Soil Inclusions' Impact
On Soil Physical Properties and Athletic Field Quality

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The growing interest in personal fitness has led to the overuse of many athletic fields. Overuse can lead to soil compaction, loss of turfgrass cover, poor playing conditions and the potential for surface-related injuries. In an attempt to minimize compaction, contractors install athletic fields with sand rootzones.

Various soil inclusions have been used to improve the playing surface quality of athletic fields. Beard and Sifers and Canaway amended sand with interlocking discreet mesh elements (Netlon). Beard and Sifers showed that additions of Netlon to a sand rootzone increased water infiltration rates, improved resistance to surface rutting and deformation, enhanced divot recovery and reduced lateral cleat turf tear.

Athletic field soil inclusions should be evaluated for their effects on soil physical properties and playing surface quality. The physical properties of a soil, including its texture, bulk density and water infiltration rate directly affect its ability to exchange air and water. Compaction decreases aeration porosity and increases soil bulk density, causing a decrease in rooting (Carrow and Wiecko).

Playing surface quality can be defined as the suitability of a surface for a particular sport. A player interacts with a surface in two ways: through impact or through shoe-to-surface interaction (traction). *Surface hardness* is the amount of impact energy a surface can absorb. Playing surface hardness affects both player performance and player safety. A soft field can create early fatigue in the leg muscles of a player, whereas fields that are hard can be dangerous when fallen upon or lead to an increase in shin splints.

Traction is a measure of the horizontal force created between a shoe and a surface during movement. An athletic field surface should provide a level of traction that benefits the player's movements without causing excessive stress to joint or ligaments.

Soil physical properties and playing surface quality should be evaluated on fields amended with soil inclusions both before and after exposure to various levels of wear. Carrow and Wiecko defined wear as turfgrass injury caused from pressure, scuffing or tearing of the grass plant tissue plus soil compaction. Divoting, pressure, scuffing and tearing are considered the most important factors in wear on soils with very high and uniform sand contents. Compaction is considered the dominant wear factor on soils with high percentages of silt and clay.

Six inclusions were tested, starting in 1995, in 10 x 10-foot grids at the Joseph Valentine Turfgrass Research Center. In the first experiment with a sand rootzone, the products tested were Netlon, Turfgrids, DuPont shredded carpet, two Nike materials and Sportgrass.

The purpose of this study was to determine if the addition of the various soil inclusions altered turfgrass wear resistance, soil physical properties and playing surface quality (hardness and traction).

Wear Levels — The turf plots were rated under three levels of wear: none, medium wear (equivalent of three NFL games per week) and heavy wear (equivalent of seven NFL games per week. A Brinkman Wear Machine was used to simulate the amount of wear.

Soil Physical Properties — Soil bulk density, soil water content and water infiltration were measured for both sand and silt-loam experiments. Soil bulk density data were derived from measurements of soil total density and volumetric water content. Water infiltration rates were measured with double-ring infiltrometers following 30 minutes of soaking.

Playing Surface Quality — Turfgrass density was rated visually on a scale of 0 to 5, five being most dense. A Clegg impact soil tester was used to measure soil hardness following wear treatments.

Traction — Linear traction measurements were made with a special device approximately 16 hours after irrigation on dry turf. Finally, a device utilizing a pitching wedge head was used to measure divot size.

Results

Density — We found turfgrass density differences among the treatments. The three rating dates were June 18, August 23 and October 18. Nike Light treatment provided denser turf than the control on all rating dates. Nike Heavies treatment was denser than the control on two of the rating dates. The Sportgrass treatment had lower density than the control on all three rating dates. When no wear was applied, there were no significant density differences among treatments.

Nike Light and Nike Heavies produced denser turf than the control on the medium and high wear levels in June and October and on the medium wear in August. DuPont shredded carpet (at 0.5 percent dry weight) was denser than the control under medium wear in August and denser than the control under high wear at 2 and 3 percent in October.

Some treatments had turfgrass densities lower than the control. Turfgrids (0.3 percent) and Turfgrids (0.5 percent) had lower density than the control under high wear in August. In October, the Netlon (0.5 percent) and Turfgrids (0.5 percent) had lower density than the control under medium wear. Sportgrass had lower density than the control under medium wear in June and August and under high wear in October.

Ratings were taken a second year, partly to gauge recovery from the first year's wear. Rating dates were June 11, August 19 and October 15. The June rating was taken after only one week of wear treatments and reflects the amount of recovery from the wear from the previous year. The first set of density ratings in the second year corresponded directly to the final density rating of the previous year and did not suggest varying rates of recovery due to treatments.

The high wear treatment sub-plots for the control, DuPont shredded carpet (1 percent), Netlon (0.3 percent), Sportgrass and Turfgrids (0.3 and 0.5 percent) had density ratings significantly lower than optimum on June of the second year.

The overuse of athletic fields can lead to soil compaction, loss of turfgrass cover, poor playing conditions and the potential for surface-related injuries.

As wear continued through the summer, treatments generally decreased in density. During the August rating, no treatments were less dense than the control and four treatments had significantly higher turf density than the control. These included DuPont shredded carpet (2 and 3 percent), Nike Light (3 percent) and Nike Heavies (3 percent).

There was slight recovery in the fall, for many of the treatments. In October, after 4.5 months of wear, six treatments had significantly higher density than the control. No treatments had lower density than the control.

Both Nike products provided greater turfgrass wear resistance as reflected by turf density ratings. Sportgrass exhibited lower density than the control on three of the six rating dates after wear was applied.

Soil Bulk Density — A lower soil bulk density means lower soil compaction. Soils lower in bulk density typically exhibit lower resistance to root penetration.

The trends in soil bulk densities were consistent across all three wear levels. During the first year, Netlon (0.5 percent) had higher soil bulk density than the control on all three rating dates. DuPont shredded carpet (0.5 percent) and Turfgrids (0.5 percent) had higher bulk density than the control in August. Nike Light (3 percent) and Nike Heavies (3 percent) had lower soil bulk densities than the control in June and October. DuPont shredded carpet (3 percent) had lower soil bulk density on all rating dates, while 2 percent and 1 percent plots of the carpet were lower in bulk density than the control in June and October. As more carpet material was added, soil bulk density decreased and this decrease appeared unaffected by the imposed wear.

During the second year, all DuPont shredded carpet plots and the Nike treatments had consistently lower soil bulk densities than the control on all rating dates. Only the Netlon (0.5 percent) treatment had higher soil bulk density than the control in the second year. On the last rating date in October, all treatments except the Netlon (0.3 and 0.5 percent) and Sportgrass treatments had significantly lower soil bulk density than the control.

The lower soil bulk densities are most evident for the recycled products that are added to the sand at the rate of 3 percent by weight. While the high rates of the recycled products showed dramatic differences in soil bulk density.

Soil Water Content — Typically, treatments had the same or lower soil water contents when compared to the control. Turfgrids (0.3 percent) had higher soil water content than the control in June and October. DuPont shredded carpet (1 percent) had a soil water content higher than the control in October. Nike Light and Sportgrass had lower soil water contents than the control on each rating date.

Overall there were fewer soil water content differences during the second year. The soil water content was higher than the control with Turfgrids and lower with Sportgrass and Nike Light.

Surface Hardness — Netlon (0.3 and 0.5 percent), Turfgrids (0.3 and 0.5 percent) and Sportgrass had higher hardness values than the control on all rating dates during both years of the study. DuPont shredded carpet (0.5 percent) had a higher Gmax value than the control in June, while 3 percent treatments had consistently lower hardness values than the control. Nike Light (3 percent) was also consistently lower. Nike Heavies (3 percent) had a lower Gmax value than the control only in June.

Results were similar for the second year of the study, except treatment by wear interaction was significant on all three rating dates. Generally the more wear applied, the higher the Gmax values.

Netlon, Sportgrass, and Turfgrids produced higher Gmax values than either the control or the recycled products. Lower surface hardness values could result in fewer impact injuries, but might create early fatigue in players' leg muscles.

Traction — Relatively few treatments had traction values different from the control. Only Sportgrass had traction values higher than the control during the October rating. Turfgrids (0.3 percent) had lower traction than the control in August and October. Turfgrids (0.3 and 0.5 percent), Nike Heavies (3 percent), Nike Lights (3 percent) and DuPont shredded carpet (2 percent) had lower traction than the control in August.

Traction values for treatments were different from the control only under high wear. Netlon (0.3 percent), Turfgrids (0.3 percent) and Nike Heavies (3 percent) had lower traction values than the control, while Sportgrass had higher traction values than the control.

During the second year, no treatments varied from the control under no wear or medium wear. Under high wear, the DuPont shredded carpet (0.5 and 2 percent), the Nike Light (3 percent) and the Turfgrids (0.3 percent) treatments had traction values higher than the control. No treatment had traction values lower than the control the second year.

Few traction differences were found during the study. Sportgrass had higher traction than the control on one rating date in the first year after exposed to high wear.

Water Infiltration — Low infiltration rates and poor surface drainage can result in puddling and wet playing conditions. We did not measure any water infiltration rate that was lower than the control treatment. Sportgrass show higher infiltration rates than all other treatments. At the end of the study, all treatments had infiltration rates between 20-27 inches per hour. This is considered adequate or high for most athletic field rootzones.

Sportgrass had a higher water infiltration rate than all other treatments in the first year. DuPont shredded carpet (2 percent) and Turfgrids (0.5 percent) had infiltration rates higher than the control the first year. During the second year, no treatments were significantly different from the control. At the end of the study, all treatments had infiltration rates between 20 and 27 inches per hour.

Divoting — We performed the divoting test once at the end of the study because the test is destructive to the plots. When averaged over three wear levels, all treatments reduced divot length compared to the control. Only Turfgrids (0.5 percent) had shorter divot length compared to the control. All treatments reduced divot length under high wear.

Results from the control indicate that as the turf density increases, divot length increases more with other treatments. The inclusions act like an artificial root system, stabilizing the granular soil and reducing divots.

The differences in soil physical properties and playing surface qualities among treatments were due to the size, shape, and rate of the inclusion. Netlon and Turfgrids are both inclusions that were designed for engineering applications. McGown et al. and Mercer et al. revealed that the size and shape of the filaments or mesh elements must be related to the size of the soil particles in which they are placed in order not to weaken the soil. McGown found that for sandy soil, ranging in particle size from 0.25 to 1.0 mm, soil strength and bulk density were maximized at an inclusion rate of 0.6 percent by weight.

The shape and size of recycled products, such as DuPont shredded carpet and Nike inclusions, can be controlled to a degree, but they are not designed to increase soil strength.

The width and depth of treatment divots showed little difference. All the treatments produced shorter divots than the control. The presence of inclusions added some shear strength to the turf surface reducing divot length. This was most evident after wear was applied and turf rooting had decreased. When there was no wear, only Turfgrids provided significantly shorter divots.

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