A Summary of Nutrient Leaching and Best Management Practices for Turf

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Nutrient Management Practices – Landscape Turf

Best management practices (BMPs) have been in place for residential and commercial lawn care for a number of years in Florida. The BMPs were developed in 2002 by the Florida Department of Environmental Protection (FDEP), UF/IFAS, the lawn care and pest control industries, environmental advocacy groups and others. An educational program began in 2003, conducted primarily by UF/IFAS and supported by FDEP. Recommended BMPs for lawn and landscape care include appropriate fertilization, including timing, rates, delivery method, sources, etc. Other components include plant selection, soil testing, integrated pest management, proper irrigation practices and cultural practices. Specific fertilization recommendations for N can be found in Table 4 for the various lawngrass species used in Fl. The majority of commercial lawn care and landscape services apply fertilizer within the ranges specified in this table, generally towards the high end for the region and species. It is very difficult to assess how much fertilizer is applied by the average do-it-yourself homeowner, but it is estimated to exceed the rates for individual applications of no more than 1 pound N 1000 ft^{-2}.

The BMP program was completely voluntary until a number of city and county governments throughout the state began to develop local fertilizer ordinances in 2006. Some of these ordinances have now passed and are currently regulating commercial fertilizer application. In the locales where these ordinances have passed, there is typically a dedicated code enforcement officer who monitors for a "Certificate of Completion" in the BMPs. There is generally a decal issued by the local government for display on commercial lawn care vehicles.

Other political issues regarding fertilization include a legislative bill that did not pass this year. This bill would have required BMP Certification for anyone who applies fertilizer commercially statewide. The bill also contained a provision for a "fertilizer license" to be issued by the Florida Department of Agriculture and Consumer Services (FDACS) upon certification in the BMPs.

Florida also saw its first statewide regulation on fertilizer in 2007. The FDACS Urban Turf Fertilizer Rule became rule as of 31 Dec, 2007. This regulates labeling of any turf sold for use on lawns or urban turf and requires that labeled rates for nitrogen (N) and phosphorus (P) be followed. This is effective on specialty fertilizer bags, or those weighing 49 pounds or less, and therefore primarily impacts the retail homeowner fertilizer market. It further requires the commercial lawn care industry to follow the Green Industry BMPs.

Other important aspects of nutrient management of lawn grasses include fertilization timing, nutrient source, phosphorus (P) application, and soil testing. In North Florida, fertilizer timing should be from early April through early October. Central Florida timing can range from mid-March to end of October, while in parts of South Florida, year-round fertilization is common.

A concern with a number of the local ordinances throughout South Florida is the "fertilizer black-out period" for a 4 or 5-mo period during summer months. This ban is incongruent with the warm-season grass growth curve and may lead to nutrient deficiencies. While some reports have demonstrated a correlation between nutrient leaching and excessive irrigation/rainfall (Bowman et. al., 1998, Morton et. al., 1988, Snyder et. al., 1984), others report increased leaching when fertilizer is applied to grass during times of less active growth.

UF/IFAS and Florida Yards and Neighborhoods recommendations directed at homeowners suggest use of a SRN fertilizer, while UF does not restrict the commercial horticulture audience to a specific product. The majority of local fertilizer ordinances, however, specify that a high percentage of N used in lawn care (50-75%) must be from a SRN source for any fertilizer application. Some research data support this concept, while some does not. Mancino and Troll (1990) reported no differences in nitrate leaching from 'Penncross' creeping bentgrass due to N source. Quiroga-Garza et. al. (2001) reported that QRN treated plots had lower nitrate leaching levels than SRN treatments under long-day conditions in 'Tifgreen' bermudagrass (*Cynodon dactylon* (L.) Pers. x *C. transvaalensis* Burtt-Davy), although the trend was reversed under short-day conditions.

Other research documents a tendency for increased nitrate leaching from QRN sources. Easton and Petrovic (2004) found increased nitrate lost from plots receiving soluble N sources. Brown et al. (1982) reported increased nitrate leached from plots receiving QRN on greens planted to 'Tifdwarf' bermudagrass. Guillard and Kopp (2004) found lowest nitrate leaching occurred from a SRN organic fertilizer in cool-season lawn grasses. In a greenhouse study conducted in large tubs, Saha et. al. (2007) noted greater leaching from QRN sources than from SRN in St. Augustinegrass (*Stenataphrum secundatum* Walt. Kuntze.).

Other aspects of fertilization that are sometimes misunderstood involve applications of granular vs. liquid fertilizer. Gross et. al. (1990) found no difference in nitrate leaching between treated tall fescue *(Festuca arundinacea* Schreb.) and Kentucky bluegrass *(Poa pratensis* L.) receiving urea as either a granular or liquid application. Non-treated control plots leached less nitrate than did treated plots.

Nutrient leaching data have supported growing and maintaining a healthy turfgrass stand through proper fertilization and other cultural practices for minimizing environmental impact. Limited nutrient leaching data exist on lawn grass species, although Erickson et. al. (2001) demonstrated minimal leaching of nitrate in St. Augustinegrass. Leaching losses averaged 4.1 kg N ha^{-1} from St. Augustinegrass sod fertilized at 300 kg N ha^{-1} yr^{-1}, while a mixed landscape planting lost an average of 48.3 kg N ha^{-1} after receiving 150 kg N ha^{-1} yr^{-1}. Similar results were noted by Saha et al. (2007) in a greenhouse tub study. Bowman et. al. (2002) found that 'Floratam' St. Augustinegrass had best nitrate uptake of 6 warm-season grasses tested, while 'Meyer' zoysiagrass had the lowest uptake. Quiroga-Garza et. al. (2001) concluded that proper timing of use of QRN sources could limit nitrate leaching, and that even QRN sources, when applied at appropriate rates and with proper irrigation practices, had limited nitrate movement.

Phosphorus is not usually a limiting factor for turfgrass maintenance in Florida and the FDACS Fertilizer Rule applies stringent limits on its use. Soil testing is recommended for all home lawns or turf sites, both for pH and to determine if additional P may be needed.

Current research is addressing a wide range of leaching issues in lawn grasses. Included are studies looking at leaching from newly sodded or sprigged turf, leaching due to soil type (muck vs. sand) during production, leaching based on N application rate, N source, timing, and leaching due to species. Research is also underway to precisely determine optimal P soil-testing methodology, P requirements for St. Augustinegrass, and P leaching from lawngrasses.

Nutrient Management Practices – Golf and Athletic Turf

Golf course BMPs were developed in 2006 by FDEP, UF/IFAS, golf course superintendents, and others. These are voluntary at this time, although the FDACS Fertilizer Rule does require that any one applying fertilizer to a golf course follow the published BMPs. Athletic fields do not have a specific BMP and generally fall under the guidelines for lawns and/or golf courses. Athletic field personnel are directed in the FDACS Fertilizer Rule to follow Sartain (rev. 2007). There are no formal educational programs associated with either of these industries at this time.

Golf course fertilization practices vary based on traffic patterns on the course (greens vs. fairways), location in the state, amount of traffic, profile of the golf course, etc. Greens are often fertilized using the "spoon-feeding" concept, where small amounts of fertilizer are applied regularly, sometimes through a fertigation system. This is a very efficient application method, with limited potential for nutrient movement to occur. Nitrogen application rates can vary from 0.5 pounds N 1000 ft^{-2} applied every 7 to 28 days, depending on traffic and budget. Smaller courses may apply 1 lb N 1000 ft^{-2} less frequently. Increased traffic can result in a need for greater rates of N, P, and K. Fertilization of tees will be less than the amount required for greens, but will vary based largely on traffic. Nitrogen should be applied to meet the demands for regrowth. Fairways receive much less fertilizer and may only be fertilized a few times per year. Average N rates for these areas would typically be 3 to 6 pounds N 1000 ft^{-2} yearly.

Golf course BMPs also discuss environmental issues, wildlife, lake and aquatic plant management, maintenance operations, pesticide use and IPM, irrigation, and the intense cultural practices required to maintain high traffic portions of the golf course.

Athletic field fertilization is also dependent upon budget, amount of play, profile of the field (Florida Field vs. a county ball park, for example). A typical recommendation would be 1 pound N 1000 ft^{-2} per active playing month. Needs for other nutrients should be determined from a soil test.

Nutrient Management Practices – Sod Production

Sod production BMPs were developed in 2007 and, unlike the previously discussed BMPs, are under the purview of FDACS since they are agricultural operations. Growers must file a "Notice of Intent to Implement" form with FDACS, which entails detailed record keeping and provides a level of "presumptive compliance" to growers under state law. In addition to fertilization, pest management, IPM, and irrigation, these BMPs also cover access roads, conservation buffers, ditch construction and maintenance, flood protection, wellhead protection, and wetlands and springs protection.

Fertilization of production sod is dependent upon degree of "cover" as the sod grows back from previous harvests from where "ribbons" of the grass are left. During grow-in, N application should be limited to 20 pounds N per acre to reduce leaching potential. Once sod has covered, 50 pounds per acre is the recommended N application rate, with no more than 300 pounds per acre applied annually. Florida sod growers are currently beginning the process of implementation of sod BMPs.

Limited published reports exist regarding nutrient movement from sod during production. Barton et. al. (2006) reported that irrigation was a larger factor then N rate in N leaching in production.

Irrigation Management – Landscape Turf

Most commercial lawn care services do not have access to irrigation controllers on residential properties. This can lead to a number of problems following fertilization or pesticide application, including N volatilization, shoot tissue burn, potential lack of compliance with pesticide labels, etc. Homeowners often are not aware of how to program their controller nor do they realize that it should be changed seasonally in many parts of the state. Improper irrigation is one of the primary reasons for lawn problems or failure.

Current UF/IFAS recommendations stress watering on an as-needed basis, due to wide variability in how much water is needed. Depending on location in the state and season, irrigation may be required twice a week or as seldom as once a month. Recommendations for frequency of irrigation are variable, but length of time to water is constant. Application of ½ to 3/4-in of water is a typical recommendation, unless there is insufficient soil to hold that amount of water, as can be found in parts of southeast Florida. In South Florida, irrigation restrictions do not currently allow adequate irrigation frequencies for some lawns, encouraging homeowners to often irrigate excessively on days they can irrigate.

In addition to the horticultural needs, BMPs for irrigation include proper design, installation, maintenance, trouble shooting, and calibrating.

Evapotranspiration differs between species and may vary due to cultural practices such as fertilization and mowing and by environmental factors such as radiation, wind, humidity, etc. Turfgrass water use is typically discussed as "potential evapotranspiration" (ETP), which is used to describe water use from a continuous turf canopy that fully shades the ground, exerts little resistance to water flow into the atmosphere, and has a constant supply of soil moisture.

Augustin (1983) estimated ETP rates for St. Augustinegrass at multiple locations in Florida and calculated irrigation requirements based on historical climate data for temperature and rainfall (Table 5). These data do not currently exist for the popular new zoysiagrass cultivars.

Irrigation Management – Golf and Athletic Turf

Irrigation requirements of turf subjected to traffic are much greater than those of a lawngrass. Proper hydration of leaf tissue has been correlated with wear tolerance in bermudagrass and seashore paspalum (*Paspalum vaginatum* Swartz.) (Trenholm et al., 1999). Best management practices for golf and athletic turf irrigation are similar to the landscape turf irrigation issues of proper design, installation, maintenance, trouble shooting, and calibrating.

Irrigation Management – Sod Production

Irrigation is critical during grow-in of new turf. Sod production may utilize water from wells, canals, or ponds onsite or may also use treated water. Water is typically distributed through center or lateral pivots, or rolling overhead systems. Sod producers may also utilize subirrigation.

Future of Industry

Clearly, all segments of the turfgrass industry need to deal with increased regulations regarding fertilization and irrigation. Educational efforts need to include both professionals as well as homeowners.

It is also important to recognize that turfgrass has important benefits to our environment. In many urban settings, turfgrass provides the only stormwater filtering mechanism, in addition to the documented benefits of cooling, oxygen production and reduced glare, noise, dust, and pollutants.

Research Gaps and Funding Needs

N and P runoff

Nutrient leaching from sod production

Water use/drought tolerance of warm-season grass species in Florida

Use of soil amendments/additives for water conservation

Site specific management of nutrients/water through use of remote sensing

Recycled water tolerance and long term effects

Impact of withholding fertilizer during warm-season grass-growing season

Effect of zero P and N fertilization on turf growth/quality and environment

Modeling and quantifying runoff from buffer zones and landscape areas

Relationship of turf fertilization to red tide

Development of a comprehensive seasonal fertilization/irrigation program for urban turf

Develop fertilizer programs for use with reclaimed irrigation water

Study the relationship between construction site soil compaction and use of subsoil fill on nutrient and water runoff

Develop model landscape for communities that minimize runoff

Conduct research surveys on consumer fertilizer and irrigation practices

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Table 1. Summary of current BMP research areas for landscape/golf/sod turf, level of knowledge, gaps.

BMP research area	Level of knowledge	Gaps
N leaching: rates	Research done - good	
N leaching: sources	Research ongoing	
N leaching: establishment	Research done - good	
N runoff	spotty	Research needed
P leaching	Research ongoing	
P runoff	Research ongoing	
Water use by species	Poor	Research needed
Soil amendments/additives	Spotty	Research needed

Table 2. Questions to and summary of vision statements by key UF/IFAS state and county faculty with active programs in BMPs for turf.

Question	Answers
1. What is your opinion/vision for the next 5 years on what the landscape/golf/sod industry needs to do to improve their irrigation management?	*Use of SWAT technology/remote sensing/ site specific application to regulate irrigation *Breeding programs *Minimizing green turf on golf courses to critical areas *Homeowner education
2. What is your opinion/vision for the next 5 years on what the landscape/golf/sod industry need to do to improve their fertilizer management?	*Absolute nutritional requirements *Identification of and greater use of controlled release products *Site specific application (sod ribbons) *Community education *Greater documentation of commercial applications *Improved fertilizer bag labeling
3. What educational programs are needed? (need to be separated for agents, for growers)	*BMPs (nutrients and water) * Elected local officials need better understanding *Dilution of the anti-turf sentiment and expound on benefits of turf *IPM *Community/homeowner education *Landscape/golf architects *Certificate programs for growers/managers *Keeping county faculty up to date *Master Gardeners *Ensuring that all units in IFAS say the same thing *Turfgrass short courses
4. What are the critical issues on the horizon (5 to 10 years) that may affect the industry?	*Fertilizer (use and cost) *Water *Anti-turf issues *Regulatory *Redevelopment and changing demographics of golf courses
5. Other	*Development of athletic field BMPs

Table 3. Current annual UF fertilization recommendations for lawngrasses.

Species/Location	Interim N Recommendations (lbs 1000 ft^{-2} yr^{-1})*, **
Bahiagrass- North	2-3
Bahiagrass- Central	2-4
Bahiagrass- South	2-4
Bermudagrass- North	3-5
Bermudagrass- Central	4-6
Bermudagrass- South	5-7
Centipedegrass- North	1-2
Centipedegrass- Central	2-3
Centipedegrass- South	2-3
St. Augustinegrass- North	2-4
St. Augustinegrass- Central	2-5
St. Augustinegrass- South	4-6
Zoysiagrass- North	3-5
Zoysiagrass- Central	3-6
Zoysiagrass- South	4-6

*Homeowner preferences for lawn quality and maintenance level will vary, therefore we recommend a range of fertility rates for each grass and location. Additionally, effects within a localized region (i.e., micro-environmental influences such as shade, drought, soil conditions, and irrigation) will necessitate that a range of fertility rates be used.

** These recommendations assume that grass clippings are recycled.

Table 4. Net Irrigation Requirements (NIR) of Florida Turfgrasses*

Month	Monthly NIR (inches) of selected Florida cities							
	Ft. Myers	G'ville	J'ville	Miami	Orlando	Pensa	Talla	Tampa	West Palm
Jan	1.65	0.18	0	2.09	0.85	0	0	0.82	1.49
Feb	1.38	0	0	1.99	0.55	0	0	0.57	1.34
March	1.86	0.38	0.34	3.12	1.26	0	0	0.99	1.95
April	3.57	2.12	1.70	3.24	2.88	0.70	1.09	3.15	3.11
May	4.12	3.70	3.34	3.05	4.73	3.02	3.28	4.90	3.33
June	2.51	3.21	3.22	2.69	3.57	3.74	3.21	3.85	2.68
July	3.26	3.09	3.23	4.32	3.59	3.89	2.59	3.38	4.47
Aug	4.06	2.85	3.53	4.75	4.68	4.39	3.79	3.67	4.32
Sept	2.91	3.51	1.94	2.74	3.41	1.77	2.58	3.96	2.04
Oct	1.54	2.38	1.59	1.13	3.17	2.13	2.13	3.93	1.30
Nov	2.96	1.44	1.16	2.85	2.28	0.13	0.35	2.10	2.65
Dec	2.07	0.58	0	2.61	1.19	0	0	1.07	1.97
Total	31.89	23.44	20.05	34.58	32.16	19.77	19.02	32.39	30.65

Revised from Augustin (1983). NIR based on historical climatic data of mean monthly temperature and rainfall. Potential evapotranspiration calculated based on the McCloud method.