SOLUTIONS TO

by Dr James Beard, Director and Chief Scientist, International Sports Turf Institute; Professor Emeritus of Turfgrass Science, Texas A&M University

Most sports and recreational turfs are subjected to traffic stresses. A hidden but very important component of traffic stress is soil compaction, which is defined as the pressing together of soil particles into more dense mass. Soil compaction tends to be greater in the upper 50 to 75 mm of the root zone profile. Proneness to soil compaction tends to be greater (a) in finer textured soils such as clays, particularly in comparison to sands in the medium particle size range, (b) at higher soil water contents, and (c) with a higher amount of canopy biomass to function as a cushion to traffic stress pressures.

Traffic stress pressure aspects

Another aspect affecting soil compaction is the intensity and frequency of pressure applied during traffic stress. Basically, pressure is calculated based on the weight of the pedestrian or vehicle divided by the surface area actually in contact with the turf-soil surface. Consequently, to minimise soil compaction it is desirable to have as great a contact surface area as possible relative to the amount of weight being applied. For example, a footballer with studs or flat-cleated shoes has a majority of the weight applied on the base of the cleats, in contrast to a flat to wafer-shaped tennis shoe where the pressure is applied broadly across the full base surface area. This results in a 25- fold greater intensity of traffic pressure where stud/cleated shoes are used in contrast to flat-soled shoes. For the same reason, a golf shoe with the traditional hubs or shoulder with spikes results in much higher pressure stress in comparison to spiked shoes with either inverted metal bases flat with the sole or else nonspiked shoes.

In terms of the frequency at which traffic pressure is applied, obviously the more frequently that pressure stresses are applied, the greater the potential for increased soil compaction problems. There are a diversity of traffic control techniques that can be used to encourage broader distribution of traffic across turfed areas. In the case of sports fields, it may necessitate developing a greater number of sports fields so that use can be reduced on any one field by rotation of play to allow turf rest and recovery periods.

Mesh system from Netlon Advanced Turf: the healthy rootzone is proven to promote quick recovery from divoting and increase the turf surface's load-bearing capacity and compaction resistance

Effects of soil compaction

The pressing together of soil particles into a more dense soil mass as a result of traffic pressure causes a number of problems in maintaining a healthy, dense turf. The first negative event resulting from soil compaction is the loss of macro-pore space and associated soil aeration. Turfgrass roots and beneficial soil micro-organisms require oxygen for respiration to support vital life processes. The loss of soil aeration results in (a) the inability of oxygen to move from the above external atmosphere into the root zone environment and, (b) the blockage in outward movement of excessive carbon dioxide and anaerobic gases that are potentially toxic to the turfgrass root system and beneficial micro-organisms. The loss of porosity in the root zone also significantly reduces the water infiltration and percolation rates and therefore increases the amount of precipitation lost by surface runoff. The lack of oxygen and presence of potentially toxic anaerobic gases and chemicals result in functional restrictions of the turfgrass root system, and eventually root dieback, which in turn is reflected in reduced turfgrass health and eventually actual thinning of the above ground canopy.

Correcting soil compaction problems

Problems develop on extensive turf areas that can only be managed through corrective measures such as turf cultivation. By definition, turf cultivation refers to mechanical methods of selectively tilling an established turf without destroying the sod characteristics. The goal of this practice is to enhance exchange of air and water between the soil and the above atmosphere. Since soil compaction is most severe in the upper 50 to 75mm, it is important that turf cultivation operations penetrate at least 80mm, and preferably 100mm deep.

A key principle in implementation of turf cultivation operations is that they be used only as needed to correct a developing soil compaction problem. In other words, it should not be used as a

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AD REF 46

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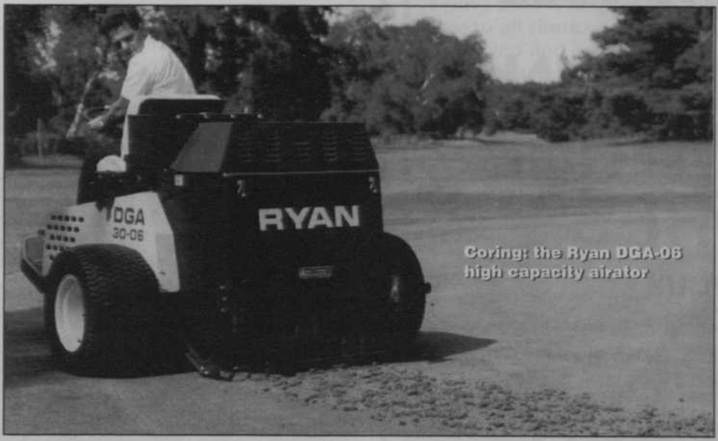
routine cultural practice, as there are negative aspects as well as positive benefits. Deep turf cultivation may never be needed on high-sand root zones constructed of the proper particle size analysis, whereas turf cultivation may be needed as frequently as monthly during the playing season on intensively trafficked, fine-textured clay soils. Symptoms used in diagnosis of soil compaction problems requiring turf cultivation include (a) a more impervious, hard soil mass as indicated by increasing difficulty in pushing a soil probe or cup cutter into the profile, (b) a reduction in the amount of water penetrating into the soil per unit of irrigation time, (c) reduced rooting depth and root number, and (d) actual thinning of the turf canopy. Turf cultivation is best accomplished when the soil is relatively moist to ensure maximum penetration and at a time of the year when moisture and temperature conditions will ensure rapid turf recovery over the openings, but when the seed germination and invasion of problem weedy species are minimised.



Coring: the Ryan DGA-06 high capacity airator

Coring

A form of turf cultivation involving a hollow tine to remove soil cores and leave a hole in the turf-soil profile is termed coring. There also are devices that produce an opening and lift out soil by means of drilling. Coring generally has been preferred over the years in terms of beneficial responses. There is the option of either (a) removing the soil cores, if of an undesirable soil texture, followed by topdressing with an improved root zone mix, or (b) returning the soil cores, if of an acceptable turf texture, during which they are broken up and matted across the turf surface where they serve as a topdressing to enhance thatch decomposition. Most traditional coring machines penetrate 85 to 100mm deep. The more recent innovative development of deep tine coring units with the capability of penetrating 200 to 300mm deep has proven very beneficial in many situations. However, this does not mean that this deep penetration unit will replace the more traditional coring devices. Both approaches have a place in the culture of intensively maintained turfgrasses for sports and recreation uses.

Slicing

A form of turf cultivation involving a deep vertical cutting action that provides soil openings and loosening, but without removal of soil, is termed slicing. It typically involves V-shaped knives mounted in a circular arrangement. The penetration

➡ 16

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248

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15 ➡ depth depends on the weight applied to the slicing knives. Slicing does not cause as much disruption of the turf surface as coring but, by the same token, it is not as effective in enhancing soil water and air interchange. However, it is used effectively where a soil compaction problem has started to develop in the upper 50 to 75mm that cannot be corrected by coring, because it would be objectionable to the users during periods of intense play, or when high level competitions are scheduled.

Injection displacement

A recent innovation in turf cultivation involves the development of high pressure pulses of water or air that create openings in the soil profile to varying depths up to more than 200mm. The water injection displacement unit has created a great deal of interest, and is an innovative mechanical procedure involving sophisticated mechanical engineering approaches. They are advantageous on greens in that turf cultivation is achieved with minimal surface disruption. However, in the process of soil displacement, the soil must be moved somewhere and there is the question of just how much localised soil compaction or differential displacement of certain soil particles may occur under continued use. Time and further research will answer these questions. In the meantime, turf cultivation by water injection displacement is another tool which the turf manager has available to choose, depending on the particular circumstances under which the soil compaction problem develops.

Spiking

Turf cultivation involving shallow perforations of the turf surface by solid tines or blades is termed spiking. Because the penetration is only 20 to 30mm, spiking does not correct a major soil compaction problem. Rather spiking is used to break up an impermeable organic/compacted surface layer. It can prove particularly effective on high-sand root zones of the proper particle size distribution when the profile as a whole has an adequate infiltration rate and all that is needed is to break up the impermeable surface layer.

Preventing soil compaction

The preferred approach to solving soil compaction problems is a preventive basis. This typically involves root zone modification which tends to be relatively costly and thus is restricted to moderate to small areas such as sports fields, putting greens, and tees. The objectives of root zone modification are to select a particle size distribution that will have minimal compaction tendency, and maximum air and water exchange with the upper atmosphere. Construction starts with the proper subsurface drainage system. A 300 to 350mm deep root zone is placed over a gravel or crushed stone drain-bed of 100mm in depth. The best long-term performance has involved placement of a 50-60mm coarse sand layer above the drain-bed to create a perched hydration zone. This minimises soil drought stresses typical of sand root zones that do not possess a perched hydration zone. Construction systems such as the older Texas-USGA Method or the more recently published 1993 USGA guidelines are found to be the most effective *(see References)*.

It is essential that the high-sand root zone contains a fully decomposed organic matter component to ensure proper buffering in terms of nutrient availability and protection against excessive leaching and allied environmental quality concerns. Note: the gravel, sand or organic matter materials being assessed for use in the root zone modification must be chosen based on established. detailed physical soil analysis, following the procedures outlined in the USGA guidelines.

Mesh system

A recent innovative development, one that has been researched since 1985, is use of the randomly oriented interlocking mesh element system. High-sand root zones have many advantages but they do tend to be less stable. There are a number of types of fibres available of a two-dimen-

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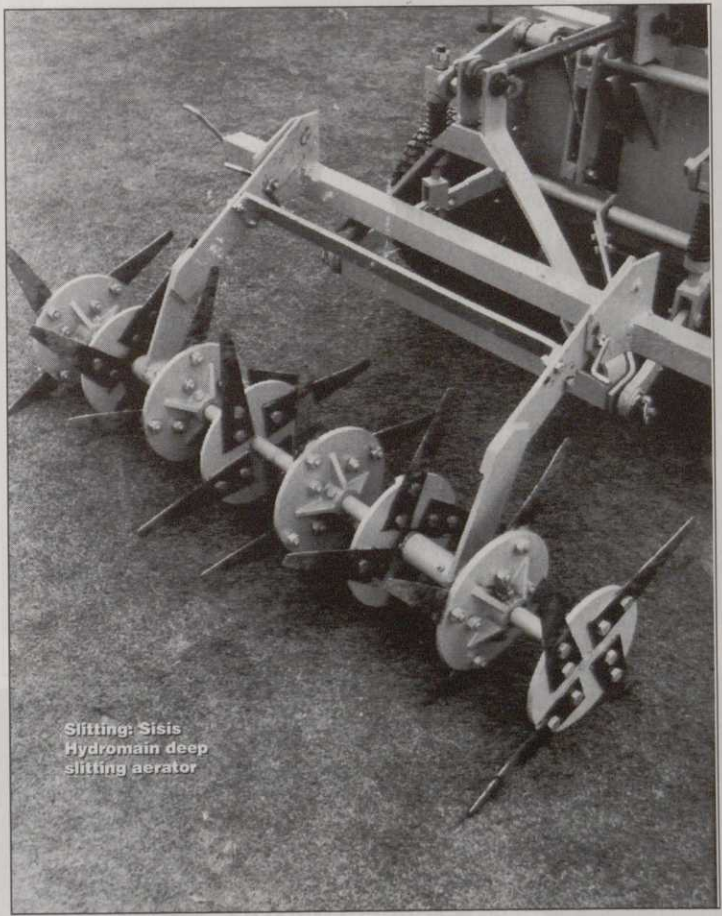
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sional nature that contribute to stabilisation of sands. However, only the three-dimensional interlocking mesh element system offers not only maximum soil stabilisation and root anchorage for reduced divoting, enhanced rate of divot turf recovery and lateral cleat tear, but also increased (a) soil water infiltration, (b) soil moisture retention, and (c) aeration, with resultant enhanced rooting and overall turfgrass health. These beneficial responses are attributed to a unique internal self-cultivation effect due to a flexing action of the three-dimensional, interlocking mesh elements randomly distributed through the upper 150mm of the root zone profile at a rate of $5kg/m^3$ The three-dimensional, interlocking mesh system with unique internal flexing also provides (a) a less hard surface, (b) a more uniform ball bounce, and (c) a superior load-bearing capacity. Based on eight years of detailed research, plus a number of successful real-world constructions installed with the proper subsurface drainage systems, the mesh element system has demonstrated great promise for use on sports fields, horse race tracks, golf tees, cart paths, and intensively trafficked areas requiring high load-bearing capacities.

References

1. USGA Green Section Staff. 1993. USGA recommendation for a method of putting green construction. USGA Green Section Record. March/April. pp. 1-3.

2. Beard, JB and SI Sifers. 1993. Stabilisation and enhancement of sand-modified root zones for high traffic sport turfs with mesh elements. The Texas Agricultural Experiment Station. B-1710:1-40.

■ *Editor's note: the interlocking mesh elements described are available world-wide as Netlon Advanced Turf. Further information concerning this process may be obtained by telephoning 0254 262431.*


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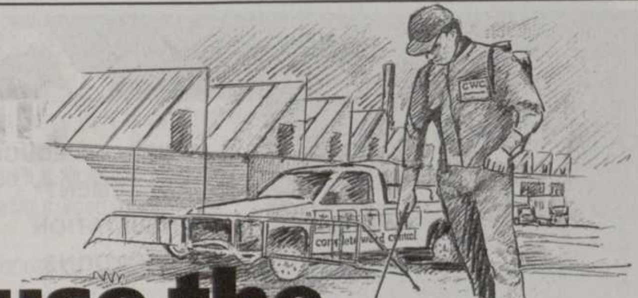
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