December, 2002

Issue No: 3

UF/IFAS Nutrient Management Education Core Group

Soil & Water Science
University of Florida
PO Box 110290
Gainesville, FL 32608

PHONE:
(352) 846-3833

FAX:
(352) 392-3902

Editors: Rao Mylavarapu
Susan Curry

E-MAIL:
RaoM@ufl.edu
Scurry@ufl.edu

UNIVERSITY OF FLORIDA

Institute of Food and Agricultural Sciences

Background

Federal, state and regional agencies are working towards formulating regulations for agricultural operations to reduce nonpoint nutrient source pollution for water quality protection. Several of our IFAS faculty are currently involved with these agencies for developing Interim BMPs for various commodities. In all cases these efforts are interdisciplinary requiring frequent interaction among the UF/IFAS faculty statewide. Several of us feel the need for a stronger coordination among IFAS faculty in responding to these needs. The creation and successful functioning of the proposed Nutrient Management Core Group will enhance the credibility of UF/IFAS faculty and educational resources and create a nodal point for liaison with all the agencies and public that are interested in the issue. Several land grant institutions have formed similar core groups or self-directed teams and have developed educational material. We will interact with these institutions to benefit from their expertise and experience.

In February of 2001, this group coordinated the FDEP319 Prioritization meeting in Gainesville. This meeting was attended by state agencies and water management districts, growers, many commodity organizations and IFAS faculty and administration. All comments from this meeting were compiled in an electronic newsletter and distributed to all participants throughout the state.

Training for Comprehensive Nutrient Management Planning for Third Party Vendors

Susan Curry, Soil & Water Science Department

Principal investigators for this project are Rao Mylavarapu, Randall Brown, and Roger Nordstedt. The goal of this project is to provide training for members of approved third party organizations and others desiring to

be trained in one or more of the first three of six elements described in the USDA-NRCS Comprehensive Nutrient Management Planning Technical Guidance. Specifically, the two elements in which participants will receive training are Nutrient Management and Land Treatment Practices. Trainees will have the opportunity to become Certified Specialists in these two areas. Also, educational programs dealing with the rationale, concepts, and particulars of nutrient management will be targeted to farmers and ranchers, agency officials, decision-makers, and other citizens who need to become knowledgeable in nutrient management problems and solutions in Florida.

A CD was developed which included the reference materials suggested by speakers, the presentations and a draft excel spreadsheet for the Florida Phosphorus Index.

Two Nutrient & Pest Management Module 7 - Florida Practicum Training Courses were delivered in June at the USDA Service Center in Okeechobee and in November at the Suwannee County Water Management District. These courses were intended for those seeking certification to complete Comprehensive Nutrient Management Plans (Nutrient Management & Land Treatment Practice Elements), Conservation Plans, Nutrient Management Plans, and/or Pest Management Plans. This course was provided at no charge to candidates who are actively seeking certification. Prior to taking this course the participants should have successfully completed “Introduction to Water Quality”, and “Nutrient & Pest Management Modules 1 – 6” courses offered by the USDA Natural Resources Conservation Service. These self paced courses are located on-line at: http://www.nedc.nrcs.usda.gov/.

Our first courses had over 60 participants. Presenters for the course included Rao Mylavarapu (IFAS), Randy Brown (IFAS), Roger Nordstedt

Training Continued page 19

Nutrient Management for Tropical Fruits and Vegetables in South Florida

Yuncong Li, Tropical Research and Education Center, Homestead

Lychee tree

Lychee flower

Lychee fruit

A soil and water science faculty member, Yuncong Li and his collaborators conducted various experiments on nutrient management for tropical fruits, winter vegetables and ornamental crops at Tropical Research and Education Center located in Homestead. In this article, we present brief summary of two of their research projects to illustrate their contribution in south Florida:

1. Optimizing fertilizer practice to improve lychee flowering: Lychee (Litchi chinensis Sonn.) is gaining popularity in American markets and is becoming a high value crop in south Florida. However, unreliable flowering and yield seriously impact on lychee production. Flowering normally follows cold or drought stress. Under warm weather, high rainfall and excessive nutrients cause unreliable flowering and fruit set. Although growers have no control over the weather, they can optimize flowering by managing the vegetative vigor of trees. When excessively watered and fertilized, lychee trees grow vigorously and produce vegetative flushes every two or three months. The lack of maturity of late vegetative flushes in the late fall or early winter prevents flowering in January and February. Vegetative flushes in late fall can be prevented by restricting nitrogen in summer. Thus, through proper nitrogen fertilizing, growers can achieve abundant flowering. Our results demonstrated that the timing and rate of nitrogen fertilizer significantly affected soil and leaf nitrogen status. High nitrogen concentrations in the leaves were associated with vegetative flushing and reduced flowering and yield.

2. Phosphorus nutrition management in calcareous soils. Calcareous soils induce an array of nutritional problem for crops and phosphorus (P) is one of them. Application of P fertilizer is important for vegetable production on calcareous soils. However, most growers apply too much P fertilizer for their crops. Over-fertilization leads to unnecessarily high production costs, may decrease yield and quality and poses a risk to the environment. In order to understand P chemistry and to make fertilizer recommendation for calcareous soils in south Florida, several laboratory and field experiments have been conducted. Soils from many farming fields were saturated with P and excessive P applied as fertilizer often precipitate and become less available to crops (Fig. 1). Apatite was formed in calcareous soils which were applied a large amount of P fertilizer over years (Fig 2). Field experiments conducted in Miami-Dade County showed that phosphorous fertilization increased AB-DTPA extractable P in the soil but did not affect the concentration of leaf P, yield and quality of crops (tomato and potato). For additional information on these experiments contact Yuncong Li (Yunli@mail.ifas.ufl.edu).

Yuncong Li and Rao Mylavarapu discuss a tomato field experiment in Homestead.

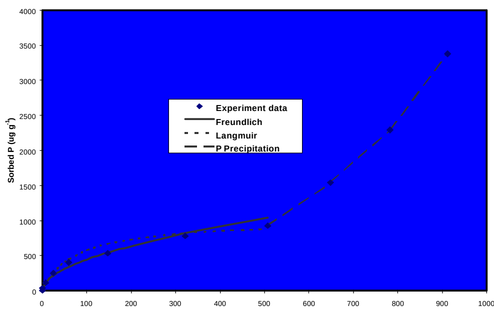


Fig. 1. Freundlich and Langmuir P sorption isotherms and P precipitation of a calcareous soil.

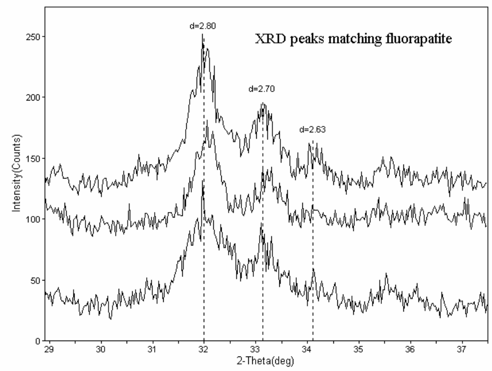


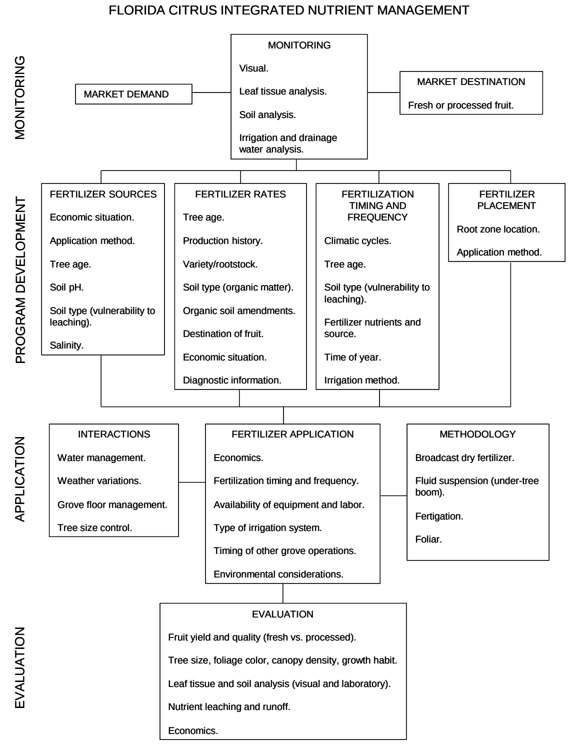
Fig. 2. Apatite formed in 3 calcareous soils which were farmed for many years

Prioritizing Citrus Nutrient Management Decisions

Thomas Obreza, Soil and Water Science Department

Citrus nutrient management is comprised of four components that cycle through a production season: ***Monitoring*** (visual observations of tree performance and checking leaf and soil analysis results); ***Program Development*** (deciding what nutrient sources to use, the rate, timing and frequency at which nutrients will be applied, and where the nutrients will be placed); ***Application*** (methods used to apply fertilizers); and ***Evaluation*** (determining whether the desired crop response was achieved).

Ideally, a citrus nutrient management plan will provide maximum yield and fruit quality while minimizing the potential for water quality impairment. Nutrient management becomes a complex subject when considering all factors that can affect program development and fertilizer application. In the current economy, citrus grove managers must prioritize their activities because they are being asked to accomplish more tasks than ever before with fewer people, reduced resources, and less time. When faced with a multitude of decisions to make, how does a manager decide where to place the most emphasis?



Citrus tree sensitivity to shortages or excesses of individual nutrients differs depending on the nutrient. For example, manganese deficiency does not affect production nearly as much as nitrogen deficiency. Similarly, an excess of boron affects fruit quality more than an excess of magnesium. In the 1960s, researchers at the CREC in Lake Alfred grew pineapple orange trees on a previously non-fertilized deep central Florida sandy soil and omitted single essential nutrients from the fertilizer program (the N omission treatment was not zero N, but half of the full N rate). They found that citrus yield was most sensitive to omission of N, K, and P, and least sensitive to omission of the micronutrients. It took 7 years for omission of micronutrients to show negative effects.

When experimenting with mature flatwoods citrus trees that were well fertilized in their non-bearing years, we showed that good water management alone provided about 30 to 40% of maximum yield. When we added sufficient amounts of N and K fertilizer to good water management, production reached or surpassed 90% of its maximum. Thus, the remaining 10% or less of a grove's yield potential was attributed to the combined effect of the remaining 11 essential elements. It is important to recognize that the groves where we conducted N and K experiments had lime, P, and micronutrient fertilizers applied to them when the trees were young.

If citrus is most sensitive to water, N, and K, then nutrient management decisions should concentrate on improving their management before considering other factors. For example, if a grove is micro irrigated, how uniform is the water distribution from sprinkler to sprinkler? Are there any plugged emitters? If a grove manager chooses to fertigate a significant portion of the N and K (a recommended BMP), it is important to check the irrigation system uniformity. If the system tests below 80%, corrective action should be implemented to even out the nutrient distribution.

What about N and K_2O fertilizer rates? In our research, we have obtained maximum yield in flatwoods citrus groves using N rates within the currently recommended range of 160 to 240 lbs N per acre per year. When we used coated, controlled-release fertilizers, rates could be lowered because nutrient use efficiency increased. Our current work with P and K fertilizer rates suggests that K influences citrus yield on the same order of magnitude as N. However, citrus is not very sensitive to P fertilization on a flatwoods soil, especially if P has accumulated in the soil from previous fertilizer applications.

In summary, when prioritizing nutrient management decisions, grove managers should recognize the relative sensitivity of citrus to various nutritional factors in their groves, and concentrate on improving the most sensitive ones first.

Nutrient Management and Water Quality in Southwest Florida

Rosa M. Muchovej, Southwest Florida Research & Education Center, Immokalee

Application of Biosolids to Bahiagrass Pasture in Southwest Florida: Impact of grazing on forage, soil, and water quality.

Grasses, when utilized as feedstuffs for livestock, are particularly attractive targets for waste utilization because they are typically under-fertilized. Additionally, the use of livestock as an intermediate consumer of crops subjected to organic waste application will attenuate potentially toxic trace element effects to humans. Proper timing of pasture applications will also reduce the amount of biosolids adhering to the forage and allows possible pathogens to die-off before grazing or harvesting. Late winter or early spring application will usually reduce potential harmful effects of biosolids. There are currently over 12 million acres of grassland in Florida that require fertilizer, of which 5 million are planted with bahiagrass (Paspalum notatum Flugge). Most of the grasslands show signs of N and Fe deficiencies. Adequate fertilization practices are an essential part of pasture grasses management and N is frequently the most limiting nutrient for production.

Previous work with biosolids has shown that biosolids are capable of supplying as much N to bahiagrass as commercial fertilizers without impairment of forage or soil quality. Determination of an environmentally safe rate of biosolids for application to bahiagrass pastures (for hay and grazing) on Southwest Florida mineral soils will contribute to lower fertilizer inputs, improved forage quality and quantity, and improved soil conditions.

Water quality degradation by nitrate, phosphorus, and trace metals is of special concern worldwide. In the state of Florida the concerns are even greater due to the predominance of extremely sandy soils, abundant rainfall (high intensity), frequently shallow ground water tables and heavy reliance on ground water as a domestic and municipal drinking water source.

The overall objective of this project is to incorporate production agriculture into a municipal biosolids management program that combines forage and cattle production designed to reduce dependence on commercial fertilizers, improve profitability, maintain or improve environmental quality, and educate the public concerning the benefits of biosolids. Specific objectives are: 1) to determine the rate of municipal biosolids application required to obtain optimum yield and quality of bahiagrass under no-grazing and under a grazing rotational system; 2) to evaluate potential environmental impacts of biosolids applications to pastures in Florida, on water quality of shallow ground water aquifers; and on runoff water; collected in the fields; 3) to determine the extent of trace metal accumulation in the soil profile and plant availability of heavy metals from biosolids application to pasture grasses; and 4) to compare the

biosolids with commercial fertilizer as a source of N and a supplier of other essential nutrients.

The 3-yr study was set up in a commercial ranch in Hendry Co., Fl, on established bahiagrass pastures growing mostly on Immokalee fine sand in South Florida to determine the release (mineralization) of nutrients, especially N, and plant uptake of nutrients and metals from biosolids and to evaluate impacts of biosolids on water and soil quality. The biosolids originated from municipal wastewater treatment facilities and had been process-stabilized to a "B" classification. Varying rates of biosolids (ranging from 0 to 20 tons/acre), depending on previous analyses of the materials employed, were applied. Rates of biosolids were determined based on total N content of the material and the highest rate tested should provide up to 320 lb N/acre. This rate is up to 3 times greater than recommended N rates for grazed bahiagrass pastures. Commercial N fertilizer at the rate of 80 lbs N/acre (IFAS recommendation for medium forage production), in the form of NH_4NO_3, is being used as a check to determine the rate of biosolids which will provide that quantity of N to the plants. Treatments were applied to bahiagrass pastures in the spring, year 2001, because that is when the supply of biosolids is high and animals are not intensively grazing (decrease direct ingestion of potentially harmful trace metals).

For the grazed plots treated with biosolids, three treatments (0, 80, and 320 lbN/a) were randomly assigned to 20 field-scale plots, of at least 2 acres in size, with 5 replications of each treatment. Beef cattle (cow/calf) rotationally graze (1 week on, 3 weeks off) the study site from May to October of each year at a stocking rate based on the carrying capacity associated with forage produced. Data will be analyzed using repeated measures analysis with continuous variables fitted to polynomial models.

Soil samples are also collected periodically, especially following rain events, at 6-inch increments to a depth of

Continued page 5

Continued from page 4

18 inches, during the growing season. These samples are analyzed for NH_4, NO_3, and for all major (S, P, K, Ca, and Mg) and micronutrients (Fe, Mn, Cu, Zn, and B) as well as selected trace metals (Pb, Cd, Ni).

The treatment plots were sized, located and oriented to attempt to avoid cross-contamination of ground water beneath the plots. A shallow (24 inch depth) and deeper (48 inch depth) ground water well was installed in each of the 40 experimental plots. A runoff sampler was also installed at the soil surface level in each experimental plot. The water is analyzed for the elements determined in the soil samples.

Ground water and surface "sheet flow" water was sampled every 35 days following the application of biosolids to bahiagrass pasture. There are two separate sub-studies conducted at the same time: (A) small plots (10' x 20') ungrazed study and (B) larger plots (2 acre) grazed study. Each study includes the same treatments with 5 replications. The treatments are 80 lbs. N/ac as ammonium nitrate, 160 lbs. N/ac as biosolids, 320 lbs. N/ac as biosolids, and 0 lbs. N/ac as a check. Each of the two studies contains 20 plots, for a total of 40 sampling plots. The treatments were applied to specific plots in May 2001. Each plot will receive the same treatment in the spring of the next two following years. The May 2001 application marked the beginning of this 3-year experiment. The 40 sampling plots are visited for water sampling every 35 days since May 2001.

At the low end or corner of each plot a permanent GKY First-Flush Sampler[1] was installed for trapping surface "sheet flow" water after a significant rain event. One week prior to the scheduled water-sampling week, the 5-L sample container inside the First-Flush Sampler is cleaned and rinsed with R. O. water. If significant, but not flooding, rainfall occurred prior to or during the water-sampling week, the collected surface "sheet flow" is recorded.

In the center of each plot, two permanent ground water collection wells were installed (24" and 48" depth). Water table height is recorded. Chain of custody records are kept one each sample.

Each water sample collected was tested in the field for pH, temperature and electrical conductivity.

Each water sample collected from the field and each QA standards, spikes, and blanks is tested for the following: TKN digestion and N analyses; NO3-N, NH4-N analyses; Ortho P - Colorimetric P analyses; Dissolved total P - digestion and P analyses; Total P - digestion and P analyses; Metal analyses – K, Ca, Mg, Zn, Mn, Cu, Fe, Al, B, Ba, Cd, Mo, Ni, Pb, Na, and Cr.
Data from the first year (2001-treatment year) have been collected and are now being analyzed. A second application was performed in May 2002 and the same methodology used in 2001 is being followed.

The results of this project will help determine the optimum application rate of biosolids for pastures based on forage production and quality, ground water quality, surface flow water quality, and concentrations of trace metals in soil and plant tissue. Information gleaned from this project will assist government agencies in conservation and land use planning as it relates to the application of biosolids.

Nitrogen fertilization of sugarcane on a mineral soil
The response (yield and tissue composition) of sugarcane variety CP781628 to three N rates (150, 250, and 350 lb N/acre), in 4 split applications is being evaluated on mineral soil for plant cane and two subsequent ratoon crops. The experimental design is a completely randomized block, with 4 replications.

The study was initiated in July 1999, with field preparation. The 12 plots (50 ft x80 ft) were planted to sugarcane variety CP781628 in Dec. 1999, when the first split application was done. Subsequent N applications were done in April, June and August, of each year. Stalk counts are done in November. Yields (tonnage and sucrose) were determined for the plant cane in January 2001. Complete cane removal was accomplished in February. Soil was sampled from the 0-6 and 6-12 in depth in the end of February and treatment application on the first ratoon crop started in March.

Ground water wells were installed in every plot and samples were collected monthly, if water was present in the wells, from March until December of each year. In the winter months the water table remains extremely low. Water samples are analyzed for pH, temperature, conductivity, NH_4-N, and NO_3-N. Leaf tissue and soil samples (from 0-6 and 6-12 in) are collected approximately every 4 weeks post treatment application. Leaf tissue is analyzed for N, P, K, Ca, Mg, Zn, Mn, Cu, Fe, B, and Na and soil is tested for P, K, Ca, Mg, Zn, Mn, Cu, Al, Na, Fe, pH, Cl-, NH_4-N, NO_3-N and organic matter. First stubble sugarcane yields (tonnage and sucrose) were determined in January 2002 and total crop removal was completed by mid-January. The same

Continued page 6

Continued from page 5

experimental procedures are being employed in 2002, for the second stubble crop. The sugarcane should be harvested by January 2003 and all data collection will be completed shortly thereafter. Preliminary results have been presented to growers at growers' meetings and advisory committee meetings. Growers may be able to reduce current N fertilizer applications on sugarcane produced on mineral soils.

Agro-Ecosystem Indicators of Sustainability as Affected by Cattle Density in Ranch Management Systems This project, known as the "Buck Island Research Project" is a cooperative effort between UF-IFAS, the Archbold Biological Station, the South Florida Management District, and USDA. The project is investigating the effects of variable cow-calf stocking rates on water, forage, and soil quality, as well as microbial communities, nematodes, and birds. Forty- (summer) and 80- (winter) acre experimental pastures were built and flumes were installed for collection of water samples and monitoring of water quality.

Forages Sub-project: To study the effect of cattle stocking rate on seasonal forage biomass production, quality, and utilization in summer and winter pastures. The specific objectives are: 1) to measure seasonal forage production from summer and winter pastures relative to the stocking rate treatments; 2) to quantify the crude protein and phosphorus concentrations present in the forage during the grazed and non-grazed periods. The study includes two pasture systems: winter range and summer improved pastures. In the winter pastures, the stocking rates are 0, 2.3 (high), 4.0 (medium), and 5.3 (low) acres per cow. In the summer pastures, stocking rates are 0, 1.4 (high), 2.5 (medium), and 3.3 (low) acres per cow. The cattle were placed in the winter pastures in January 2001, were temporarily moved to summer pastures in February due to water problems, and returned to the winter pastures in March. Summer pastures were fertilized in April, and the cattle were moved to the summer pastures in May, where they remained until October, when the calves were separated from the cows. In November, the cattle were moved to the winter pastures.

Forage samples were collected within summer and winter pastures from a grazing exclosure cage, representing ungrazed forage accumulation, and from an area in proximity to the cage (paired plot), representing the standing forage after grazing. For the summer pastures, forage was sampled monthly (June-September) while cattle were grazing and then every other month when cattle were grazing the winter range. Forage sampling in the winter pastures occurred every three months, regardless of cattle presence. All forage is clipped at ground level, weighed, and then a sub sample is dried in a forced air oven to determine percent dry matter and for forage analysis. Each sample is ground and analyzed for crude protein, digestibility, and phosphorus at the Forage Nutrition Laboratory at the University of Florida. Botanical composition is recorded for each pasture at each sampling period.

Results obtained thus far indicate that stocking rate effects on forage production and quality were minimal for both pasturing systems. For all stocking rate treatments, percent forage utilization averaged about 30-40% in the summer pastures and 20-30% for the winter pastures. Higher utilization levels were expected, given that the high stocking rates for both pasture systems were above industry levels where ranchers expect much higher utilization (50% or higher) of the available forage. This information does indicate that forage availability should not be a problem for cattlemen who graze pastures at stocking rates used in this experiment. Forage production levels for both summer and winter pastures approached levels that ranchers achieve. In some months there was a trend toward lower forage yield with increasing stocking rate, but this trend was not consistent. Forage quality was independent of stocking rate. In some months higher forage quality was observed from the grazed areas compared to the non-grazed areas. Crude protein levels approached expected levels, but IVOMD seemed lower than expected. Phosphorus levels were higher in the bahiagrass compared to the forage from the winter pastures. This is probably due to past fertilization of the summer pastures and subsequently higher soil levels. With the stocking rates evaluated in this study, forage production was adequate to support long-term beef production. Forage quality levels were seasonal, and supplementation would be needed at certain times of the year. The data generated from this project provide information regarding stocking rate effects on forage biomass, composition, and quality to be used by ranchers and various agencies to implement better management practices for Florida's beef cattle industry.

Stocking rates have been found to have no effect on nutrient loads or concentrations. Summer pastures have higher nutrient loads than winter pastures and nutrient concentrations appear to be more stable in the summer pastures but are variable in the winter pastures due to annual runoff volume fluctuations. More details can be obtained at the following web-site: http://www.agen.ufl.edu/~maerc/

Update on Improved Nutrient Management Practices for Leatherleaf Fern

Robert H. Stamps, Mid-Florida Research & Education Center, Apopka

Leatherleaf fern is the predominant cultivated cut foliage (florists' green) crop produced in the United States and Florida accounts for 97% of that production. This shallow-rooted herbaceous perennial is grown under shade on highly permeable soils. The high leaching potential of these soils places ground water at risk of nitrate nitrogen contamination. Furthermore, commercial fertilization practices consist mainly of applying water-soluble nutrients using solid-set overhead irrigation systems. Due to these factors, research and extension efforts have been conducted for many years to develop management practices designed to reduce the potential for groundwater contamination and to educate the growers about this potential problem.

As many of you may be aware, components of the research effort have included literature reviews, grower survey, lysimeter studies, field studies at new and established ferneries, and other experiments looking at specific nutritional needs of the crop. The grower survey was used to characterize the leatherleaf fern industry by collecting respondent, fernery, irrigation system, management practices and financial information. The economic aspects were important because only economically feasible solutions were practical.

Research using gravimetric lysimeters and micrometeorological monitoring equipment were conducted in an established fernery. These studies measured crop water use and effects of fertilization and irrigation scheduling setpoints on nitrogen (ammoniacal, NO_x, total Kjeldahl) leaching.

Replicated experiments using liquid and controlled-release fertilizers were carried out at a field shadehouse research facility in the heart of the fern production area. That facility was open to the industry to come and look at the treatment effects. At that site, nitrogen concentrations in the root and vadose zones, as well as in the surficial aquifer, were monitored.

Additional field studies were conducted at two commercial ferneries — one that was just being planted and one that had been in production for years. Nitrogen concentrations at the top of the surficial aquifer were monitored at these sites.

Experiments that utilized leatherleaf fern growing in containers were conducted to assess the effects of specific nitrogen sources and micronutrients on leatherleaf fern fronds. The market demands that fronds be dark green and have good vase life characteristics.

Currently, we are in the process of determining whether or not the recommended nutrient and irrigation management practices work under commercial conditions. We are monitoring groundwater nitrate nitrogen levels with five multi-level samplers at six commercial sites in three counties.

In all these projects, efforts were made to point out that the data collection efforts were for research purposes, *not regulatory ones*. In addition, frond yield and quality (color and vase life) were also regularly determined so that any adverse effects on the crop would be detected.

Throughout this process, extension programming has been an important component. Activities have included "town" meetings, newsletter articles, field days, presentations, workshops, personal letter writing and on-farm visits.

A hollow-stem auger was used to install the multilevel samplers.

Multilevel samplers and piezometric wells have been installed in six commercial ferneries.

A Nutrient Management Plan Support (NUMAPS) system for Florida crops

J.M.S. Scholberg, H. W. Beck, S. Grunwald, T. Shatar, and T. A. Obreza, Agronomy/Soil & Water Science

In Florida, the majority of drinking water wells that exceed Maximum Contaminant Levels (MCL) values for nitrate-N are located near agricultural production areas. Most Florida soils have poor water and nutrient holding capacities and are prone to nutrient losses due to leaching and/or runoff. Current advances in computer technology provide scientist with unique opportunities to develop decision support systems (DSS) that will allow farmers to take full advantage from advances in information technologies to improve the efficiency of their production system.

Historically, fertility research focused on maximizing yield, but such an approach is no longer adequate to address current environmental concerns. The lack of information on root interception capacity of Florida cropping systems is somewhat surprising since in many cases root systems are the most effective defense mechanism by which nitrogen contamination of the groundwater can be prevented. Fertilizer recommendations for most Florida crops, including citrus, forages, and vegetable crops are based on a limited number of rate studies, and are standardized over large production areas and/or management systems. Such approach will provide some general information on overall crop nutrient requirements, but it will not allow us to improve our understanding of the dynamic processes that control non-point source pollution associated with agriculture. Neither will it allow farmers and producers to take advantage of the capacity of root system to intercept nutrients before they become a threat to the environment. Although scientists have developed models that assess nitrogen uptake and leaching for agricultural production systems, the complexity and scope of most of these models confines their application to academic end-users.

Previous work in citrus allowed the development of a “temperature N uptake sum” concept. Using this approach soil temperature effects on N uptake rates can be accounted for, and universally applicable uptake functions, similar to the degree day concept used in IPM, can be developed. Such functions will define the crop’s effectiveness to remove nitrogen from the soil solution based on soil temperature and initial soil nitrogen concentrations. The longer nitrogen is kept within the root zone via appropriate irrigation management practices, the greater the uptake efficiency will be. A better understanding of crop nitrogen uptake dynamics will allow growers and farmers to improve nitrogen uptake efficiency, and thereby reduce fertilizer cost and the impact of agriculture on environmental quality.

Use of current computer technology will allow development of decision support systems (DSS) that are specifically designed as a management tool for growers. An example of an existing DSS in Florida is the Decision Information Systems for Citrus (DISC). This system includes functional modules to assist growers with application of agrochemicals and also include record keeping tools. We aim to extend this work and to take full advantage of current advances in computer technology to link scientific and site-specific information via user-friendly Nutrient Management Plan Support (NUMAPS) System. This NUMAPS system will provide optimal nutrient, irrigation and/or other crop management recommendations for a number of Florida crops including citrus, tomato and forages. Dynamic computer modules will be developed to calculate site-specific fertilizer recommendations based on diagnostic soil samples and plant tissue values, target yields, production practices, soil characteristics, and weather conditions These modules will form the building blocks and will be integrated into a versatile and grower-tested decision support system which will facilitate more efficient transfer of scientific information to the agricultural producers. Florida Automated Weather Network (FAWN) data will be combined with a state-wide digital soil database to provide default values for weather and soil information, for specific production units and will be used to assess soil water storage capacity, crop nutrient and water uptake, nutrient leaching, and runoff. Site-specific soil information such as depth to confining layers, soil water holding capacity, and drainage features along with information from on-farm weather stations, and/or soil water monitoring devices can be used to complement and/or refine this information. In this manner we aim to provide growers with a powerful nutrient and irrigation management tool.

However, except for citrus, critical information required for development of such system is greatly lacking. Additional work will thus be required to develop generic irrigation management tools, nitrogen uptake, and nitrogen management modules to provide a scientific basis required for development of the NUMAPS system. A team of UF scientists initiated the development of the NUMAPS system for citrus during the spring of 2002. Members of this team will implement a series of greenhouse and field studies to develop comprehensive information pertaining to root growth, N uptake and accumulation patterns for other Florida crops at selected locations throughout the state. This information will be used for ongoing development and validation of the NUMAPS system.

Acknowledgement This work is being funded by Florida Department of Environmental Protection (FDEP) and the Florida Department of Agriculture and Consumer Services

Best Management Practices to Reduce Nutrient Loadings in Surface Runoff from Agricultural Land

Z. L. He, D. V. Calvert, P. J. Stoffella, and Y. C. Li
Indian River Research and Education Center, Fort Pierce

Water quality throughout south Florida has been a major concern for many years. Best management practices (BMPs) have been proposed to improve water quality in the surface runoff from the agricultural land and to restore degraded water systems in the Indian River area. A field study was initiated in 2000 to investigate effects of the BMPs on nitrogen (N) and phosphorus (P) loadings in surface runoff and fruit yield and quality of citrus. The BMPs implemented included replacement of 100 % dry application of water soluble granular blend fertilizer (conventional practice) with 50 % fertigation and 50 % dry application. Surface runoff samples were collected using a portable autosampler that was installed in the field. The BMPs tended to reduce N and P concentrations in surface runoff. The differences in N and P loadings were not significant between the BMPs and conventional practices because of great variation in discharge rates affected by field conditions. There was no significant difference in fruit yield between fertigation plus dry application and dry application alone. The BMPs (fertigation) may have beneficial effects on fruit quality, depending on types of soil and size of the crop.

Study on Soil Chemical Properties and their Spectral Characteristics in Florida

W. S. Lee, J. F. Sanchez, R. S. Mylavarapu, J. S. Choe
Agricultural & Biological Engineering/Soil & Water Science

A study was conducted to develop fundamental relationship between soil properties from 4 representative soil orders in Florida and their spectral characteristics. The ultimate goal of this work is to develop a real-time soil property sensor for use in effective farm management. A total of 270 samples were collected from the three representative soil orders (Alfisol, Entisol, and Ultisol), and were used for analysis. Soil samples were obtained from 0-15.2 cm depth at 15 sampling locations in 3 replications. Reflectance of the soil samples was measured in the range of 400-2498 nm and the corresponding nutrient content (P, K, Ca, and Mg) along with pH, and soil organic matter content were measured for each of the samples. Partial least square analysis was used to build prediction models with a calibration data set of randomly chosen 180 samples. The remaining 90 samples were used to validate the models. The prediction models for measured soil chemical properties for 3 soil orders yielded R2 values of 0.24~0.88. This result could further be used toward development of soil nutrient sensor for site-specific crop management.

Development of the Green Industries Best Management Practices

L.E. Trenholm, Environmental Horticulture Department

According to recent estimates, there are approximately 4 million acres of home lawns in the state of Florida at this time. Of this, roughly 1 million acres are maintained by a professional lawn care service. Due to the high visibility of this industry and increased concerns about the fate of nutrients and pesticides applied to residential lawns, the home lawn care industry has often been targeted as a primary source of nitrate and or phosphate pollution of ground or surface waters. Because of this perception, a number of municipalities have developed localized legislation to regulate the lawn care industry, often without any scientific guidance.

In response to these recurring issues, the Green Industries Best Management Practices (BMP's) have recently been developed. Participants involved in this process included representatives from industry, the Department of Environmental Protection, Water Management Districts, and IFAS. Regular meetings of the steering committee began in the summer of 2000, where a loose, generalized outline for the content was adopted from the Professional Lawn Care Association of America BMP document.

Four committees were established to develop the content for the manual: Irrigation, Fertility, Other Cultural Practices, and Pesticide Safety. Information was included on establishment of turf and landscape areas as well as established turf and landscape areas. Although the basic objective of the manual was preservation of Florida's ground and surface waters, general maintenance regimes were included to the extent that they were an integral component of turf and landscape management. Committees met as needed to develop their modules and the steering committee met every other month to review information. While the thrust of the content is general material, specific recommendations for irrigation and fertility rates can be found in the manual.

One difference in the Green Industries BMPs from some other commodity groups is the absence of rule typically found in other commodities BMPs. Since the applicator in this case is generally not the landowner, no formal rule can be applied; however, the manual still carries the endorsement of DEP and implies proper procedure. Since the entire development process was largely industry-driven, it is apparent that concerns throughout industry for conforming to these BMPs is high and, hopefully, compliance will be high as well.

Some specific recommendations:

- When applying water-soluble nitrogen sources, only apply up to 0.5 lbs of N 1000 ft^{-2}.
- Slow release, or fertilizers containing at least 30% slow release nitrogen, may be applied at rates of up to 1 lb N 1000 ft^{-2}.
- Higher fertilizer rates may be used to help turf recover from injury or during turf establishment.
- Do not fertilize if heavy rains are forecast within 48 hours.
- Irrigate to replace water as needed by turf. In most cases, this will be ½ -3/4 in. of water per irrigation at each application. Application frequencies will vary depending upon location in state, soil type, time of year, grass species, and effects of microenvironment.

Some general recommendations:

- Fertilizer spills should be swept up rather than hosed down.
- Grass clippings can be left on the lawn, where they will not contribute to thatch, but can provide a source of recyclable nutrients.
- When fertilizing near water bodies, deflector shields should be used. If shields are not used, increase the distance of fertilized areas.

The next component of the Green Industries BMP development is to design a training manual to actually provide training for up to 15,000 lawn care and landscape workers over a 2 year period. This basically explains to them how to use the manual properly and how it will affect how they do business. A series of train-the-trainer In Service Workshops have been scheduled beginning in Jan 2003. After completing the workshop, agents will then conduct their own training programs over a 2 year period.

Long-Term Testing of Possible Fertilization and Irrigation BMPs for Watermelons Grown in North Florida

Eric Simonne, Michael Dukes, Robert Hochmuth, George Hochmuth, David Studstill and Wayne Davis
Horticultural Sciences and Agricultural & Biological Engineering

With approximately 142,000 ha, the vegetable industry in Florida has an estimated annual value of $1.2 billion. Together with tomato (40,000 acre, $500 million), bell pepper (20,000 acre, $300 million), and strawberry (7,000 acre, $160 million), watermelon (45,000 acre, $45 million) is an economically important vegetable crop for Florida . These crops are intensively grown with plasticulture (raised beds, polyethylene mulch, and drip irrigation).

Increased environmental concerns supported by reports of high nitrate levels in springs and streams throughout Florida, have resulted in the passage of the Surface Water Improvement and Management (SWIM) Act of 1987 (chapters 373.451-373.4595 of Florida statutes) by the Florida legislature. Together with the provisions of the Federal Clean Water Quality Act of 1977 (public law No. 95-217), the SWIM Act created a program which focused on preservation and/or restoration of the state's water bodies through the development and implementation of Best Management Practices (BMPs). BMPs are irrigation and fertilization practices designed to produce economical marketable crop yields while minimizing the environmental impact of crop production.

This new round of legislation was not welcomed by the vegetable industry in Florida. Growers, who already did not believe that economical yields could be produced with the fertilization recommendations of the Institute of Food and Agricultural Sciences (IFAS), requested reliable data documenting the impact of current production practices on water quality. Growers also question the relevance of using the EPA drinking water standard (10 ppm NO3-N) as the threshold for discharge monitoring, because the fate of nitrates below the root zone are unknown, and no one drinks water just below the root zone of vegetables. Because limited information was available to document the joint effect of current IFAS fertilization and irrigation recommendations on watermelon yields and their impact on nitrate leaching on a sandy soil, a large-scale field project was conducted between 1998 and 2002. The objectives of this project were to (1) determine whether commercial yields of watermelon could be produced when IFAS recommendations are followed, and (2) document the impact of these recommendations on nitrate levels below the root zone of watermelon.

The field was located at the North Florida Research and Education Center - Suwannee Valley, near Live Oak, FL where the soil is a Lakeland fine sand. Except where otherwise mentioned, cultural practices were similar for 1998, 2000, 2001 and 2002. Crop sequence was a spring watermelon, followed by a fall double crop. Each year, a rye cover crop was grown from October to February. Five-week-old watermelon transplants were established at a within-row spacing of 3 ft, onto beds spaced 7.5-ft apart. This created a plant stand of 1,900 plants/acre). Selected varieties were ›Royal Sweet= in 1998 and 2000, and ›Mardi Gras= in 2000 and 2001. High-density, black polyethylene mulch and drip tape (24 gal/100ft/hr; 12-in emitter spacing) were used as typically done in commercial fields in North Florida. Transplanting dates were 26 Mar. 1998, 21 Mar. 2000, 27 Mar. 2001 and 26 Mar. 2002.

Current IFAS irrigation and fertilization recommendations for watermelon production in Florida were followed. Based on soil test results, fertilization recommendations were 150-0-150 (N-P2O5-K2O). Fertilization consisted of a preplant application of 50 lbs/acre of nitrogen (N) and potassium (K2O), and of weekly injections of liquid 8-0-8 at daily rates ranging from 1 to 2.5 lbs/acre/day of N and K2O that provided the remaining N and K. In 1998, 2000 and 2002, the preplant fertilizer source was either 13-4-13 (›inorganic=) or chicken manure (1.5-2-2, ›organic=). In 2001, the only source of fertilizer was 13-4-13. Irrigation was applied once a day for one to three hours so as to maintain soil water tension (SWT) in the 6-to-12 inch zone between 8 cb (field capacity) and 15 cb. SWT was measured with tensiometers. Watermelons were harvested twice when they reached commercial maturity on 29 May and 9 June, 1998, 1 and 6 June, 2000, 7 and 20 June, 2001, and 23 May and 7 June, 2002. Each year, soluble solid levels were determined on eight representative watermelons from each plot from the first harvest using a hand-held refractometer. Soluble solid levels are an indication of sweetness. Watermelon with soluble solids below 10oBrix do not taste sweet.

Nitrate levels in ground water were determined every three weeks at the 4-ft depth with suction lysimeters (one per plot) and at the 20-ft depth with four shallow wells located at the edges of the field. An additional control well was placed approximately 1,500 ft up-grade from the field in a non-fertilized area under natural vegetation. Suction cup lysimeters consisted of a porous ceramic tip connected to an air-tight buried chamber that was accessible through two sealed tubes. Lysimeter operation consisted of two steps. First, a soil-water sample was collected by creating a vacuum inside the chamber with a hand-held pump. Water moved from the soil into the chamber through the porous cup because of the difference in pressures. Then, 24 hours later, samples were retrieved by placing a collection

Continued page 12

Continued from page 11

bottle at the end of one tube, and by blowing air into the other one. All suction cup lysimeters were placed at the center of one of the plastic-mulched beds. Lysimeter and well samples were refrigerated, acidified and promptly delivered to the University of Florida Analytical Research Laboratory in Gainesville, where NO_3-N levels were determined using EPA method 353.2.

Each year, the whole 4-acre field was planted. The experimental design was a randomized complete block design in 1998 and 2000. Single replications were used in 2001 and 2002. Large plots were used in 2001 and 2002 to reduce border effects and the lysimeter-to-lysimeter variability. For each year, plots for data collection consisted of four adjacent, 300-ft long rows. Data were collected on six plots in 1998 and 2000, and 8 plots in 2001 and 2002. Each year, yields were compared to typical yields found in commercial fields. The average watermelon yield in Florida was 35,000 lbs/acre in 2000, but this state average includes watermelons grown on bare-ground as well as those produced with plasticulture. However, watermelon growers who use plasticulture consider one truck load per acre a commercial yield. Lysimeter data were compared to the 10 ppm NO_3-N drinking standard value because no other value is available for comparison.

During the 4 years of this test, the warm and dry weather conditions were representative of Spring conditions in North Florida. Planting dates (between 21 and 27 Mar.) and harvests completed between 58 and 72 days after transplanting (DAT; DAT were 64, 72, 73 and 58 in 1998, 2000, 2001, and 2002, respectively) were representative of watermelon production fields in the area. Watermelon marketable yields ranged between 43,680 and 72,128 lbs/acre between 1998 and 2002 (Table 1). Watermelon fruit size ranged between 18 and 21 lbs/melon, which is close to the 18 to 20 lbs range commonly found for allsweet watermelon varieties like ›Royal Sweet› or ›Mardi Gras› when grown commercially. Sweetness ranged between 8.5 and 11.3 ^{o}Brix. Although size in 1998 and sweetness in 2000 were marginal, watermelon yields with IFAS recommendations were overall very similar to those from commercial fields. No significant yield differences were found between the two preplant-fertilizer treatments, although yields tended to be higher when chicken manure was used (Table 1). This supports the common practice that chicken manure is a suitable substitute for pre-plant inorganic fertilizer in watermelon production. This also suggests that soil water holding capacity and/or soil organic matter content are unlikely to be modified in a practical way at the chicken-manure rates used. Our rate (approximately 2 tons/acre) was based only on nitrogen content and calculated to supply 50 lbs of available N. Increasing chicken manure application rates as an attempt to increase soil water holding capacity and/or organic matter content will likely result in over fertilization (especially in phosphorus) and high salt levels (due to nitrate) early in the season.

Continued page 13

Table 1. Watermelon marketable yields between 1998 and 2002 and grown on a sandy soil using IFAS fertilization and irrigation recommendations

Year	Pre-plant fertilizer source	Mean watermelon yield^{z} (lbs/acre)	Individual fruit weight (lb/fruit)	Soluble solids at harvest (^{o}Brix)	Yield and fruit size comparable to those from commercial watermelon fields?^{x}
1998	Inorganic	43,680 a	17	n/a	Almost (87%)
	Organic	55,418 a	18	n/a	Yes (110%)
2000	Inorganic	55,605 a	20	8.5	Yes (110%)
	Organic	72,128 a	20	8.5	Yes (143%)
2001	Inorganic	46,340 +/- 4,144^{y}	18	11.0	Yes (92%)
2002	Inorganic	53,813 a	19	10.7	Yes (107%)
	Organic	57,562 a	18	11.3	Yes (114%)

^{z} Mean yields followed by different letters are significantly different
^{y} Standard deviation of the mean
^{x} Based on achieving 90% of a reference commercial yield of 50,400 lbs/acre (100%) and individual fruit weight of 10 to 20 lbs

Continued from page 12

SWT tension at the 6-to-12 inch depth tended to remain within the recommended 8-15 cb range. As observed in 2001 and 2002 (Fig. 1), SWT was greater than this range for several days (between 49 and 55 DAT in 2001, and 37 and 57 DAT in 2002), when weather demand increased crop water use as day length increased. At the same time, watermelon plants were rapidly growing and fruit development increased crop water use. Watermelon growers who have sandy soils and use drip irrigation often report a brief period of water stress shortly after fruit set especially when no rainfall occurs during that period. These results illustrate the importance of daily monitoring of SWT in order to avoid water stress or excessive water application. These results also support the need for split irrigations during fruit enlargement. Our yields and SWT results emphasize the importance of managing irrigation and fertilization together in order to obtain highest yields.

Nitrate levels in the lysimeters showed variations and ranged between 0 and 160 ppm NO_3-N (Fig. 2). On most sampling dates, they were above the 10 ppm NO_3-N EPA drinking water standard. When the field was covered with a rye cover crop from November to February, lysimeter nitrate levels ranged between 5 and 20 ppm NO_3-N. These levels tended to increase during the watermelon crop. Highest NO_3-N values observed during the watermelon crops were 7, 90, 78 and 90 ppm NO_3-N in 1998, 2000, 2001 and 2002, respectively. Highest values for each year tended to occur during the fall, several months after watermelon harvest. In 1998, 2000 and 2002, no significant differences were found between the two fertilizer treatments. On most sampling dates, lysimeter nitrate levels tended to be numerically lower when chicken manure was used, but these differences were not significant due to high variability in the measurements. Nitrate levels in the control well remained at 0 during the whole experiment, while those in the wells around the field remained between 0 and 20 ppm NO_3-N. These results suggest that when IFAS recommendations are followed, the range in nitrate levels below watermelon fields was reduced at the 20-ft depth as compared to the 4-ft depth. Further reduction may occur at greater depths. These results support growers doubts about the relevance of applying this EPA drinking water standard to shallow ground water. Moreover, expecting nitrate levels to remain below 10 ppm NO_3-N would be sufficient to maintain water quality, but, it is not necessary. Year-round fluctuations in nitrate levels also suggest that peak discharge may not occur during the watermelon crop. Hence, abandoning a field after harvest may increase nitrate discharge. Double cropping (planting a second cash crop on the same plastic) or planting a cover crop immediately after discing will help trap residual nitrate in the soil, thereby reducing the potential risk for further discharge.

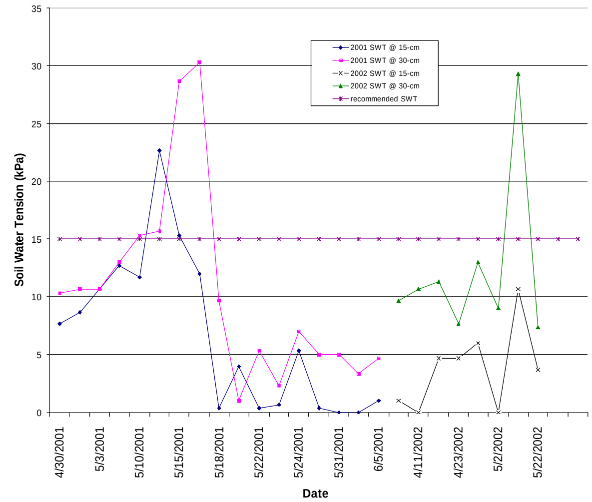


Fig. 1. Soil water tension at the 15-cm and 30-cm depths below watermelon grown in 2001 and 2002 with IFAS fertilization and irrigation recommendations.

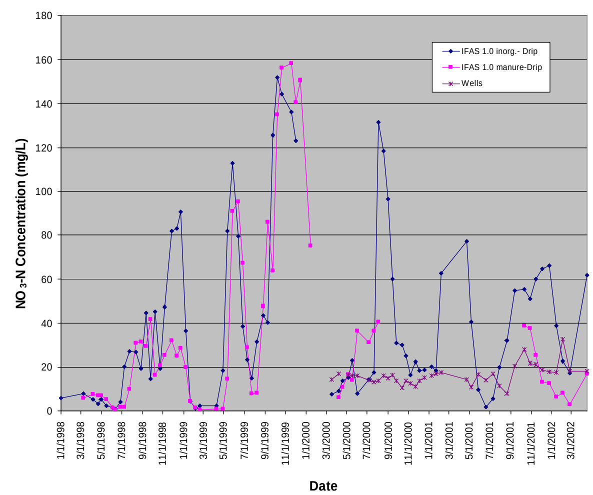


Fig. 2. Effect of fertilizer sources (inorganic and chicken manure) on nitrate (NO_3-N) levels (1 mg/L = 1 ppm)

In conclusion, economical yields of watermelon were produced three years out of four when IFAS fertilization and irrigation recommendations were followed. Yields during the fourth year (1998) were marginal. Nitrate levels fluctuated between 0 and 160 ppm NO_3-N at the 4-ft depth, but only between 0 and 20 mg/L NO_3-N at the 20-ft depth. Since reducing fertilizer applications is likely to reduce yield, efforts to reduce nitrate leaching may focus on splitting irrigation, increasing fertigation frequency (daily instead of weekly), and year-round field management.

Best Management Practices for Irrigation and Fertilization of Florida Citrus in Flatwoods Soils

Calvert D. V. and Z. L. He, Indian River Research and Education Center, Fort Pierce

There has been increasing concern over nutrient loss from agricultural practices, which may contribute to the accelerated contamination of groundwater and surface waters. This concern is greater in sandy soils, which have minimal nutrient retention capacity. This research began in October of 1993, with funding from the St. Johns River Water Management District and the South Florida Water Management District. The first phase of the three years project was completed in September 1996. A comprehensive report on the first phase of the project was submitted to the Districts with a copy to the Department of Agriculture and Consumer Service (DACS). DACS-Nitrate Bill funding for the second three years phase of this project began in October 1996. This project was approved to extend for another two years from 1999 to 2001, as approved by the Nitrate-bill Funding committee.

The objectives of this research are: (i) to evaluate the effects of varying rates of N application either as dry soluble fertilizer, liquid source through fertigation or as controlled-release fertilizer on tree growth, leaf nutritional response, fruit yield, and fruit and juice quality parameters; and ii) to develop an optimal irrigation schedule and rate of N program for improving water and N use efficiency for production of high quality grapefruit in the Indian River area.

The field experiment was conducted in a commercial grove with 26-year-old white Marsh grapefruit trees on sour orange rootstock on the east coast of Florida, Hobe Sound, Martin County. The experiment occupied an area of approximately 20 acres. The major soil type in this block is Riviera fine sand. Because of replanting of the grove (removal of the old trees, re-bedding and planting of young seedlings), an action taken by the grower, monitoring of water table and soil moisture was forced to be discontinued.

The experiment included four N rates: 0, 56, 112, and 168 kg ha^{-1} yr^{-1}. The ratio of N:P:K in the fertilizer was 1:0.2:1, accordingly varying N rates also resulted in 0, 10, 20, and 30 kg P ha^{-1} yr^{-1} and 0, 56, 112, and 168 kg K ha^{-1} yr^{-1}. The fertilizer was applied as either dry granular water soluble form (DWS, with N and P derived from ammonium nitrate and triple superphosphate, while K was from muriate of potash and sulfate of potassium and magnesium) or fertigation (FRT, liquid fertilizer with N, K, Mg, and S from potassium nitrate, magnesium nitrate, ammonium nitrate and ammonium sulfate and P from phosphoric acid). Each plot consisted of 5 uniform trees planted at a 6 x 6 m spacing (269 trees ha^{-1}) with 4 replications. The trees were irrigated using an under tree microirrigation system with one emitter (37.8 liters per hr) per tree and the irrigation was scheduled by reading tensiometers at 15 and 30 cm depth (under the tree along the dripline), using setpoint of 10 cbars during January to June (dry season) and 15 cbars July to December (rain season), respectively. These setpoints were equivalent to 20 and 40% depletion of available moisture. The annual amount of fertilizer was applied using a mechanical spreader in 3 equally divided doses (February, May and October) for the DWS, and in 15 equally divided doses (3,3,3,2,2,2 applications in February, March, April, May, September, October, respectively) for the fertigation treatment.

The concentrations of NO_3-N, PO_4-P, and K were measured in soil solution sampled using suction lysimeters installed above (120 cm) and below (180 cm) the hardpan. Six-month old spring flush leaves were sampled for mineral analysis in July every year. Twenty leaves per tree were collected from non-fruiting branches around the tree from each of the middle three trees within a plot. Fruit sampling began in October and was continued at 8-week intervals until late May next year. The fruit were analyzed for fruit weight, juice

Continued page 15

Continued from page 14

weight per box, juice percentage, soluble solids (lb/box), and Brix and acid content. Fruit were harvested on April 17, 2001 and the yields were recorded.

The concentrations of NO_3-N and PO_4-P in soil solution at both 120 and 180 cm depths increased with increasing fertilizer rates. Fertigation tended to enhance leaching of NO_3-N and PO_4-P, as compared with dry soluble granular application. The concentrations of NO_3-N and PO_4-P in soil solution were much higher at the 120 cm depth than at the 180 cm depth. The average concentrations of NO_3-N in soil solution at both the 120 and 180 cm depths over three years were well below 10 mg L^{-1}, the maximum contaminant level, even at the highest rate of fertilizer application. Solution PO_4-P concentrations at the 120 cm depth averaged 0.25 to 0.70 mg L^{-1} over three years for plots receiving various amounts of fertilizer and may constitute a P source for surface waters, as soil solution above this depth is likely to seep into water furrows through lateral movement and be discharged into drainage water. The results indicate that best management practices in this sandy soil region should be also directed to minimizing the leaching of PO4-P in addition to NO3-N.

There was a close correlation between leaf N concentrations and N rates (r= 0.93** to 0.98**). Fruit yield was related quadratically to N rates and leaf N concentrations. At 90% of maximum yield, leaf N concentrations were 22 to 23 g kg-1. Fruit quality parameters such as Brix, juice, and solids were positively correlated with leaf N concentrations, whereas fruit size and Brix/acid ratios tended to be negatively related with leaf N concentrations or N rates. However, fruit sizes or ^{0}Brix/acid ratios were acceptable for fresh marketing or processing at leaf N concentrations of 22-23 g kg^{-1}. Therefore, this leaf N concentration of 22-23 g kg^{-1} can be considered the optimal concentration guideline for fertilization of grapefruit.

Soil Amendment to Reduce Phosphorus Leaching in a Sandy Soil

Z. L. He, D. V. Calvert, P. J. Stoffella, and Y. C. Li
Indian River Research and Education Center, Fort Pierce

Leaching of phosphorus (P) in sandy soils has been considered as a nonpoint source of P that affects surface water quality. Column leaching studies were conducted to evaluate effects of soil amendments on P leaching in a sandy soil. The soil was a Riviera fine sand (loamy, siliceous, hyperthermic, Arenic Glossaqualf) from a commercial citrus grove in Florida. The soil amendments were: (1) cellulose (organic carbon; C), (2) clinoptilolite zeolite (CZ), (3) lime (CaCO3), (4) gypsum (CaSO4), (5) Recmax (a commercial product made from slag out from steel manufacture), and (6) C plus CZ. The application rate was 15 g kg-1 for all the additives. For low P soil (14 mg kg-1 Olsen-P), addition of cellulose was most effective, reducing leachate P concentration from 1.2 mg L^{-1} to below 0.3 mg L^{-1} in the first volume of leaching and from 0.9 mg L^{-1} to <0.1 mg L^{-1} in the 6th volume of leaching. The cumulative amount of P leached by the six volumes of leaching decreased among the different amendments in the order of control, zeolite > gypsum > cellulose + zeolite > Recmax, lime > cellulose. For high P soil (amended with 100 mg P kg-1 soil), Recmax was the most effective, which reduced leachate P from >60 mg L^{-1} to below 0.5 mg L^{-1} in the first volume of leaching, followed by cellulose and lime amendment.

Research and Extension work in the nutrient management and water quality area in the EAA.

Samira Daroub, Everglades Research & Education Center, Belle Glade

The Everglades Agricultural Area (EAA) comprises 700,000 acres of highly productive land south and downstream of Lake Okeechobee. The soils in the EAA are organic soil and the majority of the land is in sugarcane production. Other crops include rice, sod, sweet corn, lettuce and other vegetables. The University of Florida/ Institute of Food and Agricultural Sciences (UF/IFAS) Best Management Practices (BMP) research and education projects to reduce phosphorus (P) load from the EAA started in 1986. Results from this work resulted in a number of BMPs that affectively reduced P loads coming off the EAA. Some of these BMPs included banding fertilizer for vegetable crops at reduced rates, and using proper fertilizer handling and application methods for all crops. A combination of improved drainage uniformity and a reduction in drainage pumping also yielded significant reductions in P loads for all crops. Mandatory BMP implementation for the EAA stared in January 1995. A list of BMP options adopted by the South Florida Water Management District (SFWMD) is in the enclosed table.

Our current research and extension efforts are multi faceted. One important objective of the project has been to improve the implementation and to assess the efficacy of the implemented BMPs. Seven farms, that have different BMPs implemented, are included in this project where extensive array of monitoring instruments were installed to each site to track changes in P concentrations, and drainage water discharge. The farm level reductions appear to be reflected in basin-level monitoring data produced by the SFWMD. Hydrologically adjusted farm-level load reductions, expressed as the SFWMD adjusted unit area load (AUAL), averaged 54.9 % for the project sites (7-year average referenced to WY93-94). The EAA basin-level AUALs decreased by approximately 41.4% and total P concentrations by 7.9%.

Another equally important area of our research includes development of management strategies to address particulate phosphorus (PP) source and transport mechanisms. Farm-level studies showed that P attached to particulate matter in drainage water samples accounts for up to 60% of total P leaving the farm. The majority of PP in the EAA is sourced from in-stream biological growth rather than soil erosion. The sediment that contributes to PP export is recently deposited biological material such as settled plankton, filamentous algae, and macrophyte detritus. These materials can be readily suspended under the turbulent conditions that exit at the pump start up. This highly mobile material causes a high concentration of suspended solids during the early periods of pump events. High velocity in the canal is the single most important factor in PP transport. Some BMPs recommended include the removal of biomass accumulated and transport it well away from the canal. In addition, it is recommended to evaluate pumping stratigies and revise them to reduce velocity spikes.

Extension effort involves BMP training workshops for growers, which are tailored for individual growers. A half- day sessions for BMP training cover the different soil, fertilizer, PP and hydraulic BMPS. The BMP training is part of the permit requirement issued by the SFWMD and needs to be done annually. It is an important venue we have to share our most recent research results with the growers and farm managers. We have three EDIS publications regarding PP in various stages of review and publication. We also have started an on-farm BMP demonstration program at EREC. The research station at Belle Glade has been divided into BMP and non-BMP plots to show the effects of implementing PP BMPs.

Table 3 – Best Management Practices Summary and "BMP Equivalent" Points

BMP	PTS	DESCRIPTION
WATER DETENTION ½ Inch Detained 1 Inch Detained	5 10	• water table management by controlling levels in canals, field ditches, soil profile, fallow fields, aquatic cover crop fields, prolonged crop flood; • measured on a per event basis – rainfall vs. runoff
FERTILIZER APPLICATION CONTROL	2 ½	uniform and controlled boundary fertilizer application (e.g. direct application to plant roots by banding or side-dressing; pneumatic controlled-edge application such as AIRMAX)
FERTILIZER CONTENT CONTROLS		
Fertilizer Spill Prevention	2 ½	• formal spill prevention protocols (handling and transfer) • side-throw broadcast spreading near ditch banks
Soil Testing	5	avoid excess application by determining P levels needed
Plant Tissue Analysis	2 ½	avoid excess application by determining P levels needed
Split P Application	5	apply small P portions at various times during the growing season vs. entire application at beginning to prevent excess P from washing into canals (rarely used on cane in EAA)
Slow Release P Fertilizer	5	avoid flushing excess P from soil by using specially treated fertilizer which breaks down slowly thus releasing P to the plant over time (rarely used in EAA)
SEDIMENT CONTROLS		EACH SEDIMENT CONTROL MUST BE CONSISTENTLY IMPLEMENTED OVER THE ENTIRE ACREAGE
Any 2 Any 4 Any 6	2 ½ 5 10	• leveling fields • ditch bank berm • sediment sump in canal • strong canal cleaning program • field ditch drainage sump • slow field ditch drainage near pumps • sump upstream of drainage pump intake • cover crops • raised culvert bottoms • veg. on ditch banks • other BMP
OTHER Pasture Management	5	reduce cattle waste nutrients in surface water runoff by "hot spot" fencing, provide watering holes, low cattle density, shade, pasture rotation, feed & supplement rotation, etc.
Improved Infrastructure	5	uniform drainage by increased on-farm control structures
Urban Xeriscape	5	lower runoff & P by using plants that require less of each
Det. Pond Littoral Zone	5	vegetative filtering area for property stormwater runoff
Other BMP Proposed	TBD	proposed by permittee and accepted by SFWMD

Ecologically Enhanced Stormwater/Irrigation Reuse Pond

Mark Clark, Soil & Water Science Department

Water consumption, pollutant runoff, and stormwater flood control are among numerous environmental concerns that often seem in conflict with maintaining profitability of a company. Yet sustaining natural resources and the economy will require that these objectives not be mutually exclusive. A project started by University of Florida students in spring 2000 may show that in at least one instance, implementation of environmentally sound practices have proven mutually beneficial to both environmental resources and a company mission.

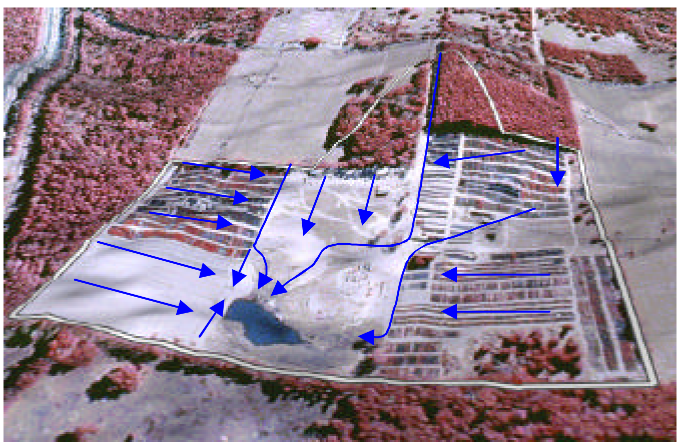


Figure 1. View of San Felasco Nursery (1999) looking south. Blue arrows indicate direction of runoff. Note location of pre-enlargement pond in foreground.

The initial catalyst of the project came with the desire by San Felasco Nurseries to develop water based cold protection for their more sensitive nursery stock during the winter months. This cold protection was not feasible at the time due to limited groundwater pumping capacity. In addition, limited groundwater pumping rates required 8 hrs to completely irrigate all of the nursery stock at night. These limitations could have been solved by drilling a larger well and adding pumping capacity, but instead an alternative was implemented. It was decided that increasing the capture rate of rainfall and irrigation runoff from the fields and reusing it may be sufficient to supply the needed water for cold protection while significantly reducing the demand on groundwater. In addition, although not presently required to mitigate for changes in stormwater runoff resulting from landuse changes, increased runoff rates due to roadways, ground covers, buildings and greenhouses have resulted in a significant increase in rainwater runoff that could be temporarily intercepted and used for irrigation before it evaporated or infiltrated into the ground. Implementation of this system required establishment of a large storage pond to receive runoff. Ecological Engineering design of this pond provided some additional opportunities to address water quality and ancillary ecological benefits.

San Felasco Nursery's north site, which is approximately 75 acres in size, is located in northwest Alachua County. The nursery has become one of the biggest wholesale nurseries in North Central Florida and is recognized as experts in the growing of herbaceous perennials but also carry a wide variety of woody containerized plants. The facility has 60 acres of nearly impervious surface composed of, 45 acres of ground cloth underlain by plastic, 8 acres of shade houses, 2 acres of green houses/cold frames, 2 acres of retractable roof green houses, and a net work of roads throughout the property. The property rest's on the south slope of a concave landscape with surface runoff collecting in a depression at the north edge of the property with no surface runoff from the site (Figure 1).

Sizing the runoff reuse pond was conducted by estimating runoff volumes using runoff coefficients established for various landuse surfaces and irrigation/rainfall conditions. Runoff estimated for nightly irrigation events were upward of 55% (165,000 gallons/irrigation night) and 65% for all surfaces during rainfall events in excess of 0.25 inches (1.3 million gallons for a 1 inch storm event). Thus although intermittent, a conservative runoff capture potential of 64 million gallons per year could be expected assuming 52 inches annual rainfall, 180 days at maximum irrigation effort and 40% loss of volume in the pond to evaporation and infiltration. Although timing of rainfall events will not completely meet irrigation demand, thus requiring some ground water pumping, capture volume is approximately the same as irrigation requirements in 1999 (62.8 million gallons). This would be significant water conservation onto itself; however, additional benefits with respect to nutrient management are implied in this water reuse system and with an ecologically enhanced pond design.

By recirculating a significant portion of the surface runoff from irrigation and stormwater, the previously "open" nutrient and pollutant cycle is now partially closed. Nutrients originally leached from the planting containers that would have been carried to the pond and eventually groundwater, are now made available again to the plant and total water volume moving through the nursery is reduced, decreasing infiltration and runoff that might pose a threat to groundwater. To increase storage capacity, and thereby water for reuse, additional storage was required in the natural depression of the landscape at the San Felasco site. A rainfall runoff model was developed to determine the approximate storage

Continued page 18

Continued from page 17

capacity needed for a given rainfall event. It was decided that a total storage volume of 6 million gallons would be used, a compromise between stormwater runoff mitigation and land allocated to the pond system. This volume relates to the 5 year 6 hr storm event or a 4.5 inch rainfall. Storage requirement could have been met by a simple excavation with steep slopes and rectangular design; however, modifying the design provided an opportunity for additional benefits. The enhanced design included the addition of a small (1.5

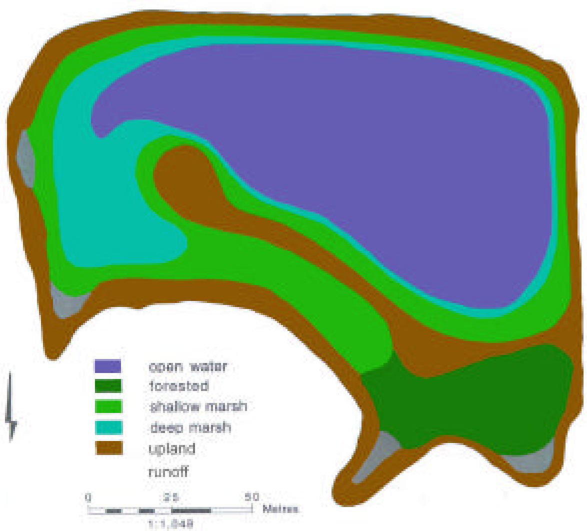


Figure 2 Design of irrigation reuse pond with integrated wetland treatment system.

acre) wetland and forebays for sedimentation (Figure 2). This design allows for 60 % of irrigation water and 50% of the stormwater to flow through the wetland prior to entering the pond. Sediment carried by the runoff water is mostly deposited within the wetland and forebays prior to discharge to the pond and significant nitrate reductions occur within the wetland complex. Direct groundwater infiltration of nitrate through the wetland and pond soil/sediment is negligible due to anaerobic conditions causing denitrification of nitrate-nitrogen species if present. Additional ancillary benefits of the wetland include a rich and growing vegetative species diversity (57 species initially planted), the wetlands are also being developed so that specimens of various wetland plants can be shown to customers in a more natural setting (Figure 3), and wildlife utilize the wetland and pond as evidenced by tracks and sightings reported by employee's of the nursery.

Only limited quantification of the projects benefits have been made to date due to a delay in putting the reuse

Figure 3. Red Maple (*Acer rubrum*) and Bald Cypress (*Taxodium ascendens*) among two varieties of Iris (*Iris virginica*) and needle rush (*Juncus effuses*) as a more natural presentation of these species to customers visiting the Nursery.

pumping system on line. It is anticipated that these pumps will be installed in the next few months and quantitative evaluation for successes and limitations of this project can be made.

Acknowledgements: The spring 2000 student design team consisted of Kerry McWalter, Shannon Ludwig, John Kasbar and Melanie Craig. Alan Shapiro, owner of San Felasco Nurseries was instrumental in this project and he is thanked for his financial support of the project, willingness to open up his business to our research, and

This newsletter was created to disseminate information on current projects in the Nutrient Management area. If you would like to submit an article for inclusion in a future newsletter please contact:

Susan Curry
PO Box 110290
Soil & Water Science
University of Florida
Gainesville, FL 32611
(352) 392-1805
scurry@ufl.edu

Enrichment and Release Potential of Phosphorus and Heavy Metals in Aggregate Fractions of Sandy Soils

Z. L. He, D.V. Calvert, P. J. Stoffella, and Y. C. Li
Indian River Research and Education Center, Fort Pierce

Minimal information is known on the enrichment and release potential of P and heavy metals in aggregate fractions of sandy soils. To obtain a better understanding of this subject, five aggregate-size fractions, ranged from 1.00-0.50 to < 0.053mm, were separated from seven Florida sandy soils by dry sieving. Each aggregate fraction was characterized by phosphate sorption, sequential fractionation of P, total, water and Mehlich III extractable concentrations of P and heavy metals. Aggregates in all the sandy soils were dominated by the 0.5-0.25 mm and 0.25-0.125 mm fractions, both, on average, accounting for 80.6 % of the whole soil. Chemical analyses indicated that elemental enrichment (particularly heavy metals) increased with decreasing aggregate sizes. As surface area / volume ratios increase with decreasing aggregate size, increasing enrichment with decreasing aggregate size may be an indication of surface enrichment of these elements on clay minerals. The higher percentages of water-extractable and Mehlich III–extractable P and heavy metals were found in both the 0.50-0.25 mm and 0.25-0.125 mm aggregate fractions, suggesting that P and heavy metals in these two fractions had higher release potential. Phosphorus adsorption maximum of the <0.053 mm fractions in all the sandy soils were higher than other larger size fractions, and the differences in P adsorption capacity for various fractions could be explained by the differences in Al, Ca and Fe contents among the different fractions. The sequential fractionation of P suggested that 1.00-0.50 mm fraction contained larger percentage of Ca-bound P, whereas the 0.50-0.25 mm, 0.25-0.125 mm and 0.125-0.053 mm fractions had higher ratios of labile P forms (H_2O-P and $NaHCO_3$-P), and therefore, a greater P release potential. Results from P release dynamics in water from various aggregate fractions suggest that P release from smaller aggregate fractions is faster than from larger aggregate fractions because of larger amounts of water soluble P enriched in the smaller aggregate fractions.

Training for Comprehensive Nutrient Management Planning Continued from page 1

(IFAS), Gerald Kidder (IFAS), Jerry Sartain (IFAS), Vince Seibold (Florida Department of Environmental Protection), Tom Obreza (IFAS), Greg Hendricks (NRCS), Steve Boetger (NRCS), Nga Watts(NRCS), Justin Jones (IFAS) and Susan Curry (IFAS). These presentations were well received by the participants. All participants rated the program good or excellent. The participants liked the mixture of science, theory and practice.

Field visits to local dairies were conducted and Nutrient Management Plans for these dairies will be developed by each student. The data collected included soil survey information, field inventories and land uses, identification of sensitive areas, cropping history and rotations, and current practices and land treatments. There was also discussion of the waste management system, bio-security, and conservation practices. The assessment and calculations involved in determining the phosphorus index (P-index) were explained. Other topics of discussion were land treatment practices to reduce risks, current manure and fertilizer applications, and irrigation methods. Participants successfully completing this course with an 80% or higher on the post-test must submit two Nutrient Management Plans to NRCS for approval. At this time they will be certified for Nutrient Management.

The next planned course will take place in Okeechobee in mid-May, 2003.