

COMPACTION RESISTANCE AND DRAINAGE: THE DRIVING FORCE BEHIND SAND BASED ROOT ZONES

*By Eugene Mayer
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Growing quality turf on high-traffic areas, as found on golf greens and athletic fields, is a challenge for the best of turf managers. There are many factors that have to be met and implemented in a timely fashion for one to be successful in achieving and maintaining a good playing surface. One can learn very quickly from experience that the two predominant limiting factors in growing turf in high-traffic areas are compaction and drainage.

This became evident back in the early 1900s when golf was becoming established. Greens were hard and it was difficult to maintain grass on them, even at higher mowing heights which would not be acceptable today. These greens, called push-up greens, were rock hard because they were constructed of native soil with high silt and clay content and greenskeepers would have to roll them with heavy rollers to help make the putting surface smooth.

From these experiences, the entrepreneurial superintendents hit on the idea of adding sand to help alleviate hardness. Some of the greens were built using a mixture of soil, sand, and manure. This not only helped alleviate some of the hardness, but also helped from a plant nutritional standpoint. The next improvement for greens evolved into a 1-1-1 (sand-soil-organic) volume ratio. As the game of golf evolved and play increased, it became more evident that putting surfaces needed to improve to meet the requirements and expectations of the golfers. Various university researchers started to address this problem and in time introduced new recommendations for incorporating additional sand into a golf green root zone. From their research and research sponsored by the United States Golf Association Green Section (USGA), new recommendations were developed. In 1960 the USGA Green Section staff published "*Specifications For A Method Of Putting Green Construction,*" edited by Dr. Marvin Ferguson.

The specifications for the root zone mixture prescribed that it had to be at least 12 inches deep and meet certain physical requirements. The two primary physical requirements centered on permeability (water movement through the root zone) and porosity (pore space) after compaction. Few natural soils

would meet these requirements; therefore, it is necessary to use a mixture of sand, soil, and organic matter. Because of differences in such factors as sand particle size and shape, as well as the soil component and decomposition level of organic matter, it will be necessary to have laboratory analysis to provide satisfactory recommendations.

Based on additional research and the performance of greens constructed from the 1960 specifications, revised recommendations were published by the USGA Green Section in 1989. In these specifications, drainage and resistance to compaction were still emphasized as was stated in the 1960 specification. The latest recommendations, again based on additional research, experiences of golf course superintendents, and performance of existing greens, were published in 1993.

High-sand root zones create additional advantages other than resistance to compaction and increased drainage. These include more rapid drainage, better aeration, more pore space, deep rooting, minimized disease factors, protection against salt problems, and developing a putting surface that holds a proper shot without being overly wet. There are also disadvantages, but the advantages outweigh them. Also, the disadvantages may be overcome by certain management practices.

The two primary disadvantages are 1) that the sand is unstable — meaning the loose sand sifts under the turf canopy, especially in newly seeded establishing greens — and 2) maintaining an optimum nutrient level for good plant growth. As a golf green matures in two to three years, it will become more firm because of organic matter build up in the root zone from decomposing roots and the development of a thatch layer. Nutrient availability and reserves can be maintained and controlled with the use of slow-release or controlled-release sources of nutrients.

Stringent specifications, based on research and verified by laboratory analysis, must be followed when constructing high-sand-based systems to assure that they will be functional. Equally important during the construction phase is quality control to assure that all specifications are met when the final material is put into place. If the specifications are not followed and the incorrect material is used, the results could be disastrous to the extreme of making the surface and root zone as hard as concrete or as loose as a sandy beach or desert.

The latest USGA Green Section recommendations cover the subgrade, drainage, gravel, and intermediate layers and the root zone mixture. The keys for the root zone mixture are the particle size distribution (Table 1) and the physical properties (Table 2) of the root zone mix. Laboratory analysis needs to be performed on material sources to determine if they meet the predetermined specifications. The majority of the sand size distribution must be in the 0.25 mm to 1.00 mm range, with not more than 20% of the particles in the 0.15 mm to 0.25 mm range and no more than 10% in the very fine sand, silt, and clay range. Detailed recommendations can be obtained from the USGA Green Section.

In addition to the USGA green construction method there is also the “California” or alternative method. This method is also a sand-based method, but differs primarily that it does not deal with intermediate layers or plastic liners and does not give regard to the perched water table concept. This concept is built on the premise of abrupt change in particle size from the root zone to the intermediate layer to the gravel layer. This interface prevents the further downward movement of water until a point of near saturation is reached; when that occurs, gravity overcomes the interface effect. Thus the interface permits a droughty-type soil to remain at or near field capacity for longer periods of time. The "California" system specifies the same particle sizes of sand, and it will produce a compaction-resistant growing medium with good internal drainage characteristics.

Athletic Fields

The drawbacks of sand-based athletic fields are similar to ones found in sand-based greens: that the sand root zone is very unstable and shifts easily under play, and nutrient management requirements are increased.

A high-sand root zone is very loose and shifts easily as one would experience on a beach. This unstable sand is quite prevalent in a newly constructed field and for a period as long as 3 to 5 years. Additionally, severe divoting occurs under play that requires sharp and frequent running turns. Divots will be more frequent than you would normally find on soil-based fields, and the divots can be quite large at times, reaching sizes of a square foot or more. This is more evident using cool season turf species than the warm season grasses.

Sand-based fields need time to mature to overcome this severe divoting and the shifting of sand problem. As the field matures, the root mass and decomposed roots will form organic matter in the

sand, as in the case of golf greens, and this will help stabilize the sand and provide more of an anchor for the roots. This period of time is longer for cool season grasses (3 to 5 years) than warm season grasses (2 to 3 years).

To overcome this divoting and unstabilized condition, many modifications are being tried at the time of construction. This includes the use of more organic matter, incorporation of soil, use of various types of fibers or mesh elements, and growing natural grass into synthetic turf fibers and backing.

In Europe, Australia, and other places overseas, a mesh element is being used to stabilize the sand in many stadiums and horse racing tracks. This mesh element has been researched in the U.S. with good results, but has only received limited use here under actual playing conditions. The product was marketed as Netlon and is now being marketed by Strathayr Turf Systems as ReFlex Mesh Elements. ReFlex mesh incorporated into a sand root zone reinforces the stability of sand, prevents compaction, enables root zone aeration, and provides rapid drainage rates and increased moisture retention.

A more recent method to stabilize the sand has also come into play in the last few years. This method uses synthetic turf fibers attached to a backing to grow natural turfgrass intertwined in the material. The synthetic material is buried shallow in the sand to provide stability and good footing. The first such product that was used commercially is marketed as SportsGrass. A few installations have been made and have received a lot of interest. Installations were made on fields for the University of Utah, Baltimore Ravens, Green Bay Packers, and others. Performance evaluations have been mixed and continue to be debatable, although the product has done a good job in stabilizing the sand. The system has generated enough interest that experimental materials using this concept are being researched.

Nutrient Requirements

Nutrient requirements for sand-based systems are critical, primarily because of the lack of nutrient-holding capacity of sand. This capacity is measured in the laboratory as cation exchange capacity, or CEC.

The nutrient supply or availability in straight sand is either non-existent or very low. Or stated another way, the CEC is low and will not hold a large supply of nutrients.

Though many sand-based systems are similar in concept, and perhaps even in design, there are usually marked differences between individual installations. The basic materials used to construct these root zones are all different and highly variable. There are many types and forms of sand, the primary construction material. If peat, sedge, or soil are used in the base construction mix, they too can be highly variable.

Depending on the sand source, the pH can vary from acid to very basic. In most cases, the phosphorus and potassium will be low.

Secondary and minor elements - including magnesium, calcium, manganese, iron, zinc, and copper - are normally also very low or non-existent in sand-based fields.

The low availability of nutrient supply in sand-based systems must be taken into consideration in the fertilizer program to provide vigorous grass growth.

Soil tests are very critical. Testing is needed in sourcing material for construction or for topdressing. Also take soil tests when the site is completed and put into play, then at least once a year, preferably twice a year — or, if problems exist, quarterly.

Results of soil tests on a periodic basis provide information on current status and outline the direction the fertility program is heading.

The fertilizer usage should be built on a yearly program, not applied only as deemed necessary or when the grass is showing signs of nutrient deficiencies.

Fertilizers will need to be added more frequently, mainly because of the low nutrient-holding capacity of the sand. The goal is to provide a steady, continuous supply of all essential nutrients to the grass plant for excellent turfgrass growth and health throughout the growing season. This is the difficult part of a fertility program.

Soluble types of fertilizers give surge and lush turfgrass growth and do not remain in the root zone layer. They tend to leach more readily than the controlled-release forms. Also, soluble types of fertilizer must be applied more frequently and have a tendency to burn turfgrass if over-applied.

Dry fertilizers are available in either blended or homogeneous forms. Blended fertilizers physically mix together particles of different compounds containing various nutrients. Though the total blend contains all components of the fertilizer formula, the individual particles contain only a portion of the complete formula. Differences in particle sizes and weights may cause segregation of the particles during application. Homogeneous fertilizers combine nitrogen, phosphorus, potassium, and any minor elements in the formula, within each particle.

Slow-release sources of nitrogen help sustain turfgrass growth on a more uniform and continuous basis, as well as providing minimum leaching and volatilization.

Slow-release types of fertilizers are readily available. The different forms of controlled-release fertilizers can be divided into two basic categories. One category, called chemical reactive forms, includes such fertilizers as methylene ureas, ureaform, and IBDU. The second class is the physical-coated fertilizers which include sulfur-coated ureas and polymer-coated fertilizers.

The chemical reactive forms of fertilizers release primarily by microbial action, water, and temperature. The physical-coated nutrients release primarily by osmosis or breakage of the coated layer.

In the coated fertilizers, the type of material or materials used for the coating and the thickness of the coating layer or layers greatly determine the length of time required for nutrient release.

Each of the available controlled-release nitrogen products have their own set of characteristics and release rates. It's important to understand how specific controlled-release nitrogen fertilizers release and the type of turfgrass response they provide. This information is available on the product label, on product description sheets, and also from company representatives.

The ideal choice for a sand-based system would be a controlled-release fertilizer that provides a linear response in grass growth. A small amount of nutrient supplied to the turfgrass plant each day will

provide a uniform, constant, consistent growth rate for both the top and the roots, while providing a good dark green color.

It is not desirable to have surge growth that produces a large quantity of clippings. This can weaken plant health and also reduce wear tolerance. A healthy turfgrass plant provides better wear tolerance, better density, better playing surface, a greener color, and a better appearance.

Phosphorus and potassium are almost always low in sand-based systems. It is necessary to supply these on a more frequent basis than in soil fields.

Phosphorus levels can be built up in sand-based systems and, once they reach the desired level as determined by soil test analysis, the amount and frequency of phosphorus application can be reduced. However, frequent monitoring is needed to determine if phosphorus levels are decreasing or increasing too rapidly. Phosphorus does tend to stay in the root zone longer than many of the other nutrients.

Potassium levels in sand-based systems can fluctuate quite rapidly. It is necessary to keep checking on availability and supply of potassium with periodic soil tests and to add potassium-containing fertilizers on a regularly scheduled fertilizer program. Potassium is not tightly held on the sand particles and therefore tends to release more easily. Since the turfgrass plant readily uses potassium, it's important to build up and maintain potassium levels on a continuous basis.

Secondary and minor elements also need to be added and monitored on a regular basis in sand-based root zones. Minor elements always tend to be low in availability. Because minor elements are only needed by the grass plant in minute quantities, it's very important to keep the correct level in a sand-based root zone. Be careful not to over-apply minor elements, because there's a very narrow range between low or high levels of minor elements in the sand profile. Monitor minor elements through regular soil tests to provide guidance for the timeliness of application and quantity needed. When using minor element fertilizer packages, check to ensure that the element sources are among those that make nutrients available to the turfgrass plant.

Management requirements for sand-based systems — whether golf greens, athletic fields, or other applications — are entirely different and require greater expertise than turf grown on soil. Sand-based

systems will not solve all the turf problems, nor will they be more economical to construct or maintain, but they do offer some excellent advantages. By providing improved resistance to compaction, increased and more rapid drainage, and a better root environment, these advantages make possible a more acceptable putting or playing surface with a tolerance for more play.

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Table 1**PARTICLE SIZE DISTRIBUTION OF USGA ROOT ZONE MIX**

Name	Particle Diameter	Recommendation (by weight)
Fine Gravel	2.0 - 3.4 mm	Not more than 10% of the total particles in this range, including a maximum of 3% fine gravel (preferably none)
Very Course Sand	1.0 - 2.0 mm	
Coarse Sand	0.5 - 1.0 mm	Minimum of 60% of the particles must fall in this range
Medium Sand	0.25 - 0.50 mm	
Fine Sand	0.15 - 0.25 mm	Not more than 20% of the particles may fall within this range.
Very Fine Sand	0.05 - 0.15 mm	Not more than 5%
Silt	0.002 - 0.05 mm	Not more than 5%
Clay	Less than 0.002 mm	Not more than 3%
Total Fines	Very fine sand +	Less than or equal to 10%
	silt + clay	

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Table 2**PHYSICAL PROPERTIES OF THE ROOT ZONE MIX**

Physical Property	Recommended Range
Total Porosity	35% - 55%
Air-Filled Porosity	15% - 30%
Capillary Porosity	15% - 25%
Saturated Conductivity	
Normal Range	6 - 12 inches/hr (15-30 cm/hr)
Accelerated range	12-24 inches/hr (30-60 cm/hr)

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PHOTO CAPTIONS

1. Close up of sand-based root zone
2. Placing a sand-based root zone on an athletic field
3. Laying sod on a sand-based root zone on an athletic field
4. Unstable sand on a newly installed sand-based field
5. Deep, healthy roots growing in a sand-based root zone
6. Placing a sand-based root zone for a newly constructed green
7. Flat tile drainage pattern for a newly constructed green being covered with pea gravel