

# Review of Nutrient Management Systems for Florida Vegetable Producers: A White Paper from the UF/IFAS Vegetable Fertilizer Task Force<sup>1</sup>

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**Abstract.** The Vegetable Fertilizer Task Force (VFTF) was created by the UF/IFAS Dean for Extension in 2006 to review nutrient management systems for Florida vegetable producers. The VFTF identified differences between actual fertilization practices and UF/IFAS fertilizer recommendations, especially for vegetables grown with subsurface (Central and South Florida) and overhead (Miami-Dade County) irrigation. In these areas, differences were highest for fall crops when the frequency of leaching rain has historically been highest. With the development of the statewide Best Management Practice (BMP) program for vegetables,

**UF/IFAS fertilizer recommendations have become quasi-regulatory. The recommendations of the VFTF aim at bridging the gaps between science-based results and the diversity in production systems found in the Florida vegetable industry.**

The vegetable industry in Florida is large (300,000 acres; \$1.2 B farm gate value) and diverse (over 50 crops; three growing seasons; different soil types and irrigation methods). Because of the low water holding capacity of Florida's sandy and gravelly soils, and because of irregular rainfall patterns, fertilization and irrigation management have traditionally been two important components of successful vegetable crop production in Florida (Hochmuth 1992a, b; Locascio, 2005). As production systems evolve, improved

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cultivars are used, and regulations change, cultural practices and fertilization recommendations need to be updated. Appointed by the UF/IFAS Dean for Extension in 2006 to review nutrient management systems for Florida vegetable producers, the vegetable fertilizer task force (VFTF) was comprised of horticulturists, agricultural engineers and county faculty representing all major vegetable areas of Florida. The charges to the VFTF were to (1) review new data generated since the last fertilizer recommendations were developed, (2) propose science-based updates, (3) develop interim recommendations where research data were missing, (4) develop a strategic plan to fill gaps in knowledge, and (5) determine funding sources for needed research. How recent UF/IFAS fertilizer research results may be incorporated into science-based recommendations for Florida's vegetable producers is outlined in this paper.

## 1. Principles of Fertilization and Current Recommendations for Vegetable Crops Grown in Florida.

Current fertilization recommendations for vegetable crops are based on three fundamental principles: soil testing, crop nutritional requirement and the linear bed foot (LBF) system (Simonne and Hochmuth, 2005). First, fertilization recommendations are based on soil testing for all essential nutrients. UF/IFAS recommended extractants are the double-acid Mehlich 1 extractant for acid-mineral soils up to a soil pH of 7.3, the AB-DTPA extraction for alkaline soils with a soil pH above 7.4, water extraction for P in organic soils, and acetic acid for K, Mg, Ca, Si, and Na in organic soils (Hochmuth et al., 2000; Mylavarapu, 2002). In contrast, N recommendations are not based on soil test. Because none of the extractable N fractions is well correlated with growth or yield response, N recommendations are based on the crop nutritional requirement (CNR). The CNR is defined as the total amount in lb/acre of an element needed by a crop to produce optimal economic yields. The third principle is that for mulched crops, fertilizer rates are calculated based on the number of LBF, and not on the field surface. The number of LBF for a given bed spacing is calculated by dividing the field surface by the bed spacing. These principles are discussed in detail in "Nitrogen management practices for vegetable production in Florida" (Hochmuth, 2000) and "IFAS standardized fertilization recommendations for vegetable crops" (Hochmuth and Hanlon, 2000).

Crop-by-crop fertilizer recommendations for vegetables grown on sandy soils may be found in the Vegetable Production Handbook for Florida (edited by Olson and

Simonne, 2005). UF/IFAS fertilizer recommendations include a base fertilizer rate and a supplemental rate allowed after a leaching rain (defined as 3 inches of rainfall in 3 days or 4 inches in 7 days), an extended harvest season, and/or when plant nutritional status is diagnosed as "low" based on whole leaf analysis or petiole sap testing (when interpretation data are available; Simonne and Hochmuth, 2005). Fertilizer placement (banded, broadcast or modified broadcast), the amount applied pre-plant, and detailed fertigation schedules are also parts of UF/IFAS recommendations. These recommendations which are based on research results available in the mid 1990s propose a single N rate for all irrigation systems, production seasons and sandy soil types of Florida (Hochmuth and Cordasco, 2000a-f, 2003a-c).

Recommendations for vegetable crops grown on muck soils may be found in "Fertilization recommendations of crisphead lettuce grown on organic soils (Hochmuth et al., 2003a) and "Fertilization of sweet corn, celery, Romaine, escarole, endive, and radish on organic soils in Florida" (Hochmuth et al., 2003b).

Fertilizer recommendations for vegetable crops grown on the calcareous soils of south Miami-Dade County are at this point incomplete because no calibrated soil test is available for the area (Li et al., 2006a-j).

In addition, several publications describing best management practices (BMPs) have adopted all or part of UF/IFAS fertilizer recommendations. These documents are (1) "Water quality/quantity best management practices for Florida vegetable and agronomic crops" (FDACS, 2005) for the state-wide BMP program; (2) "Tri-county agricultural area water quality protection cost share program, Applicants' handbook" (Livingston-Way, 2002), "Best management practices for potato production in Northeast Florida" (Hutchinson et al., 2002a) for the Tri-County Agricultural Area (TCAA); and, (3) "Nutrient best management practices in the Everglades Agriculture Area: Soil testing" (Daroub et al., 2005) for N and in "Phosphorus management for vegetable production" for P (Hochmuth et al., 2003c) for the Everglades Agricultural Area (EAA). The adoption of UF/IFAS fertilizer recommendations as the BMP rates elevates the recommendations to a quasi-legal status. Hence, UF/IFAS fertilizer recommendations must be adapted to all major growing conditions used in vegetable production in Florida and be supported by the best science available. This is a prerequisite for vegetable growers to fully adopt and implement the BMP program.

## 2. Differences Between UF/IFAS N Recommendations and Actual Industry Rates.

Phone interviews of key growers and members of the vegetable industry, and feedback from members of Extension advisory groups were conducted in Spring 2006. Comments revealed that vegetable producers have implemented current UF/IFAS recommendations with different rates of success (Tables 1-6). Overall, industry rates are below, near, or greater than UF/IFAS N recommended rates based on crop, location, growing season and irrigation method. This observation does not support the hypothesis that growers' rates always exceed UF/IFAS recommended rates. However, this observation supports the need for regional recommendations, supported by targeted research and educational programs. Typically, N fertilizer rates used for polyethylene-mulched and drip-irrigated crops in the panhandle and in North-central Florida were similar to the UF/IFAS N recommended rates. The growing conditions and seasons in these two regions of Florida are the closest to those where most of the vegetable fertilizer research was conducted. Moreover, UF/IFAS has been able to successfully develop nutrient management programs in these areas (Hochmuth et al., 2003d; Simonne et al., 2005).

The greatest differences between UF/IFAS N recommended rates and industry rates were found with crops grown in the fall, winter or spring seasons and with subsurface or overhead irrigation. These crops include tomato (*Lycopersicon esculentum* Mill.), bell pepper (*Capsicum annuum* L.), eggplant (*Solanum melongena* L.), potato (*Solanum tuberosum* L.), watermelon [*Citrullus lanatus* (Thunb.) Matsu. & Nakai] and squash (*Cucurbita pepo* L.). It should be noted that growers often report fertilizer rates on a surface basis, even when they use a bed spacing smaller than the standard one (adequate conversions have been made in the tables). In addition, crop specific recommendations need to be developed for new crops once they become of economical importance. For example, grape tomato N requirements are different from those of round tomato, but grape tomato growers must follow UF/ IFAS recommendations for determinate, large round tomato.

Producers have common reasons why fertilizer recommendations are too low and why higher application rates may be "justified." These include "these rates were developed in small plots in North Florida under conditions different from those of South Florida," "the cultivars now in use are more vigorous and may need more fertilizer than the ones used ten or fifteen years ago," "current recommendations do

not take into account the longer growing seasons typical of South Florida," "no link has been established between high fertilizer rates and environmental problems in my watershed," "indeterminate grape tomatoes develop a larger bush, have a longer harvest season and may require more N than the determinate round tomatoes," and "the greater denitrification potential with subsurface irrigation should be taken into account in the recommendation." These reasons may deserve careful consideration. Another reason why fertilizer rates in excess of UF/IFAS recommendations may be used is economics. Because fertilizer as a crop input has historically represented only 10% to 15% of the total production cost, fertilizer rates in excess of the UF/IFAS recommended rates have been used as insurance toward productivity. Simply put, it only takes an increase in yield of five 25-lb carton/acre (when the market is \$8/25-lb carton) to offset the cost of an extra 100 lbs/acre of N at a cost of \$0.40/lb of N. As the statewide BMP program for vegetables is widely promoted and implementation begins, it is essential for growers to trust UF/IFAS fertilizer recommendations. UF/ IFAS recommendations must be scientifically based, but also be practical and flexible under all growing conditions to ensure the success of the BMP program.

Why is it so important for growers to follow UF/IFAS fertilizer recommendations today? The BMP manual for vegetable crops recognizes that fertilizer rates may be used in excess of the UF/IFAS recommended rates as described in Option 2 of BMP33 "Optimum fertilization management/application" (p. 93, FDACS, 2005). However, this option should be viewed as a temporary solution, and not as a license to systematically over-fertilize. In the long run, if the current BMP program does not improve water quality of impaired water bodies, then it is likely to be replaced by a more stringent regulatory program. Hence, it is essential to reconcile science-based UF/ IFAS recommendations with the needs of today's vegetable industry. It should be noted that current "Producer Soil Tests" reports generated by the UF/IFAS Extension Soil Testing Laboratory (ARL/ ESTL) contains a comment that states "these interpretations and recommendations are based upon soil test results and research/experience with the specified crop under Florida's growing conditions." This comment acknowledges that the science behind nutrient management must pass the test of time before it can be fully trusted.

As an educational institution involved in research and Extension, the real question for UF/IFAS is: if UF/IFAS fertilizer recommendations are supported by the best science possible, why have some large segments of the Florida vegetable industry not been able to implement them? In

other words, are we witnessing an Extension failure (not being able to change grower's behavior through education) or is it a failure due to the "across-the-board" approach to vegetable fertility management in Florida? Obviously, the answer is not simple, and it is probably a combination of several factors (Simonne and Ozores-Hampton, 2006).

### 3. Revise Current Data Interpretation and Summary Methods for Fertilizer Trials.

One challenge faced by researchers who have tried to identify statewide fertilizer recommended rates is the diversity in growing conditions, bed spacing, plant population, and number of harvests made by Florida's vegetable producers. This diversity can be circumvented by using the relative yield method for data standardization (Hochmuth and Cordasco, 2000a-f, 2003a-c). While this approach is numerically efficient, it artificially gives the same weight to the trials that yielded poorly (and which do not adequately represent commercial growing conditions) as to those with high yields. Hence, data collected before the mid 1990s, summarized and interpreted using this method should be carefully re-evaluated by region, irrigation method and growing season.

### 4. Updates of Recommendations Based on Research Results Generated since the Last Recommendation Update of the mid 1990s.

The update of nutrient management recommendations needs to be based on research results published since the last update and reinterpretation of previous studies. Research has been conducted in several areas of fertilization and irrigation management and should be incorporated into UF/IFAS recommendations as a summarized below.

*4.1 Fertilizer recommendations using controlled release fertilizer programs for potato production* will be based on research results from Florida (Hutchinson, 2004a, b; Hutchinson et al., 2003; Hutchinson and Simonne, 2003; Muñoz-Arboleda et al., 2005, 2006; Pack et al., 2006; Simonne and Hutchinson, 2005) and on-going on-farm evaluation (Hutchinson et al., 2002b).

*4.2 Preliminary N recommendations for drip-irrigated grape tomato* will be based on a 2-year field study conducted at the

North Florida Research and Education Center—Suwannee Valley. Results from 2005 suggested that N fertilization for grape tomato could be done by incorporating 50 to 70 lb N/acre in the bed, followed by weekly injections of 0, 1.0, 2.0, 2.5, 3.0, 3.5 lb/acre/day for 1, 2, 3-4, 5-10, 11-14, and 15-16 WAT, respectively (Simonne et al., 2006c). Because the length of the growing season for grape tomato may vary, emphasis should be placed on weekly N rates and irrigation management, rather than on seasonal N rate. The study was repeated in 2006, but results are not yet available.

*4.3 The influence of soil and/or foliar applied Ca on postharvest quality and yield of strawberry fruit (Fragaria ananassa Duch.)* was the topic of a Master's student in Horticultural Sciences Department (Esmel, 2005). This 2-year field and laboratory study found no effect of supplemental Ca on yield and firmness of 'Sweet Charlie' strawberry under Central Florida growing conditions.

*4.4 Tomato growth and yield response to N rates.* This in-depth project studied the effect of N and irrigation management on N accumulation, growth, and yield of tomatoes grown in Florida. Apparent N recovery decreased as N-rates increased with values ranging from 0.61-0.96 and 0.36 to 0.74 for sub-irrigated and drip irrigated crops, respectively. Nitrogen accumulation for well-managed tomato production was in the order of 125 to 178 lb/acre of N, with approximately 70% of this amount accumulated by the fruits (Scholberg, 1996).

*4.5 The "Lake Manatee project"* (Stanley et al., 2003) addressed two important issues in central Florida: how much N is denitrified in seepage-irrigated soils and what is the real environmental impact of vegetable production on the water quality of Lake Manatee?

Overall, there was no clear correlation between  $\text{NO}_3\text{-N}$  concentrations in the reservoir and fertilizer application dates. The  $\text{NO}_3\text{-N}$  concentrations also appeared to follow a seasonal pattern, with lower levels during the summer months (June to September). In regard to nutrient enrichment and subsequent algal growth, it does not appear that the amount of agricultural activity in the watershed is of the greatest importance, but rather how close that activity is located to the reservoir. Some citrus production is situated directly adjacent to Lake Manatee, which results in direct surface runoff. The use of riparian buffer zones or filter strips to control  $\text{NO}_3\text{-N}$  losses from agricultural lands may also be helpful in this situation. Substantial losses in  $\text{NO}_3\text{-N}$  can occur through denitrification and assimilation by buffer vegetation. This study is unique in Florida as it documented at the watershed level that fertilizer-intensive production

does not necessarily result in reduction in environmental quality.

*4.6 Integrated water and N fertilization of bell pepper and watermelon grown with plasticulture* was studied in a two-year experiment at the North Florida Research and Education Center—Suwannee Valley. Greatest bell pepper yields were achieved with a combination of 125% of the UF/IFAS N recommended rate for bell pepper (200 lb N/ acre) and 100% UF/IFAS irrigation rate (Simonne et al., 2006b). Greatest marketable watermelon yields were achieved with 100% of both UF/IFAS N recommended rate for watermelon (150 lb N/acre) and UF/IFAS irrigation (see Simonne et al., 2006 in [Table 7](#)).

*4.7 Fine-tuning the leaching rain definition.* The UF/IFAS (Simonne and Hochmuth, 2005) and BMP (DACS, 2005) definition of leaching rain is 3 inches in 3 days or 4 inches in 7 days. While consensus exists that such rains are likely to be leaching, smaller rainfall amounts may also leach nutrients. Research on water table response to rainfall for Immokalee fine sand has shown that 1 inch of rainfall results in raising the water table by 16 inches (Jaber and Shukla, 2006). Hence, a 1-inch rainfall event in one day may result in nutrient leaching at the beginning of the season when the water table is kept near the 14-inch depth high due to limited rooting depth, and most of the fertilizer still present in the bed.

#### *4.8 Current on-going projects:*

*4.8.1 Large round tomato N rates.* A 3-year research/Extension project spearheaded by Ozores-Hampton and a group of Extension specialists and agents is underway in South and Central Florida (Ozores-Hampton et al., 2005). A gap exists in information on N fertilizer rate work on currently grown cultivars in this area. Overall, results show that the risk of leaching rain occurrence in South Florida changes over three growing seasons (fall, winter and spring) and that reduced rates may be used during some seasons and growing areas where only two harvests are targeted. Total marketable yields with the UF/IFAS N rate (200 lb N/ acre) were often not statistically different from those with higher rates (especially during the first two harvests), but in some instances, the opposite occurred. Hence, the reduced rate may be between 200 and 300 lb N/acre.

*4.8.2 Phosphorus rates:* McAvoy and Obreza (2005) conducted a study to investigate the effects of varying P rates for snap bean production. This study showed no effects of reduced P rates on yield and quality over six consecutive crop growing seasons. Preliminary research results from

investigating the effects of N and P fertilizer rates and water management (UF/IFAS and grower average) on tomato and watermelon crop yield and quality, water use and quality, and economic impact showed increased yield with the grower nutrient and water management system over two seasons for watermelon (Shukla et al., 2005; see Hendricks et al., 2006 in [Table 7](#)). Preliminary results (one season) from the same study on tomato did not show any increase in crop yield with the grower rate. A similar one-year study in Miami-Dade County showed no sweet corn (Olczyk et al., 2003), potato (Li et al., 2000) and large round tomato (Lamberts et al., 1998; Li et al., 1997, 1998) yield reduction when reduced P was used. In addition, data from the project of “Crop nutrient requirements for vegetable crops on limestone soils of south Florida” by G. Hochmuth, E. Hanlon, M. Lamberts and S. O’Hair (1994-1997) and several projects conducted by Li et al. (1997-2004) indicated that P application rates could be reduced for calcareous soils with high P concentrations without reducing yields.

*4.8.3 Soil moisture monitoring as a means to increase fertilizer efficiency:* Soil moisture sensors (tensiometers) were evaluated by Olczyk et al. (2000, 2002), Muñoz-Carpena et al. (2002, 2005), and Li et al. (1998) for use in South Florida calcareous soils and were shown to lead to reduced use of irrigation water with no decrease in marketable yield.

#### *4.8.4 Additional on-going nutrient management projects potentially instrumental to UF/IFAS recommendations:*

- Water movement in different soils of Florida, 2003-06 (on farm, PI: E. Simonne; Simonne et al., 2003a, b, 2004, 2005, 2006a, d)
- Bell pepper on the east coast, 2006-08 (at center and on farm, PI: B. Boman)
- Controlled-release fertilizer use on seepage tomato, 2006-08 (at SWFREC center and on farm, PI: K. Cushman)
- Reduced P rates in South Florida, 2006-2008 (on farm, PI: K. Cushman)
- Nutrient leaching by round tomato on drip in North Florida, 2004-07 (at NFREC-SV, PI: E. Simonne)
- Drip-irrigated round tomato response to N rate in North Florida, 2005-2006 (at NFREC-SV, PI: G. Hochmuth)
- BMPs and runoff, east coast, 2004-07 (on farm, PI: P. Stofella)

- Irrigation rate, N rate and cultivar on strawberry, 2001-2006 (at GCREC-Dover and GCREC-Wimauma, PI: B. Santos; Simonne et al., 2001)
- Leaching by strawberry fields, 2005-2007 (on-farm, PI: C. Stanley)
- Controlled-release fertilizer use on cole crops, melons, and sweet corn in Florida (2006-2008, PI: C. Hutchinson)
- Comparison of water and nutrient management systems for tomato and watermelon in Southwest Florida, 2003-2006 (at SWFREC, PI: S. Shukla; Shukla et al., 2004)
- Effects of soil moisture based water table management for seepage irrigation for pepper and eggplant in Southwest Florida, 2002-2005 (on farm, PI: S. Shukla)
- Development of crop coefficients for watermelon for Florida, 2003-2006 (at SWFREC, PI: S. Shukla)
- Ground water recharge, upflux, and nutrient loadings with watermelon and bell pepper in SW Florida, 2004-2006 (at SWFREC, PI: S. Shukla; see Hendricks et al., 2006 and Srivastava et al., 2006 in [Table 7](#))
- Effects of compost on water and nutrient movement with bell pepper and eggplant in SW Florida, 2004-2006 (At SWFREC center, PI: S. Shukla; Jaber et al., 2005a-c)

## 5. Proposed Interim Updates to be Used until Scientific Basis is Achieved.

Interim recommendations based on best professional judgment may be used temporarily while sufficient research data are developed. Interim recommendations while science-based data are being collected should be adopted as follows:

### 5.1 Adaptation of UF/IFAS N recommendations to seepage irrigation in South Florida:

*Situation:* Current N fertilizer recommendations do not consider irrigation method or season.

*Issue:* How to adapt N fertilization from drip to seepage irrigation? How to take into account growing season?

*Justification:* Overall, denitrification rate estimates developed for production systems outside of Florida cannot be transferred to Florida (Simonne and Morgan, 2005).

Approximately 23% of the N fertilizer was unaccounted for in a N balance made on bell pepper grown in lysimeters (Stanley and Clark, 1993). The N not accounted for was assumed to be lost by denitrification. The fertilizer rate used in this experiment was 300 lb N/acre, and the potential denitrification estimate from this study was 69 lb N/acre/season. In addition, the occurrence of leaching rains in South Florida is typically two to four occurrences during fall plantings, one to three during winter plantings, and zero to two during spring plantings.

*Interim recommendation:* Current N rates may be adapted to seepage irrigation by increasing them by 20% to 25% to compensate for denitrification. Current N rates may be adapted to fall conditions by allowing additional fertilizer (30 lb/acre of N and 16.6 lb/acre of K based on the historical frequency of leaching rains). Hence, the proposed interim N rate for seepage irrigated crops is 240-300 lb N/acre for eggplant, pepper, and tomato, and 180-220 lb N/A for cucurbits grown with seepage irrigation. Based on research/experience in the TCAA, an interim rate of 220 lb N/A is recommended for chipping potato.

### 5.2 Maintenance P rates:

*Issue:* Growers and UF/IFAS research and education centers do not feel comfortable in following the recommended 0 lb/acre P when Mehlich-1 soil test results are “high” or “very high.” The same applies to growers in Miami-Dade County but no calibrated soil test is available for P in calcareous soils.

*Interim Recommendation:* Allow for 8.8-13.2 lbs of P/acre targeted maintenance rate when soil-test P recommendation is “high” or “very high.” Starter P should be banded next to seed or transplant, and not as broadcast application. This recommendation for starter P fertilizer already exists in the footnotes of the Producer’s Soil Test reports of the ARL/ESTL (footnote 354), but is not included in the Vegetable Production Handbook.

### 5.3 Nitrogen fertilization for grape tomato grown with seepage irrigation:

*Issue:* No recommendation for grape tomato grown with seepage irrigation currently exists.

*Interim recommendation:* Calculate estimated seasonal rate for grape tomato grown with seepage irrigation by multiplying length of growing season (days) by daily rates (lb/ acre/day). Monitor foliar N concentration for further fine-tuning.

## 6. Strategic Plan to Identify Priority Research/Demonstration and their Funding.

### 6.1. Priority publications/communications:

- Develop and release in EDIS a manual entitled “Guidelines for on-farm fertilizer and irrigation demonstrations in Florida in the BMP era: Design, implementation, analysis, and interpretation.”
- Create a database maintained by UF/IFAS that would allow for rapid access of research on water and nutrient management for vegetable crops in Florida and funded by FDACS, FDEP, and water management districts.
- In cooperation with the Florida State Horticultural Society and the UF/IFAS Water Institute, support the organization of a research/Extension statewide conference on recent advances in nutrient management and BMP research.

### 6.2. Priority research and demonstration needs:

- Summarize and interpret data from fertilizer trials by region, irrigation method and growing season using data generated before the mid 1990s found in Hochmuth and Cordasco (2000a-f, 2003a-c), since then (Couto et al., 1999; Esmel, 2005; Lamberts et al., 1998; Li et al., 1997; Muñoz-Carpena et al., 2005; Pandey and Shukla, 2005; Shukla et al., 2004, 2005; Simonne et al., 2001), and in preparation (Table 7).
- Evaluate the economic benefit to vegetable producers at varying fertilization rates. This should address the issues such as risk-benefit analyses of reduced fertilizer rates using multiple-year research.
- Quantify the amount of N lost by denitrification during the crop in drip and seepage-irrigated systems and allow for compensation in the recommendations.
- Evaluate the effects of water table fluctuations due to rainfall, freeze or wind protection on nutrient leaching. Incorporate the nutrient leaching under varying water table fluctuations into the recommendations.
- Determine nutrient requirements for extended market conditions (>3 picks, especially pepper and eggplant) including comparisons between all fertilizer applied at planting and part of the fertilizer wheel-injected

according to the supplemental fertilizer provision (Simonne and Hochmuth, 2005).

- Determine N requirement for tomato, snap bean, summer squash and sweet corn in south Miami-Dade County.
- Determine N-P-K requirements for gape tomato grown with drip or seepage irrigation.
- Verify N and P rates for crops grown on the organic soils of the EAA.
- Incorporate long-term weather prediction and rainfall potential in fertilizer recommendations (el Niño, la Niña, neutral years).
- Develop and test controlled-release fertilizer-based fertilization programs for all major crops (pepper, eggplant, cucurbits, okra, boniato) grown with seepage and/or overhead irrigation.
- Determine historical frequencies of leaching rainfalls for Fall, Winter and Spring plantings in major vegetable growing areas of Florida.
- Update nutrient management recommendations using cultivars currently in use, which may be more vigorous than older varieties. Evaluation should include grade distribution and postharvest evaluation.
- Demonstrating the feasibility of using a single fertilizer band that would cut the rate significantly of crops grown with subsurface irrigation. Also, demonstrate and encourage the use of one band, reduced rate or no banded fertilizer in drip-irrigated fields to reduce total rates used.
- Include in a nutrient management recommendation whether each water basin is N or P limited. The recommendation should include more flexibility for P rates in N-limited watersheds, and for N rates in P-limited watersheds.
- All the above research/Extension priority needs to focus on productivity first, which is the main focus of UF/IFAS production recommendation. Also, the following research/Extension activities should also be considered to facilitate BMP adoption:
- Investigate and demonstrate the feasibility of summer flood fallow and denitrification at the end of the crop as a BMP for vegetable production in Flatwoods region of Central and South Florida.

- Investigate and demonstrate the benefits of summer cover crops in Central and South Florida.
- Quantify the effects of varying amounts of rainfall, and moisture and water table fluctuations on N losses to ground water. This should be incorporated in the fertilizer recommendation.
- Support systems research seeking the development of zero or limited nutrient and water discharge.

In summary, the recommendations of the VFTR are:

1. UF/IFAS nutrient management recommendations for vegetable crops should be defined as “the rates of fertilizer and water that qualitatively and quantitatively optimize the yield of vegetable crops over multiple years and that reflect regional and seasonal differences.”
2. UF/IFAS nutrient management recommendations must continue to be based on science, follow the core principles of soil testing, crop nutritional requirement and linear-bed foot system, and take into account irrigation method and growing season.
3. Data collected before the mid 1990s and interpreted statewide should be re-evaluated by region, irrigation method and growing season.
4. Based on research data developed since the mid 1990s, UF/IFAS nutrient management recommendations updates should be adopted as described in this document.
5. Data used for developing UF/IFAS nutrient management recommendations should be collected under standardized experimental procedures that ensure the highest possible quality and targeted applicability of the results.
6. Science-based results in nutrient management should be tested in large plots, under farm or farm-like growing conditions before being incorporated into UF/IFAS recommendations.
7. In the absence of science-based data, the fertilizer recommendations based on best professional judgment described in this document should be adopted on an interim basis.
8. The funding for the continuous updating of UF/IFAS nutrient management recommendations should be coordinated at the state level among different funding sources (FDACS, DEP, water management districts,

USDA, commodity groups, etc.) and supported by adequate research and Extension FTE provided by UF/IFAS at the state-wide faculty, county faculty and technical support levels.

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**Table 1. Location, main soil type, irrigation method and production season of the main vegetable producing regions of Florida.**

Region	Area	Main soil type	Irrigation System	Production Season
Northwest	Panhandle <sup>z</sup>	Sandy and loamy	Drip, dryland	Spring, fall
North central	Suwannee Valley <sup>y</sup>	Sandy	Drip, dryland	Spring, fall
Northeast	Tri-county Agricultural Area <sup>x</sup>	Sandy	Seepage	Spring, fall
Central	Manatee and Hillsborough Counties	Sandy	Seepage, drip	Winter, spring, fall
East coast	Palm Beach County	Sandy	Seepage, drip	Winter, spring, fall
	Everglades Agricultural Area <sup>w</sup>	Organic ("muck")	Seepage	Winter, spring, fall
Southwest	Charlotte, Collier, Glades, Hendry, and Lee Counties	Sandy	Seepage, drip	Winter, spring, fall
South	Miami-Dade County	Calcareous rocky and marl	Overhead, drip	Winter, spring, fall

<sup>z</sup> Jefferson County and west.  
<sup>y</sup> Madison, Taylor, Hamilton, Suwannee, Lafayette, Dixie, Levy, Alachua, Gilchrist, Union, Bradford, Baker and Columbia Counties.  
<sup>x</sup> St. Johns, Putnam and Flagler Counties.  
<sup>w</sup> Palm Beach and eastern part of Hendry County.

**Table 2. UF/IFAS N fertilizer recommendations and industry survey for the main vegetable crops grown in Northeast Florida.**

Crop	Growing season	Production system		N fertilization (lbs/acre)	
		PM/BG <sup>z</sup>	Irrigation	UF/IFAS	Industry
Chipping potato	Spring	BG	Seepage	200	220-240
Table stock potato	Spring	BG	Seepage	200	180-220
Potato using controlled release fertilizer	Spring	BG	Seepage	n/a	n/a
Head Cabbage	Winter, spring	BG	Seepage	175	240
Broccoli	Winter, spring	BG	Seepage	175	240
Napa Cabbage	Winter, spring	BG	Seepage	175	225

<sup>z</sup> PM/BG = Polyethylene mulch or bare ground production.

Table 3. UF/IFAS N fertilizer recommendations and industry survey for the main vegetable crops grown in Central Florida.

Crop	Growing season	Production system		N fertilization (lbs/acre)	
		PM/BG <sup>z</sup>	Irrigation	UF/IFAS	Industry
Strawberry	Winter	PM	Drip	150	140-175 <sup>y</sup>
Cucurbit	Spring	PM	Drip	150	150-275 <sup>x</sup>
Round or grape tomato	Winter	PM	Drip	200	210-325
Round or grape tomato	Winter	PM	Seepage	200	250-350
Potato	Winter	BG	Seepage	200	220-300
Head or Napa cabbage	Winter	BG	Seepage	175	175-250
Bell pepper	Winter	BG	Drip	200	220-300
Bell pepper	Winter	BG	Seepage	200	220-300
Green beans	Winter	BG	Seepage	100	100-140
Cantaloupe	Spring	PM	Drip	150	130-140 <sup>x</sup>
Cucumber	Spring	PM	Drip	150	150-160 <sup>x</sup>
Summer squash	Spring	PM	Drip	150	100-110 <sup>x</sup>
Bell pepper	Spring	PM	Drip	200	170-180 <sup>x</sup>
Eggplant	Spring	PM	Drip	200	160-180 <sup>x</sup>
Tomato	Spring	PM	Drip	200	180 <sup>x</sup>

<sup>z</sup> PM/BG = Polyethylene mulch or bare ground production.<sup>y</sup> Rates ranging from 0.75 to 1 lb/A/day. Total N applied depends on length of season. <sup>x</sup> Double crop mostly after strawberry; rates shown were converted back to standard bed spacing.

Table 4. Current UF/IFAS N fertilizer recommendations and industry survey for the main vegetable crops grown in Florida's East Coast region.

Crop	Growing season	Production system		N fertilization (lbs/acre)	
		PM/BG <sup>z</sup>	Irrigation	UF/IFAS	Industry
Bell pepper	Fall	PM	Seepage	200	280-350
Round tomato	Fall	PM	Seepage	200	280-350
Eggplant	Fall	PM	Seepage	200	280-350
Cucurbits	Winter	PM	Seepage	130-150	150-200 <sup>y</sup>
Round tomato	Winter	PM	Drip	200	200
Eggplant	Winter	PM	Drip	200	200
Bell pepper	Winter	PM	Drip	200	200

<sup>z</sup> PM/BG = Polyethylene mulch or bare ground production.<sup>y</sup> Double crop mostly after bell pepper or tomato; rates shown were converted back to standard bed spacing.

**Table 5. UF/IFAS N fertilizer recommendations and industry survey for the main vegetable crops grown in Southwest Florida.**

Crop	Growing season	Production system		N fertilization (lbs/acre)	
		PM/BG <sup>z</sup>	Irrigation	UF/IFAS	Industry <sup>x</sup>
Round or Roma tomato	All <sup>y</sup>	PM	Drip	200	280-420
Round or Roma tomato	All <sup>y</sup>	PM	Seepage	200	260-350
Grape tomato	All <sup>y</sup>	PM	Drip	200	360-390
Grape tomato	All <sup>y</sup>	PM	Seepage	200	300-380
Bell pepper	Winter, fall	PM	Seepage	200	300-450
Bell pepper	Winter, fall	PM	Drip	200	350-470
Summer squash	All <sup>y</sup>	PM	Seepage or drip	150	180-225
Cucumber	All <sup>y</sup>	PM	Seepage or drip	150	175-225
Watermelon	All <sup>y</sup>	PM	Seepage or drip	150	200-220
Eggplant	All <sup>y</sup>	PM	Seepage or drip	200	280-350
Potato	Winter, fall	BG	seepage	200	200-230

<sup>z</sup> PM/BG = Polyethylene mulch or bare ground production.  
<sup>y</sup> All = Winter, spring and fall.<sup>x</sup> Double crops included.

**Table 6. UF/IFAS N fertilizer recommendations and industry survey for the main vegetable crops grown in South Miami-Dade County, Florida.**

Crop	Season	Production system		N fertilization (lbs/acre)	
		PM/BG <sup>z</sup>	Irrigation	UF/IFAS <sup>x</sup>	Industry
Round tomato	Winter	PM	Drip	n/a	350-450
Pepper	Winter	PM	Drip	n/a	350-450
Eggplant	Winter	PM	Drip	n/a	350-450
Sweet corn	Winter	BG	Overhead	n/a	200-480
Bean	Winter	BG	Overhead	n/a	80-200
Boniato	All <sup>y</sup>	BG	Overhead	n/a	200-400
Okra	All	BG or PM	Overhead	n/a	80-200
Cucumber	Spring, fall	BG or PM	Overhead	n/a	80-200
Summer squash	Winter	BG	Overhead	n/a	80-200
Grape tomato	Spring, fall	PM	Drip	n/a	350-450

**Table 7. Authors, title and intended journal of publication of manuscripts in preparation that may be used to update UF/IFAS nutrient management recommendations.**

Hendricks, G., S. Shukla, K. Cushman, T. A. Obreza, and E. McAvoy. 2006. Effects of water and nutrient management practices on watermelon yield in South Florida. Irrigation and Drainage Engineering.
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Srivastava, S., S. Shukla, and F. H. Jaber. 2006. Evapotranspiration and crop coefficients for pepper. Irrigation and Drainage Engineering.