Figure 1. Emptying the mower basket into a bucket with volume markings. This bucket is graduated in liters.

Measuring clipping volume is easier and more useful than I expected

BY MICAH WOODS

It would be a stretch to call something a revolution if everyone was already doing it. And turfgrass managers the world over have always paid attention to how much the grass is growing and how many clippings are in the baskets. So I don't call the measurement of clipping volume a revolution, but I have found the information incredibly useful. That's how I usually describe clipping volume: a surprisingly easy thing to do that provides incredibly useful information.

I never thought I'd write a book about grass clippings. But last December, I did just that, publishing *One Bucket at a Time* (www.asianturfgrass.com/buckets) to put together a lot of things I've written about this topic. If you are interested in this, please see the book for a lot more details and links to additional information. The #ClipVol hashtag has a lot of information about this too.

When I first learned about clipping volume, I was working as a superintendent in Japan almost 20 years ago, and I didn't think much of it. It was just a number to collect, but not something that I used for anything, other than perhaps to notice that there was a lot of grass growing, then to pat myself on the back because we were producing some healthy turf.

My recent interest in clipping volume started in 2013. That spring, Andrew

McDaniel started working as the greenkeeper at Keya Golf Club in Fukuoka, in the western part of Japan. As is customary at many courses in Japan, the volume of clippings in the baskets was recorded each time the greens were mown (Figure 1).

While the measurement of clippings is common in Japan, there are a few uncommon things about the course maintenace at Keya. One is that they have a foreign greenkeeper. Another is that the greens are korai (manilagrass, or *Zoysia matrella*). Keya also hosts a tournament on the Japan men's professional tour every year, the KBC Augusta tournament during the last week of August. Because Andrew is at Keya, it was easy for me to learn about the maintenance there. And the korai and the tournament are a challenging combination; dormant korai makes a fast putting surface during the six months from November to April when it isn't growing. But the last week of August? That's when korai is growing the fastest, and this is a grass that is notorious for moderate speeds; a couple years ago I summarized 72 stimpmeter measurements I've made from korai greens around Asia under non-tournament conditions during the growing season—the median speed was 7 feet 8 inches. Now Andrew was going to host a professional tournament on greens of this grass.

This is a story I've told a lot when I've taught seminars about clipping volume. How Andrew and I knew going into the summer of 2013 that golf balls don't roll as far across a korai surface as they do across bentgrass or bermudagras or *Poa annua* greens; how Andrew was going to try to produce the best possible greens for the tournament by cutting the grass as short as possible, rolling, using growth regulators, and reducing nitrogen (N) fertilization. We didn't know what the speed would be, but we had a laugh and hoped for the best. The greens during the tournament in 2013 were beautiful (Figure 2), the korai grass was thriving in the late August heat, the ball rolled true, and the speed during the tournament gradually increased from 9 feet to 9 feet 6 inches. That's not incredibly fast, but it is fast for korai greens in Japan in August, so everyone was happy.

After the tournament, however, Andrew and I noticed something as we reviewed the data from the week. The clipping volume was going down during the tournament week, dropping a little bit every day, and the green speed was going up a little bit every day. It was apparent that when less clippings were being mown off the korai greens, there was a faster green speed. So when Andrew started planning for the 2014 tournament, he now had a target clipping volume—he would try to start the 2014 tournament week at the clipping volume he'd had at the *end* of the 2013 tournament week. He did that, and in 2014 the green speeds were from 9 feet six inches to 10 feet.

That's the story of how I got interested in clipping volume. After that, I started looking carefully at clipping volume. I realized there was a practical use for it, at least for the case of the korai greens at Keya. And there would probably be a similar use for clipping volume at other places. Then as I started looking at clipping volume data more often, and asked other greenkeepers in Japan, and eventually around the world, to share clipping volume data with me, I found a number of other uses for the data. Here's how clipping volume works and what it is all about.

Figure 2. Greenkeeper Andrew McDaniel using the Greenstester on a korai putting green at Keya GC during the 2013 KBC Augusta tournament week.

Units of measure

When putting greens are mown, the clippings are usually collected in a basket. That basket needs to be emptied. The mower operators pay attention to how often the baskets need emptied, and the operator or a supervisor may check how many times the baskets have been dumped, or may have a look at a handful of clippings to check the cut quality and the color and the succulence of the leaves. That's standard practice, and I expect everyone in the world is paying attention to clippings like that, but the idea of putting a number to the volume of clippings has been less common.

Remember though, the baskets need to get emptied anyway. It takes about 30 seconds per empty, or with a triplex, about 90 seconds, to empty the clippings into a measuring bucket and then record the volume. What I call the "standard" procedure for measuring volume is to empty the clippings into a bucket or tub with graduated volume markings on it. After the clippings are in this measuring container, hit the side of the container a few times, or hit the container onto the ground a few times; the purpose of this is to make the clippings bounce a little and then to let gravity settle them; one also does this to try to smooth the clippings across the top of the container. If the clippings aren't smooth enough, use your hand to make them smooth, but don't press down to compress the clippings. Then record the volume of the clippings.

On a computer somewhere, the surface area of the mown green or greens is embedded in a file. The operator may put the volume data into a file from a phone immediately, while still out on the course, or the data may be added to a file later. And then the numbers of volume as measured out on the course get converted into a standard of volume per area.

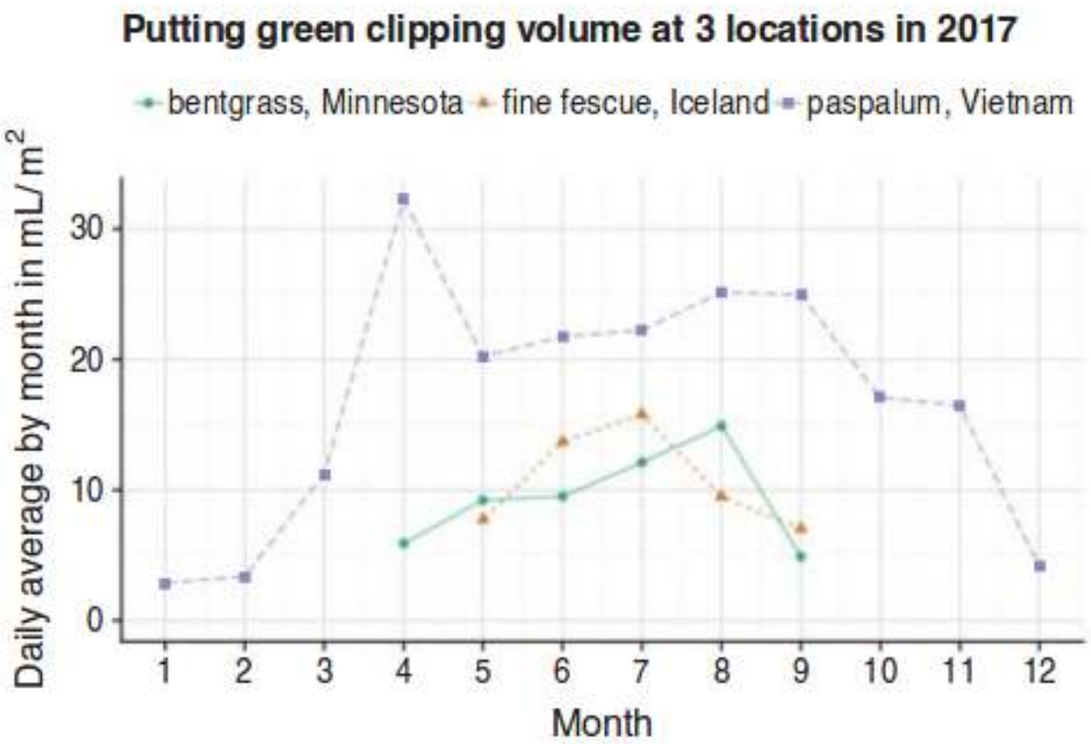

Figure 3. The average daily clipping volume, shown on a monthly basis during calendar year 2017, for fine fescue in Iceland, seashore paspalum in Vietnam, and creeping bentgrass in Minnesota.

Now, instead of "one empty every three greens," or "we didn't get many clippings today," one has a specific number. And what are the units of that specific number? I like to use milliliters per square meter (mL/m^2), and I recommend that everyone else does as well. What's the advantage of this? Well, those units almost always produce a volume more than 0 and less than 100 (Figure 3). That's an ideal range of numbers to work with, and one does not need to use decimal points, nor does one need to make adjustments for 100 m^2 or 1,000 ft^2.

When I started doing this I was using units of liters per 100 m^2. That's a number 1/10th the size of the mL/m^2 unit I use now, so instead of a typical clipping volume of 13 mL/m^2, it is reported as 1.3 $L/100\ m^2$. One ends up with decimal points every time the number is thought about or communicated. Then during tournament conditions, one might get 7 mL/m^2 from a double cut. Notice there are no decimal points. But in the old units I used to use, that comes to 0.7 $L/100\ m^2$. Again, decimal points. To avoid the decimal points, I suggest using mL/m^2. As an aside, 1 quart per 1000 ft^2 is about the same as 1 L per 100 m^2. But again, there are decimal points.

Now if you haven't done this yet, and these numbers sound ridiculous, I have to point out that when people are doing this, they actually aren't looking at the mL/m^2 so much. That unit is used for reporting and for communication and comparison. But on a day to day basis, people look at the volume. Let's say it is liters. I know that a clipping volume of less than 5 liters from the 9th green at Keya GC means the green is growing at just the right rate for a golf tournament. The people mowing the 9th green every day know that too. So does the greenkeeper. That's the number that we look at. How many liters (which means "how much volume") did we get off this green today? Eventually, after that number goes into a spreadsheet or database, the area of the green will be accounted for, and the clipping volume comes out at 8 mL/m^2. Or less. 5 L from the 9th green at Keya is 8 mL/m^2.

For a single property, looking just at volume works fine, and that is what one tends to look at. The volume for a green is measured every day, from that one can tell if the volume is normal or abnormal, and if it is abnormal something should be checked. It is only in the data analysis and communication of this that the mL/m^2 units get used.

Machine consistency, and green to green consistency

It is customary to note which machine is mowing certain areas of the course. Sometimes there are differences between machines. The clipping

volume measurement often catches these differences that one wouldn't otherwise notice.

When clipping volume measurements start at a facility, one of the first things that gets noticed is any differences between machines. At Keya Golf Club, the extra mowers that came on loan for use during the tournament were the identical model to the mowers used by the club. But when one of the loaned machines would cut a green, it was removing twice the clipping volume as the club's own machine, despite being set up by the same mechanic a discrepancy was found, because of the clipping volume data, the mechanic found that the loaned machines had larger diameter reels, because they hadn't been ground as much as the club's reels.

There are also differences in growth from green to green. Knowing what those differences are might lead to differential management that could lead to improved turfgrass conditions. Or at least to a better understanding of why turf in one area is growing so well, and why another area struggles.

Playability

As I mentioned, my initial interest in clipping volume was related to playability. The greens at Keya were faster when there was a lower clipping volume (Figure 4). To try to achieve predictable green speeds for specific events, it makes sense to know what the target clipping volume is, and then to take steps to achieve that.

Dr. Bill Kreuser has measured a lot of green speed and clipping mass, and he has a large data set that shows there is not a consistent relationship between clipping yield and green speed. There are a lot of other things that affect green speed besides how many clippings are in the basket. Effective mowing height is probably the most important of those.

But I appeal to common sense here, to demonstrate that clipping volume, on a broad scale, has a big impact on speed. This is especially clear for warm-season grasses. But it would be similar for cool-season grasses in spring and autumn. Let's take an ultradwarf bermudagrass green in the middle of winter when it is dormant, double cut it every day at 0.100 inches (2.6 mm) and roll it, and then measure the speed. The clipping volume will be 0, because it's the middle of winter and the grass is dormant. Now do this in mid-summer, the clipping volume will be greater than 0, because the grass is growing, and I'm confident that the speed in summer will be slower than the speed in winter. Wouldn't it be the same for creeping bentgrass? Double cut at 0.100 inchess for a week in late November, assuming there is no snow. Roll every day too. The clipping volume

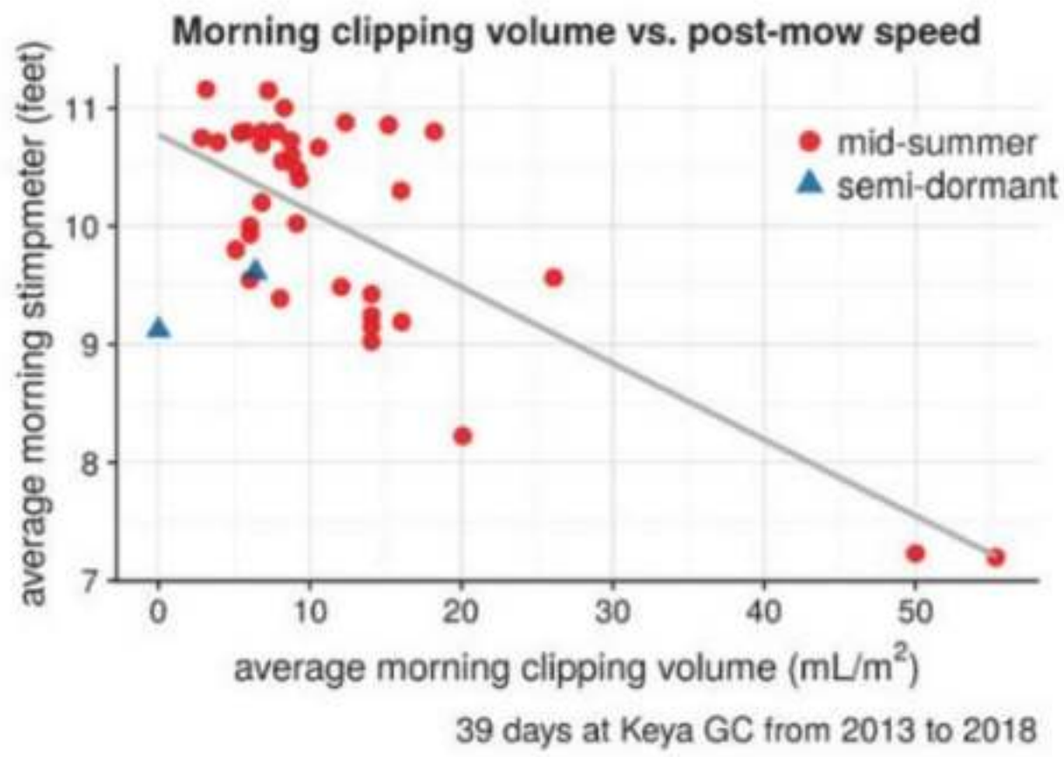

Figure 4. Data from measurements made over 6 years show that clipping volume is related to green speed at Keya GC. When more clippings are produced by the grass, the greens are slower.

will be low, approaching 0, because it is so cold the grass won't grow. This treatment in June would result in more clipping volume and a slower green speed, because the grass is growing.

Turfgrass performance

As I continued to think about and study clipping volume, I realized that this measurement can be used for a lot more than just green speed. Knowing how much the grass is growing gets to the very core of turfgrass management. In the first chapter of *A Short Grammar of Greenkeeping* (www.asianturfgrass.com/books), I wrote:

> *"No matter what grass is used, there is a simple concept that I find very important in the planning of golf course maintenance. It is a simple definition of the core principle in golf course maintenance or greenkeeping. The definition is this: greenkeeping is managing the growth rate of the grass to create the desired playing surface for golf. All of the work done to the turf is centered around managing how fast the grass will grow ... And the best golf course conditions will be created when the superintendent is able to create just the right growth rate."*

If the turf is too thin, or can't withstand the traffic it receives, one will take steps to increase the growth rate. If the turf is growing too fast, then a lot of otherwise unnecessary work is required to produce the desired surfaces. In addition to extra mowing and whatever else is done to create the surface, one will generally try to reduce the growth rate as well. Knowing the clipping volume now, and how that compares to the desired clipping volume, can be really useful. Every turf manager knows the importance

of the growth rate. Having a number to describe the growth rate makes it easier to achieve the desired conditions (Figure 5).

Nutrient use and optimum nutrient supply

This is a topic I'm always interested in, and I've been fascinated by this ever since the late 1990s when I was a superintendent in Shanghai. I was growing cool-season grasses in a transition zone climate—to be more specific, I've just looked it up and the classification is 'humid sub-tropical'—and I wanted to be sure the grasses were supplied with all the nutrients they required, and to do so in a way that would optimize their tolerance against the various difficulties that ensue when growing bentgrass and bluegrass and ryegrass in fescue in a humid sub-tropical climate.

What does clipping volume have to do with nutrient use and optimum supply? Well, healthy grass has a known concentration of nutrients in it. If we know how much the grass is growing, we can instantly combine the growth number and the nutrient content of healthy grass and we have a maximum nutrient use. The optimum nutrient supply can then be that number—the maximum nutrient use—-or something less than that. If we assume the soil supplies nothing, which you might want to do if it is mid-summer, the roots are shrinking, and one is scared that the grass can't get what is in the soil, then clipping volume can be used to get a number to resupply 100% of each nutrient the grass used. Or if one does a soil test and finds that the soil has enough to meet the plant requirements—I recommend using the minimum levels for sustainable nutrition (MLSN) as a particularly effective way to do this—then one can grow grass with confidence knowing that for the clipping volume happening right now, there remain enough nutrients in the soil to meet 100% of the grass requirements.

Resource use, and back to playability again

The best golfing surfaces are those that grow the slowest. There needs to be enough growth to recover from traffic damage, but that's all. Any growth beyond that is creating a need for mowing that otherwise wouldn't be required. Any growth beyond the amount required to recover from traffic damage is also producing organic matter that may need to be physically removed or diluted with sand topdressing.

I've noticed a couple things about the measurement of clipping volume that are related to this. One is that when a golf course superintendent measures the clipping volume, and at the same time tries to keep making the surfaces better and better, what often happens is a reduction in growth. It seems to me that as the manager gets more familiar with the property, and finds out how much the grass needs to grow in order to produce the desired surfaces, some of the extra and unnecessary growth gets cut out.

Another thing I've noticed, is that if one works through the calculations of nutrient use from harvested clippings, the amounts are small. Let's say, for nitrogen at least, that my estimates of nutrient use from clipping harvest generally come in a little below the lower end of textbook ranges.

The implications of both of these things are that when clipping volume is measured, one might be able to reduce nutrient supply with confidence that the grass is still being supplied with all it can use. And more importantly, one may be able to produce better turf conditions while at the same time growing less grass. Better conditions are great. Growing less grass can be too. That might lead to lower topdressing requirements, less disruptive core aeration and less scarifying, less mowing, longer equipment life, lower greenhouse gas emissions, lower energy use, and less disruption to golfers.

I've written about all of these clipping volume things on my website, and a lot of this is in the book too. Some of this is fact, some is speculation, and many of these things are still being actively studied, tested, and updated. One thing is sure, though. I've been surprised at how useful these data have been to me. I've been surprised at how useful the data have been to turfgrass managers who measure the clipping volume. And if this way of managing turf makes sense to you, then I'm sure you'll find the same thing.

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Figure 5. Knowing the clipping volume, and how that relates to the desired clipping volume, can be useful in improving turfgrass conditions, and in improving the efficiency of the work, all over the world.