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IFAS EXTENSION

Introduction to Best Management Practices for Phosphorus Control onOrganic Soils [1]

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This BMP series was written specifically to address the concern for phosphorus control in the Everglades Agricultural Area. The information contained in the series may be applied to any agricultural area composed primarily of organic soils or Histosols. However, *please be aware that this information may not be applicable to any other soil types*.

BACKGROUND

Heightened concerns in recent years over the impact of drainage waters from the Everglades Agricultural Area (EAA) on the Everglades have prompted the South Florida Water Management District (SFWMD) to develop both an EAA regulatory program and stormwater treatment areas (STAs) to clean up this water. These efforts are the result of many years of study, debate, political wrangling, and complex litigation.

Initially, abatement program efforts were centered around the SWIM (Storm Water Improvement Management Act) plan, a program being developed for the Everglades by the SFWMD. In 1988, however, the SWIM process was overshadowed by a lawsuit filed in Miami Federal District Court. The passage of the Marjory Stoneman Douglas Act in 1991 was critical to the resolution of the lawsuit by defining how some the settlement requirements might be met and funded. This lawsuit resulted in a July 1991 settlement that directed the SFWMD to design and install four STAs and to develop a regulatory program (EAA BMP Rule). The BMP Rule will require all farmers in the EAA basin to install practices to reduce the phosphorus discharge from their properties. These farm water quality practices are known as Best Management Practices or BMPs.

The proposed BMP Rule will require that the BMPs reduce the total amount of phosphorus in the EAA drainage waters by twenty-five percent before it enters the STAs which will then have to further reduce the total phosphorus discharge to obtain a net reduction level of seventy-five percent as required by the lawsuit settlement. The phosphorus reduction will be measured against the historical total phosphorus load for the years 1979 to 1988.

This BMP series will describe the BMPs that are appropriate in terms of design, installation, management and phosphorus reduction amounts for implementation in the EAA. Because only a limited number of BMPs in the EAA have been studied at this time and because BMP technologies from other areas cannot be easily transferred to the EAA, this BMP series will be limited more to discussions of how to get started with BMPs rather than to specific designs or procedures. **It is important to note that field-scale evaluation of BMPs has not been done. Therefore the specific effectiveness of the BMPs at this scale is not yet known.** As research and other monitoring data become available, the BMPs will be refined and presented in greater procedural detail in

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future revisions of this BMP series. Despite the aforementioned limitations, this BMP series should be a useful tool in the development of BMP plans to meet the requirements of the EAA BMP Rule.

Please note that the BMPs in this BMP series will only pertain to phosphorus reductions.

WHAT ARE BMPS?

Best Management Practices are those on-farm applications designed to reduce phosphorus losses in drainage waters to an environmentally acceptable level while simultaneously maintaining an economically viable farming operation for the grower. Practices which have a high potential for negatively impacting the financial profitability of a farm could not, therefore, be considered BMPs. In cases where the economic price of implementing certain BMPs puts an excessive financial burden on the farmer, such practices could only be considered BMPs if external funds were available to return an acceptable profitability to the farm.

It is important to note that the above definition is not the same as the one given in the South Florida Water Management District BMP Rule. The Rule definition is specific to practices that will reduce phosphorus levels by 25%. It does not take into account profitability. However, it is clear that if profitability is not maintained, the practice itself cannot be maintained. Therefore, the reader is cautioned that the practices presented in this BMP series, though labelled as BMPs, will only be BMPs for *your* operation if they can be implemented on your farm in an economically viable fashion.

WATER QUALITY DESIGN CRITERIA FOR BMPS IN THE EAA

The overall design criteria for Best Management Practices implementation should simply be to minimize the amount of phosphorus leaving a farm. Though the BMP Rule has targeted a specific level of phosphorus reduction, it is in the interest of all parties to maximize phosphorus reduction to the greatest extent possible. Phosphorus reduction levels greater than the 25% BMP Rule criteria will serve to increase Everglades restoration, reduce cost of stormwater treatment areas, and enhance the environmental/political image of the Everglades Agricultural Area.

As previously mentioned, the EAA BMP Rule, which is actually the Regulatory section of the Everglades Storm Water Improvement Management Plan, requires that by 1996, BMPs reduce the phosphorus delivered to the Everglades system from the EAA by twenty-five percent. This reduction is required only for water generated within the EAA. Pass-through water from Lake Okeechobee to the Water Conservation Areas (WCAs), therefore, will be handled separately by the stormwater treatment areas.

Verification of a reduction in phosphorus load will be based on the comparison of yearly phosphorus load measurements to historical phosphorus load measurements for the years 1979-1988. Future annual loads will be adjusted for differences in land area (land taken out for the STAs) and in rainfall variations from the 1979-88 base-period. In this way, valid comparisons can be made.

Note also that the phosphorus reduction comparisons can be made only at EAA basin *outlets* (S2, S3, S5-A, S6, S7, S8, and S100) because no historical data are available for individual farm discharges. Compliance with the BMP Rule will therefore be judged at the EAA basin level, requiring the net impact of all the BMPs within a basin to reduce phosphorus loads by twenty-five percent. For this reason, the BMP Rule is primarily an implementation rule in that it requires BMP plans for each farm to be developed and implemented within a given time schedule. Failure to implement BMPs would result in enforcement penalties/fines. And, if basin compliance is not met, a specific water quality load standard will be set for each individually-permitted farm discharge point. Non-compliance at the basin level will necessitate the revision of each BMP plan and additional BMP implementation with an updated scheduling and enforcement requirement.

UNCERTAINTY OF BMP EFFECTIVENESS RANGES

Each Best Management Practice presented in this BMP series is provided with an estimated range of the phosphorus reduction percentage expected when implemented in the Everglades Agricultural Area. In using these ranges, it is necessary to understand both what they represent as well as their uncertainty. Only three of the listed BMPs have been field tested and these were tested for only a limited set of conditions. Therefore, most of the stated phosphorus reduction ranges were based on corollary data and basic knowledge of the physical and chemical processes of

the EAA. The presented BMP effectiveness (% phosphorus reduction) ranges include this uncertainty. They also, however, reflect the variabilities of existing conditions among farms in the EAA. That is, farms implementing a BMP for the first time can expect to experience the full benefit of that BMP, whereas those farms already practicing a specific BMP should, of course, expect no additional phosphorus reduction due to continued implementation of that BMP. As more data become available, these ranges will be narrowed appropriately.

CONCENTRATION VERSUS FLOW CONTROL FOR PHOSPHORUS LOAD REDUCTIONS

As stated earlier, Best Management Practices are designed to reduce phosphorous loads by either reducing the volume of water discharged, reducing the concentration of phosphorus in the water, or both. The Fertility BMPs (see fertility BMPs) are designed to reduce phosphorus concentrations whereas the Water Management BMPs (see Water Management BMPs) were developed primarily to reduce net water discharge from the farm, though some phosphorus concentration reduction may be realized.

The relative acreage to which various BMPs can be applied is extremely important for determining the basin level impact of a BMP. For example, BMPs targeted to reduce phosphorus concentrations will be most effective for high fertility crops and low oxidative soils. These represent only about 15% of the entire EAA basin. Therefore, phosphorus concentration reduction BMPs would have a relatively small basin level impact. Because of this, it is estimated that only about 5-15% of the proposed 25% decrease could be achieved by phosphorus concentration reductions. The remaining 10-20% would have to come from drainage volume reductions.

Please note that the above percentages are only estimated limits for achieving the 25% Rule criteria and are not the limits of a fully implemented BMP program, which potentially could produce phosphorus reductions of up to 60%. The actual percentage attributed to concentration versus volume reductions will depend on the relative farm-level selection of BMPs.

BASIN RESPONSE TO FARM LEVEL BMPS

The phosphorus reduction ranges presented here are for the responses expected from individual farming systems with only a single crop, fertility, and water management system. Therefore, the combined impact of Best Management Practices across a large farming operation or an entire basin must be corrected for the percentage of land that each unique farming system represents within that larger area. The farm-scale phosphorus reduction ranges are based on a combined analysis of several studies. None of these studies, however, included farm-scale experiments. The presented ranges, therefore, cannot currently be proven on the basis of scientific data.

Based on individual BMP effectiveness ranges, Izuno and Bottcher (1991) estimated that the overall range of phosphorus reduction that could be accomplished for the Everglades Agricultural Area basin was between 20-60%. This range reflects their opinion of what could be achieved at a reasonable cost (20% reduction figure) and, in addition, what might be realized at a higher, unknown cost (60% reduction figure). Though a 40% or greater phosphorus reduction might reasonably be expected through implementation of BMPs, assurances cannot be given that these levels could be accomplished within our previously stated definition of a BMP, i.e. a practice which maintains the economic vitality of the farm.

IMPACTS OF BMPS ON CROP YIELDS

The Best Management Practices presented in this BMP series are designed to impact minimally on crop yields. The reader, however, is cautioned that data currently available on yield impacts remains limited. Therefore, any implementation of BMPs must be done with a cautionary approach. ***Sudden, large changes in farm operations are not recommended***, especially in regard to water retention. Practices of this kind should be implemented in a step-wise fashion so that an understanding of both the nature of the BMP as well as its impact on yields can be properly assessed. It is important for farm operators to learn the full operational responses of any single BMP for multiple conditions before attempting to carry out any further large-scale activities.

ACCUMULATIVE EFFECT OF MULTIPLE BMPS

The presented reduction ranges are not necessarily cumulative for multiple applications of BMPs. The effectiveness of any one Best Management Practice may be significantly reduced or eliminated by the additional implementation of any other BMP. Also, the operational, nutritional, and hydraulic influences of an existing BMP must be taken into account when considering supplementary BMPs. This is particularly true for same-category BMPs such as those dealing with flow reduction.

REDUCED DRAINAGE VERSUS WATER SUPPLY

There is some concern that water supply might be negatively impacted if proposed Best Management Practices significantly reduce the amount of water being pumped from the Everglades Agricultural Area farmlands. It is important to note that BMPs can only impact regional water supplies if they increase evapotranspiration (ET) from the farm. Since evapotranspiration is expected to increase only when the water retention BMPs are being used, (and then to increase only slightly), the question becomes: "What happens to the water that is no longer being pumped?". It will still be in Lake Okeechobee because the majority of the reduced drainage will be directly reflected in reduced irrigation demand by the farms. The water in Lake Okeechobee will continue to be available for regional water supply. Offsetting existing EAA drainage water with pass-through Lake water represents about a 50 % reduction in phosphorus loading to the stormwater treatment areas. It is worth noting that under these conditions the stormwater treatment areas will likely have significantly higher ET rates than existing land uses, resulting in a net regional water supply loss.

SUMMARY OF BMPS

Table 1 provides a summary of the Best Management Practices presented in this document. As demonstrated by the currently available information, a 25% phosphorus reduction from BMPs is a reasonable and obtainable goal. Even higher reductions, however, are potentially obtainable. The table shows how water management BMPs have a greater potential for reducing phosphorus loads than fertility practices. It is important to remember, though, that water management BMPs primarily achieve their reductions by decreases in water volume, whereas fertility BMPs have a greater likelihood of lowering phosphorus concentrations.

SEEPAGE CONTROL

One variable which the farmer cannot always control is the amount of seepage water entering their farm from nearby areas with higher water levels. This problem is most acute for farms bordering the water conservation areas (WCAs) and Lake Okeechobee because of water elevation differences of as much as seven feet.

Seepage from the primary canals in the Everglades Agricultural Area is also a problem. Even though head differences (1-3 feet) are less than those of the Lake or of WCAs, the seepage paths are normally shorter. The nature of the soils and underlying strata permits a significant amount of water to flow (seep) under and through the dikes retaining this water. In some regions of the EAA, the underlying marl rock is extremely permeable so that if the higher water bodies have canals cut into this formation, very large seepage rates can occur. Some farms are forced to continuously pump out this seepage water in order to maintain optimal water tables.

The Best Management Practices Rule allows for seepage to be removed from the phosphorus reduction requirements through a variance option when the existing condition can be appropriately documented. Documentation must include continuous discharge and rainfall records for the farm. If you suspect seepage is a problem, we advise you to contact the South Florida Water Management District to obtain additional data before initiating a monitoring program.

Fertility BMPs as well as some of the water management BMPs can still work for farms suffering from excessive seepage. The relative beneficial impact of these BMPs, however, will be reduced because the expressed BMP reductions would only be for the rainfall excess portion of the farm's discharge. In extreme cases, a majority of the phosphorus being pumped from the farm may have originated in seepage water which will not be impacted by BMPs.

Seepage rates can only be decreased by the following techniques:

* Reducing the hydraulic gradient by reducing head differences (not normally practical) or by increasing flow path. This would require increasing dike thickness or distance to first farm canal.

* Reducing hydraulic conductivity of media in flow path by limiting the extent of cuts into the marl rock for farm canals/ditches near farm borders or by installing low conductivity barriers (not normally practical).

Often seepage rates cannot be reduced and simply must be controlled by additional pumping. In these cases, it will be necessary from a monitoring standpoint to separate farm drainage discharges from the seepage discharges, in order for a true measure of BMP effectiveness to be obtained. In some situations, it may be possible to pump a seepage interceptor canal separately to obtain seepage rates. The interceptor effectiveness in collecting this seepage water, however, will vary according to the underlaying characteristics of the marl rock layer. The best method of separating seepage flow is by conducting a hydrological analysis of the discharge records in combination with a time series of the surrounding water levels. A professional engineer should be consulted for detailed analysis, but a rough estimate of the seepage rate can be calculated by adding pump discharge rate to the estimated farm evapotranspiration rate and subtracting the estimated irrigation rate. This calculation is best performed during a prolonged irrigation (dry) period. We suggest that the separated flows (seepage and excess rainfall) be reported in the BMP Rule permit reports.

Table 1. Reference List of Proposed Best Management Practices for the Everglades Agricultural Area

BMP Code/Name	Phosphorus Reduction Range (%)[1]	Crop
Fertility BMPs	5-20[2]	All
Calibrated Soil Testing	0-10 0-25	Sugarcane Vegetables
Banding of Fertilizer	0-40 0- 5	Vegetables Plant Care
Prevention of Misplaced Fertilizer	0-15	All
Split Application of Fertilizer and Use of Slow Release Forms	0-10	All
Water Management BMPs	20-60[2]	
Minimizing Water Table Fluctuations	0-50	All
Retention of Drainage On-Farm	15-60	Sugarcane
Retention of Vegetable Field Drainage Water in Sugarcane or Fallow Lands	20-90	Vegetables
Use of Aquatic Cover Crops	5-20	All
Coordinated Farm Cropping Patterns	n/a	All
NET BASIN EFFECT if all BMPs implemented	20-60[2]	All

[1] Ranges are for individual farms after considering uncertainty and the variability of farm management unless otherwise noted.

[2] Phosphorus reduction range is for entire EAA Basin. Note that the upper limits are very theoretical and are not expected to be achieved without significant cost.

WATER MONITORING

Monitoring of the quantity and quality of water entering or leaving a farm, as well as specific internal water conditions will be very useful in developing and refining a BMP program. The BMP Rule requires outflows of water and phosphorus to be monitored by October 1993. Because the BMP Rule only pertains to outflows to District canals, its monitoring requirements will not provide a complete picture of the water and phosphorus dynamics on a farm.

As emphasized throughout this BMP series, the success of any BMP program will depend heavily on the farmer's knowledge and understanding of the hydraulic and phosphorus dynamics of the farm. The only way to really know if a particular practice is working is to monitor its effects. An appropriate monitoring program should include water flow measurements, rainfall, phosphorus concentrations of drainage and irrigation, and in-field water table levels. Details of the equipment and procedures for monitoring are provided in the Institute of Food and Agricultural Sciences Extension Circulars 1036 and 1040, entitled "Agricultural Water Quality Sampling Strategies" and "Water Quality Sampling, Analysis, Instrumentation, and Procedures," respectively.

BEST MANAGEMENT PRACTICES: CONCLUSIONS

Ongoing environmental concerns for the Everglades continue to require that the Everglades Agricultural Area release the cleanest (low phosphorus) water possible to the south. It is in the best interest of all parties to reduce phosphorus levels as much as possible *as long as the economic vitality of the agricultural industry is not undermined*. We believe that the Best Management Practices presented in this guide can obtain the required phosphorus reductions without imposing significant economic hardship if the BMPs are implemented in the step-wise fashion presented. Sudden, large changes in farming operations are not recommended until the grower is fully secure in his experience in the implementation and on-going use of these practices.

As seen in Table 1, the currently available information indicates that the 25% phosphorus reduction from BMPs is a reasonable and obtainable goal and that even higher reductions are potentially obtainable. The presented BMPs are designed both to reduce phosphorus concentrations in the drainage water as well as to cut back the volume of discharged water. We expect that the greatest reductions of phosphorus from the EAA will occur due to reduced drainage volumes.

A successful BMP program will require farm operators within the EAA to significantly increase their knowledge and skills. They will need to be aware of crop responses to water table variations as well as understanding detailed hydraulic responses of the water control systems to climatic conditions. Though an increased level of knowledge and managerial skills will be needed, they will more than likely improve overall farm efficiency and thereby offset some of the cost of the BMPs. With the implementation of the BMP programs outlined in this guide, the future farming vitality of the EAA can be maintained while protecting down-stream natural resources.

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