



UNIVERSITY OF VERMONT EXTENSION

CULTIVATING HEALTHY COMMUNITIES

Fertilization and Nutrient Management Guidelines for Golf Turf in Vermont

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Introduction

Recommendations based on soil testing and other soil and turf information are the basis for nutrient management that optimizes turf growth, quality and function while also accounting for surface and ground water quality concerns. This publication documents the approach and specific soil test and turf data used to generate these recommendations at the University of Vermont.

Although this publication is focused on soil fertility and fertilization, it is recognized that the establishment and maintenance of viable and functional turf requires many cultural practices including proper site preparation, selection of adapted species and varieties, proper mowing, liming and fertilization, irrigation, integrated weed and pest management, aeration, thatch control, and other practices. All of these practices are important and any one of them can become the limiting factor in the development of poor turf if not attended to properly. Guidelines in this publication are based on the scientific literature, the best understanding that is currently available, and current Vermont laws for golf course nutrient management.

Recommendations will be applicable to both surface and ground water concerns, and will cover most aspects of turf usage and management. Many of the best management practices recommended in this guide are based on the "New England Regional Nitrogen and Phosphorus Fertilizer and Associated Management Practice Recommendations" from the University of Connecticut (Guillard 2008) as well as other regional university publications (see References).

University of Vermont Soil Test Recommendations for Turf

The soil testing program at the University of Vermont is a joint effort of the Agricultural and Environmental Testing Laboratory which manages the processing and chemical analysis of the soils and UVM Extension which interprets and develops nutrient recommendations that are presented in the soil test report. Information provided by the turf manager on the *Soil Test Submission Form* is combined with laboratory results to create a computerized soil test report that shows soil test results, nutrient recommendations, and other information about fertilizer application.

The University of Vermont uses a modified Morgan's solution (1.25 *M* ammonium acetate, pH 4.8) to analyze most nutrients in its soil testing program. Research in Vermont, New York, and other New England states has shown it to be a good indicator of plant nutrient availability. Recommendations are revised periodically based on on-going research.

Soil Test Sampling

The results obtained from a soil test are only as good as the sample submitted; therefore, proper collection is critical for obtaining a useful, accurate recommendations. The UVM Soil Testing program suggests collecting 12 or more subsamples per location in a regular grid pattern. Avoid any obvious spots where there may have been previous spills or over-application of lime or

fertilizer. For turf, it is recommended to sample to a 3 to 4 inch depth and discard thatch and leaf material. This can be achieved using a trowel or shovel, but a soil probe is the best and easiest method. Each subsample collected should be approximately a 1" by 1" column 3 to 4 inches deep from the soil surface.

Subsamples can be pooled into a clean, plastic bucket (avoid metal buckets) and mixed together to make one sample. From the composite sample, a ½ cup of this mix should be placed in a plastic bag for submission to the lab. Be careful not to contaminate the sample with lime or fertilizer during sampling or mixing. Fill out the questionnaire as completely as possible, including the correct Crop Code.

The frequency of sampling a particular site depends on needs. It is highly recommended to test a soil before establishment or renovation so that lime and critical nutrients can be incorporated into the soil during site preparation. For established turf, sampling every three years can be useful to monitor any changes on soil test levels and adjust annual lime and fertilization programs. In some situations, more frequent sampling may be required if nutrient levels have the propensity to rapidly change. This may be the case with sand-based tees and greens that have low organic matter since their cation exchange capacity (CEC) is usually lower and, therefore, more conducive for leaching of potassium.

If the site varies in soil type, previous fertilizer or lime treatments or other past management practices, it is recommended to take separate samples and tests for each site since fertility histories may be quite different. For golf courses, it may be feasible and more cost effective to subsample across multiple tees or greens if they are of similar turfgrass type and soil material and are managed in a consistent manner (mowing, irrigation, fertilization, etc.). Fairways should probably be sampled and tested separately due to their larger size and variation of native soil types. If samples are collected from a site every three years, then approximately a third of the course could be sampled each year.

Soil pH and Lime Recommendations

Maintaining an optimum soil pH level is important for maximizing availability of plant nutrients, for encouraging activity of beneficial soil microorganisms, and for maintaining soil conditions that will support good root growth and turf quality. Most turf can grow well within a range of soil pH from 6.0 to 7.0 and the optimum pH within that range may depend on very specific needs. This is also the range in which there is most likely a balanced availability of plant essential nutrients. The UVM Soil Test for lime recommendations for turf uses 6.5 as the target soil pH on their soil test report (to adjust above or below this pH, use Table 1).

Most soils in Vermont have a natural tendency to be acidic (low pH) and need periodic applications of lime to maintain pH in a range optimum for turf growth and quality. The primary function of lime is to raise the pH of the soil. However, over application of lime can result in raising the pH above optimum levels and excessively high pH levels (over 7.5) can cause poor nutrient availability and create other turf problems. Also, it is more challenging and expensive to lower soil pH than to raise it. Therefore, lime application rates should be based on achieving the target pH goal and lime should not be applied without a soil test.

The UVM Soil Test lime recommendation is based on a combination of soil pH and reactive Al soil test. The pH tells us whether or not aglime is needed. However, different soils with the same pH may require very different amounts of aglime to reach the optimum pH. The reactive Al level is an indicator of the amount of reserve soil acidity that needs to be neutralized in order to change the pH and is used to determine the application rate of lime (Table 1).

The most common liming material is calcium carbonate (sometimes referred to as Aglime) usually pulverized into a powder for quick reaction with soil acidity. A pelletized form of Ag Lime is often used on turf for ease of application and reduction in dustiness. Recommendations are given in tons of aglime per 1000 square feet, assuming a calcium carbonate equivalent (CCE) of 90% or higher. Most aglime sold in Vermont is within this range, but if your liming material has a CCE less than 90%, application rate should be increased accordingly. A common liming material in much of Vermont is aglime/wood ash blend (typically 80% aglime, 20% wood ash). While lime-ash has a slightly lower CCE than pure aglime, it contains some potash and other nutrients and is an excellent liming material.

The best time to apply lime for correcting soil pH is during establishment when the lime can be tilled in during site preparation. Good distribution of lime throughout the root zone is best. If the recommendation is over 100 lbs., it would be best to till in half the amount and then apply the rest and till again during the final site preparation. Do not apply more than 200 lbs. of lime per TSF at establishment. Since lime moves slowly into the soil, it is best to limit topdress applications on established turf to 50 lbs. per TSF. If soil test calls for more than this, apply in 50 lb. increments once in spring and once in the fall. Repeat this until the total recommendation is reached.

Table 1. Aglime requirement for turfgrasses based on soil pH, reactive Al, and target pH

		Recommended Aglime[1]					
Soil		Target Soil pH[2]			Target Soil pH[2]		
Test pH	Reactive Al	6.2	6.5	6.8	6.2	6.5	6.8
	ppm	*tons/acre*			*lbs/1000 square feet*		
>6.7		0	0	0	0	0	0
6.5-6.7	0-40	0	0	1	0	0	50
	>40	0	0	2	0	0	100
6.2-6.4	0-40	0	0.5	1	0	25	50
	>40	0	1	2	0	50	100
5.6-6.1	0-40	1	1.5	2	50	70	95
	41-70	1.5	2	2.5	70	90	115
	71-100	1.5	2.3	3	75	100	140
	101-150	2	2.8	3.5	90	125	160
	151-200	2.5	3.3	4	115	150	185
	>200	3	4	5	140	185	230
<5.6	0-40	1.5	2.3	3	70	105	140
	41-70	2	2.8	3.5	90	125	160
	71-100	2	3	4	95	140	185
	101-150	2.5	3.5	4.5	115	165	210
	151-200	3	4	5	140	185	230
	201-250	3.5	4.5	5.5	160	210	255
	251-300	4	5	6	185	230	275
	>300	5	6	7	230	275	320

[1] Limit a single application to 2 tons/acre or 100 lbs/TSF. If the recommendatioin is higher than this, split over one or two years.

[2] The default target pH on the soil test lab report is 6.5. However, some turf situations are better suited within the lower or higher range of 6 to 7.

Nitrogen Recommendations

Nitrogen (N) is the mineral element needed in the largest quantities in turfgrasses. Although there is an abundant amount of N in our atmosphere, it is not directly available to plants and only a limited supply of N is available to plants either in the form of soil nitrate (NO_3^-) or ammonium ion (NH_4^+). In most cases, N fertilizer must be applied regularly to maintain high quality turf. At the same time, too much N is a waste of money and can create unnecessary turf growth, predispose the plants to certain diseases, increase the likihood of excess thatch layers and increase the risks of nitrate leaching into the ground water.

The actual nitrogen needs for turf vary much depending on many factors including function, turf vigor, species and soil N availability. Table 2 provides guidelines for N rates. To reduce the risks of N leaching, the least amount of N should be used as possible to meet desired turf goals. Many turf managers have found that even 1/2 rates can provide acceptable results under some circumstances. No more than 1 pound of soluble N per thousand square feet (TSF) should be applied at any one time.

Table 2. Recommended annual rates of nitrogen for golf course turf in Vermont

	Pounds of actual N / 1000 sq. ft. / year[1]	
Turf Type and Species	Establishment/Grow-In[2]	Maintenance[3,4]
Golf Greens and Tees	3 - 6	3 - 5
Golf Fairways	3 - 6	2 - 5
Golf Roughs	2 - 4	0 - 3

[1] To reduce the risk of leaching or runoff, no more than 1.0 lb. of soluble N should be applied in any one application.

[2] Grow-in includes the period from first mowing of turf (established from seed, sprigs or plugs) to the date when turf is opened for play. Use maintenance recommendations for grow-in of sodded turf.

[3] Maintenance of established turf as well as grow-in period for sodded turf.

[4] For many utility or low input turf situations, if clippings are routinely returned to the turf at mowing and if soil organic matter is high (above 4%) , there may be no need for nitrogen fertilizer every year. Monitor by observing growth and color.

Phosphorus and Potassium Fertilization Recommendations

Phosphorus (P) and potassium (K) are considered the second and third primary plant nutrients. Phosphorus is extremely important for many plant functions including respiration, cell division, root and seedling development, and plant maturation. Potassium is important for maintenance of turgor pressure (which has a strong influence on drought tolerance, cold hardiness and disease resistance) and enzyme activation in the turf plants.

The recommendations for P and K are determined by the levels found in the soil test and are based on meeting turf needs as well as building up or maintaining soil P and/or K levels . Thus, a soil test with a very low P or K level will have a high recommended rate, and a soil test with an optimum or high level will give a zero or minimum recommendation since there is already an adequate supply in the soil to meet turf needs.

Application rates for P (Table 3) and K (Table 4) are based on the fertilizer chemical formulas P_2O_5 and K_2O, respectively. For maintenance applications of established turf, no more than one pound of P_2O_5 or K_2O should ever be applied per TSF at any one time regardless of source including organic materials such as compost. More than 1 lb. P_2O_5 could be applied if incorporated into the soil such as during soil preparation for turf establishment. Fertilizers should never be applied just before a heavy rain or irrigation which could result in leaching or runoff. To reduce the risks of P runoff, the least amount of P should be used as possible to meet desired turf goals.

If soil test is very low for P and K, the best time to correct for these nutrients is during establishment so the nutrients can be tilled into the soil during final site preparation. This is particularly true for P since it moves so slowly through the soil. If correcting a low P or K soil on an established turf, it may take a couple years using multiple applications.

Table 3. Recommended annual rates of phosphorus for golf course turf in Vermont

Turf Usage	Soil Test P (ppm P)	Test Interpretation	Total Annual Phosphorus Recommendation[1] (lbs. P_2O_5 / 1000 sq. ft)	
			Establishment[2,3]	Maintenance[4]
Greens and Tees[5,6]	Less than 2	Low	3	3 - 4
	2 - 3.9	Medium	2 - 2.5	1 - 3
	4 - 9.9	Optimum	0.5 - 1	0.5 - 1
	10 and above	High or Excessive	0	0
Fairways	Less than 2	Low	2.5	2
	2 - 3.9	Medium	1.5 - 2	1 - 1.5
	4 - 9.9	Optimum	0.5 - 1	0.5 - 1
	10 and above	High or Excessive	0	0
Rough and Low Traffic Areas	Less than 2	Low	2.5	2
	2 - 3.9	Medium	1.5 - 2	1 - 1.5
	4 - 9.9	Optimum	0.5 - 1	0 - 0.5
	10 and above	High or Excessive	0	0

[1] P fertilizer should never be applied just before a heavy rain or irrigation which could result in leaching or runoff.

[2] It is best to incorporate P fertilizer into the soil before turf seed or sod establishment, in which case, all the recommended P fertilizer can be applied at once. For grow-in situations (no-till), P fertilizer may be spread over multiple applications limiting a single P application to no more than 1 lb. of P2O5 per thousand square feet.

[3] A small amount of P placed near the seed may be beneficial during establishment depending on time of year and soil conditions even if soil test P calls for no P fertilizer.

[4] Generally for established turf, P should be applied in small rates with multiple applications following all guidelines for reducing risks of P runoff.

[5] At low/medium soil test values, recommendations for native soils will vary somewhat from sand-based greens.

[6] Low rates of foliar applicatioins may increase plant uptake; however, unabsorbed foliar P can pose a risk of loss from runoff during heavy precipication or excessive irrigation events. A light irrigation after P fertilzer application has been shown to reduce P runoff.

Routine soil tests (every three to five years) will help monitor changes in soil P and K levels. Since sand-based tees and greens generally have a low CEC, it may be prudent to soil test every one to two years to monitor any changes in soil K levels.

Table 3. Recommended potassium rates for golf course turf in Vermont

Turf Usage	Soil Test K (ppm K)	Test Interpretation	Potassium Recommendation[1] Establishment[2] (lbs. K_2O/ 1000 sq. ft/year)	Maintenance[3] (lbs. K_2O/ 1000 sq. ft/year)
Greens and Tees	Less than 25	Low	5	5
	25 - 99	Medium	2 - 5	2 - 5
	100 - 159	Optimum	1 - 1.5	1
	160 and above	High or Excessive	0	0
Fairways	Less than 25	Low	4	5
	25 - 99	Medium	2 - 3	2 - 5
	100 - 159	Optimum	1 - 1.5	1
	160 and above	High or Excessive	0	0
Rough and Low Traffic Areas	Less than 25	Low	4	4
	25 - 99	Medium	2 - 3	2 - 3
	100 - 159	Optimum	0 - 1	0 - 1
	160 and above	High or Excessive	0	0

[1] Fertilizers should never be applied just before a heavy rain or irrigation which could result in leaching or runoff.

[2] If K is recommended for establishment, it is best to incorporate 1 lb of K2O per thousand square feet into the soil before turf seed or sod establishment and topdress the remainder once the turf is growing . K fertilizer may be spread over multiple applications limiting a single application to no more than 1 lb. of K2O per thousand square feet.

[3] For established turf on low CEC soils such as sands, K should be applied in small rates with multiple applications. For high CEC soils, K applications can be achieved with one or fewer applications depending on the total recommended rate.

Secondary Nutrients and Micronutrients

Calcium (Ca), magnesium (Mg), and sulfur (S) are secondary nutrients taken up in smaller amounts than N, P and K. In most cases, turf needs little to no additional Ca or Mg as long as soil pH is adequate. Lime can come in two forms – calcium limestone which has only Ca or dolomitic limestone (which has Ca and Mg). If the soil test calls for lime but Mg is adequate, then using only calcium carbonate will usually satisfy Ca. It the soil is low in Mg, using dolomitic limestone will often satisfy Mg needs. In the rare event that Ca or Mg is recommended for turf with an adequate pH, you can use gypsum as a source of Ca or Epson salt as a source of Mg. Neither of these have any liming effect on soil pH.

Sulfur (S) has not been found to be a problem for most turf situations. There are usually adequate supplies in the soil in the northeast U.S. The major times that S is applied to turf is when soil pH is too high (above 7.5) and elemental S is used to lower soil pH.

The micronutrients include iron, manganese, zinc, boron, copper, molybdenum, and chlorine and are required only in minute amounts in the plant. Most soils in the northeastern U.S. have adequate amounts of micronutrients and fertilization of these nutrients are not needed. However, turf grown on sand-based greens or tees may benefit from micronutrient applications. Deficiencies can occur under rare circumstances such as when the soil pH is extremely high (above 8.0) on sandy soils which leads to some micronutrients becoming unavailable.

Iron fertilizer is used by turf managers as a way to enhance turf color as a substitute for part of the nitrogen requirement. Iron will enhance color without the stimulation of growth caused by N. Frequent mowing and susceptibility of certain diseases cause by excess N may be reduced.

Over application of some micronutrients can actually be toxic to turf. For instance, turfgrasses are particularly sensitive to boron if applied at too high a rate. Some micronutrients can become antagonistic to the uptake of other micronutrients. Over application of copper can lead to deficiencies of iron. So, care must be taken when applying these nutrients.

N and P Best Management Practices for Water Quality Considerations

Many parks, golf courses, and residential landscapes are located near ponds, lakes, rivers and coastal waters. These surface waters can be degraded by nutrient loss resulting from over-application or improper application of fertilizers and/or compost. Groundwater can also be contaminated from nutrient lost from turf. The following is adapted from a list of recommended practices developed by a New England consortium of turf and water quality professionals (Guillard, 2008).

Recommendations for Managing Nitrogen

- If the turf is considered unacceptable, assess the possible reasons (pests, compaction, shade, low fertility, etc.). If fertilization is deemed necessary:
  - Do not apply before spring green-up and apply no later than September 30th. Avoid mid-summer fertilizing.
  - Slow-release formulations are preferable to soluble, fast release formulations.
  - If a soil test indicates phosphorus (P) and / or potassium (K) are adequate, then fertilize with only nitrogen (N). If only blended fertilizers are available, choose the one with the lowest P content.
  - If near surface water (streams, rivers, lakes, estuaries, bays, coastal areas, vernal pools, wetlands, or drainage areas), leave a buffer strip of at least 25 feet of unfertilized grasses or other vegetation around water bodies.
  - Avoid using combination products that include both fertilizer and weed killers. Fertilizers with herbicides should not be applied within 25 feet of surface water.
- Other management considerations:
  - In areas where practical, return clippings and mow as high as possible. Clippings can supply slow- release nitrogen to the turf and allow for reduced fertilizer applications.
  - Maintain soil pH levels between 6.0 and 7.0.
  - If supplemental watering is applied, avoid overwatering. Do not exceed a total of 1- 1 ½ inches of water per week, including rainfall amounts.
  - When establishing new turf, if organic matter is below 3%, incorporate compost or another organic material into the soil to raise the % of organic matter content to at least 3%, preferably 5%.

Recommendations for Managing Phosphorus

- Always test the soil to determine phosphorus levels before applying.
- If phosphorus fertilizer is required:
  - Avoid using P fertilizers on bare ground or on low- density turf, unless it is a new seeding.
  - Use P- free fertilizer on established turf unless soil tests indicate P is required.
  - Avoid applying phosphorus fertilizers when moderate to heavy rain is in the forecast.
  - Leave a buffer strip of unfertilized grasses or other vegetation around bodies of water.
  - Never apply phosphorus fertilizers to saturated or frozen ground.
  - Avoid using products that include both fertilizers and weed killers as the application rates of such products are based on the weed killer rather than the fertilizer.
- Other management considerations:
  - Return clippings where practical.
  - Maintain a soil pH of 6.0 to 7.0. This will ensure that most of the nutrients necessary for good turfgrass growth will be available to the grass plants. Monitor pH levels to determine if liming is necessary or not.
  - Soil test annually for P when applying organic fertilizers derived from composts to ensure that P levels do not become excessive.

References

Guillard, Karl. 2008. New England regional nitrogen and phosphorus fertilizer and associated management practice recommendations for lawns based on water quality considerations. Turfgrass Nutrient Management Bulletin B-0100, University of Connecticut. http://www.lawntolake.org/PDFs/NE_WQ_Fert_Rec.pdf

Jokela, Bill, Fred Magdoff, Rich Bartlett, Sid Bosworth and Don Ross. 2004. Nutrient recommendations for field crops in Vermont. Br. 1390, University of Vermont Extension, Burlington, VT.

Landschoot, Peter. 2003. Turfgrass fertilization: a basic guide for professional turfgrass managers. The Pennsylvania State University, University Park, PA. http://plantscience.psu.edu/research/centers/turf/extension/factsheets/turfgrass-fertilization-professional#af

VGCSA. 2012. Environmental Best Management Practices for Virginia's Golf Courses. Virginia Golf Course Superintendents Association. http://www.vgcsa.org/-best-management-practices

Jan/2017
