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ORGANIC MATTER MANAGEMENT

Extract and replace versus injection on sand-based greens

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If you are in a situation where you need to reduce your organic matter percentage on putting greens or other sports turf rootzones, what is a good programme to implement?

Conventional wisdom tells you to core aerate, remove the plugs, topdress heavily with sand and brush it in to fill the holes. Intuitively, extraction and replacement are more effective than sand injection alone, using either high pressure water injection or solid tine and backfilling with sand. But how significant is the difference?

There are people out there who imply you cannot effectively manage organic matter without extracting a portion of the rootzone. The purpose of this article is to examine the math behind both extraction and replacement or sand injection alone.

Understanding the effect each method has from a direct mathematical standpoint will help you create a suitable plan of action that has the least cost and disruption to play.

Suppose you have greens that are 4.57% organic matter (OM) within the top 76.2mm of your greens. Your goal may be to reduce it to 3.25% as quickly as possible and maintain it somewhere at or below that threshold in the future.

You set the time period that you would like to achieve this at 1.5 growing seasons. During that time period you estimate you may gain another 0.43% OM so you set the start point for reduction at 5%.

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How many times do you need to core aerate with what size tines?

Of course, the larger the tines’ diameter and the tighter the spacing, the fewer the number of applications will be needed.

In the case of injection, the same logic applies where the tighter the spacing, the fewer applications you will need to perform the task. This logic is related to the “area of disruption” often spoken about and where the USGA and others have recommended that the total of any given growing season falls under the guidelines of 10 to 20% surface disruption for organic matter control.

For this exercise we will assume that all core holes can be successfully filled with topdressing. Excess sand topdressing left in the turf canopy is assumed zero and subsequently not factored in. Although this does not occur in practice we adopted this simplification to directly compare core extraction and filling with sand to injection.

An additional component of these calculations is determining the bulk density (BD) of the soil mix. The equation used for this calculation comes from the Estimated Bulk Density Calculation from USDA-NRCS, which employs data of the component sand (1.56 g cm-3) and organic matter (0.22 g cm-3) bulk density values. This equation, BD = 100/(% OM/OM BD)+((100-%OM)/SAND BD)) computes to an existing BD of 1.196g cm-3 after the

Figure 1:

assumed growth is factored in.

Following core extraction and refilling with sand, the average organic matter content across the green is calculated by using a soil mixing equation adapted from Taylor and Blake (1984). In this equation for core extraction and refilling, the mass of organic matter remaining after extraction is divided by the mass of added sand plus the mass of the remaining rootzone. Thus, extraction of organic matter and presuming that the added sand contains essentially zero organic matter serves to reduce the average organic matter within the green itself.

For sand injection, the mixing equation is a bit different because no organic matter is removed by coring. Here the mass of the existing organic matter prior to application is divided by the mass of the added sand plus the mass of the existing rootzone. Presuming the added sand also contains essentially zero organic matter, injection by itself serves to reduce the average organic matter within the green, in this case by dilution. To re-set the total soil weight back to the 0-76.2mm zone we then use the new bulk density multiplied by the total volume of the 0-76.2mm zone.

The present situation tracks the organic matter changes within the surface 76.2mm of a green and 50.8mm by 50.8mm spacing on both the coring tines or the sand injector. The calculations are also for 12.7mm diameter tines or equivalently 12.7mm diameter injection holes. The calculation procedure is, however, adaptable for different depths, spacing and hole diameters.

The results for these calculations following eight consecutive applications of either core extraction and refilling with sand or sand injection demonstrate an essentially equivalent degree of organic matter reduction within the green where core reduced the OM to 3.04% and injection to 3.11% (Figure. 1).

Using conditional probability when coring and refilling allows for a "shortcut" to arrive at the net change in soil weight and percent OM when a total number of applications are entered. Conditional probability factors in the amount of new

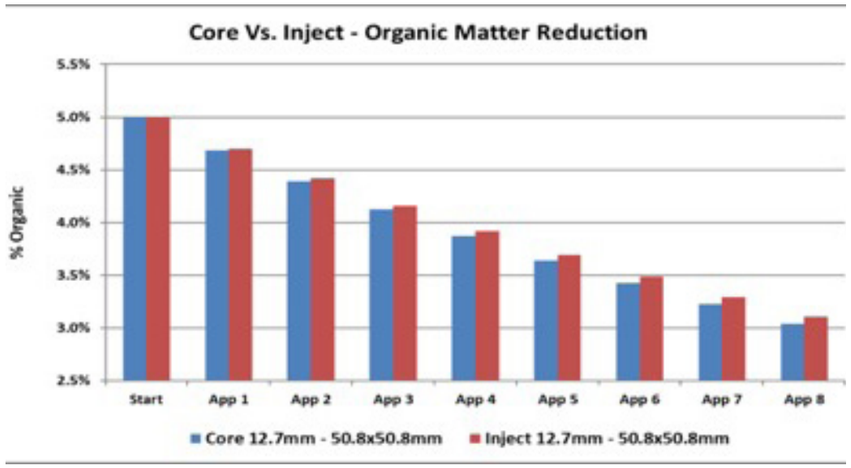


Table 1:

Conditional probability	3.10%
% of green hit	33.15%

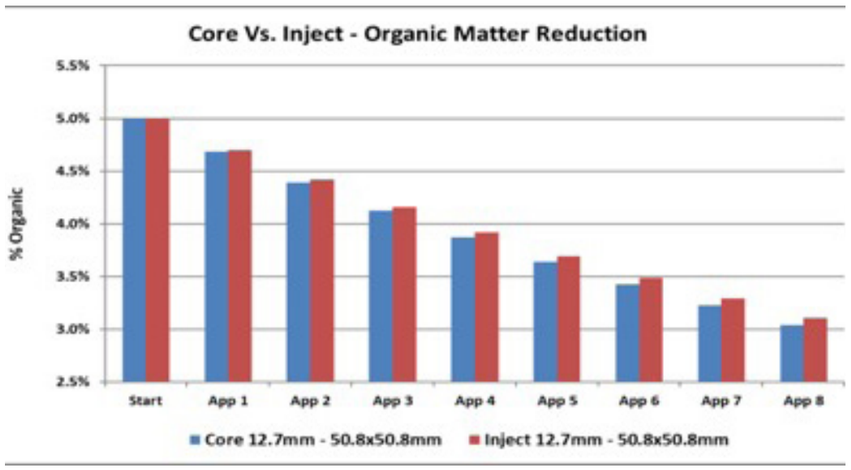
Application #	**8**					
Kilograms	**Sand**	**OM**	**Total**	**BD**	**Sand**	**OM**
Spacing	8,042	423.3	**8,465**	1.1958	95%	5.00%
Weight change	995	(140.30)				
New weights	9,037	283	9,320	1.3165	96.96%	3.04%
	96.96%	**3.04%**				

amendment extracted from the previously filled core holes. In other words, the percent of hitting virgin green space diminishes each time. The equation is 1-((1-area of disruption)X(1- area of disruption) to the power of (# of applications -1) or 1-((1-4.91) X(1-4.91)^(8-1)=33.15%.

The product of 33.15% is then multiplied by the original OM weight of the soil profile to arrive at the weight extracted. It will be replaced with sand that is 7.091 times heavier then OM (SAND BD 1.56/OM BD.22). This new sand weight is added to the original sand weight and the new OM weight to arrive at total soil weight. The new OM weight is then divided by total soil weight to arrive at the new percent OM (Table 1)

Sand injection will result in elevating the green over time. Coring and then filling the holes will add to elevation,

Figure 2:



but not nearly as much. It does this because it would be impossible to get 100% of the sand brushed into the aeration holes. Somewhere in the neighbourhood of 20 to 30% more sand topdressing needs to be applied in addition to what the math

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Table 2: Maintain Organic %

New OM%	3.10%
1 Yr growth	0.30%
Total Target	**3.40%**

Core & replace				
Millimetres	**Width**	**Length**		
Spacing	76.2	50.8	**Tine Size**	12.7
Target Depth	63.5			

Injection				
Millimetres	**Width**	**Length**		
Spacing	38.1	50.8	**Hole size**	8.3
Target Depth	63.5			

Area of disruption	
Core	0.00%
Injection	96.96%
	96.6%

Organic % reduction	
Core	-0.13%
Injection	-0.12%
Topdressing	-0.15%
	-0.40%
New OM%	**3.00%**

Sand Cubic M/93m²	
Core	0.19*
Injection	0.17
Topdress	0.13
	0.70

Topdress		
^Apps	**Cubic Ms/93m²**	**Total**
16	0.0212	0.34

^3 App equivalent when filling core holes when left in canopy. 13 stand alone apps

Total tonnes sand based on:		
9,292	**sq.meters**	**96.00**

* Amount needed to fill holes only

works out for the aeration holes alone. In general, the greater the area of disruption, the higher the percentage will make it to the holes. Careful consideration has to be given to not over saturate the surface area between the core holes when attempting to fill them as this may contribute to sand layering.

Of course, using coring and injection together is a viable option. A scenario that may be sensible when on a short timeline to reduce organic matter percentage dramatically is to start off with a very aggressive core aeration and backfilling. This way you get the benefits of extraction without the harvesting of newly amended sections of the green. Coring after multiple injections is just like coring after coring and backfilling. Its effectiveness diminishes because of the extraction of new material already in place.

Using 12.7mm tines at 38.1 x 38.1 mm spacing is a lot of work but gets you down to 4.45% organic quickly, which is close enough to pick away at it with less disruptive-to-play injection methods. It will take quite a bit of sand to backfill these holes but if you can endure the pain it is a great jump start.

The total tonnes needed to fill just the holes for 9,290m2 will be 96. You will need to order approximately 20 to 30% more to account for sand left in the turf canopy and waste in general. Following up with multiple injections at 76.2 x 76.2mm spacing with an average hole size of 8mm will slowly get you to your target zone. After eight injections the OM has dropped to 3.1%. Each injection will use 41.5 tonnes of sand based on 9,290m2 (Figure. 2).

Once you have the organic matter percentage down to where you want it, the next goal is to maintain that percentage uniformly in the upcoming years. You have

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already done the hard part and it should not be too difficult to manage going forward. Organic matter build-up over a given amount of time could span a broad range. It is dependent on the type of turf you are maintaining, fertility inputs, climate and other factors. Regular testing will help to determine if you are on target with your maintenance regime.

There has been quite a lot of discussion on the amount of sand required to be applied during any growing season to prevent organic matter build up. Again, there are many variables that could influence this. Research and surveys have put the range as low as 0.51m3 or as high as 1.4m3 per 93m2. For the most part it does not matter how you get it there but common sense would have you using the several known methods in combination while making sure it stays in the target zone.

At this point the target zone could be 0 to 63.5mm in depth. In reality, once organic matter is under control the best thing you can do is make sure you have a reasonable topdressing programme that

uses light infrequent applications to thoroughly cover 100% of the surface area. This method covers the surface area organic build up.

To make sure organic build up stays diluted underneath the canopy and in the most active root zone area, some form of aeration and incorporation method should be used. It could be a combination of several methods such as coring and replacing, injection, deep verticutting and replacing or solid tine and backfilling. Each has its own attributes. The positive thing is that since you are starting at a good point, the total area of disruption does not have to be as dramatic as when your goal was to drop organic percentage.

Consider leaning toward methods that have tighter spacing but with smaller holes or verticut lines to ensure a more homogeneous coverage. Keep in mind that core holes smaller than 9.5mm are very difficult to backfill with sand.

Table 2 demonstrates a maintenance regime after the organic matter percentage has been dropped to a healthy level. It assumes there is an average of a 0.3% increase in organic matter percent per year for the entire 63mm zone. It is acknowledged that the OM growth is greatest near the surface and progressively less with depth. This assumption can and will fluctuate in different climatic regions and will change with differing maintenance inputs and turf varieties.

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Download the resource

You can download a table showing the aeration surface area, volume and organic matter impact caused by various practices from the Resources area of the BIGGA website. www.bigga.org.uk/resource/table-for-downloading-om-article-table-3-metric-pdf.html

Assuming you are able to replace all extracted material properly, coring and replacement will slightly exceed straight injection from a mathematical standpoint in reducing organic matter percentage by weight. Relying on straight coring alone would be very labour intensive and will definitely disrupt play during your short corrective time period. Because of the injection method's low impact on playability, you may want to seriously consider incorporating this method into your programme. Could you even try to use injection all by itself? The math should help you decide.

This article first appeared in Golf Course Industry using imperial measurement, most recently converted to metric.

Continue the conversation:
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