C., but do not have to re-enroll and the existing NOI continues to provide a presumption of compliance with state water quality standards so long as:
 - (a) They grow an annual crop that is fertilized with less than 100 lbs N/acre; or
 - (b) They grow strawberries or cucurbits on plastic mulch with drip irrigation, and apply greater than 75% of the nitrogen fertilizer via fertigation at a rate that does not exceed 150 lbs N/acre per season; or
 - (c) They have a Conservation Plan developed or approved by Natural Resources Conservation Service that has been reviewed within the past five years and updated as necessary; or
 - (d) They grow vegetable and/or agronomic crops within the permit boundaries of the Everglades Agricultural Area or C-139 Western Basins Area and have been issued a permit under Chapter 40E-63, F.A.C.

Rulemaking Authority 403.067(7)(c)2, FS., 570.07(10) and (23), FS. Law Implemented 403.067(7)(c)2, FS. History—New.

APPENDIX 10

Notice of Intent and BMP Checklist



ADAM H. PUTNAM
COMMISSIONER

Florida Department of Agriculture and Consumer Services
Office of Agricultural Water Policy

FDACS-OAWP
Mayo Building
407 S. Calhoun St. MS-E1
Tallahassee, FL 32399

**NOTICE OF INTENT TO IMPLEMENT
WATER QUALITY / QUANTITY BMPs FOR
FLORIDA VEGETABLE AND AGRONOMIC CROPS (2015)**

Rule 5M-8.002, F.A.C.

- **Complete all sections of the Notice of Intent (NOI).** The NOI may list multiple properties only if they are within the same county, they are owned or leased by the same person or entity, and the same BMPs identified on the checklist are applicable to them.
- Submit the **NOI** and the **BMP Checklist**, to the Florida Department of Agriculture and Consumer Services (FDACS), at the address below.
- **Keep a copy of the NOI and the BMP checklist in your files** as part of your BMP record keeping.

You can visit <https://www.flrules.org/gateway/ChapterHome.asp?Chapter=5m-8> to obtain an electronic version of this NOI form.

If you would like **assistance** in completing this NOI form or the BMP Checklist, or with implementing BMPs, contact FDACS staff at (850) 617-1727 or AgBmpHelp@freshfromflorida.com.

Mail this completed form **FDACS Office of Agricultural Water Policy**
and the **BMP Checklist** to: Mayo Building, 407 S. Calhoun Street, MS-E1
Tallahassee, Florida 32399

Person To Contact

Name: _____

Business Relationship to Landowner/Leaseholder: _____

Mailing Address: _____

City: _____ State: _____ Zip Code: _____

Telephone: _____ FAX: _____

Email: _____

Landowner or **Leaseholder Information** (check all that apply)

NOTE: If the Landowner/Leaseholder information is the same as the Contact Information listed above, please check: **Same as above**. If not, complete the contact information below.

Name: _____

Mailing Address: _____

City: _____ State: _____ Zip Code: _____

Telephone: _____ FAX: _____

Email: _____

Operation Name: _____

County: _____

Tax Parcel Identification Number(s) from County Property Appraiser

Please submit a copy of your county tax bill(s) for all enrolled property, with owner name, address, and the tax parcel ID number(s) clearly visible. **If you cannot provide a copy of the tax bill(s), please write the parcel owner's name and tax parcel ID number(s) below in the format the county uses.** Attach a separate sheet if necessary (see form provided).

Parcel No.: _____ Parcel Owner: _____

Parcel No.: _____ Parcel Owner: _____

Parcel No.: _____ Parcel Owner: _____

Parcel No.: _____ Parcel Owner: _____

Parcel No.: _____ Parcel Owner: _____

Additional parcels are listed on separate sheet. (check if applicable)

Total # of acres of all parcels listed (as shown property tax records): _____

Total # of acres on which BMPs will be implemented under this NOI: _____

In accordance with section 403.067(7)(c)2, Florida Statutes, I submit the foregoing information and the BMP Checklist as proof of my intent to implement the BMPs applicable to the parcel(s) enrolled under this Notice of Intent.

Print Name: _____
(check all that apply) Landowner Leaseholder Authorized Agent (see below)*

*Relationship to Landowner or Leaseholder: _____

Signature: _____ Date: _____

Name of Staff Assisting with NOI: _____

NOTES:

1. You must keep records of BMP implementation, as specified in the BMP manual. All BMP records are subject to inspection.
2. You must notify FDACS if there is a full or partial change in ownership with regard to the parcel(s) enrolled under this NOI.
3. Please remember that it is your responsibility to stay current with future updates of this manual. Visit the following website periodically to check for manual updates: <http://www.freshfromflorida.com/Divisions-Offices/Agricultural-Water-Policy>

Additional Tax Parcel Listings

Operation Name: _____

County: _____

Parcel No.: _____ Parcel Owner: _____

Parcel No.: _____ Parcel Owner: _____

Parcel No.: _____ Parcel Owner: _____

Parcel No.: _____ Parcel Owner: _____

Parcel No.: _____ Parcel Owner: _____

Parcel No.: _____ Parcel Owner: _____

Parcel No.: _____ Parcel Owner: _____

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Parcel No.: _____ Parcel Owner: _____

Parcel No.: _____ Parcel Owner: _____

Parcel No.: _____ Parcel Owner: _____

Parcel No.: _____ Parcel Owner: _____

Parcel No.: _____ Parcel Owner: _____


Parcel No.: _____ Parcel Owner: _____

Parcel No.: _____ Parcel Owner: _____

FLORIDA VEGETABLE AND AGRONOMIC CROP WATER QUALITY / QUANTITY BMP CHECKLIST

Checklist Instructions

Note: Before you fill out this checklist, follow the section on BMP Enrollment and Implementation, which begins on page 7 of this manual. Read the text and the BMPs in Sections 1.0 – 8.0 before filling out the checklist, in order to know what the practices entail. The checklist summaries are for identification purposes only.


1. Check "In Use" for each BMP that you are currently practicing and will continue to practice.
2. For the applicable BMPs you do not implement currently but will implement, enter the month and year you plan to implement them in the "Planned" column. FDACS rule requires that applicable Level 1 BMPs in the manual be implemented as soon as practicable, but not later than 18 months after submittal of the NOI.
3. If you are using or will be using a practice similar to a BMP in the checklist, you may enter AMU (alternative measures used) under the "In Use" or "Planned" column. Be sure to include an implementation date (month/year) in the "Planned" column. Explain in the comments section what alternative measure(s) you are or will be implementing. If applicable, include the NRCS FOTG number associated with the practice.
4. For BMPs you will not implement, check all of the following that apply under "Will Not Implement."
 - NA = Not Applicable (you do not have a resource concern that requires use of the BMP).
 - TNF = Technically Not Feasible.
 - ENF = Economically Not Feasible.
 - Other = You must explain your reason in the comments section at the end of the checklist.
5. Make sure you follow the record-keeping requirements. BMPs that include record keeping are marked by the following pencil icon: 
6. Mail this BMP checklist with your NOI form to FDACS, and keep a copy of both documents in your files.





BMP #	BMP Group <small>(See body of manual for full description of practices)</small>	In Use	Planned	Will not implement <i>(check reason below)</i>			
		Check/ or AMU	Month/ Year	NA	TNF	ENF	Other



1.0 Field and Bed Preparation


1.1. Field and Bed Preparation


1. Plow down old crop residues well in advance of preparing for the next crop. Generally, a 6 week period between plowing down residues or a cover crop is recommended to allow adequate decay of the material. This does not apply to conservation tillage operations.						
2. Use deep tillage to penetrate and break tillage pan layers in fields that are cultivated, as needed. Breaking compaction layers allows deeper root penetration to facilitate plant absorption of water and nutrients.						
3. Use laser leveling to re-grade fields that historically have not drained well or that have correctable erosion issues. Re-grading can improve water management and help conserve soil resources.						
4. Evaluate field slope and proposed row length prior to farming a field. While drainage may improve as the slope/grade increases, it may also decrease in some areas as row length increases.						

BMP #	BMP Group (See body of manual for full description of practices)	In Use	Planned	Will not implement (check reason below)			
		Check/ or AMU	Month/ Year	NA	TNF	ENF	Other
	5. When preparing beds, the height of the bed should be no more than 12 inches; the bed width will depend on the crop and the number of rows per bed. New bed geometry research being conducted on plastic-mulched crops may change this guidance in the future.						
	6. Evaluate the use of contour farming and other conservation practices (e.g., grassed waterways, filter strips) to address drainage needs and anticipated erosion issues, especially when farming on significantly sloped fields in North Florida.						
1.2. Drainage Ditches							
	1. Construct drainage ditches based on water removal requirements for the particular crop and needed conveyance capacity, and ensure that ditch side slopes are constructed in accordance with the soil type and characteristics.						
	2. When using combination culvert/riser boards in ditches, remove only the number of boards necessary to achieve desired drainage.						
	3. Minimize sediment transport by designing and maintaining the ditches to slow water velocity in the main canal or in ditches near discharge structures.						
2.0 Nutrition and Irrigation Management							
Plastic Mulch Production – Subsection A							
2.1.1. Plastic Mulch Nutrient Management							
	 1. Test soils on an annual basis prior to forming beds. Base P fertilization rate on soil test results from a public or private laboratory that employs the standard testing methods used by the UF-IFAS Extension Soils Testing Laboratories. Refer to Appendix 2 for guidance on accepted P extraction methods and sample collection. Keep a copy of all laboratory test results to track changes over time.						
	2. When determining the N, P, and K fertilization rates appropriate for your crops, consult UF-IFAS recommendations in the Nutrient Management of Vegetable and Row Crops (SP500), as revised, or other credible sources of information with published scientific support. Manage nutrients carefully, using the applicable BMPs in this section and section 2.1.2, to minimize offsite discharge and leaching.						
	3. Maintain and calibrate fertilizer application equipment.						
	4. Use the Linear Bed Foot (LBF) System to convert from lbs/acre to lbs/100 LBF, after determining the typical bed spacing using Table 3 .						

BMP #	BMP Group (See body of manual for full description of practices)	In Use	Planned	Will not implement (check reason below)			
		Check/ or AMU	Month/ Year	NA	TNF	ENF	Other
	5. When using drip irrigation, incorporate all P, micronutrients, and up to 40 percent of the recommended UF-IFAS amount for N and K in the bed, and apply the remaining N and K in recommended increments (via fertigation). The weekly N application may increase as the plant matures during its fruiting stage. For extended harvest periods, see the Supplemental Fertilizer Application Guidance below.						
	6. When using seep irrigation, incorporate all P, micronutrients, and up to 20 percent of the recommended amount for N and K in the bed, and apply the remaining N and K in narrow bands on the bed shoulders underneath the plastic.						
	7. Use tissue test (leaf/petiole) results to: determine the need for supplemental fertilizer applications, evaluate the effectiveness of N, P, and K, fertilization programs, and diagnose micronutrient deficiencies. See Supplemental Fertilizer Application Guidance below. Keep a copy of all laboratory test results.						
	8. If growing two crops on the same plastic mulch within a 12-month period, take a representative soil sample in the bed, away from the residual fertilizer bands. Use either the drip irrigation system or a liquid fertilizer injection wheel to apply any additional fertilizer, based on the second crop's nutrient requirement and soil test result.						
	9. Clean up and remove plastic as soon as practicable after the last harvest to help reduce runoff effects and disease incidence during the next cropping cycle.						
	10. Keep records of all nutrient applications that contain N or P.						
Special Nutrient Management Measures							
	11. Work with FDACS field staff and/or UF-IFAS extension agents to implement one or more of the specific measures listed in Appendix 5 , or similar approved measures, to mitigate the use of additional N inputs. Document the measures you will implement in the Comments section of the BMP checklist, and have staff help you develop a written remedial action plan.						
	12. After implementing the high-rate management measure above, consult with a professional engineer to ensure and document that most of the production area surface water runoff is retained onsite or treated before discharging. Another option is to begin converting your farm to drip irrigation, documenting the number of acres to be converted each year.						
2.1.2. Plastic Mulch Irrigation Management							
	1. Use available tools and data to assist in making irrigation decisions. Tools may include water table observation wells, on-site soil moisture sensors, crop water use information, and weather data. Real-time weather data is available through the FAWN website; or by installing your own on-site weather station.						

BMP #	BMP Group (See body of manual for full description of practices)	In Use	Planned	Will not implement (check reason below)			
		Check/ or AMU	Month/ Year	NA	TNF	ENF	Other
	2. Install rain gauges on your operation and monitor them to schedule irrigation events. Larger rain events may contribute enough moisture underneath plastic mulch to substitute for the next irrigation event.						
	3. If one is available, get a Mobile Irrigation Lab evaluation to check the emission uniformity of the system. This will confirm that the main, sub-main, and laterals are able to deliver proper pressure and flow to the drip tapes. This should be done every three to five years, even if the drip tapes are replaced annually. Make adjustments as needed.						
	4. During the first two weeks of crop establishment of transplanted seedlings, water frequently but carefully to prevent excessive runoff from occurring. This is very important if you also have and use overhead irrigation to acclimate the transplants.						
	5. Irrigate based on available water holding capacity in the soil root zone. When daily irrigation needs are greater than the available water holding capacity (during long, warm days) or when plants are flowering or developing fruit, splitting (pulsed) irrigation events into multiple daily applications will be of benefit.						
Additional Level I BMPs for Plastic Mulch with Seepage Irrigation							
	6. For frost/freeze protection, raise water tables by increasing water levels in irrigation canals and ditches.						
	7. Maintain the water table (saturated zone) at the lowest level necessary to reach plant rooting depths. Removable boards on water control structures can be an effective tool to manage the water table.						
	8. Install water table observation wells midway between ditches or water furrows at the anticipated high and low water-table elevations within each field. Inspect them periodically and make any needed repairs.						
Level II BMP							
	9. Install tailwater recovery pond(s) to conserve water and recirculate the dissolved nutrients on cropland. If this option is not technically or economically feasible, describe in the comments section of the BMP checklist an alternative means to address discharge issues.						
Bare Ground Production Systems – Subsection B							
2.2.1. Bare Ground Nutrient Management							
	1. Test soils on an annual basis. Base P fertilization rate on soil test results from a public or private laboratory that employs the standard testing methods used by the UF-IFAS Extension Soils Testing Laboratories. Refer to Appendix 2 for guidance on accepted P extraction methods and sample collection. Keep a copy of all laboratory test results to track changes over time.						



BMP #	BMP Group (See body of manual for full description of practices)	In Use	Planned	Will not implement (check reason below)			
		Check/ or AMU	Month/ Year	NA	TNF	ENF	Other
	2. When determining the N, P, and K fertilization rates appropriate for your crops, consult UF-IFAS recommendations in the Nutrient Management of Vegetable and Row Crops (SP500), as revised, or other credible sources of information with published scientific support. Manage nutrients carefully, using the applicable BMPs in this section and section 2.2.2, to minimize offsite discharge and leaching.						
	3. Maintain and calibrate fertilizer application equipment.						
	4. Use automated or manual shutoff valves on the fertilizer application equipment so that no fertilizer is applied in the turn row or other non-production areas.						
	5. Keep records of all nutrient applications that contain N or P.						
Additional Level I BMPs for Raised Beds							
	6. Apply up to 40 percent of the N and K at planting or shortly after planting. Delay the first application based on the approximate number of days until germination (or cracking for potatoes), and the root system characteristics. P should be banded or injected, and applied as close as possible to planting but no more than 10 days before.						
	7. Use the Linear Bed Foot (LBF) system to convert from lbs/acre to lbs/100 LBF, after determining the typical bed spacing using Table 3 .						
	8. Apply the remaining fertilizer in split applications (or more frequently if fertigating) during the early part of the growing season or according to specific crop needs.						
Additional Level I BMPs for Field Crops Planted at Grade							
	9. Apply all of the P and up to 30 percent of the N and K at planting or shortly after planting. Delay the first application based on the approximate number of days until germination (or cracking for potatoes), and the root system development characteristics. P should be applied as close as possible to planting but no more than 10 days before.						
	10. Apply additional fertilizer only after the root system has advanced into the inter-row area to maximize interception of available nutrients. Apply it in one or more applications during the early to middle part of the growing season, or according to specific crop needs.						
	11. If incorporating legumes/cover crops, compost, manure, or biosolids, or irrigating with reclaimed water, determine the N and P contribution by multiplying the average nutrient concentrations by the rate of material applied, and decrease N and P fertilization rates accordingly.						

BMP #	BMP Group (See body of manual for full description of practices)	In Use	Planned	Will not implement (check reason below)			
		Check/ or AMU	Month/ Year	NA	TNF	ENF	Other
12.	Consider incorporating a global positioning system (GPS) and associated navigation instrument (parallel-tracking device) to reduce overlap; grid map soil units to deliver fertilizer at a variable rate; or another precision agriculture technique, and describe it in the comments section of the BMP checklist.						
Special Nutrient Management Measures							
13.	Work with FDACS field staff of UF-IFAS extension agents to implement one or more of the specific measures listed in Appendix 5 , or similar approved measures, to mitigate the use of additional N inputs. Document the measures you will implement in the Comments section of the BMP checklist, and have staff help you develop a written remedial action plan.						
14.	After implementing the high-rate management measure above, begin converting your farm to either drip irrigation, or a high-efficiency, computer controlled, pivot irrigation system if your farm is in a karst area. Both speed and zone control variable rate application must be evaluated.						
2.2.2. Level I – Bare Ground Irrigation Management							
1.	Use available tools and data to assist in making irrigation decisions. Tools may include water table observation wells, onsite soil moisture sensors, crop water use information, and weather data. Real-time weather data is available through the FAWN website; or by installing your own on-site weather station. Agronomic or field crops grown in North Florida should follow the recommendations in Reference 2 below.						
 2.	Install rain gauges on your operation and monitor them to help schedule irrigation events. Rain events of 1/4 to 1/2 inch are usually sufficient to substitute for the next irrigation event.						
3.	If a Mobile Irrigation Lab is available, get an evaluation to check the distribution or emission uniformity and the conveyance efficiency of the irrigation system(s). This should be done every three to five years. Make adjustments as needed.						
4.	Do not irrigate beyond field capacity.						
5.	For center pivot irrigation systems, install low-pressure irrigation sprinklers with drops and speed and/or zone variable rate controls if economically feasible.						
Additional Level I BMPs for Seepage Irrigation							
6.	For frost/freeze protection, raise water tables by increasing water levels in irrigation canals and ditches.						
7.	Maintain the water table (saturated zone) at the lowest level necessary to reach plant rooting depths. Removable boards on water control structures can be an effective tool to manage the water table.						

BMP #	BMP Group (See body of manual for full description of practices)	In Use	Planned	Will not implement (check reason below)			
		Check/ or AMU	Month/ Year	NA	TNF	ENF	Other
	8. Install water table observation wells midway between ditches or water furrows at the anticipated high and low water-table elevations within each field. Inspect them periodically for any needed repairs. Alternatively, use water table reference elevations for open seepage systems.						





Sugarcane Production Systems – Subsection C

2.3.1. Sugarcane Nutrient Management


 1. Test soils prior to planting cane. Base P fertilization rate on soil test results from a public or private laboratory that employs the standard testing methods used by the UF-IFAS Extension Soils Testing Laboratories, or alternate test methods that have a calibrated crop response. Refer to Appendix 2 for guidance on P extraction methods and sample collection. Keep a copy of all laboratory test results to track changes over time. Band or air-induct all P as a pre-plant application.						
2. Repeat the application of P fertilizer every year after harvesting. The rates should follow the calibration curve according to first, second, and third ratoon and the soil test done prior to planting.						
3. Maintain and calibrate fertilizer application equipment.						
4. No N fertilizer is recommended for sugarcane grown on deeper muck soils. However, young sugarcane plants in any soils that have been exposed to anaerobic conditions caused by excessive rainfall or floodwaters may require N fertilizer.						
5. For sandy, sandy muck, shallow muck, or mineral soils, apply fertilizer in accordance with UF-IFAS recommendations in the Nutrient Management of Vegetable and Row Crops (SP 500), as revised, or other credible sources of information. Do not apply more than 50 lbs of soluble N/acre in any single application. For mucky sands and/or sandy mucks, apply less than the recommended annual rate for sandy soils. Manage nutrients carefully, using the applicable BMPs in this section and section 2.3.2, to minimize offsite discharge and leaching.						
6. Incorporate fallow flooding into the rotation cycle for non-production sugarcane fields in organic muck soils, if feasible, to prevent soil subsidence and oxidation.						
 7. Keep records of all nutrient applications that contain N or P.						

2.3.2. Sugarcane Irrigation Management

1. Use available tools and data to assist in making irrigation decisions. Tools may include water level observation, removable soil moisture sensors, crop water use information, and/or weather data. Real-time weather data is available through the FAWN website; or by installing your own on-site weather station.						
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BMP #	BMP Group (See body of manual for full description of practices)	In Use	Planned	Will not implement (check reason below)			
		Check/ or AMU	Month/ Year	NA	TNF	ENF	Other
	2. Install rain gauges on your operation and monitor them to help schedule irrigation events. Rain events of 1/4 to 1/2 inch are usually sufficient to substitute for the next irrigation event.						
	3. Irrigate up to field capacity and not beyond.						
	4. Maintain the water table at the lowest level necessary to reach sugarcane rooting depths. Removable boards on water control structures can be an effective tool to manage the water table.						
	5. If fields are flooded temporarily, monitor the water levels and berms for integrity.						
	6. For frost/freeze protection, raise water tables by increasing water levels in irrigation canals and ditches.						
Hay and Silage Production Systems – Subsection D							
2.4.1. Hay and Silage Nutrient Management							
	1. For established stands of hay, take soil samples during the dormant season and test them on an annual basis. Base P fertilization rate on soil test results from a public or private lab that employs the standard testing methods used by the UF-IFAS Extension Soils Testing Laboratories. Refer to Appendix 2 for guidance on accepted P extraction methods and sample collection. Keep a copy of all laboratory test results to track changes over time.						
	2. Maintain and calibrate fertilizer application equipment.						
	3. Fertilize perennial grasses for hay crops in the spring as soon as the crop starts growing. Apply up to 80 lbs N/acre/cutting, and all of the recommended P and K in early spring. Reduce the N accordingly, after the next-to-last cutting in the fall.						
	4. Begin spring harvest (first cutting) of hay when the grass reaches the recommended height(s) listed in Table 4 .						
	5. For producers growing annual silage or other forages, consult UF-IFAS recommendations in the Nutrient Management of Vegetable and Row Crops (SP500), as revised.						
	6. Keep records of all nutrient applications that contain N or P.						
2.4.2. Hay and Silage Irrigation Management							
	1. Use available tools and data to assist in making irrigation decisions. Tools may include water table observation wells, on-site soil moisture sensors, crop water use information, and weather data. Real-time weather data is available through the FAWN website; or by installing your own on-site weather station.						
	2. Install rain gauges on your operation and monitor them to help schedule irrigation events. Rain events of 1/4 to 1/2 inch are usually sufficient to substitute for the next irrigation event.						

BMP #	BMP Group (See body of manual for full description of practices)	In Use	Planned	Will not implement (check reason below)			
		Check/ or AMU	Month/ Year	NA	TNF	ENF	Other
	3. If a Mobile Irrigation Lab is available, get an evaluation to check the distribution (sprinkler) or emission uniformity and the conveyance efficiency of the irrigation system(s). This should be done every three to five years. Make adjustments as needed.						
	4. Do not irrigate beyond field capacity.						
Protected Growing Systems – Subsection E							
2.5.1. Protected Growing Systems BMPs							
	1. Follow all applicable BMPs in this manual.						
	2. Use gutters or other means to convey roof runoff water to an onsite catchment pond for evaporation or reuse.						
	3. Consider installing a nutrient leachate collection system and conveying leachate outside the greenhouse for use on another crop (nursery plants, turfgrass, hay field, etc.) or convey leachate to a constructed treatment wetland.						
3.0 Irrigation System Maintenance							
3.1. Pressurized Irrigation Systems							
	1. On a periodic basis, examine sprinkler nozzles or emitters for wear and malfunction, and replace them as necessary.						
	2. If PVC pipes are exposed, re-paint/treat them if the treatment material has worn out; and install or repair impact protection posts, if applicable.						
	3. Clean and maintain filtration equipment so it will operate within the recommended pressure range.						
	4. Flush irrigation lines regularly to prevent emitter clogging. To reduce sediment build up, make flushing part of a regular maintenance schedule. If fertigating, flush all fertilizer from the lateral lines before shutting down the irrigation system to prevent microbial growth.						
	5. Test irrigation source water quality annually to detect issues with water chemistry that may result in irrigation system plugging or affect plant health.						
	6. Ensure that totalizing flow meters are calibrated every 8 years, using proper equipment, such as non-intrusive ultrasonic flow meters. An exception to this is if other calibration or reporting requirements are set forth as part of a water management consumptive use permit.						
3.2. Non-Pressurized (Seepage) Irrigation Systems							
	1. Clean debris and control undesirable aquatic vegetation in irrigation ditches and canals, to maintain water flow and direction.						
	2. Keep water-level-control structures (such as culverts and risers) in irrigation ditches in good working order.						
	3. Maintain irrigation swales/furrows at the correct slope, so that water is applied evenly along the field.						

BMP #	BMP Group (See body of manual for full description of practices)	In Use	Planned	Will not implement (check reason below)			
		Check/ or AMU	Month/ Year	NA	TNF	ENF	Other
	4. Use a culvert and screw gate or similar device for the irrigation system, where possible, to conserve water.						
3.3. Pumping Plant							
	1. Ensure that the pump, engine/motor, and fuel tank (if applicable) are mounted on a firm foundation, and that all engine/pump/shaft alignment points are correct and within manufacturer's specifications.						
	2. Obtain the operating pressure (total dynamic head) and system capacity (flow rate in GPM), and then use the specific pump manufacturer characteristic curve to operate the unit to maintain efficiency based on field conditions.						
	3. For diesel engines older than twenty years, have a comprehensive evaluation done by a professional to determine the pumping plant efficiency.						
4.0 Sediment and Erosion Control Measures							
4.1. Road Construction and Maintenance							
	1. Stabilize access roads that cross streams and creeks, using rock crossings, culverts, or bridges.						
	2. Maintain vegetative cover on road banks.						
	3. When constructing above-grade access roads, locate the road(s) a minimum of 25 feet from regulated wetlands.						
4.2. Ditch Maintenance							
	1. Maintain permanent vegetative cover on ditch banks.						
	2. Protect ditch banks from erosion in areas subject to high water velocities, using rip-rap, concrete, headwalls, or other buffering materials.						
	3. Keep all control structures free from obstructions.						
	 4. Do not remove sediments below the ditch's original invert elevation, which can be determined by perm it drawings, basic survey drawings, and/or changes in soil characteristics and color. Keep drawings of the design cross-sectional area for future reference.						
Level II BMPs							
	5. Install check dams in drainage ditches, perpendicular to the direction of flow and downstream of the area contributing the sediment. Check dams can be created using a variety of materials such as rock, rip rap, or sand bags.						
	6. Install sediment traps within the water conveyance system. Clean out traps periodically, as sediments will accumulate over time. If you are experiencing recurring erosion problems, install a flashboard riser water control at the sediment trap outlet.						

BMP #	BMP Group (See body of manual for full description of practices)	In Use	Planned	Will not implement (check reason below)			
		Check/ or AMU	Month/ Year	NA	TNF	ENF	Other

4.3. In-Field Erosion Control

1. If a farm field discharges sediments offsite or directly to a waterbody, install and maintain filter strips, sediment basins, or similar measures.						
2. As needed, apply mulch on steep non-production areas to provide temporary erosion control until plants establish. Select non-invasive plants or a seeding mixture to provide short-term and long-term vegetative cover.						
3. Use a combination of vegetative cover (e.g., rye, millet) and/or geo-fabric material to stabilize the ground at the downstream side of plastic mulch rows.						
4. For plastic mulch production systems, install plastic-covered spill ways where cross ditches flow into lateral ditches.						
5. Use a conservation practice to protect soils during non-production or fallow periods.						

Level II BMP

6. Contact NRCS or FDACS for technical assistance in implementing conservation tillage.						
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Level III BMP

7. Contact NRCS or FDACS for technical assistance and to inquire about possible cost-share in implementing diversions and terrace control.						
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5.0 Water Resources Protection

5.1. Wetlands Protection

1. Install and/or maintain a minimum 35-foot, non-fertilized vegetated buffer upland of the landward jurisdictional boundary of all wetlands and lakes, unless you have an existing WMD permit (e.g., ERP, or management and storage of surface waters permit) that specifies a different buffer. For lakes that have an adopted TMDL for nutrients, expand the buffer to 50-feet.						
2. For existing operations that are unable to meet the vegetated buffers specified above, submit to FDACS a written description of the alternative measures you will take to protect the wetlands from water quality impacts (Use the comments section at the end of the BMP checklist).						

5.2. Streams Protection


1. Install and/or maintain a riparian buffer along perennial streams on production areas that exceed 1-percent slope and discharge directly to the streams. Contact FDACS, NRCS, or an NRCS approved Technical Service Provider for assistance in properly designing the riparian buffer.						
2. Locate and size any stream crossings to minimize impacts to riparian buffer vegetation and function and to maintain natural flows.						

BMP #	BMP Group (See body of manual for full description of practices)	In Use	Planned	Will not implement (check reason below)			
		Check/ or AMU	Month/ Year	NA	TNF	ENF	Other

5.3. Protection for First- and Second-Magnitude Spring Recharge Basins

1. Install and/or maintain a 100-foot non-fertilized vegetated buffer upland of the landward boundary of springs and spring runs.						
2. Install and/or maintain a 50-foot non-fertilized vegetated buffer around sinkholes and other visible karst features.						
3. Do not exceed the UF-IFAS recommended fertilizer rate for N and P, including any contributions from irrigation sources.						
4. If you have a sinkhole on your property, never use it to dispose of any materials, including pesticide containers.						

5.4. Well Operation and Protection

1. If injecting fertilizer or chemicals, use backflow-prevention devices at the wellhead to prevent contamination of the water source.						
2. Inspect wellheads and pads at least annually for leaks or cracks, and make any necessary repairs.						
3. If in the Homestead area, use the criteria in the 1997 Handbook for the Voluntary Retrofit of Open, Uncased Agricultural Wells to address open bore wells to ensure that the Biscayne aquifer is protected.						
 4. Maintain records of new well construction and modifications to existing wells.						

6.0 Stormwater Management

6.1. Stormwater Conveyance Systems

1. Install gutters and downspouts on all buildings adjacent to production areas, and divert stormwater away from the production area toward vegetated areas. When not detrimental to crop health, collect and use this water for irrigation.						
2. Operate and maintain all stormwater management conveyances (swales, ditches, and canals) to ensure that they operate as designed.						
3. If you have an existing operation that does not have an WMD surface water perm it and has a history of downstream flooding issues, develop and implement a written stormwater management plan that provides specific responses to various types and levels of rainfall, as feasible. The goal of the plan should be a reduction in volume of off-site discharge. Evaluate the plan's effectiveness and make adjustments as needed.						
4. If the total impervious area of your operation (e.g., asphalt or concrete roads/parking lots, roofs, greenhouses) exceeds 10 percent of the total land area, have a site-specific evaluation performed to determine whether off-site storm water runoff is an issue. USDA-NRCS may be able to perform this at no cost.						

BMP #	BMP Group (See body of manual for full description of practices)	In Use	Planned	Will not implement (check reason below)			
		Check/ or AMU	Month/ Year	NA	TNF	ENF	Other

7.0 Integrated Pest Management

7.1. Pesticide Storage and Mixing

1. Store pesticides in an enclosed, roofed structure with an impervious floor and lockable door, at least 100 feet from wells, wetlands or other waterbodies, and sinkholes.						
2. When practicable, construct a permanent mix/load facility with an impermeable surface, and locate it at least 100 feet from wells, wetlands or other waterbodies, and sinkholes.						
3. Where permanent facilities are not practicable, use portable mix/load stations or conduct any field mix/load activities at random locations in the field; use nurse tanks if applicable.						
4. Use a check valve or air gap separation to prevent backflow into the tank or water source when filling a sprayer.						

7.2. Level I – Aquatic Plant Management

1. Use barriers, traps, screen devices and/or debris baffles to control floating aquatic weeds.						
2. Use biological control agents or herbicides registered and labeled for aquatic applications, when chemical control is warranted.						

8.0 Recycling and Industrial Materials Management

8.1. Waste Reduction BMPs

1. Store fertilizers in an enclosed, roofed structure with an impervious floor and lockable door, at least 100 feet from wetlands, waterbodies, or sinkholes.						
2. Recycle used oil, solvent bath waste, and antifreeze using appropriate means.						
3. Ensure that all regulated petroleum storage tanks are registered, and meet the requirements of FDEP rule for secondary containment.						

APPENDIX 11

Notice of Intent to Implement for EAA, C-139 and Western Basin Areas



ADAM H. PUTNAM
COMMISSIONER

Florida Department of Agriculture and Consumer Services
Office of Agricultural Water Policy

FDACS-OAWP
407 S. Calhoun St.
Tallahassee, FL 32399

NOTICE OF INTENT TO IMPLEMENT BEST MANAGEMENT PRACTICES FOR

(check appropriate area)

- Everglades Agricultural Area (EAA)
- C-139 & Western Basins Area

Section 403.067(7)(c)2, Florida Statutes and Rule 5M-8.002 F.A.C.
Phone (850) 617-1700; Fax (850) 617-1701

In accordance with Florida Statute 403.067(7)(c)2 and Rule 5M-8.002 F.A.C., the following information is hereby submitted as proof of my intent to implement Best Management Practices for agricultural land(s) located in the EAA or C-139 and Western Basins Area within the South Florida Water Management District. Multiple parcels and associated tax identification numbers may be listed on one NOI. If parcels are owned in more than one county, then one NOI should be submitted for each county with the list of associated tax identification numbers on each NOI. Use an additional sheet if necessary.

Farm _____

Leaseholder _____

Authorized Local Contact _____

Local Contact Address _____

Local Contact Phone _____

Farm Name _____

Total Number of Acres Enrolled _____

County _____

Property Tax ID Number/s (from Property Appraiser)

Submit this completed *Notice of Intent to Implement* form to the Department of Agriculture and Consumer Services at the address below along with a copy of the list of BMPs implemented under SFWMD Rule 40E-63, F.A.C. Keep a copy of your completed Notice(s) of Intent to Implement. **You must submit the *Notice of Intent to Implement* if you wish to receive a presumption of compliance with state water quality standards.** A submitted *Notice of Intent to Implement* is also a requirement to be eligible for some sources of BMP cost share funding.

Signature of Farm Owner or Leaseholder _____ Date _____

Mail this completed form to: **FDACS-OAWP**
407 S. Calhoun Street
Tallahassee, Florida 32399



