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Role of an Extension Soil Testing Program in the Development of Best Management Practices: A Florida Case Study

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Abstract
Extension faculty in many states, particularly those involved with soil-testing programs, are faced with the complex task of developing Best Management Practices (BMPs) that potentially minimize environmental impacts from inorganic and organic fertilizers. Experiences gained by Extension faculty at the University of Florida in developing nutrient BMPs based on soil-test recommendations are presented with specific applications to the middle Suwannee River Basin of Florida. The article illustrates practical dilemmas faced and lessons learned as grower-friendly BMP versions or Interim Measures have evolved. Scope and limitations of educational information should be documented as an aid to subsequent regulatory requirements.

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Introduction

As part of land grant universities' public-service mandate, most state Extension soil testing programs offer analytical services and appropriate nutrient recommendations for successful agricultural production. As a result of nutrient-related water quality impacts, Extension personnel in many states are working with regulatory agencies to identify best management practices (BMPs) that minimize such hazards. A case study is presented here on the role played by state Extension faculty at the University of Florida when developing nutrient BMPs for an environmentally sensitive region of the state.

With costs of fertilization being relatively low, and despite soil-test based nutrient recommendations, producers typically over-fertilize as a perceived insurance against the risk of crop failure. Complexity in determining plant-available amounts of nutrients is further increased if some nutrients are from organic sources.

The rates at which fertilizers, manures, and other organic materials are applied are often based on the agronomic rate specified for a particular crop by the state soil-testing program. Agronomic rate, in turn, is defined as the amount of nitrogen (N) needed by the crop to produce optimum yield. For organic materials, the agronomic rate is calculated based on the estimated plant-available N content of the material. In other situations, land application of organic materials is based on P content of the materials instead.

In light of surface- and groundwater environmental concerns, the rates of N and P applications are being increasingly monitored by state regulatory agencies. Land-grant universities through the Cooperative Extension system have for years been conducting educational programs such as soil testing, field demonstrations, and training sessions that promote both economically and environmentally sustainable agricultural practices. Regulatory agencies are increasingly requiring that nutrient-management practices be based on recommendations of local land-grant Extension programs. Because programs offered through Cooperative Extension are primarily educational in nature, the role of Cooperative Extension is generally to provide technical and scientific assistance to the regulatory agencies.

Presence of eco-sensitive areas such as the Everglades, Lake Okeechobee, and the Suwannee

River Basin in Florida makes it very important to protect water quality from contamination by agricultural nutrients. Cooperative Extension specialists and agents at the Institute of Food & Agricultural Sciences of the University of Florida (UF/IFAS) actively collaborate with state agencies such as the Florida Department of Agriculture and Consumer Services (FDACS), the Florida Department of Environmental Protection (FDEP), the Natural Resource Conservation Service (NRCS), and the state's five water management districts to supply research-based information, create risk-assessment tools, and conduct training sessions.

The Suwannee River Basin in Florida

The Suwannee River Basin (SRB) in north central Florida is highly vulnerable to both surface- and groundwater contamination. Soils in the SRB are predominantly loamy sand or sand in texture (Entisols) overlying an eroded limestone (*karst)* topography. The SRB is an agriculture-dominated economy, rural to semi-urban in nature, with groundwater serving as the primary source of drinking water.

The Suwannee River Water Management District (SRWMD) is responsible for both water quantity and water quality in the SRB. More than two decades of water quality data for the SRB have demonstrated a statistically significant (at the 95% confidence level), time-dependent increase in the concentration of nitrate-nitrogen in the river and several of its associated freshwater springs. The primary source of the nitrate-nitrogen is groundwater entering the river's surface water system via a series of springs (Hornsby & Mattson, 1998).

The Approach

In response to the critical need for protecting water quality in the basin, a partnership comprised of 24 state, local, and private agencies called "The Suwannee River Partnership" was formed, led by the FDACS. Other major partners include FDEP, NRCS, UF/IFAS, SRWMD, the Florida Farm Bureau, etc. With UF/IFAS as a crucial member, a technical subcommittee called the Suwannee Fertilizer Work Group (SFWG) was created under the partnership and charged with the responsibility of evaluating nutrient-management practices throughout the basin.

In March 2000, FDACS asked the SFWG to initiate discussions concerning the implementation of improved nutrient-management practices for forage crops, which represent the largest crop acreage in the basin. Scope of this responsibility was outlines by the FDACS through the following working definition (Florida Legislature, 2001):

> Best Management Practices means practices or combinations of practices determined by research or field testing of representative sites to be the most effective and practicable methods of fertilization designed to meet nitrate groundwater quality standards, including economic and technological considerations.

Soil-test recommendations from UF/IFAS have been developed for optimum crop production based on crop nutrient requirements. Assessment of environmental impacts has not traditionally been an objective of the state's soil-testing program. In addition, economic and technological considerations as defined by FDACS above have been outside the scope of research activities that have led to most Soil Testing Laboratory nutrient recommendations.

In acknowledgement of the need to link nutrient-management activities with environmental impacts through further research, FDACS termed the current phase an "Interim Measure" or pre-BMP stage. The following operative definition (FDACS, 1996) was provided as a consequence:

> Interim Measures means primarily horticultural practices consistent with the fertilizer recommendations published by the University of Florida or the Florida A&M University or modified by the FDACS, to reflect public input.

This definition emphasizes two important aspects of the BMP development process. First, the process is science-based as developed and adopted by the state's land-grant universities. Second, FDACS reserves the right to modify certain elements to make the final package acceptable to grower-clientele. In particular, FDACS strives to make both the Interim Measures and the resultant BMPs economically viable for the growers. Several states have likewise implemented BMPs in a phased manner, via one or more iterations of "interim measures."

The UF/IFAS Role

Along with information presented via the soil test reports, significant and detailed information about successful crop production is contained in an assembly of UF/IFAS Extension publications. A primary emphasis of the UF/IFAS team has been to coordinate and complete all intended revisions to the educational materials for forage crops, particularly on nutrient recommendations.

Although the current Interim Measures involve only the SRB, because of the statewide responsibility for unified recommendations, the UF/IFAS revisions and updates have included all forage-production areas in the state. Because hay production constitutes the largest forage subcategory within the SRB, most initial UF/IFAS updates have centered on hay production.

At the UF/IFAS Extension Soil Testing Lab (http://soilslab.ifas.ufl.edu/), all tests and

recommendations are tied to specific crops. A new reference category called "Hay Production" was created to include all forage crops that are cultivated either solely or in combination for hay production. Bermudagrass, stargrass, digitgrass, and rhodesgrass were initially included in this group. As the discussions continued it became clear that addition of Bahiagrass to the list of crops being considered was crucial as well. Bahiagrass management for grazed; grazed and hayed; seed production; and hayed, single and multiple cuts was subsequently discussed in Soil & Water Science Factsheet 129 (http://edis.ifas.ufl.edu/SS163) (Kidder, Chambliss, & Mylavarapu, 2002).

Soil test reports also include "management tips" as footnotes. These briefly describe additional considerations relating to the source(s) of nutrient(s), timing and rate of application, placement of fertilizer, likely need for secondary or micronutrients, cultural operations, etc.

The Process

Meetings between UF/IFAS and FDACS initially were held on a monthly basis to discuss proposed modifications, discuss feedback from various other groups, and re-prioritize needs. Four public meetings were held at two locations in the SRB over a 3-month period where input from the grower community was sought. Other major attendees at these meetings apart from producers included the FDEP, USDA-NRCS, SRWMD, the Florida Farm Bureau, etc.

Based on the above small-group and public-meeting inputs, the following two soil-test footnotes were created.

Footnote 1: "These interpretations are based on soil-test results and research/experience with the specified crop under Florida's growing conditions. We do not test for soil N, as there is no meaningful soil test for predicting N availability. Thus, the N recommendation was developed from research that measured response of the indicated crop to applied N fertilizer. If you expect significant nutrient release from organic sources such as crop residues or organic amendments, estimate the amount mineralized and subtract that amount from the fertilizer recommendations given below to arrive at crop needs."

Footnote 2: "UF/IFAS fertilizer and lime recommendations are advisory in nature and emphasize efficient fertilizer use and environmentally sound nutrient management without losses of yield or crop quality. It is generally assumed that the nutrients will be supplied from purchased, commercial fertilizer and that expected crop yields and quality will be typical of economically viable production. Growers should consider UF/IFAS recommendations in the context of their entire management strategy, such as return on investment in fertilizer and the benefits of applying manure or biosolids (sewage sludge) to their land. There is insufficient research available at present to support the use of UF/IFAS soil test results for environmental nutrient-management purposes. Such use is discouraged until correlation is proven."

The above two comments carefully define the role that Cooperative Extension is expected to play when developing nutrient-management BMPs. Levels of soil N dynamically fluctuate depending on inherent soil and climatic factors; hence, a soil test for N is considered generally unreliable. Footnote 1 dispels the traditional notion that the need for N is determined through a soil test. The limitation on the regulatory use of soil-test results for nutrient-related environmental decisions is explicitly stated in Footnote 2.

Wording is consistent with the recent statement from the Council for Agricultural Science and Technology (CAST, 2000) and with a resolution adopted by the SERA-IEG-6, the regional group coordinating nutrient and waste management. Hochmuth, Hanlon, Kidder (2000) and Mylavarapu (2002) also discussed such use of soil test results in the case of Florida. These recent statements show that the role of soil-testing programs in the process of BMP development aimed at environmental protection is relatively new.

Another major practical recommendation that came from growers dealt with organic sources of N. The following footnote was subsequently included on soil-test reports for all forage crops, emphasizing that application timing is subject to dynamic factors controlling the mineralization of N from various organic materials. At present as an initial broad-brush approach, only 50% of the total N content of the organic sources is typically estimated to be plant-available during the year following application.

Special Footnote: "A different set of economic factors is usually considered when organic waste or other organic materials rather than fertilizer are supplying the crop nutrients. Additionally, it is often impractical to follow the application timing discussed above when using organic waste materials from other operations."

Practical Dilemmas

A major aspect that initially missed our attention but came out during the small-group and public meetings was that several producers apparently relied on anhydrous ammonia as a source of N, with significantly lower price in comparison to granular N fertilizer being the main consideration for this choice. Because special equipment is required for anhydrous ammonia incorporation, the producers rely on a particular dealer for application and typically apply the N only once per year. Because split application of N is an absolute requirement by all the state soil-testing programs, once the recommended dosage is over 30 lbs/A, application of the entire N rate in one application

proved to be a major dilemma for all agencies involved. As all parties debated the issue, the economic and practical aspects of such agricultural operations became apparent.

Though adoption of an "interim measure" in this case is strictly voluntary, FDACS pointed that it is still important to accommodate growers' interests and needs. Economic and practical considerations are crucial to successful adoption of recommended practices, and so to exclusively base any recommendation on scientific factors alone can result in failure of the program.

The fact that the recommendations are "interim" in nature and therefore are open to improvements in the future in order to become more consistent with research findings was recognized by UF/IFAS and other members of the SFWG. The SFWG agreed to make an exception to accommodate anhydrous ammonia in order to expedite Interim Measure development. Anhydrous ammonia also has been estimated to be subject to approximately 20% volatilization losses. UF/IFAS immediately revised and published an Extension Fact Sheet (Kidder, 2000) to document these assumptions.

The ESTL soil-test report recommends 80 lbs N/A per cutting, when producing hay. It was recognized by the SFWG that the typical producer's rate might be as much as twice this value. The issue of a more pragmatic approach with regard to actual N rates applied and the number of split applications required was debated among the members of the SFWG. To provide maximum opportunity to make the process work and to gradually help growers see the merits of adopting UF/IFAS nutrient recommendations, a compromise was made for the sake of Interim Measure. Thus, the interim measure allowed 100 lbs N/A maximum, with an overall maximum of up to 400 lbs N/A per year (i.e., 4 cuttings).

The final version of the Interim Measure for Forage Grasses in the SRB is shown in Table 1.

Table 1.
Nitrogen Recommendations Contained in the Final "Interim Measure" for Forage Grasses in the SRB

Season	Bahiagrass and Bermudagrass		Bahiagrass Only	
	Grazed	Multiple Cuts of Hay	Grazed	Not Grazed
	Lbs/A			
Spring	100	100	100	0
Summer	100	100**	100	100*

*For Bahiagrass not grazed during the spring, apply only one application in late spring/early summer.
** Apply an initial application annually and no more than 100 lbs N per acre after each cutting except the last cutting in the fall.
Apply no more than 400 lbs N per acre per year.

The following text containing practical considerations and concessions then was appended to the final document on Interim Measures for forage production in the SRB:

> In accordance with the typical estimates available, it is assumed that 50% of the total N content of natural sources such as manure and biosolids is plant-available. Thus, the total N application rate for natural organic fertilizer sources may be up to two times the stated recommended rate. It is further assumed that, under typical application practices, 20% of the N applied as anhydrous ammonia is lost to the atmosphere. When utilizing anhydrous ammonia as the N source, a maximum of 125 lbs may be applied instead of 100 lbs of N per acre per application. The total N content of an organic nutrient source should be determined from either the guaranteed analysis provided by its manufacturer/distributor or from laboratory analysis of a representative sample. UF/IFAS publications such as Circular 1016 and PS-1 may also be consulted for nutrient estimates. UF/IFAS fertilizer recommendations for forage crops grown statewide can be obtained from SL 129. These and other UF/IFAS publications are available from county Extension offices or on the Web at http://edis.ifas.ufl.edu/.

Lessons Learned

- As a result of grower participation in the process of Interim Measure development, it is evident that despite continuous education through Cooperative Extension over the years, the actual grower rates of nutrient application often are higher than prescribed rates coming out of the state's Extension soil-testing program.
- It is evident that additional research must be conducted to measure the magnitude of environmental impacts from agricultural nutrients.
- It is important to make sure that all related educational material available through

Cooperative Extension has been updated when considering BMP development. It is absolutely critical that all Extension documents be consistent with one another and with current research findings, because the issues can become regulatory in nature instead of otherwise solely educational.

- All limitations and scopes should be explicitly stated and documented to provide a basis for any future legal challenges.
- The process of BMP adoption is a slow one involving human perceptions. Therefore, it is important to incorporate as much flexibility into the process as possible. Adoption of improved practices is a stepwise process, with initial steps not often able to withstand careful research scrutiny.
- The "Interim" nature of the process provides opportunities for improvement based on scientific findings.
- As long as the growers maintain a record of nutrient and water applications, some flexibility with respect to the maximum amount that can be applied is acceptable with regard to the Interim Measure. It should be realized that some compliance monitoring will also likely be required as a part of the final BMP adopted.
- The process is not a fast-paced one. It took more than a year from the time things were set in motion to the time that final public comments were received and the Interim Measure rule was adopted.

It is critical to the mission of Cooperative Extension that final responsibility for regulatory-measure adoption lay with the appropriate (non-Extension) state agency. It has to be very well understood that the primary responsibility of a land-grant university is limited to providing technical input into the process, rather than actual implementation of the plan. Close ties, transparency, and coordination among the all the partners are critical to the success of the BMP development process.

Acknowledgment

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