What Fertilizer Should I Use?[1]

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[1] This handout is a supplement to the presentation given on this topic at the Sustainable Turfgrass Management in Asia 2013 conference at Pattaya, Thailand.

When choosing a fertilizer, the first step is to identify which elements are necessary to apply and to determine how much of each is required. Then the costs of various sources of those elements should be determined. One must also make a decision on whether to apply fast-release or slow-release forms of nitrogen. Depending on the fertilizer type and the application equipment available, one will also decide between granular or liquid application of the fertilizer.

This document provides a guide to determining what nutrients are required, in what quantities, and it gives some of my thoughts related to the use of different types of fertilizers. There are many ways to do this. This is how I would do it. Let's imagine that we will answer the question "what fertilizer should I use?" for a golf course near Bangkok in central Thailand.

To illustrate the steps we will take in answering that question, this discussion concerns the ultradwarf bermudagrass putting greens on the hypothetical course. For simplicity, I will imagine the total surface area of the greens to be 10 000 m^2 or 1 ha. However, the same steps that I discuss here can be applied to any turfgrass area.

Which elements are required?

Mineral
Nitrogen
Phosphorus
Potassium
Calcium
Magnesium
Sulfur
Boron
Chlorine
Iron
Manganese
Zinc
Copper
Molybdenum
Nickel

Table 1: The 14 essential mineral elements for plants

The essential mineral elements are listed in Table 1. Not all of these are required as fertilizer – for many of the elements the grass can obtain all that it needs from the soil without a need for supplemental fertilizer.

To determine which elements must be applied as fertilizer, we can estimate plant requirements using the temperature-based growth potential of PACE Turf[2] as described in my previous handout.[3] In this hypothetical case of deciding which fertilizers to use for 1 ha of bermudagrass greens in central Thailand, I will estimate the maximum monthly nitrogen use of the grass to be 3.2 $g/m^2/mo$.

[2] Wendy Gelernter and Larry Stowell. Improved overseeding programs 1. the role of weather. *Golf Course Management*, pages 108–113, March 2005

[3] Micah S. Woods. Nutrient requirements of tropical turfgrass. Technical report, Asian Turfgrass Center, 2013

This is 20 % less than the 4 $g/m^2/mo$ I suggested for bermudagrass in the previous handout. There are two reasons for this.

1. I expect that I will regularly apply the growth regulator trinexapac-ethyl (Primo Maxx) to these greens. These applications will reduce the clipping production of the grass and will also reduce the amount of nitrogen and other nutrients that are harvested through clippings.[4]
2. I prefer to be conservative when planning how much nitrogen to apply. Once it is applied, we can't take it back. But if we have slightly under-estimated how much the grass may use, we will easily see it and can add a little bit more nitrogen.

[4] Patrick E. McCullough, Haibo Liu, Lambert B. McCarty, Ted Whitwell, and Joe E. Toler. Bermudagrass putting green growth, color, and nutrient partitioning influenced by nitrogen and trinexapac-ethyl. *Crop Science*, 46: 1515–1525, 2006

Based on the growth potential for Bangkok and a maximum monthly nitrogen use of 3.2 g/m^2/mo, and assuming leaf nutrient content is as in Table 2, then over the course of a year, the grass will use the elements in the amounts shown in Table 3. But what the grass uses is not necessarily the same as what we need to apply as fertilizer. We should account for what the grass will obtain from the soil.

Element	Percent %
Nitrogen	4
Potassium	2
Phosphorus	0.5
Calcium	0.5
Magnesium	0.2
Sulfur	0.1
Iron	0.01
Manganese	0.005

Table 2: Approximate percentage of the most abundant mineral elements in the leaves of many turfgrass species

How much of each element is required?

WE MUST KNOW how much is in the soil before we can determine how much to apply as fertilizer. We can use the MLSN guidelines[5] to interpret the results of a soil test.

Let's assume we have tested the greens and found a pH of 6.6 with Mehlich 3 extractable K, P, Ca, and Mg at 84, 44, 519, and 69 ppm, respectively.[6] The Fe and Mn are used in tiny amounts by the grass so we won't worry about them. We may occasionally add them in a micronutrient fertilizer. The S is required in relatively low amounts by the grass and we will supply some through planned applications of ammonium sulfate or other sulfate-containing fertilizers through the year, so we won't look at that in detail here.

Element	Annual Use g/m^2/yr
Nitrogen	35.6
Potassium	17.8
Phosphorus	4.5
Calcium	4.0
Magnesium	1.8
Sulfur	0.9
Iron	0.1
Manganese	0.01

Table 3: Estimated annual use of the most abundant mineral elements in turfgrass leaves using the growth potential for Bangkok and a maximum monthly nitrogen use of 3.2 g/m^2/mo

[5] Micah S. Woods and Larry Stowell. Minimum levels for sustainable nutrition soil guidelines. Technical report, Asian Turfgrass Center and PACE Turf, 2012

[6] These are typical values for greens in Southeast Asia. In an analysis of 100 greens tested by Asian Turfgrass Center in five countries of Southeast Asia, these were the median values. So in this hypothetical case, we are also dealing with a typical one.

That leaves us with N, K, P, Ca, and Mg with estimated use as in Table 3 and with soil amounts as mentioned. We can convert the soil amounts which are in ppm to the same amount we think of for fertilizers, in mass per area. To do this, I assume average annual root depth of 10 cm and a soil bulk density of 1.5 g/cm^3. This gives us a conversion factor of 6.7. If we apply any element at a rate of 1 g/m^2, it will increase the soil concentration in the top 10 cm by 6.7 ppm.

Now we can directly compare the available nutrients in the soil to the nutrients the grass is expected to use.

Element	Annual Use g/m^2/yr	Amount in Soil g/m^2/yr	Annual Deficit g/m^2/yr
Nitrogen	35.6	na	35.6
Potassium	17.8	12.5	10.5
Phosphorus	4.5	6.6	0.6
Calcium	4.0	77.5	none
Magnesium	1.8	10.3	none

Table 4: For our hypothetical bermudagrass at central Thailand, using a maximum estimated nitrogen use of 3.2 g/m^2/mo at a growth potential of 1 , and using typical soil nutrient levels, the estimated annual use compared to the amount in the soil for N, K, P, Ca, and Mg.

Table 4 shows in the deficit column just how much of each element we need to apply over the course of the year to supply what the grass is expected to use and to keep the amount of that element above the MLSN guideline in the soil.

For N, there is very little in the soil, and we are using growth potential rather than soil test level to determine how much N to apply. The grass is expected to use more K than is available in the soil, so to meet the plant requirements, and to keep soil K above the

MLSN guideline of 35 ppm, we need to add 10.5 g K/m^2/yr. There is almost enough P in the soil to meet the plant requirements, but not quite enough; we will need to apply 0.6 g P/m^2/yr to ensure the plant has enough P and that soil P remains above the MLSN guideline of 18 ppm.

There is more than enough Ca and Mg in the soil to meet the needs of the grass and to keep the soil level above the MLSN guidelines for those elements, so no Ca or Mg are necessary as fertilizer in this year.[7]

[7] The soil should ideally be tested annually to monitor changes in soil nutrient content and to calculate the fertilizer requirement for the upcoming year.

What is the cost of the fertilizer?

Nitrogen and potassium will be the elements required in the largest amounts as fertilizer in most situations. Urea is the nitrogen fertilizer with the lowest price. Potassium chloride (KCl) is the potassium fertilizer with the lowest price. We do not always want to use the fertilizers with the lowest price, but we should determine what the lowest possible product cost is before selecting any fertilizer.[8]

[8] Stanley J. Zontek, Dave A. Oatis, Darin Bevard, Keith Happ, Jim Skorulski, Bob Vavrek, and Adam Moeller. Does the grass know the cost? *Green Section Record*, pages 32–36, May-June 2010

For any fertilizer more expensive than urea or KCl, we can then determine if the difference in price between the lowest cost option and the more expensive option is worth it. This value could come from a slow-release formulation that saves in labor costs or from a fertilizer formulation that is easier to apply. The plant takes up urea or ammonium or nitrate, and potassium is taken up as the potassium ion, [K^+].

The source of N or K does not matter to the plant when it comes to supplying these nutrients,[9] but a slow-release formulation can provide significant savings in labor costs, and a formulation that is easy to apply with a facility's existing equipment will also provide value.

[9] J.B. Sartain. Tifway bermudagrass response to potassium fertilization. *Crop Sci.*, 42:507–512, 2002; and E.A. Guertal. Fertilization of bentgrass with commercial foliar products: Greenhouse evaluations. *Applied Turfgrass Science*, pages doi:10.1094/ATS–2010–0914–01–RS, 2010

For our 1 ha of bermudagrass turf, we have estimated a nitrogen requirement of 35.6 g/m^2/yr and a potassium requirement of 10.5 g/m^2/yr. Urea is 46% N and KCl is 52% K.[10] For one hectare, we will need 774 kg of urea and 202 kg of KCl.

[10] On a fertilizer bag we see 0-0-60 for the analysis of KCl because the 60% is on a K_2O equivalent basis.

At Thailand, the recent price of urea was 16.4 baht/kg and the price of KCl was 18 baht/kg. This is approximately $0.55 /kg for urea and $0.60 /kg for KCl. The cost for our nitrogen and potassium for the year then is just 12,700 baht for 774 kg of urea and 3,640 baht for 202 kg of KCl. The total cost is 16,340 baht or US $547.

Fast release or slow release nitrogen

There are many types of fertilizer and many types of slow release nitrogen sources.[11] For putting greens, my preference is to

[11] J.B. Sartain and J.K. Kruse. Selected fertilizers used in turfgrass fertilization. University of Florida Extension, April 2001

use fast release nitrogen because that allows me to control precisely the supply of nitrogen to the grass and thus the growth rate of the grass. This is not the only way to manage the grass, as there is a recent trend for some turfgrass managers to use only granular (and I presume only slow-release) nitrogen sources on ultradwarf bermudagrass.[12]

Fast release nitrogen should not be applied in a single application at rates exceeding 2 g N/m^2. It is typical to apply fast release nitrogen at rates of 0.5 g N/m^2 to 1.25 g N/m^2.[13] You will see that to meet the annual requirement of 35.6 g $N/m^2/yr$, I will have to make about 36 applications of fertilizer per year. If I do not have equipment that makes those applications easy, or if have high labor costs that would make a huge difference in labor cost between 12 applications, which is what we expect when using slow release nitrogen, and 36 applications, then it makes sense to consider slow release fertilizers instead.

[12] Todd Lowe. Changing times in ultradwarf bermudagrass putting green management. *Green Section Record*, 50(13):1–3, June 2012

[13] I have heard of some golf courses applying fast release nitrogen at rates of up to 5 g N/m^2 in a single application. This is not advisable. A high performance putting green will only use about 0.2 g $N/m^2/day$. Adding more than 2 g of fast release N/m^2 in a single application will cause undesirably rapid growth. Adding more than 3 g of fast release N/m^2 in a single application will also increase soil available nitrogen above 20 ppm which has been identified as potentially damaging to turf. Slow release nitrogen can be applied at high rates. Fast release nitrogen should be applied at low rates.

Liquid or granular application

WHEN APPLYING LOW RATES of nitrogen, it is impossible to get even coverage across the turf surface when using granular products. We then tend to get spotting of the turf with some areas turning green where a fertilizer granule has landed, and other areas remaining more yellow because a fertilizer granule did not land in that area. At high rates of nitrogen, there are a lot of granules and then the surface does not get spotted. Because I chose to use fast release nitrogen, and because we don't want to exceed a rate of 2 g N/m^2 in a single application with fast release sources, I will choose to make liquid applications.

Of course the question of liquid versus granular and fast versus slow release must be considered for each area of the property. I may not mind making 36 applications of liquid fertilizer to 1 ha of greens in a year, but I don't want to do that to 35 ha of rough! I would make a different choice for the rough.

Foliar uptake of nutrients

There is foliar uptake of some nutrients. With nitrogen the uptake by the leaves is usually about 50% of the applied amount[14] although some researchers find uptake is usually less than 50%.[15] Because only some of the elements applied will be absorbed by the foliage, and half or more remain on the leaf and can be rinsed off into the soil for root uptake, I prefer to use the term *liquid* fertilization rather than *foliar* fertilization when describing liquid fertilizer applications.

[14] J. Chris Stiegler, Michael D. Richardson, and Douglas E. Karcher. Foliar nitrogen uptake following urea application to putting green turfgrass species. *Crop Science*, 51:1253–1260, 2011

[15] Bruce Branham, Shelby Henning, and Richard Mulvaney. Optimization of foliar nitrogen nutrition to improve turfgrass performance under shade or mowing stress. *USGA Turfgrass and Environmental Research Online*, 9(19): 1–5, October 2010