Turfgrass Nutrition: Soil Testing and Interpretation

Turfgrass is often an integral part of the urban landscape. When turfgrass is properly maintained, it provides many positive ecosystem services such as aesthetic appeal, reduced air temperatures, improved water quality, enhanced water infiltration, carbon sequestration, and mitigation of air and noise pollution. However, when turfgrass is improperly maintained, these ecosystem services are diminished and possible harm to the environment can occur. This can occur through increased or misguided pesticide use, overuse of water, and off-target movement of nutrients – namely nitrogen (N) and phosphorus (P).

The PNOC has reviewed and approved turfgrass N fertilizer recommendations several times since 2012 all of which have trended downward 25 – 80%. Additionally, in 2014, the PNOC supported the UF/IFAS Turfgrass Science team's recommendation to allow 0.7 lbs soluble N per 1,000 ft^2 which differed from FDEP's 0.5 lb recommendation contained in their educational materials. Over time, recommendations for nutrients other than N, nor soil test interpretations, have been reconciled by the Turfgrass Science team or PNOC. These two issues are the focus of this document.

Phosphorus Fertility

<u>P Soil Tests:</u> Many studies conclude that P soil reservoirs are extensive and supply sufficient P for turfgrass growth and development of established turfgrass (Frank and Guertal, 2013)[i]. Additionally, the historical soil-test calibration on which P rates are based are derived from forage- or field-crop calibration data and generally lead to an overestimation of turf need (Frank and Guertal, 2013).

Current UF/IFAS soil test interpretations for turfgrass are the same as those used for agronomic crops (Rao et al. 2021)[ii]. The soil P interpretations are as follows: Mehlich-3 soil P ≤ 25 mg kg^{-1} is categorized as low P; 26 – 45 mg kg^{-1} is categorized as medium; and > 45 mg kg^{-1} is categorized as high. The ESTL recommends P application of 0.50 lbs P_2O_5 per 1,000 sq. ft. per year when soil test results are "low" or "medium". The current evidence from peer-reviewed scientific literature suggests that P recommendations based on agronomic P status categories would lead to over-fertilization of P on turfgrass.

Over 30 years ago, Cisar et al. (1992) found a lack of response of St. Augustinegrass to P fertilization, with the establishment, clipping weight, and sod tear resistance unaffected by the P rate[iii]. The authors suggested that soil-test recommendations for P fertilizer could be reduced without negative effects on sod production, because responses to P fertilization were only seen when soil-test P was low (Cisar et al., 1992).

More recently, Liu et al. (2008) conducted a study to determine the critical minimum P application rate, the critical minimum tissue P concentration, and the critical minimum Mehlich-1 P concentration in soil for St. Augustinegrass to achieve optimum growth and turf quality[iv]. Using four different soil types, they determined that the critical soil-test levels at which no additional St. Augustinegrass growth occurred were between 5 and 9 mg kg^{-1} (Mehlich-1). They concluded that "the P status categories specifically for St. Augustinegrass need to be adjusted according to these findings. No P application would be recommended if Mehlich-1 P concentration is above 10 mg kg^{-1}." These data suggest that optimum growth of St. Augustinegrass can be attained at very low Mehlich-1 soil test P levels.

Similarly, Kreuser et al. (2012) conducted a field Mehlich-3 soil test calibration study on a creeping bentgrass (*Agrostis stolonifera* L. 'Penn A4') sand-based putting green[v]. A factorial of four soil test P (STP) levels, 0 to 95 mg P kg^{-1}, was established with monopotassium phosphate and Mehlich-3 STP level, clipping yield, tissue P content, and visual turfgrass quality were quantified monthly for two growing seasons. The Mehlich-3 STP content critical point for visual turfgrass quality ranged from 6 to 11 mg kg^{-1}.

A newer approach to calibration methods for turfgrass has been proposed by Stowell and Woods (2013) – Minimum Levels for Sustainable Nutrition (MLSN)[vi]. This method was created using a dataset of 16,163 soil samples collected worldwide from sites with 1.) good performing turfgrass (multiple turfgrass species), 2.) pH of 5.5 – 8.5; and 3.) with total CEC < 6 cmol kg^{-1}. The resulting 3,683 soil samples were fit to a log-logistic model to identify the concentration where 10% of the soil samples would have a lower nutrient concentration (*i.e.,* the MSLN sufficiency levels represent the 10^{th} percentile where turfgrass at the site was performing well). These guidelines suggest that P fertilizer should be withheld when Mehlich-3 soil test is > 21 mg kg^{-1}.

Using the Mehlich-1 to Mehlich-3 conversion determined by Rao et al., (2020)[vii] to convert the Liu et al., (2008) recommendation of 10 mg kg^{-1}, the critical minimum Mehlich-3 concentration for St. Augustinegrass would 22 mg kg^{-1}. A Mehlich-3 soil test value of ≥ 22 mg kg^{-1} indicates a turfgrass response to P is unlikely and, therefore, P may be omitted from nutrient applications without concern for a reduction in turfgrass health or growth. When Mehlich-3 soil test values are < 22 ppm, P application may be warranted, but the exact amount of P one should apply is difficult to estimate because soil test P values and a response to applied P have not been calibrated.

<u>P Fertilizer Recommendations:</u> As of December 31, 2007, the Florida Department of Agriculture and Consumer Services (FDACS) adopted a rule that regulates products that can be used to fertilize home lawns. The Urban Turf Fertilizer Rule (RE-1.003(2) FAC) regulates what can be sold and marketed as lawn fertilizer and requires specific wording on the fertilizer bag. This rule was enacted in response to concerns over potential pollution of water resources resulting from the N and P in these fertilizers.

For P application, a maximum of 0.25 pounds of P_2O_5 per 1,000 square feet is allowed per application, with no more than 0.50 pounds allowed annually. No additional P can be applied unless a soil test indicates that P levels are deficient. On newly planted lawns, one may apply a starter fertilizer that contains higher P as a one-time application after planting to encourage establishment. Directions for use of these fertilizers limit P application to no more than 1.0 pound of P_2O_5 per 1,000 square feet.

This FDACS rule is consistent with the current evidence-based recommendations. Liu et al., (2008) evaluated St. Augustinegrass grown in four different sand soils with P added at 0, 0.14, 0.27, 0.54, or 1.09 g m^{-2} 4 wk^{-1}. The lowest level of P produced turf with the same quality as that observed in any other P treatment, and this result occurred in three of the four soils tested. There was no response in the growth of St. Augustinegrass when P was applied beyond the 0.14 g m^{-2} rate and determined that P application of 0.14 g P m^{-2} 4-wk^{-1} (0.37 lbs P / 1,000 ft^2 / year) is recommended when P is required[viii].

Gonzalez et al. (2013) determined that when tissue analysis indicates that P fertilization is required and the soil has the capacity to retain additional P, application of 0.8 g P m^{-2} yr^{-1} (0.164 lbs P / 1,000 ft^2) to zoysiagrass and 1.07 g P m^{-2} yr^{-1} (0.22 lbs P /1,000 ft^2) to St. Augustinegrass is appropriate and does not result in increased P leaching[ix].

RECOMMENDATION: Phosphorus soil tests for Florida turfgrasses have limited use. As noted, soil test P values are often not calibrated to a turfgrass response, thus, applying specific amounts of P based upon a soil P test have been proven unreliable. However, soil test values may be used to indicate when P *should not be applied*. The UF Turfgrass Science Team suggests that P be recommended only when Mehlich-3 soil test values are ≤ 20 mg kg^{-1}. The recommended rate of P to apply should remain consistent with FDACS Urban Turf Rule requirements.

Bahiagrass Nitrogen Rates:

Current recommended N rates for bahiagrass (lawns) are 1 to 3 lbs N per 1,000 ft^2 per year in north and central Florida and 1 to 4 lbs N 1,000 ft^2 per year in south Florida. For perspective, maintenance fertilization of established bahiagrass pastures range from 1.3 (low), 2.3 (medium), and 3.7 lbs N 1,000 ft^{-2} yr^{-1} (high).

A publication from the research conducted at the UF/IFAS Ft. Lauderdale Research and Education Center as part of the FDEP-funded urban turf nutrient fate stated the following: "Results indicate that current University of Florida N application recommendations to bahiagrass in southern Florida are higher than necessary to produce an acceptable bahiagrass lawn. Nitrogen applied at 49 kg ha^{-1} yr^{-1} (1.0 lb N 1,000 ft^{-2} yr^{-1}) led to acceptable turf quality during each cycle. An N rate of 49 kg ha^{-1} yr^{-1} (1.0 lb N 1,000 ft^{-2} yr^{-1}) appears to be more advantageous than the current low rate of 98 kg ha^{-1} yr^{-1} (2.0 lb N 1,000 ft^{-2} yr^{-1}) in terms of reducing inputs and reducing the potential for NO_3–N leaching without adversely influencing quality or color. It is recommended that the currently recommended high N rate [196 kg ha^{-1} yr^{-1} (4.0 lb N 1,000 ft^{-2} yr^{-1})] be lowered to 98 kg ha^{-1} yr^{-1} (2.0 lb N 1,000 ft^{-2} yr^{-1}) to reduce the risk of NO_3–N leaching from seasonal fluctuations in growth rate and rainfall. Under southern Florida conditions, lowering the high recommended N rate to 98 kg ha^{-1} yr^{-1} (2.0 lb N 1,000 ft^{-2} yr^{-1}) would not result in a reduction of turf quality below acceptable levels."[x]

RECOMMENDATION: The UF Turfgrass Science team recommends that these rates be adjusted to 1 to 2 lbs N 1,000 ft^2 per year regardless of region in Florida.

[ii] Frank, K. and E. A. Guertal. 2013. Potassium and phosphorus research in turfgrass. p. 493-519. *In* J. C. Stier, B. P. Horgan, and S. A. Bonos (eds.) Agronomy Monograph 56. Turfgrass: Biology, Use, and Management. ASA, CSSA, SSSA, Madison, WI.

[ii] Mylavarapu, R., D. Wright, and G. Kidder. 2021. UF/IFAS Standardized Fertilization Recommendations for Agronomic Crops. https://edis.ifas.ufl.edu/publication/SS163

[iii] Cisar, J. L., G. H. Snyder, G. S. Swanson. 1992. Nitrogen, phosphorus, and potassium fertilization for Histosol-grown St. Augustinegrass sod. Agronomy Journal. May/June. 84(3): p. 475-479.

[iv] Liu, M., Sartain, J. B., Trenholm, L. E., and Miller, G. L. 2008. Phosphorus Requirements of St. Augustinegrass Grown in Sandy Soils. Crop Science. May/June. 48(3): p. cover, 1178-1186.

[v] Kreuser, W. C., P. H. Pagliari, and D. J. Soldat. 2012. Creeping Bentgrass Putting Green Mehlich-3 Soil Test Phosphorus Requirements. Crop Sci. 52:1385–1392. doi: 10.2135/cropsci2011.08.0416

[vi] Stowell, L. and M. Woods. 2013. Minimum levels for sustainable nutrition (MLSN). Appl. Turfgrass Sci. 10(1). doi.10.2134/ATS-2013-0008BC.

[vii] Mylavarapu, R., T. Obreza, K. Morgan, G. Hochmuth, V. Nair, and A. Wright. 2020. Extraction of Soil Nutrients Using Mehlich-3 Reagent for Acid-Mineral Soils of Florida. https://edis.ifas.ufl.edu/publication/SS620

[viii] Liu, M., Sartain, J. B., Trenholm, L. E., and Miller, G. L. 2008. Phosphorus Requirements of St. .

[ix] Gonzalez, R., J. B. Sartain, J. K. Kruse, T. A. Obreza, G. A. O'Connor, and W. G. Harris. 2013. Orthophosphate Leaching in St. Augustinegrass and Zoysiagrass Grown in Sandy Soil under Field Conditions. J. Environ. Qual. 42:749–757. doi:10.2134/jeq2012.0233

[x] McGroary, P., T. W. Shaddox, J. L. Cisar, J. B. Unruh, and L. E. Trenholm. 2017. Annual nitrogen requirement of bahiagrass lawns maintained in sub-tropical climates. Int. Turfgrass Soc. Res. J. 13:1-9.