PROJECT 15: Utilization of legumes in crop rotation programs to reduce nitrate leaching from potato production into sensitive Florida watersheds

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COOPERATING ORGANIZATIONS:

St. Johns River Water Management District
North Florida Growers Exchange
Florida Department of Agriculture and Consumer Services
(matching funds)

PROJECT LOCATION: Hastings, FL; Lower St. Johns, 03080103. The project will be located on three grower sites in the Tri-County Agricultural area (TCAA; Putnam, Flagler, and St. Johns counties).

WATERSHED RESTORATION ACTION STRATEGY:

Lower St. Johns; SWIM Plan
The River Agenda*

*The River Agenda is a strategic five-year plan developed by stakeholder groups to reduce point and nonpoint pollution entering the St. Johns River and its tributaries. The SJRWMD Cost-Share BMP program has been funded through this initiative.

ESTIMATED POLLUTANT LOAD REDUCTION:

The St. Johns River Water Management District (SJRWMD) estimated potato production acres in St. Johns, Flagler and Putnam counties (Tri-county Agricultural Area or TCAA) in the 2000 production season at 26,000 acres. If all growers adopted the reduced nitrogen rate BMP, nitrogen use, on average, would be reduced by fifty pounds per acre. Experimental modeling conducted by the SJRWMD has shown that adoption of the BMP nitrogen rates would reduce the agricultural component of the nonpoint source pollution load by 26%. In the 2001 production year, the percent of growers adopting the voluntary BMP nitrogen rate was approximately 13%. If incorporating a legume summer cover crop and/or cash crop into the crop production sequence is demonstrated as a source of nitrogen for a potato crop, then growers may feel more confident in reducing their nitrogen inputs to the IFAS recommended/BMP rate or below. There is the potential to get the remaining 87% of the growers in the TCAA to adopt the BMP or sub-BMP rate.

PROJECT OBJECTIVES:

1. Demonstrate a cropping sequence that utilizes nitrogen fixed by legumes for potato production on three grower farms in the TCAA. Any reduction in inorganic fertilizer requirements will be documented and delivered to all stakeholders. This cropping sequence demonstration will verify existing nitrogen BMPs and provide evidence for or against the adoption of new cropping sequence BMPs.
2. Disseminate information using the extensive IFAS extension infrastructure on the project objectives and results at various extension meetings, agricultural fairs, and through a dedicated website.

PROJECT DESCRIPTION:

Discussion of the problem.

Farm ground in the Tri-county Agricultural Area (TCAA) near Hastings, Florida has been in potato production for over 100 years. St. Johns, Flagler, and Putnam county potato farms produce $65,000,000 worth of potatoes on 20-25,000 acres annually. Potato is also an important crop across the state of Florida with concentrated production around the towns of Immokalee and Homestead and in Manatee and Okeechobee counties. Annual statewide potato production totals 38-40,000 acres making potato one of the top five valued horticultural crops in the state (Hodges *et al.,* 2000).

Potatoes grown in Florida for the fresh (table) and chip markets dominate national markets at specific times of the year because of Florida's "unique" production season. However, advances in breeding programs and climate-controlled storage have enabled northern state potato production to encroach on Florida's winter/spring production window. As a result, there has been a decrease in available production contracts. In addition, the St. Johns River Water Management District (SJRWMD) and Florida Department of Agriculture and Consumer Services (FDACS) are in the process of developing Best Management Practices (BMPs) for potato production in the TCAA and across the state. Although the BMPs in consideration do not restrict farming, growers are concerned that the nitrogen rate recommendations could reduce production per acre further eroding their economic viability.

To stay competitive, farmers need to diversify their crops and/or plant more than one cash crop per year. The concern is that increased crop production would negatively impact the water

bodies close to production areas. Any further expansion of production should be done cautiously with the environmental impacts fully understood.

As mentioned, SJRWMD has developed a cost-share program for potato growers in lower St. Johns River basin that addresses nutrient management issues and grower concerns surrounding the adoption of BMPs (Livingston-Way *et al.,* 2000). This voluntary program provides a monetary incentive for farmers to implement *verified* BMPs and to compensate for any potential increase in costs or risk that may result while the farmers adjust to the new technology. There are many components to the cost share program that are designed to contribute to achieving a reduction in nutrient load. These components are varied and include direct payments to growers for use of IFAS recommended nitrogen rates as well as offsetting costs for upgrading water control structures.

One BMP currently under consideration by the SJRWMD is the use of a cropping sequence that would utilize legumes to supply nitrogen to the potato crop. Legumes can fix nitrogen from the atmosphere for use by subsequent crops, recycle un-used nutrients, reduce soil erosion, and add organic matter to the soil (Abdul-Baki and Teasdale, 1993; Abdul-Baki, et al, 1996). It is proposed that legumes could be used both as a summer cover and a second cash crop during the year without increasing nutrient load in the surrounding water bodies. The use of legume cover crops and cash crops may reduce the need for inorganic fertilizer in the potato crop by providing a "slow-release" organic nitrogen source. Legumes have been estimated to contribute up to 75 kg/ha of nitrogen to a following potato crop (Porter and Sisson, 1991). In addition, an organic nitrogen source is less likely than an inorganic nitrogen source to move out of the rows during heavy rains thereby reducing the impact of farming practices on the area's water resources. However, in order to be adopted as a cost shared BMP, the crop sequence BMP needs verification at field scale.

A three-year research project was funded by the Nitrate Bill BMP Program and is currently underway to document the impact of legume rotation crops on potato plant growth and tuber production. By monitoring the nutrient inputs and nutrient uptake by the potato crop, the nitrogen use efficiency of the potato plant can be calculated. This is an intensively managed and instrumented project located at the Hastings REC's Yelvington farm.

The "319" proposal will move the Nitrate Bill funded project from the research farm to the grower. It is the goal of the assembled team to explore the more successful treatments in a demonstration setting on grower farms using 319 monies. If successful, this project will demonstrate a successful model for BMP development across the state. The TCAA BMP development model demonstrates how growers, university faculty, and regulatory personnel can work together to develop BMPs. In turn, university research can work to verify the proposed BMPs. In the TCAA, the BMP development partners have worked together in a non-adversarial way for the betterment of the entire community.

List of Tasks and Associated Outputs:

Task 1.

Project Design. This project will demonstrate the ability of a legume cover crop and cash crop to supply nitrogen to a following potato crop. The demonstrations will be conducted at *three* grower locations in the TCAA. The demonstration will be conducted over a three-year period starting with the planting cycle closest to the funding date. Plots will be maintained at the same field location for the duration of the demonstration. Each nitrogen treatment will be applied to a plot no less than ¾ acre in size. The treatments will *not* be replicated at each field site. The demonstration will consist of the treatments listed in Table 1.

Conducting the demonstration over a three-year period is important to the success of the project. Weather conditions in North Florida have been drier than normal in recent years. The benefit of an organic source of nitrogen is maximized during normal (wet) weather patterns. In production years with normal rainfall patterns, the potential for inorganic nitrogen to be washed from the potato bed is increased. Evaluation of treatments over several production seasons will increase the chance of evaluating the treatments under varied weather conditions.

Table 1. Demonstration plot description.

Site	TRT	Summer	Fall	Winter/Spring	N Rate
Hastings	1	Cowpea	No Crop	Potato	BMP Rate
	2	Cowpea	No Crop	Potato	¾ BMP Rate
	3	Cowpea	Green Bean	Potato	BMP Rate
	4	Cowpea	Green Bean	Potato	¾ BMP Rate
	5	Sorghum	No Crop	Potato	Grower Rate
	6	Sorghum	No Crop	Potato	¾ BMP Rate

Crop Production Practices. Crops in the TCAA are grown on beds consisting of sixteen rows. The rows are raised with a between row spacing of 40 inches (center to center). The ground is irrigated with seepage irrigation. The water table is controlled by the flow of water into irrigation ditches spaced between beds. Raised rows are used to facilitate drainage during rain events. All crops in this demonstration will be produced on this system of land management.

The cropping cycle will begin with the crop nearest the time of funding. All crops will be planted following the schedule listed under the section titled *Project Milestones*. The sorghum/sudan grass hybrid (*Sorghum vulgare* x *Sorghum vulgare* var. sudanese, var. SX17) and cowpea (*Vigna unguiculata*, var. Iron Clay) will be seeded in a single row at a 10 and 80 lb/acre rate, respectively. Fertilization of the sorghum/sudan cover crop will follow local grower standard practices. Cowpea seed will be inoculated with rhizobium before planting and will not be fertilized. Both crops will be chopped and incorporated before the cowpea sets seed.

Bush green beans (*Phaseolus vulgarus*) will be inoculated with rhizobium prior to planting. Beans will be seeded in a single drill per row with in-row spacing of 2.5 cm. Nitrogen (58 kg/ha) will be incorporated into the rows prior to planting. Phosphorus and potassium

application rate will be determined by a pre-plant soil test and will be incorporated prior to planting. Ground not planted with bush green beans will be maintained as a weed-free fallow. Beans will be mechanically harvested when two-thirds of the pods reach marketable size. Beans from each plot will be weighed and graded.

Potatoes (*Solanum tuberosum*, var. Atlantic) will be cut to a target size of 57 g and planted on a single row at an in-row spacing of 23 cm. The total nitrogen applied to the potato crop will be 168, and 224 kg/ha corresponding to ¾ BMP and the BMP rate. The timing of nitrogen application will follow standard grower practices. Phosphorus and potassium application rate will be determined by a pre-plant soil test. The IFAS recommended amount of phosphorus will be applied prior to planting. Potassium application will be split and applied with the nitrogen side-dress. The "Grower Rate" in Table 1 is defined as the standard grower fertilization practice and may vary depending on specific grower practices.

Stand counts will be taken during the potato season at emergence, flowering, and at harvest by counting the number of potato plants in the center three rows of each plot. Early plant vigor will be assessed three weeks after emergence and rated on a one to ten scale. The time from planting to emergence and first flower will be recorded for each plot.

Twelve 10-meter sections will be harvested from each plot with a mechanical harvester by the Hastings REC staff. This corresponds to 120 row-meters (390 row-feet or 3% of an acre) from each plot. The potatoes will be transported to the Hastings REC, graded into five size classes, and rated for general appearance, disease, and nematode damage. Specific gravity and marketable yield per treatment will be determined.

Pendamethalin may be used to control weeds in the cowpea and sorghum/sudan planting following label directions. Metalachlor may be used in the bush green beans and the potatoes for weed control. Fungicidal treatments will be made in the bush green beans and potatoes on an "as needed" basis following the recommendations of IFAS extension personnel. Nematicide treatments will follow standard grower practices.

Soil Analysis. Soil samples will be taken at cover crop planting; at pre-plant and first bloom in the bush bean crop; and at pre-plant and full bloom in the potato crop. Nitrate, ammonia, potassium, and phosphorus will be measured at the UF/IFAS Analytical Research Lab (ARL) on the University of Florida campus. In addition, soil organic matter, total nitrogen, and soil pH will be measured yearly before cover crop planting. Water content will be determined gravimetrically at sampling.

Water Analysis. Four lysimeters will be buried in each plot at a depth 30 cm below the top of the row to measure nitrate, phosphorus, and potassium moving through the root zone during the potato season. This is a total of 24 lysimeters that will be maintained at each location. A sample will be pulled from the lysimeters weekly during the potato season. In addition, a sample will also be taken within 48 hr after a leaching rain event. A leaching rain event is defined as greater than 2.5 cm of rain in a 24-hour period.

Additionally, a six-inch diameter PVC pipe will be buried in each plot to a depth of one meter. This pipe will act as a well casing providing easy access to the water table below each plot. A 25 ml water sample will be collected from each casing on a weekly basis and analyzed at the ARL for nitrate, phosphorus, potassium, and electrical conductivity. A sample will also be

taken within 48 hr after each leaching rain event. A weekly water sample from the irrigation water will serve as a background nitrate check. Over the potato production season, there will be at least 8,640 separate analyses ran on all farms (2,160 samples x nitrate + phosphorus + potassium + EC). This number will increase depending on the number of leaching rainfall events.

Tissue Analysis. The procedure for measuring nutrients in plant tissue will be the same for the various crops grown over the production year. Four plants from each plot at each date will be dissected into leaves and stems. Each tissue type will be oven-dried, weighed and ground before analysis. Total Kjeldahl nitrogen, potassium, and phosphorus will be analyzed following standard protocols at the ARL. Bean pod and potato tuber nutrient content will be measured at harvest following standard protocols.

The cowpea and sorghum plants will be sampled once before cutting and incorporation. Green bean plants will be sampled at first flower and at harvest. Potato plants will be sampled when fertilizer is first side-dressed and at full flower.

In addition, the bush green bean and potato plant sap nitrate will be measured with a Cardy sap meter two weeks after emergence and at full flower. The most recently matured leaf will be used for measurement.

All sampling will follow Florida Department of Environmental Protection approved methodologies.

Output 1.

We will be able to demonstrate the potato production differences associated with the grower practices and the legume crop rotation practices. Any reduction in inorganic fertilizer requirements will be documented and delivered to all stakeholders. This cropping sequence demonstration will verify existing nitrogen BMPs and provide evidence for or against the adoption of new cropping sequence BMPs.

Task 2.

Dissemination of Information. A team of state and county faculty has been assembled for this project with a broad background in crop production practices. This team will be responsible for contributing to the education program supporting the project. Outreach programs are as follows:

North Florida Growers Exchange Meeting: The NFGE is a potato grower group for the TCAA that meets regularly during the potato season to discuss production concerns. A meeting will be sponsored in May of each year to discuss the objectives and progress with the TCAA growers. A meeting will be scheduled with this group in each of the three funded years of the project.

Tri-County Agricultural Fair: An Agricultural Fair is held at the Putnam County Extension Center in October of each year. The Hastings REC and Tri-County faculty base discussion topics on issues facing growers in the TCAA. The project components and results will be discussed at this meeting during each year of the project.

Hendry County/Miami-Dade County Extension Workshop: A separate workshop will be conducted with potato growers in both counties to discuss the project objectives and results. Growers in these two counties farm approximately 8,000 acres of potatoes. The growers will be

surveyed on their production practices. These meetings will serve to familiarize potato growers in other growing regions of the state with the BMPs developed for the TCAA. Through this communication, a realistic picture of the BMPs that can be transferred statewide will be developed.

Website Development: A website will be developed and maintained that will describe all information pertaining to the project. Resources will be posted on the website that state and county faculty can incorporate into presentations. A database of statewide potato production practices will be maintained on the website.

Output 2.
Education of the grower community on the outcome of the demonstration project will enable growers to make informed decisions about their production practices. This project will disseminate information utilizing the power of the IFAS extension infrastructure, *i.e.* county faculty involvement; county faculty newsletters; the IFAS web based information system, EDIS; grower field days; etc.

PROJECT WATERSHED CHRACTERISTICS
Watershed size: Lower St. Johns River, 50,302.7 watershed acres

Land Used within the watershed (acres/percentage):
Agriculture/Urban: 20-50%
Forested: 25-50%

SPECIFIC OUTPUTS/DELIVERABLES
The reporting output will include regular progress reports (16), a draft project report, five hard copies of a comprehensive final project report, and one electronic copy in MS Word. The final report will also include one copy of slides that have been taken throughout the duration of the project.

The output will also include regular extension discussions at field days and agricultural fairs (12 meetings over a three year period at three in state locations). A website that details all progress on the project will be maintained for the duration of the project. Fact sheets on all aspects of the project will be developed and distributed to growers directly (2 fact sheets a year). Fact sheets will be distributed to county faculty for inclusion into extension newsletters (5 county agents directly involved x 2 fact sheets x 3 years = 30 potential additions to extension newsletters).

The lower St. Johns River basin and the TCAA are classified by FDEP as Group 2. This means that the establishment of TMDLs for the basin is targeted for the year 2002. In order to attain a "presumption of compliance" from FDEP, growers will need to follow the voluntary BMPs set forth in the SJRWMD Cost Share Program. In order to maximize grower compliance, successful BMP options need to be maximized. This project will enlarge the palette of BMP options available to growers.

Project Milestones:

Task	Months after Contract Completion
Field Demonstration	
Prepare and submit QAPP	3
Apply fertilizer and plant potatoes	4, 16, and 28
Monitor pests, crop growth, and plant nutrition	4-9, 16-21, and 28-33
Harvest and grade potatoes	9, 21, and 33
Plant summer cowpea and sorghum rotational crops and take soil samples	9, 21, and 33
Monitor summer crop growth and pest populations	9-11, 21-23, and 33-35
Chop and incorporate cover crop, plant green beans, and take soil samples	12, 24, and 36
Monitor green bean growth, nutrient status, and pest populations	12-14 and 24-26
Harvest green beans	14 and 26
Incorporate green bean crop and fumigate ground	15 and 27
Prepare quarterly reports	As needed
Prepare final report	36
Outreach	
Develop website to post objectives, information, and results of demonstration	3
Conduct presentations that highlight objectives and preliminary findings:	
North Florida Growers Exchange Meeting, Palatka, Florida	8 and 32
Hendry County Extension Meeting	12 and 36
Miami-Dade County Extension Meeting	12 and 36
Professional Society Meetings	22, 23, 34, and 36
Tri-County Agriculture Day	13 and 25
Regular updates to state-wide IFAS - EDIS system and extension newsletters	Continuously

All tasks will be repeated during each of the three funded years.

COOPERATORS:

State Faculty.

Dr. Chad Hutchinson, University of Florida/IFAS, Hastings REC, Hastings, Florida. Dr. Hutchinson will serve as the principal investigator on the project. His role will be to oversee the demonstration project and the distribution of funds. Dr. Hutchinson will be responsible for directing the project manager and technical help at the Hastings sites. Dr. Hutchinson has the automatic potato production and grading equipment located at the Hastings REC at his disposal. Dr. Hutchinson has an extensive background in using cover crops in crop production systems and will be a valuable resource on the project.

Dr. Eric Simonne, University of Florida/IFAS, Department of Horticulture, Gainesville, Florida. Dr. Simonne will serve as a plant nutritionist on the project. Eric has a statewide appointment and will be called upon to present information at grower meetings on potato nutrition topics. His

role will be to participate in the planning and coordination and water inputs, collection of soil and water samples, processing and analysis of the soil and plant tissue samples.

Dr. Rao Mylavarapu, University of Florida/IFAS, Soil and Water Science Department, Gainesville, Florida. Dr. Mylavarapu will serve as the soil scientist on the project. Rao has statewide responsibility as a Nutrient Management Specialist and also runs the UF/IFAS Soil Testing Program as the Director of Extension Soil Testing Lab overseeing UF/IFAS Standardized Fertilizer Recommendations for Florida crops. His role will be to participate in the planning and coordination of the collection of soil and water samples and the processing and analysis of the soil, water, and plant tissue samples. Dr. Mylavarapu's experience as a soil scientist will be beneficial in understanding the nutrient dynamics in the soil under the various cropping systems.

Dr. Ron Rice, University of Florida/IFAS, Everglades REC, Belle Glade, Florida. Dr. Rice has expertise in phosphorus management and its influence on crop growth. Dr. Rice will interpret the phosphorus cycling in the demonstration plots.

Dr. Marion White. University of Florida/IFAS, Central Florida REC, Apopka, Florida. Dr. White has experience in producing numerous crops under Florida growing conditions including green bean and potato. Dr. White will consult during production of green bean crop and contribute to the interpretation of the potato results at each site.

Dr. George Hochmuth. University of Florida/IFAS, North Florida REC, Quincy, Florida. Dr. Hochmuth was involved in the original research that developed nitrogen BMPs for the TCAA. Dr. Hochmuth's extensive expertise in nutrient management in crop production in Florida will make him an invaluable resource for information regarding potato production in the TCAA.

Dr. Sanjay Shukla, University of Florida/IFAS, Southwest Florida REC, Immokalee, Florida. Dr. Shukla will interpret the influence of irrigation and production practices on demonstration plot performance. This information will be used to develop BMP recommendations for potato growers in South Florida.

County Faculty.
TBA, Putnam County Extension Director and Extension Agent
Mr. Chuck Lippi, Flagler County Extension Director and Extension Agent
TBA, St. Johns County Extension Agent
Mr. Gene McAvoy, Hendry County Extension Agent
Ms. Teresa Olczyk, Miami-Dade County Extension Agent

The county faculty will be involved in the local extension meetings and will be an integral part of the grower outreach program. They will provide local information on crop production practices and will arrange for grower participation in crop planting and field days.

REFERENCES

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