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Update and Outlook for 2003 of Florida's BMP Program for Vegetable Crops[1]

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Increased environmental concerns supported by reports of high NO_3-N and P levels in some springs and streams in Florida, have resulted in the passage of the Surface Water Improvement and Management (SWIM) Act of 1987. Together with the Federal Clean Water Quality Act of 1977, the SWIM Act created a program that focused on preservation and/or restoration of the state's water bodies through the development and implementation of Best Management Practices (BMPs). BMPs are cultural practices that should increase or maintain yields while being environmentally robust, economically feasible, and based on science and best professional judgment. BMPs are based on IFAS research results, and therefore, follow IFAS recommendations (Maynard and Olson, 2001). Florida growers, faced with the new BMP program, legitimately requested reliable data documenting the impact of current production practices on water quality. Much of this research has been completed as outlined in Table 1.

In this context, the goal of our multi-disciplinary research and extension program is to (1) actively participate in the development of the BMP manual, (2) develop research-based information supporting the efficacy of fertilization and irrigation BMPs, and (3) provide vegetable growers with recommendations and educational programs that help them comply with the new legislation. This paper outlines the current status of the BMP manual for vegetables, describes several research projects on the testing of possible BMPs for vegetable crops, and discusses challenges and opportunities for the implementation and adoption of the BMP program in Florida.

The BMP Manual for Vegetables Grown in Florida

The "*Agronomic and Vegetable Crops BMP Manual for Florida"* will describe BMPs for the 142,000 ha, $1.4 billion vegetable industry in Florida (Witzig and Pugh, 2001). The seven sections of the manual are Pesticide management, "Conservation Practices and Buffer," "Sediment Control," "Irrigation and Nutrient Management," "Water Resources," "Seasonal and Temporary Farming Operations," and "Record Keeping and Accountability." Each section is divided into specific BMPs. Each BMP description is 2 to 3 pages long, consisting of a title, pictures, working definition, set of "things to do" (BMPs), "things to avoid"

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(potential pitfalls), supplemental technical criteria, and references (Table 1 and Table 2).

In a competitive marketplace where only the most efficient producers remain in business, the cost of implementing BMPs is of great concern to the grower community. Thus, several cost-share programs are available to partially reimburse the cost of BMP implementation. These programs are administered by USDAs Farm Agency Service (the Conservation Reserve Program, and the Conservation Reserve Enhancement Program), the Natural Resources Conservation Service (the Environmental Quality Incentive Program, Emergency Conservation Program, Small Watershed Program, Stewardship Incentive Program, Wetlands Reserve Programs, Wildlife Incentives Program), or by state or local agencies (Tri-county Agricultural Area – Water Quality Cost Share Program –see Livingston-Way, 2000; the Indian River Citrus Area – Water Quality Protection Program, Alternate Water Supply Construction Cost-Share Program, the Suwannee River Partnership).

Current Research Projects With Drip Irrigation

While extensive, recommendations for vegetable production are readily available (Maynard and Olson, 2001), the documentation of the environmental impact of these recommendations is still incomplete (Table 3). As illustrated in the following research projects, several strategies are under investigation to reduce the risk of N leaching.

In a project entitled "Field Testing of Possible BMPs for Watermelon Conducted at the North Florida Research and Education Center-Suwannee Valley (NFREC-SV)," spring watermelons were grown between 1998 and 2002 following current IFAS fertilization and irrigation recommendations (Maynard and Olson, 2001). Nitrate levels in the soil water at the 1.6-m and 7-m depth were monitored every three weeks with suction-cup lysimeters and wells. Watermelon marketable yield ranged between 43,680 and 72,280 kg/ha, which was comparable to current commercial yields (Witzig and Pugh, 2001). Nitrate-nitrogen concentration in the lysimeters ranged from 20 to 150 mg/L NO_3-N except when cover crops were grown between vegetable crops. Under cover crops, nitrate concentration in the lysimeter samples ranged between 5 and 20 mg/L NO_3-N. Nitrate concentration in the monitoring well samples was always below 20 mg/L NO_3-N. It was concluded that economical yields of watermelon may be produced with current fertilizer and irrigation recommendations. However, it was not possible to maintain NO_3-N levels in the soil water or the shallow groundwater below the EPA drinking water standard, when current production recommendations were followed.

The relevance of using the EPA drinking water standard (10 mg/L NO_3-N; USEPA, 1994) as the threshold for discharge monitoring has been questioned because the fate of nitrate below the root zone is unknown, and water just below the root zone of vegetables is typically not used for potable water supply. Monitoring water below the root zone does account for dilution of nitrate in the root zone. However, this concentration has been selected because no alternative threshold exists for shallow water.

Because NO_3-N moves with the water front, optimizing irrigation management may reduce nitrate leaching. Scheduling drip irrigation is the topic of an on-going project (2000-2003) at NFREC-SV. The goal of this project is to develop specific guidelines for drip irrigation scheduling of bell pepper using real-time weather data. In one experiment, bell pepper (*Capsicum annuum*) was grown with plasticulture under factorial combinations of three N (75%, 100% and 125% of the recommended 224 kg N/ha rate) and four irrigation rates (33%, 66%, 100%, and 133% of I3, the reference rate). Varying drip tape and fertilizer injector numbers created factorial combinations of N and irrigation rates. For I3, daily drip irrigation was based on class A pan evaporation and a crop factor ranging between 0.20 and 1.00 depending on crop growth stage. Total seasonal irrigation was 74,687 L/100 m of bed for I3. Soil water tension decreased with increasing water amounts and remained under 20 kPa with the 66% I3 rate in the top 30-cm soil zone. Bell pepper yields were significantly affected by N and irrigation rates (all $p<0.01$). Fancy yield was significantly greater with 125% than with 100% N rate. Fancy and marketable yields responses to water rates were both quadratic ($p<0.01$) and maxima occurred at 97% and 94% of I3, respectively. A combination of 280 kg/ha of N and 95% I3 resulted in highest bell pepper yields grown with plasticulture (Simonne et al., 2001).

In another experiment conducted at NFREC-SV, three levels of sensor-based, high-frequency irrigation treatments and four levels of twice-daily irrigation treatments were applied to bell pepper. The two highest sensor based irrigation treatments resulted in yields similar to the two highest daily irrigation treatments (marketable yields ranged between 17,000 and 20,000 kg/ha for these treatments), but used approximately 50% less seasonal irrigation water. This resulted in irrigation water use efficiencies of 1209-2316 kg/ha/m^3 for the sensor- based treatments while daily treatments ranged from 703 to 1612 kg/ha/m^3. Sensor based irrigation treatments resulted in significantly higher soil volumetric moisture levels at the 15 and 30 cm depths. These results indicate that high frequency irrigation events can maintain crop yields while reducing irrigation water requirements.

Another possible strategy to reduce the risk of nutrient leaching in Florida sandy soils is to increase soil water holding capacity (SWHC) by using inorganic amendments such as Phyllipsite-type zeolyte (Agriboost, ASI Specialties, Washington, DC). Its alumino-silicate arrangement creates an open, three dimensional, cage-like structure which can absorb and retain cations. Because of their high specific surface, zeolites are able to absorb up to 30% of their dry weight in gases such as nitrogen and ammonia, over 70% of water, and up to 90% of certain hydrocarbons. Phillipsite is one of the zeolites with high CEC and water retention capability of potential application in plant production (Dwairi, 1998). Blends (w:w) of air-dried USGA-approved sand and Agriboost were made at rates of 100:0, 92:8, 88:12, 75:25, 70:30, 60:40, 50:50, and 0:100. The SWHC of the 100:0 and 0:100 mixes (sand alone and Agriboost alone) were 26% and 31%, respectively. The addition of Agriboost linearly increased the SWHC of the USGA sand. However, in this test, the magnitude of the increase was practical at rates exceeding common rates used for soil amendments (few tons per hectare). Depending on pricing strategy, the use of this type of amendment may be limited to high value areas such as golf courses and up-scale landscapes.

Current Research Projects With Seepage Irrigation

Bare-ground culture with seepage irrigation is another production system used in Florida for many crops including potato *(Solanum tuberosum)*. With seepage irrigation, the height of a perched water table is controlled by the flow of water into irrigation ditches spaced between planting beds. Two cultural practices are under investigation to reduce the potential for NO_3-N movement into the perched water table. The first is the use of legumes planted as both summer cover crops and fall cash crops to supply N to the following winter-spring potato crop. With legumes in rotation, growers may be able to supply potato plants with high N rates while meeting the BMP rate for inorganic N. The treatments are cowpea (*Vigna unguiculata*), sorghum/sudan grass hybrid, or no summer cover crop in combination with fall planted green bean (*Phaseolus vulgaris*). Potatoes were planted in all plots following beans and fertilized at four nitrogen rates (0, 112, 168, 224, 280 kg/ha). The summer and fall legume crops add approximately 55 kg/ha of N to the system. We found that growers may reduce the inorganic N rate well below the 224 kg N/ha BMP rate and still maintain historic yields.

The second alternative production system is the use of controlled release fertilizers to replace all or part of the N required for production. Research to identify a CRF program that releases N at a rate and concentration that matches potato plant need during the season is ongoing. However, initial experiments have shown that total applied nitrogen can be reduced by 45% using some CRF sources compared to the BMP recommendations without impacting yield (Hutchinson and Simonne, 2002).

Extension Educational Efforts

Specific educational programs cannot be implemented until the final approval of the BMP manual. Yet, state, county and commodity meetings are increasing the importance of water and regulatory issues. The Florida Drip Irrigation School is a day-long program that focuses on fertilizer, water and chemical management in plasticulture (Simonne et al., 2002). Education, communication, patience, and economical feasibility will be keys to the successful implementation of this BMP program in Florida.

References

Dwairi, I.M. 1998. Evaluation of Jordanian Zeolite Tuff as a Controlled Slow-release Fertilizer for NH4+. Environ. Geol. 34(1):1-4.

Hutchinson, C.M. and R. Mylavarapu. 2002. Utilization of Legumes in Rotation with Potato to Reduce Nitrate Leaching in Florida Watersheds. HortScience (abs.) 37(5):745-746.

Hutchinson, C.M. and E.H. Simonne. 2002. Development of Controlled-release Fertilizer Program for Potato Production. The Vegetarian. http://www.hos.ufl.edu/vegetarian/02/march/march02.htm#Development .

Livingston-Way, P. 2000. Tri-County Agricultural Area Water Quality Protection Cost Share Program, Applicants Handbook. St. Johns River Water Management District, Palatka, FL.

Maynard, D.N. and S.M. Olson. 2001. Florida Vegetable Production Guide, 267 pp., Univ. of Fla., Gainesville, Fla.

Simonne, E., M. Dukes, G. Avezou, R. Hochmuth, G. Hochmuth, D. Studstill, and W. Davis. 2001. Crop Factors for Scheduling Irrigation of Bell Pepper Grown with Plasticulture NFREC-SV Res. Rept. 2001-07.

Simonne, E., D. Studstill, R. Hochmuth, T. Olczyk, M. Dukes, R. Munoz-Carpena, and Y. Li. 2002. Drip Irrigation: The BMP Era. Citrus&Vegetable Mag., Oct. pp.6-18.

Witzig, J.D. and N.L. Pugh. 2001. 1999-2000 Florida Agricultural Statistics Vegetable Summary. Fla. Dept. Agric. Consum. Serv., Tallahassee, Fla.

Table 1. Proposed sections in the "Agronomic and Vegetable Crops BMP" manual for Florida and corresponding BMPs.

General Area/Area of Application	BMP Area
Pesticide management / Farm level	Integrated pest management, Precision agriculture, Pesticide record keeping Personal protective equipment, Pesticide storage, Spill management, Pesticide application equipment washwater and container management, Pesticide equipment calibration Pesticide mixing and loading activities
Conservation practices and buffer/watershed and farm level	Field border, Riparian buffers, Wellhead protection, Wetlands protection, Windbreak
Sediment control/Watershed and farm level	Access road, Bed preparation, Conservation tillage, Contour farming, Critical area planting Ditch construction and maintenance, Filter strip, Sediment basin, Grade stabilization structures, Land leveling, Grassed waterway
Irrigation and nutrient management/ Field level	Soil survey, Soil testing/soil pH, Micronutrients, Proper use of organic fertilizer materials, Linear bed foot system for fertilizer application, Chemigation/fertigation, Controlled-release fertilizers, Optimum fertilizer management, Supplemental fertilizer application, Irrigation scheduling, Irrigation system maintenance and evaluation, water supply, Frost and freeze protection, Tail water recovery systems, Tail water reuse and waterborne pathogens, Tissue testing, Double cropping, Cover crops, Conservation crop rotation
Water resources/farm level	Farm pond, Flood protection, Pipelines, Springs protection, Water control structure, Water table observation well
Other	Seasonal and temporary farming operations
Record keeping and accountability	Fertilizer record keeping, Rainfall/irrigation record keeping, Inventory of on-farm pesticide storage, Pesticide applicators record keeping, Worker protection training log

Table 2. Type of action and expected type of impact on water quality for fertilization and irrigation practices targeted by the BMPs.

Fertilization and irrigation proposed BMP	Relative level of supporting research data	Expected impact on water quality	Type of action on nutrients
Soil survey	Complete for Florida	Remote	Increase overall farming efficiency
Soil testing and soil pH	Complete	Indirect	Provides basis for adequate nutrient applications
Micronutrient	Complete	Indirect	Apply adequate amounts and form
Proper use of organic fertilizer materials	Extensive	Indirect	Supply some nutrients; increase soil water holding capacity
Linear bed foot system for fertilizer application	Complete	Indirect	Make adequate fertilizer calculation for plasticulture
Chemigation/fertigation	Complete	Indirect	Increase overall farming efficiency; supply adequate fertilizer amounts in the bed
Controlled-release fertilizer	Very limited	Direct	Supply adequate fertilizer amounts; reduce leaching risk
Optimum fertilization management	Complete	Direct	Supply adequate fertilizer amounts

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Fertilization and irrigation proposed BMP	Relative level of supporting research data	Expected impact on water quality	Type of action on nutrients
Supplemental fertilizer application	Extensive	Indirect/Adverse	Replace leached fertilizer based on leaf or petiole results
Irrigation scheduling	Incomplete	Direct	Reduce leaching risk from irrigation water
Irrigation system maintenance and evaluation	Complete	Indirect	Increase overall farming efficiency; increase irrigation and fertilization uniformity
Water supply	Complete	Mostly indirect Direct	Define water quality parameters for proper irrigation management Use of back-flow prevention device
Frost and freeze protection	Needs updating	Direct	Reduce leaching risk from frost protection irrigation
Tail water recovery systems	Extensive	Indirect	Creates structures for recycling drainage water and run-off
Tail water reuse and waterborne pathogens	Incomplete	Direct	Recycling drainage water and run-off
Tissue testing	Extensive	Indirect	Monitoring tool for fine-tuning fertilization
Double cropping	Extensive	Mostly indirect	Increase cost-efficiency of production Traps residual fertilizer
Cover crops	Incomplete	Indirect	Traps residual fertilizer, adds nitrogen to the soil (legumes), increases soil organic matter content
Conservation crop rotation	Complete	Indirect	Management of air-borne and soil-borne pathogens

Table 3. Supporting research, expected impact on water quality and benefits of proposed BMPs.

Proposed fertilization and irrigation BMPs	Supporting research in Florida	Expected impact on water quality	Society, Grower, and Environmental Benefits
Soil survey	Complete	Remote	Increase overall farming efficiency
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