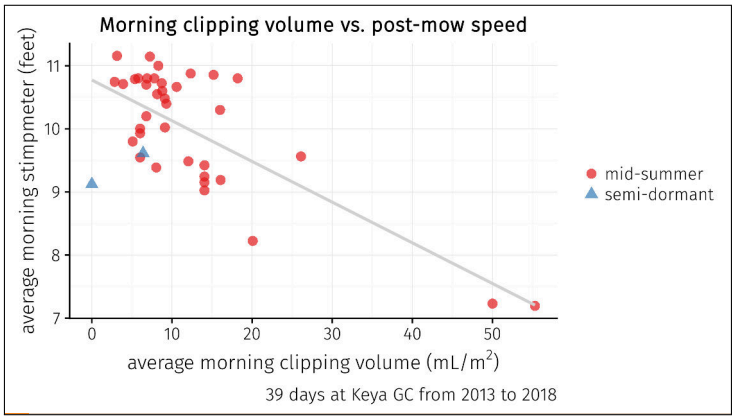
Optimising turf: growth, organic matter, and nutrients

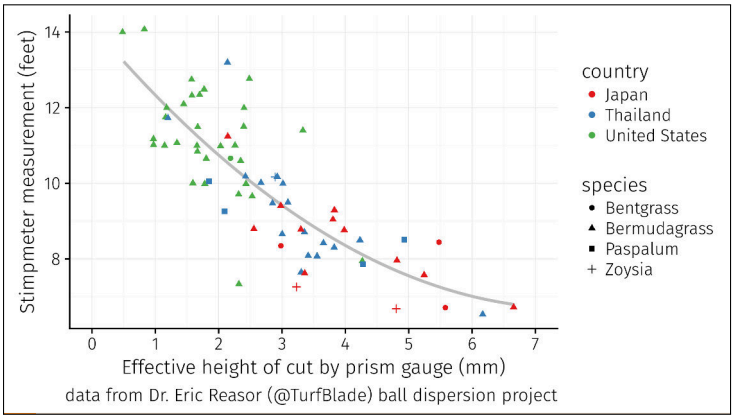
Micah Woods, Ph.D.

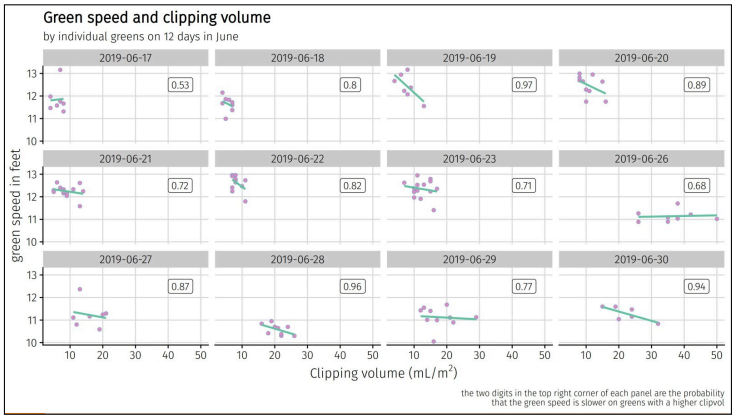
January 19, 2025

Asian Turfgrass Center
www.asianturfgrass.com

PACE Turf
www.paceturf.org







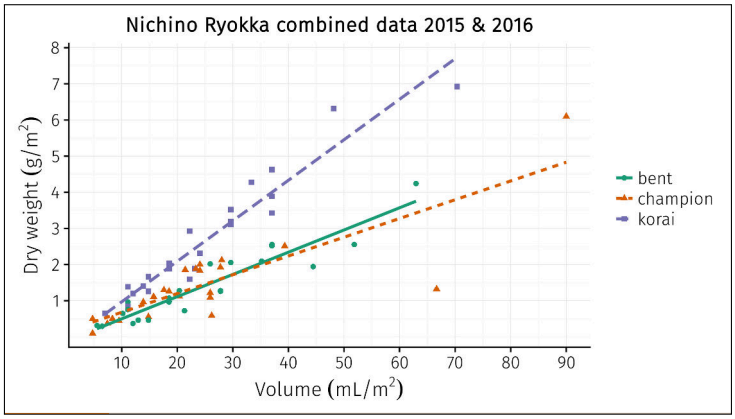
Machine and cutting unit setup and clipvol variation

Video time stamp: 1 second

Video time stamp: 4 seconds

Video time stamp: 10 seconds

Estimate dry mass as 6% of the fresh clipvol



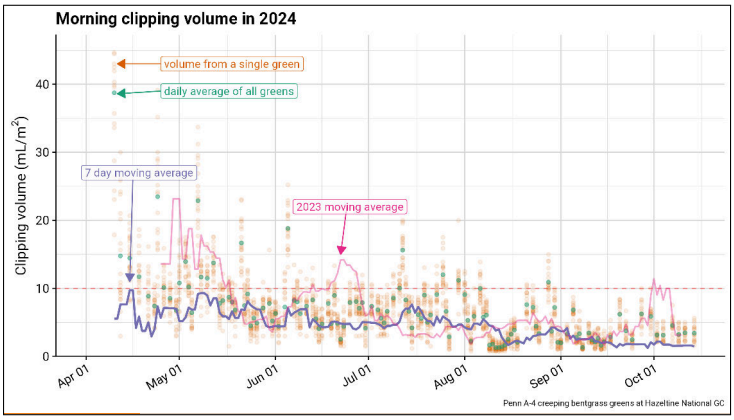
Estimate clipping harvest dry mass from clipping volume

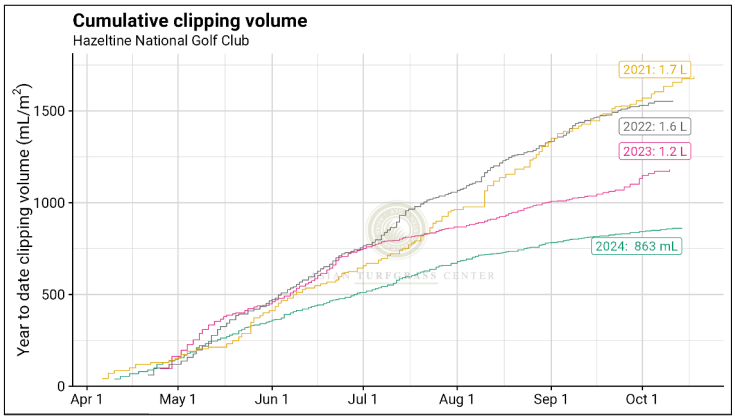
Creeping bentgrass leaf nutrient normals

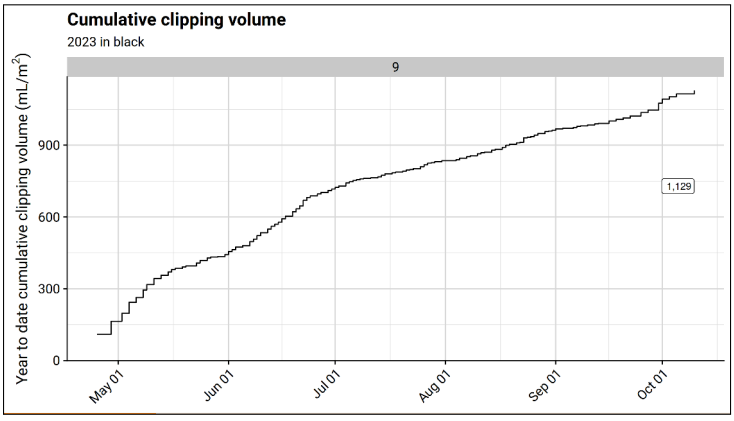
element	25th percentile	Median (%)	75th percentile
N	4.3	4.8	5.3
P	0.5	0.6	0.6
K	1.8	1.9	2.0
Ca	0.5	0.6	0.7
Mg	0.2	0.2	0.3
S	0.5	0.5	0.6

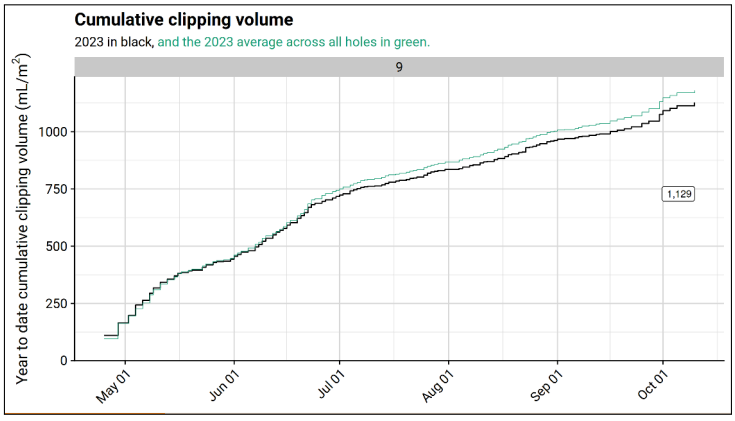
Estimate nutrient harvest from clipping volume

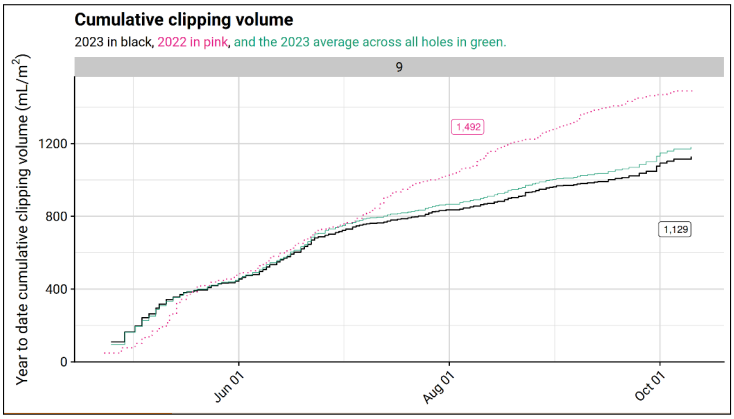
Estimate clipping volume from N supply

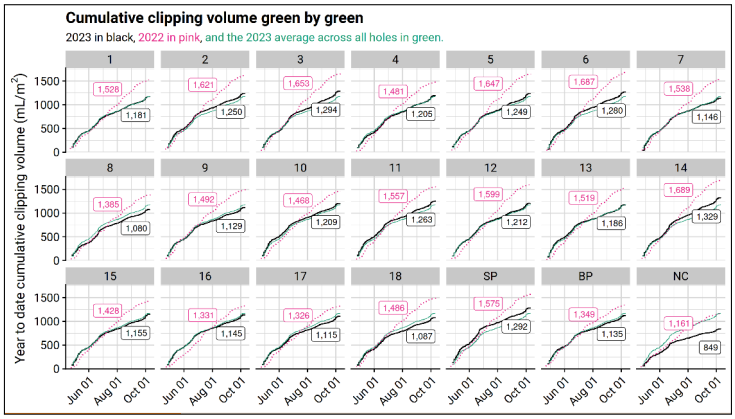












date | time | 1 | 2 | 3 | 4 | 5 | 6 | .... | 18 | avg | sd | notes

The Turf GvX is the actual growth of the grass compared to the expected growth of the grass.

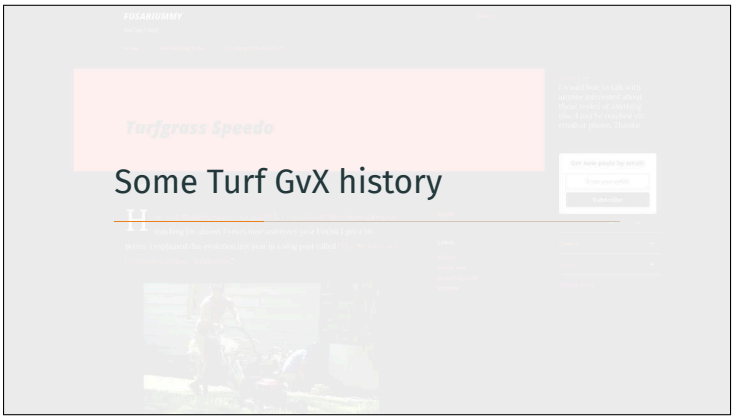
Use the GvX for ...

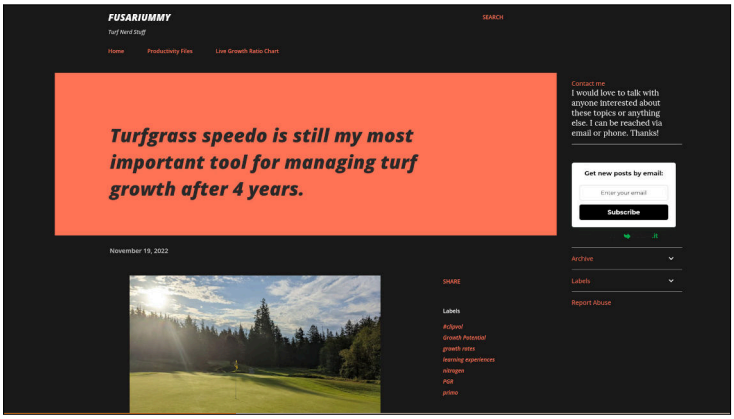
- adjusting N fertilizer
- adjusting plant growth regulators

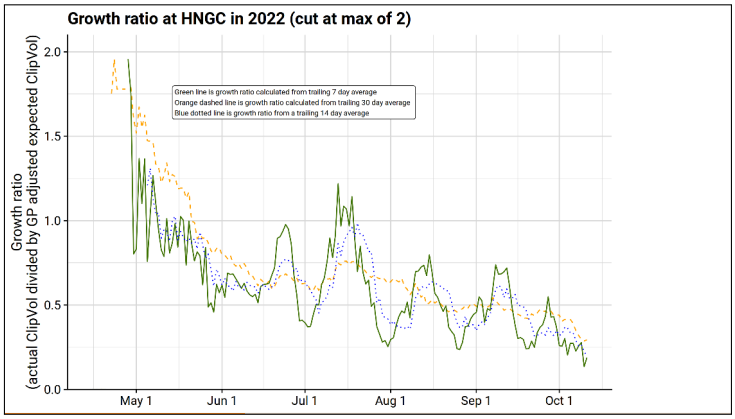
Results may include ...

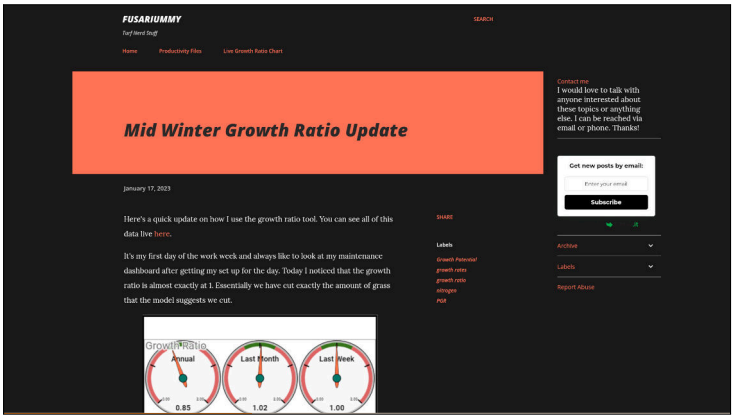
- Improved playing conditions
- Fewer inputs (N, sand, mowing)

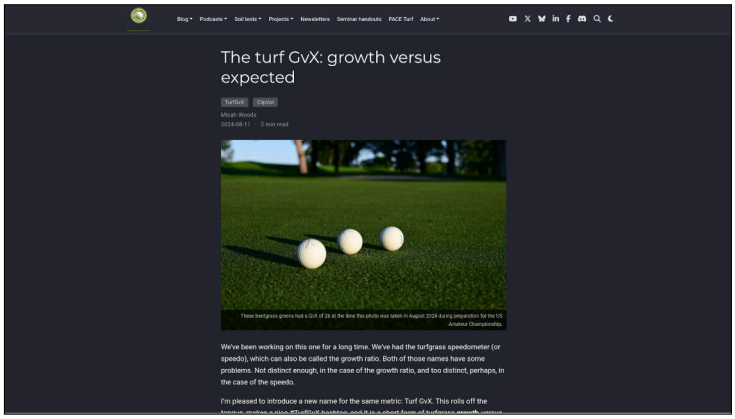
Some Turf GvX history



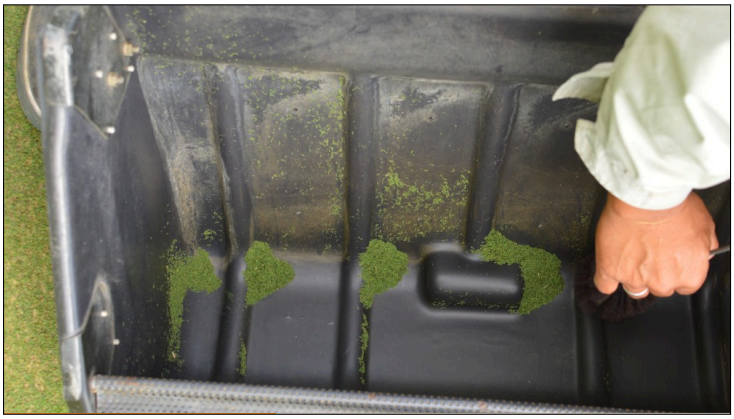








Actual growth



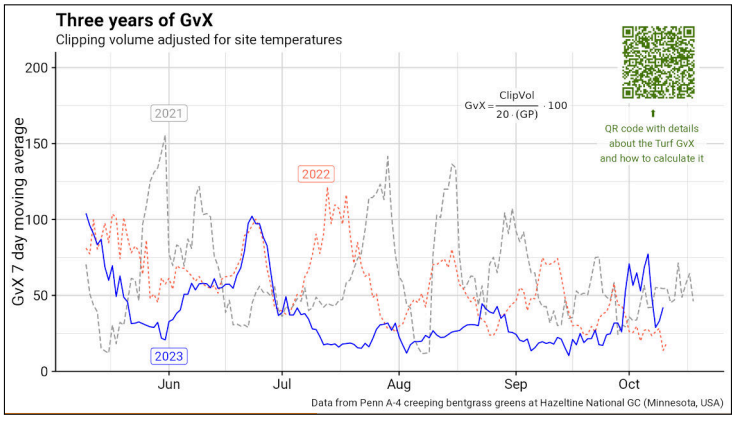
The standard units for clipping volume (ClipVol) are mL/m^2 or L/1000 m^2.

Expected growth

Calculating the GvX

$$\text{GvX} = \frac{ClipVol_{14}}{20 \times GP_{14}} \times 100$$

where $ClipVol_{14}$ is the 14 day average of clipping volume and GP_{14} is the 14 day growth potential average.



Adjusting N based on GvX

$$N_o(\frac{GvX_o}{GvX_a}) = N_a$$

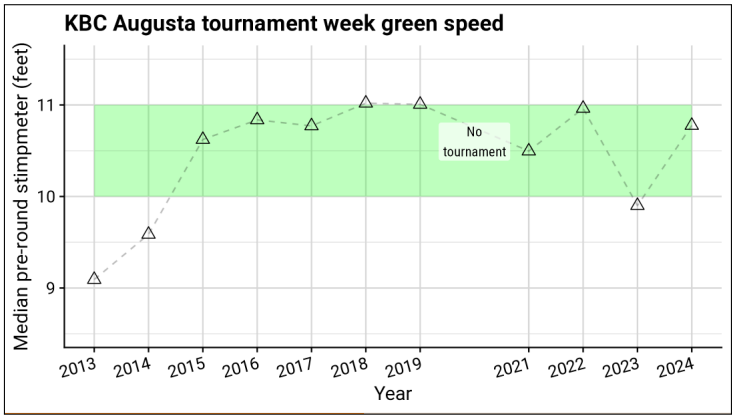
where N_o is the standard N rate in a single application, GvX_o is the desired GvX, GvX_a is the actual GvX, and N_a is the adjusted N rate for the application.

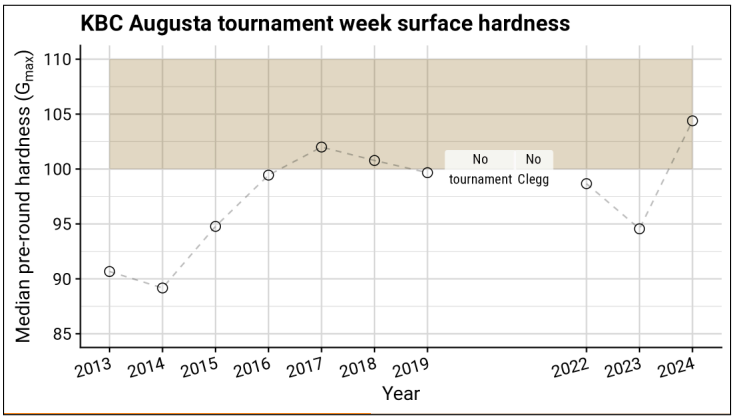
Calculate the adjusted N rate.

Playing conditions

What to measure?

- Stimpmeter
- Bobble test (smoothness, trueness)
- Surface hardness (firmness)





RESEARCH

Comparing Three Methods to Measure Putting Green Trueness

Douglas T. Linde,* Andrew D. Mitchell, and Brendan Hannan

ABSTRACT

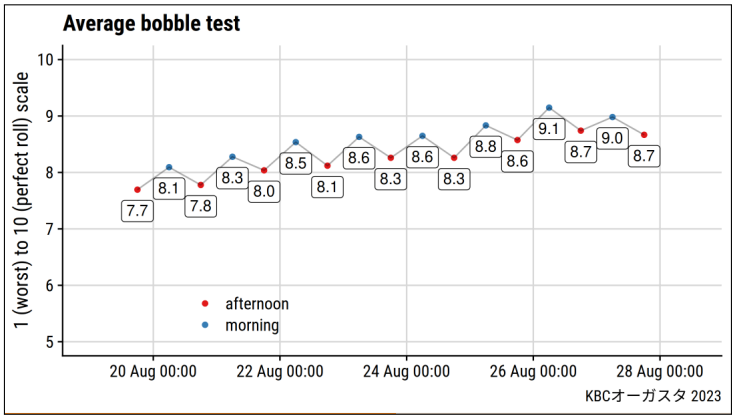
Since there was not a standard method to measure putting green trueness, a golf course and plot study were conducted to compare three methods to measure putting green trueness. In 2013, the Royal & Ancient (R&A) "Holing Out Test" (HOT), a visual bobble test, and a ball spread test were conducted on 150 greens from 50 New Zealand golf courses. In 2015, a plot study was conducted to compare the methods

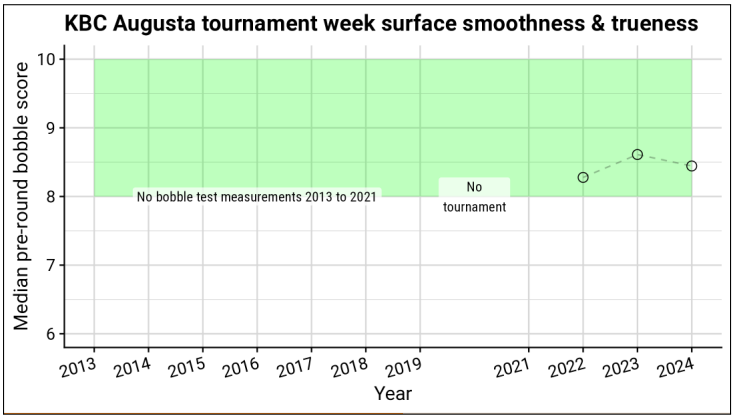
D.T. Linde, Plant Science Dep., Delaware Valley Univ., 700 E. Butler Ave., Doylestown, PA 18901; A.D. Mitchell and B. Hannan, New Zealand Sports Turf Institute, P.O. Box 347, Palmerston North, NZ 4440. Received 12 May 2016. Accepted 6 June 2017. *Corresponding author (douglas.linde@delval.edu). Assigned to Associate Editor Scott Ebdon.

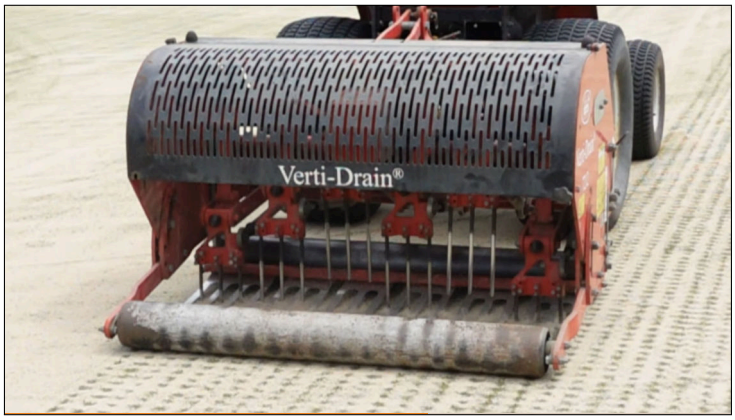
Abbreviations: HOT, Holing Out Test; NZSTI, New Zealand Sports Turf Institute; PGA, Professional Golfers Association of America; R&A, Royal & Ancient; STRI, Sports Turf Research Institute; USGA, United States Golf Association.

least putts on a core-aerated green without topdressing. Based on the survey, most golfers assessed trueness visually by how many times the ball bounces as it rolls. However, the similar ranking of the photos by most respondents indicated that golfers also assessed trueness based on the appearance of the surface.

The golf course and plot studies had similar results. Both had weak correlations and a large difference in sensitivity between the HOT and the other methods. Thus, the HOT was not measuring the same characteristics as the other methods. The bobble test was the easiest method to administer, took the least time to conduct, and measured a wide range of trueness. The HOT was the least effective method to measure trueness and was difficult to administer. On many of the greens tested, rolled balls

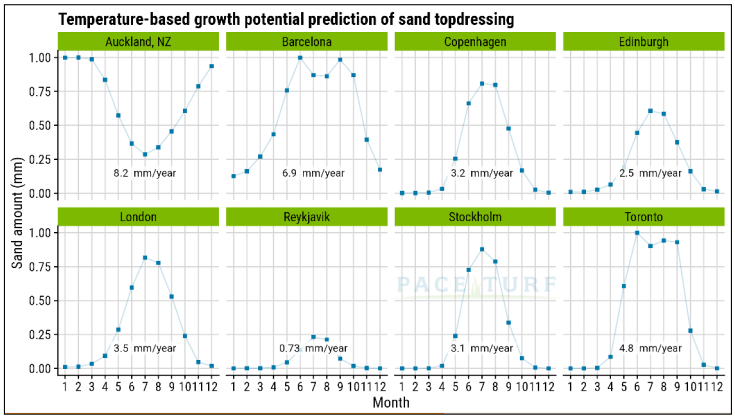






Soil Organic Matter | Soil Organic Material

Know the sand application rate



1 mm ≈ 16 tons/ha

Measure total organic material (OM246)

The definition of soil organic matter

soil organic matter: The organic fraction of the soil exclusive of undecayed plant and animal residues. See also humus.

humus: the well decomposed, more or less stable part of the organic matter in mineral soils.

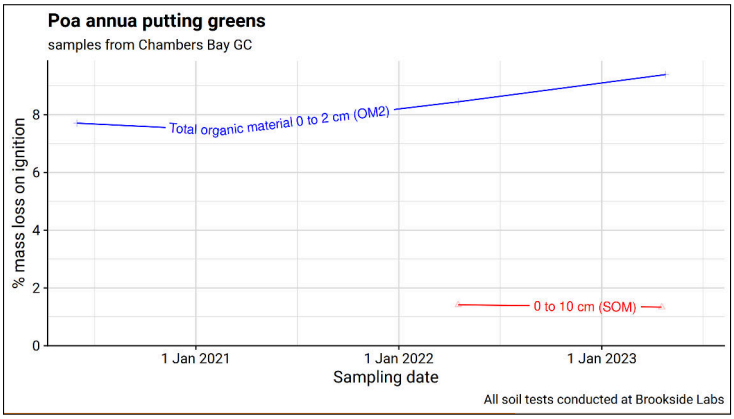
Total organic material

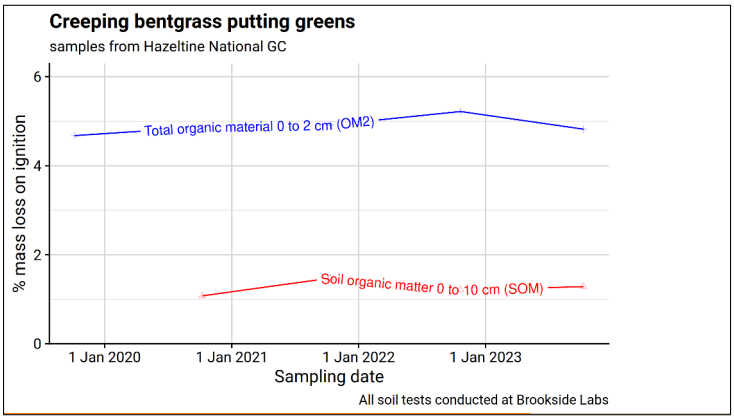
total organic material: organic material in a soil sample that has not passed through a sieve. This test is conducted on the sample as it is received at the laboratory, with no removal of living or dead plant material prior to testing.

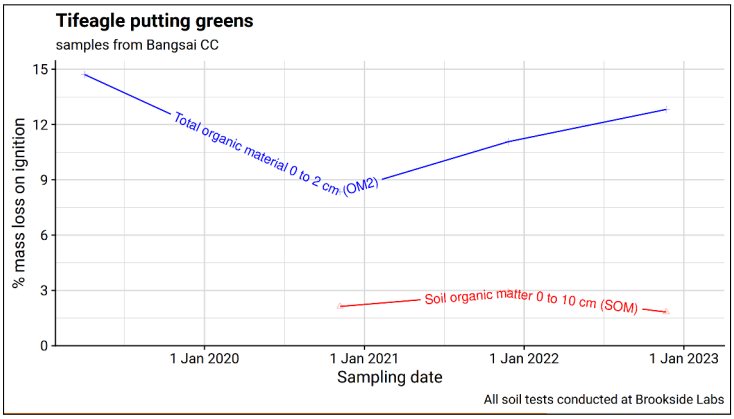

Keya GC, Fukuoka


Bangsai CC, Thailand


Bangsai CC, Thailand


Poa annua putting greens
samples from Chambers Bay GC
% mass loss on ignition
0
2
4
6
8
Total organic material 0 to 2 cm (OM2)
0 to 10 cm (SOM)
1 Jan 2021
1 Jan 2022
1 Jan 2023
Sampling date
All soil tests conducted at Brookside Labs

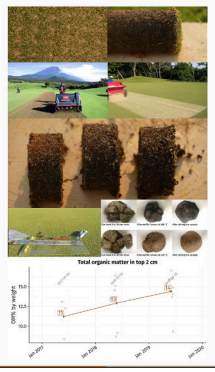

Creeping bentgrass putting greens
samples from Hazeltine National GC
% mass loss on ignition
0
2
4
6
Total organic material 0 to 2 cm (OM2)
Soil organic matter 0 to 10 cm (SOM)
1 Jan 2020
1 Jan 2021
1 Jan 2022
1 Jan 2023
Sampling date
All soil tests conducted at Brookside Labs


Tifeagle putting greens
samples from Bangsai CC
% mass loss on ignition
0
3
6
9
12
15
Total organic material 0 to 2 cm (OM2)
Soil organic matter 0 to 10 cm (SOM)
1 Jan 2020
1 Jan 2021
1 Jan 2022
1 Jan 2023
Sampling date
All soil tests conducted at Brookside Labs

At the laboratory

Organic matter bullet list

- Standard tests for soil organic matter *exclude* thatch, stems, & roots.
- Standard turfgrass tests are to a 10 cm depth, but organic matter accumulation (and ball reaction) are at the surface.
- Total organic matter in soil samples taken to a 2 cm (0.8 inches) depth measures *prior topdressing effect* & *future topdressing requirement*.
- I like to test 100% of the sample that is sent to the lab, with no screening, no removal of plant material, & burning at 440 °C.
- The average total OM I've measured in the top 2 cm on greens is *7.3%*.
- For golf courses, I recommend testing *at least 3 putting greens annually* & taking at least 5 subsamples per green to form a composite sample.
- By looking at *change in total OM over time*, one can adjust the topdressing amount to achieve the desired results.
- By looking at change in the total OM at the 2 to 4 cm & 4 to 6 cm depths, one can assess the need to add sand (or to remove material) at those depths. You might be surprised *at how stable the OM is at depth*, raising questions about *the need for coring*.



Nutrients by MLSN

General concepts

1. Keep nutrients from getting too low. They *can* get too low.
2. Grass grows well in a lot of soils.
3. Growth rate is important.
4. Think of it as ensuring nutrient supply matches the growth rate.

One can express the quantity of an element required as fertilizer as Q.

$$a + b - c = Q$$

where,

a is the quantity of the element used by the grass
b is the quantity of the element kept in the soil
c is the quantity of the element present in the soil
Q is the quantity of the element required as fertilizer

Reference

September, 2014

Minimum Levels for Sustainable Nutrition Soil Guidelines

The Minimum Level for Sustainable Nutrition (MLSN) Guideline is a new, more sustainable approach to managing soil nutrient levels that can help you to decrease fertilizer inputs and costs, while still maintaining desired turf quality and playability levels. The MLSN guidelines were developed in a joint project between PACE Turf and the Asian Turfgrass Center. All soil analyses were conducted at Brookside Laboratories, New Bremen, OH.

	MLSN Soil Guideline
pH	>5.5
Potassium (K ppm)	37
Phosphorus (P ppm)	21
Calcium (Ca ppm)	331
Magnesium (Mg ppm)	47
Sulfur as sulfate (S ppm)	7

Nitrogen requirements are best determined based on **turf growth potential**, which incorporates site-specific weather and turf type to calculate nitrogen demand (Gelernter and Stowell, 2005. Golf Course Management, p. 108-113, March, 2005).

How the guidelines were developed

From a database of over 17,000 soil samples, we selected 3,721 that were classified as having:

- not poor performing turfgrass
- pH 5.5 - 8.5: to avoid aluminum toxicity at pH less than 5.5, and to avoid alkalinity hazard at pH greater than 8.5
- total exchange capacity <6 cmol/kg

A log-logistic model provided a significant fit of the data, and was used to identify the concentration (in ppm) of each nutrient that 10% of the soil samples fell below, but were still performing well. This 10th percentile value is the MLSN soil guideline shown above.

For more information, see the Facebook MLSN page at: www.facebook.com/mlsnturf

PACE TURF

ASIAN TURFGRASS CENTER

version 14091801

MLSN Cheat Sheet

Definition

MLSN is an initialism for *minimum levels for sustainable nutrition*. This is a method for soil test interpretation and fertilizer recommendations.

MLSN really quick start

If you have Mehlich 3 soil test data, you can directly compare your test results (in ppm) to the MLSN guideline levels. If your soil is above the guideline, then you don't need to add that element – today. You can be confident that high quality turfgrass can be produced in soils with that quantity of the element. If your soil is below the guideline, you can have high quality turfgrass too. But you should be aware that there are few soils producing high quality turfgrass with nutrient levels that low. You'll probably want to add enough of the element to raise it above the MLSN guideline.

That's only the situation for today. Is your grass alive? We hope so! If it is, then it is using nutrients. The nutrient content in the soil is going to be lower tomorrow than it was today – unless your grass is dead or dormant – because the grass uses nutrients. To really use the MLSN guidelines, you need to look not at today, but into the future. This cheat sheet is meant to provide all the explanations and calculations you'll require.

MLSN quick start

These are the steps to take to get started using MLSN – in the standard way – immediately. If you don't know how to get these quantities, don't worry. The other sections of this cheat sheet show how to find these quantities, and how to make more modifications to fit your site.

1. **Soil test** Take soil samples to a depth of 10 cm. Then use the Mehlich 3 extractant to find soil test K, P, Ca, Mg, and S. Look at the results in parts per million (ppm). Express the results as mass per area. Call this quantity c.
2. **Estimate grass use** Find grass use of those elements over a time duration (t). Express those use estimates as mass per area. Call this quantity a.
3. **Check the MLSN guideline** Express the value for each element as mass per area. Call this quantity b. The MLSN minimum levels for each element are given in this table.

Element	ppm

Estimating grass use

The value a is the expected grass use for time t. There are three ways to get that value.

Estimate from growth One can collect the clippings, express them as a mass, and calculate the quantity of nutrients in that mass of clippings. Clipping volume is a rapid way to estimate the mass. For every 1 L of clippings m^{-2}, expect a dry mass of 63 g. Then, calculate nutrient content by considering the elements in healthy turf. I typically use these numbers.

Element	% in dry leaves			
	Agrostis & Poa	*Cynodon*	*Paspalum*	*Festuca*
N	4	3	3	3
K	2	2	3	1.5
P	0.5	0.5	0.5	0.3
Ca	0.5	0.5	0.5	0.5
Mg	0.2	0.2	0.2	0.2
S	0.2	0.2	0.2	0.2

If you know that your turf contains different concentrations of nutrients than shown in this table, please make the adjustments to fit your site.

Estimate based on N supply The grass cannot grow more than the N supply. Dividing the N supply by the percentage N in the leaves gives the maximum clipping yield. One can then work out the maximum use of all the elements. For example, *Cynodon* supplied with 15 g N m^{-2} has a maximum clipping yield of $\frac{15}{0.03} = 500$ g. To account for N mineralization, I make an estimate based on soil organic matter being 5% N and 2.5% of that N mineralized in one year (Havlin et al., 1999, p. 109).

Predict based on GP If one doesn't know clippings or N supply, the temperature-based growth potential (GP) provides a straightforward way to get an estimate of N use, and consequently, of maximum possible growth. One sets a maximum N rate for any duration (d) of the year, calculates GP for time intervals of length d, and multiplying maximum N by GP gives the expected N use (Woods, 2013).

The MLSN guidelines

The MLSN guidelines are given in units of ppm. This is mg of element per kg of soil. In the calculation of a fertilizer requirement, I express the MLSN guideline amount as b. This amount is added to the amount the grass uses. This ensures that 100% of grass use, plus the MLSN minimum amount in the soil, are present in any fertilizer

The soil test amount

The soil test amount c is the amount from a Mehlich 3 soil test. Note that conversion of soil test results from concentration units (ppm) to mass of nutrients per area, depends on the rootzone depth and on the soil's bulk density. You can either customize this for your location, or use the standard conversions.

Soil tests other than Mehlich 3

We recommend Mehlich 3 soil testing (Mehlich, 1984) when using MLSN. If you use a different soil testing method, but want to use the MLSN guidelines, you will have to convert the test results to their expected values in Mehlich 3 – or convert the MLSN guidelines to expected values in the other extractant. This conversion process introduces an unknown amount of error into the calculation.

P We've calculated an MLSN for the Bray-2 (30 ppm) and Olsen (6 ppm) extractants. We don't have information on other extraction methods for P.

K, Ca, Mg When using 1 N ammonium acetate, or the Morgan extractant, the approximate MLSN guidelines convert to 30 ppm for K, 265 ppm for Ca, and 38 ppm for Mg. Alternatively, multiply the ammonium acetate or Morgan test results by 1.2 and then use the unmodified MLSN guideline.

S No known conversion.

How and why MLSN works

It works by ensuring the grass is supplied with all the nutrients it can use while keeping a safe amount of each nutrient untouched in the soil as a reserve. The MLSN calculation identifies the amount of nutrients the grass uses at a particular site. It then ensures the grass is either supplied with 100% of those nutrients from fertilizer, from soil, or from a combination of soil and fertilizer (Woods et al., 2014).

This approach recognizes that grass uses nutrients. Rather than trying to maintain all the nutrients the grass could ever use, and then some, in a hypothetical optimum soil that doesn't exist, the MLSN approach makes a careful estimate of plant use and makes sure the grass is supplied with that much while still keeping a safe amount in reserve, untouched, in the soil. This approach puts the turfgrass manager in control.

> "The fundamental principle of successful greenkeeping is the recognition of the fact that the finest golfing grasses flourish on poor soil and that more harm is done by over, rather than under-fertilizing" (MacKenzie, 1998).

Why MLSN is needed

Conventional soil test interpretation is based on guidelines that are

MLSN is a value for b

$$\overbrace{a+b}^{\text{amount needed}} - \overbrace{c}^{\text{amount present}} = \overbrace{Q}^{\text{fertilizer requirement}}$$

a is a site-specific use estimate, b is the MLSN guideline, and c is the soil test result.

General concepts

1. Keep nutrients from getting too low. They *can* get too low.
2. Grass grows well in a lot of soils.
3. Growth rate is important.
4. Think of it as ensuring nutrient supply matches the growth rate.

Finding the *plant use* amount

Option 1: Easy and conservative (safe) method

The easiest way recognizes that the grass growth is limited by N. For any N rate (N), the maximum clipping yield (G) can be calculated from this equation, where N_{leaf} is the leaf N content:[1]

$$G = \frac{N}{N_{leaf}}$$

[1] Express the leaf N not as a percentage, but as g/g. For example, 4% N would be expressed as 40 g N/1000 g clippings, or 0.04.

Option 2: more precise, less conservative

Measure clipping volume, get mass of clipping volume ($clipvol$) from conversion equations. Bentgrass and bermudagrass clippings can be estimated as:

$$G = 0.06(clipvol)$$

N:P:K at 8:1:4

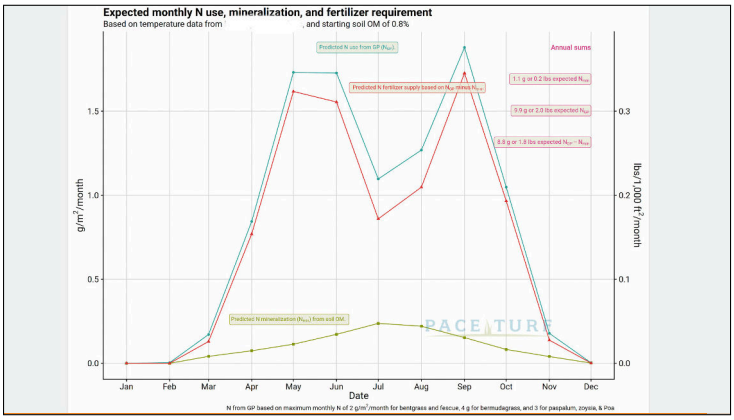
I've often used an N:P:K estimate of 8:1:4 to calculate expected nutrient use.

Normal nutrient content of creeping bentgrass leaves

element	25th percentile	Median (%)	75th percentile
N	4.3	4.8	5.3
P	0.5	0.6	0.6
K	1.8	1.9	2.0
Ca	0.5	0.6	0.7
Mg	0.2	0.2	0.3
S	0.5	0.5	0.6

Option 3: prediction based on grass type and weather

One can also predict the estimated N use using the PACE Turf growth potential (GP).



A quick case study

Test results from this green (0–10 cm depth)

pH	5.7
OM	1%
M3 P	12 ppm
Bray 2 P	2 ppm
Ca	296 ppm
Mg	31 ppm
K	16 ppm

Online handout with slides & more info

www.asianturfgrass.com
www.paceturf.org