Core Cultivation

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Barring a freakish late season snow storm, many of the state's golf courses will be open for play by the time you have a chance to read this issue of *THE GRASS ROOTS*. Having survived the hectic moments of getting the course ready for opening day, many of you will now begin to think about programming into your work schedule a late spring or early summer core cultivation of greens and, perhaps tees and fairways. After all, the long standing recommendation is to schedule turf cultivation for times when the turf is not under heat or moisture stress. As your thoughts turn to core cultivation, have you ever asked yourself the questions "Exactly why do I do this and what am I accomplishing? Do the end results justify the labor and cost involved and the irate comments of golfers? ". If these questions have not arisen in your mind, perhaps they should.

Core cultivation has long been viewed as an effective means for controlling soil compaction, which leads to the question "What is a compacted soil?". By definition, a compacted soil is one whose bulk density is greater than normal. In other words, the soil, when completely dried in it's undisturbed ("bulk") state, has a certain weight per unit volume. The units used by researchers to express soil bulk density are grams per centimeter cubed (g/cm3).

Pore space is a vital part of the soil's bulk volume and may actually comprise one-half or more of this volume. Thus, soil bulk density reflects the total amount of pore space present and a second definition of a compacted soil is one whose porosity is less than normal. Soil compaction occurs at the expense of porosity.

But soil compaction does more than just reduce total pore volume. During the compaction process, soil pores are collapsed.

The least stable and most easily collapsed pores are the larger ones. In essence, large pores become smaller pores. This, in many respects, is more significant from the turfgrass perspective than is the actual reduction in total porosity. Soil pore space consists of large, non-capillary pores occupied by air after drainage occurs and smaller, capillary pores that store water. Compaction reduces air-filled pore space and increases capillary pore space. The result is a wetter, colder soil that may be incapable of providing sufficient oxygen for optimal growth and functioning of turfgrass roots.

In recreational turf areas, soil compaction is largely confined to the top inch or two of soil. Collapse of large pores extending to the soil surface often has a drastic effect on the water infiltration rate of the soil. Rapid infiltration occurs via large soil pores. Water will infiltrate about 16 times faster through a pore with a diameter of 1/4 inch than one with a diameter one-half this size, or 1/8 inch. Reducing water infiltration rates can lead to temporary ponding or increased loss of water via runoff during irrigation or rainfall. Standing water shuts off oxygen and carbon dioxide exchange between the atmosphere and soil and is the leading cause of turfgrass thinning and die-out in compacted soils. Only *Poa annua*, with its ability to grow in compacted wet soils and its infamous annual regenerative capacity via prolific seed production, can thrive in these areas.

Does core cultivation truly eliminate soil compaction? If not, how effective is it in treating the undesirable effects of compaction? A review of the literature reveals some disconcerting things. First is the fact that there is little research that has carefully documented the effects of core cultivation on soil physical properties and turfgrass growth and survival. Secondly, the research that has been done presents conflicting results regarding matters such as the influences of core cultivation on water infiltration rates, oxygen diffusion rates in soil, turf quality and thatch levels. Thus, the widely used practice of core cultivation does not have a solid research background. Realization of this recently led Dr. Paul Rieke at Michigan State University to undertake a detailed study of the effects of core cultivation on soil physical properties and turfgrass quality.

Dr. Rieke and his group subjected a creeping bentgrass putting green established on loamy sand to seven hollow or solid tine core cultivations over a 3-year period. A summary of their findings follows.

Effects of core cultivation on soil physical properties

Soil bulk density: Compaction increased bulk density 4.0%; cultivation had no effect; hollow tine cultivation produced an insignificant 2.9% lower bulk density than did solid tine cultivation.

Soil total porosity: Decreased 9.7% by compaction; no improvement from cultivation of the uncompacted soil; only hollow tine cultivation restored the porosity of the compacted soil to its original (uncompacted soil) value.

Water infiltration rate: Compaction reduced infiltration 45%, from 3.3 to 1.8 in/hr; cultivation had no influence on water infiltration rates on compacted or uncompacted soil.

Effects of core cultivation on creeping bentgrass

Bentgrass quality: The effects of core cultivation varied with the time of year; until mid-season, bentgrass quality was better on the compacted soil than the uncompacted soil; thereafter, the uncompacted soil had the highest quality bentgrass; cultivation yielded better turf quality on May 10 but not on July 8; by August 7, cultivation had improved turf quality on the compacted soil, but quality was best on the uncompacted, noncultivated soil; on August 30, turf quality was 18% better on the uncompacted soil than the compacted soil and cultivation had improved quality 9% on the compacted soil and 16% on the uncompacted soil; quality with hollow tine cultivation was 23% better than with solid tine cultivation; these effects carried through to

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September 17. Throughout the study the reductions in bentgrass quality were largely due to scalping during mowing. Early in the season, bentgrass growth on the compacted soil was more prostrate than on the uncompacted soil, the result being less scalping. Cultivation covered stolons with soil and reduced scalping.

Root weight density in the top 3 inches of soil: Reduced 9% by compaction and 9% by cultivation.

Total root weight to 9-inch soil depth: Reduced 12% by compaction and 9% by cultivation.

While the results of Dr. Rieke's research have to be interpreted with a bit of caution because the soil bulk density in the compacted and uncompacted greens did not differ greatly, his observations are not at all unusual. Similar results have been observed in other studies conducted around the country.

The fact that cultivation had no significant influence on soil bulk density brings to light the fact that core cultivation does not control or eliminate soil compaction. Rather, core cultivation treats some of the symptoms or consequences of compaction. Even then, the results are inconsistent and one has to ask "Why?". This is where more research is needed. In the meantime, some speculation is possible.

Without a reduction in soil bulk density, there is no way that core cultivation can significantly alter soil porosity, simply because porosity is a function of bulk density. But what about water infiltration rates? After all, core cultivation creates very large pores. But whether or not these pores improve infiltration first depends on how long they remain intact and open to the soil surface. Unless the core holes are backfilled with porous material such as sand, their lifetime is short and the effect of core cultivation on water infiltration rates is transitory.If the cores are shattered rather than being removed, core holes and existing large soil pores can be rather quickly sealed by the shattered soil. We observed this phenomenon in our turf runoff plots last year. A single core cultivation of the silt loam soil followed by shattering of the dried cores reduced the infiltration rate of simulated rain from 1.68 to 0.98 in/hr.

The impact of core cultivation on water infiltration rates also depends very much on what lies at the bottom of the core holes. A compacted soil layer or an abrupt change in soil texture at that interface can largely negate the effect of core cultivation on water infiltration except during light rains or irrigation. Water-filled pores that are slow to drain contribute little to water infiltration rates. Research has shown that repetitive core cultivation can create a compacted soil layer at the bottom of the coring zone that reduces the rate of water movement through soil. Dr. Rieke saw evidence of this in his study and earlier research at Michigan State University showed that when a sandy loam soil with a bulk density of 1.62 g/cm3 was hollow tine cultivated, the soil bulk density at the bottom of the holes attained values as high as 1.82 g/cm3. From these observations, Dr. Rieke has concluded that "... cultivation in a noncompacted soil can be damaging to soil structure and should be utilized only when clear objectives exist".

As observed by Dr. Rieke and other researchers, the effects of core cultivation on turfgrass quality are often inconsistent and of short duration. Presumably, the more compact the soil, the greater the effect of core cultivation on turfgrass quality. There is some evidence for this. But what this suggests is that unless you know for a fact that your soil is heavily compacted, there is little assurance that core cultivation will significantly improve turf quality.

So what type of evidence can we use to help form a judgement as to whether or not core cultivation will yield results that justify the labor and expense involved? In my judgement, inadequate water infiltration is as good a criteria as any. Desirable turfgrasses do not survive in excessively wet soils and the wetter the soil, the greater the amount of compaction caused by traffic. Low infiltration rates are clear signals that aeration is inadequate as well. But remember—core cultivation is not a sure cure-all for low infiltration rates. What lies below the normal depth of cultivation is crucial. Judicious use of a soil probe will tell you if deeper cultivation might not be what is really needed to improve water infiltration or if there is a chance that core cultivation of any type is an answer to the problem.

One other justification one might cite for core cultivation is thatch control. Date collected by Dr. Rieke in his study revealed what others have observed—there was no permanent reduction in total organic matter as a result of core cultivation even though the cores were returned rather than removed. Mixing thatch with soil increases the bulk density of the thatch but does not seem to hasten its decomposition. In view of the fact that there are less laborious ways of managing thatch on putting greens (eg. verticutting plus sand topdressing), thatch control alone appears to be an inadequate justification for core cultivation in this instance.

The bottom line here is that core cultivation of turf is not a panacea. Favorable results cannot be guaranteed. The practice is justifiable only when it is being applied to treat an evident problem and there is good reason to believe that core cultivation is the solution.