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Differentiating Between Wear and Compaction

How their interaction affects turf stress

By W.M. Dest and J.S. Ebdon

Traffic is broken down into wear and soil compaction, but few studies directly compare these two confounding factors and their interactive effects on plant response.

The objectives of our study were first to differentiate between the influence of wear and soil compaction and their interaction and which had the greater effect on turfgrass stress and species composition; and second, to compare the effects of soil compaction between a native soil and sand rootzone on their physical properties conducted in the field and their relationship to plant stress.

Material and methods

A field experiment was conducted at the Joseph Troll Turf Research Center at the University of Massachusetts-Amherst over a three-year period. Experiments were established in two soil types: a native silt loam and a sand rootzone.

The compaction treatments were applied using a vibro-tamper prior to seeding the plots. A 3-inch depth of the topsoil and sand rootzone were removed and the soil below 3 inches compacted with the vibro-Tamper to ensure that the soil was compacted to a 6-inch depth below the surface. The 3 inches of soil removed was replaced and the Vibro-Tamper used again to compact the top 3 inches. Wear treatments were simulated with a steel brush set into a frame in which the height of the brush can be set so that injury to the leaves can be adjusted through the setting to compensate for mowing height. The brush was guided over the plots by movable tracks set at the edge of the plots. Each plot received the same number of oscillations starting at 75 on Sept. 13, 2005, to as many as 200 over the duration of the experiment. Treatments were set out in a randomized complete block design with three replications on each soil. Plot size was 4 feet by 4 feet.

The plots were established with a seed mixture comprised of 25 percent Kentucky bluegrass (America and Touchdown) and 75 percent perennial ryegrass (Fiesta 3, Express and Cutter) on Sept. 14, 2004. The plots were mowed at 1.25-inch cutting height two to three times per week depending on the season and growth rate. Grass clippings were returned. The plots were irrigated to maintain active growth. After initial fertilization at seeding, the sand rootzone plots were fertilized

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with nitrogen at 413 pounds, 231 pounds and 148 pounds and acre, and the silt loam at 283 pounds, 187 pounds and 148 pounds an acre in 2005, 2006 and 2007, respectively.

Percent turfgrass cover prior to wear treatments was taken in the fall 2004 to spring 2005. Wear ratings were taken immediately after wear treatments using a scale of 1 to 9 (1 equals severe wear with 50 percent bare ground, 5 equals leaf injury with loss of color and density, 6 equals leaf injury with loss of color and less than 6 acceptable with progressively less injury) starting in 2006. Recovery from injury was rated several days after the wear treatments using the same scale with acceptable recovery indicated when the rating was greater than 6 with 9 equaling 100-percent recovery.

Five cores (1.2 square inches) were taken from all plots prior to wear treatment on June 6, 2006, and after termination of the study on June 14, 2008, to assess species composition. Aerial shoots of Kentucky bluegrass and perennial ryegrass were separated by species and pooled to estimate species composition by count.

Six cores (1.2 square inches) were taken in October 2007 to a depth of 6 inches to measure root weights. The cores were divided in half to measure root biomass between 0 to 3 inches and 3 to 6 inches, respectively. The soil was washed from the cores and dried at 70 degrees C until a constant weight was obtained.

The roots were weighed and then ashed at 600 degrees C for two hours. The ash weight was subtracted from the oven-dry weight to obtain the weight of the roots.

Penetration resistance was measured using a Proving Ring Penetrometer with a cone point, which was pushed slowly and at a constant rate into the top 2 inches of soil. Two readings were taken per plot beginning in 2004 with the results reported in megapascals (MPa).

Two intact cores 2 inches in diameter by 2.4 inches in length were obtained in the fall 2006 with a brass cylinder fitted inside a metal tube from each plot for determining bulk density and air-filled porosity. Thatch and soil were removed to 2 inches below the surface before inserting the metal tube with the brass cylinder.

Soil samples were collected from the silt loam and sand rootzone prior to setting out the experiment to determine the soil's maximum dry density using the Proctor Test, Modified Compaction Effort, ASTM D1557-07 (2008). The maximum dry density is used as a reference in which the observed bulk density is expressed as a proportion of the maximum dry density. Field-saturated hydraulic conductivity (Kfs) was determined in the fall 2007 using the Guelph Field Permeameter (Reynolds, 1993; Reynolds & Elrick, 1985), which maintains a stable depth of water in an uncased auger hole.

Results: grass establishment

Full cover on the silt loam was achieved by April 20, 2005, while full cover on the sand rootzone did not achieve full cover until June 29, 2005. Soil compaction also significantly reduced stand establishment over both soils up until June 7, 2005 (Table 1).

Although most of the reduction in vegetative cover was associated with the sand rootzone, the data strongly suggests that soil compaction as a result of construction activities can have a profound effect on turfgrass establishment.

Species composition

Perennial ryegrass increases significantly in the population with a concomitant decrease in Kentucky bluegrass in the compacted plots compared to the non-compacted plots, suggesting that perennial ryegrass exhibited greater compaction tolerance than Kentucky bluegrass.

However, wear treatment has no significant effect on species composition. A significant effect from soil type was detected by June 2008. Specifically, there was a significantly greater perennial ryegrass in the stand over Kentucky bluegrass in the silt loam compared to the sand rootzone.

Wright et al. (1978) found perennial ryegrass had a competitive advantage over Kentucky bluegrass in soils with a more favorable moisture environment (low soil moisture tension), which may explain the higher perennial ryegrass populations in the silt loam.

However, Kentucky bluegrass increased in the population from 2006 to 2008, showing its greater recuperative potential compared with perennial ryegrass.

Rooting

Under compaction, the sand rootzone exhibited significantly greater rooting at the zero- to 3-inch depth compared to the silt loam corresponding to a 1.5- to 2.4-fold greater root mass, likely a result of high aeration porosity in the sand.

Alternately, rooting was significantly inhibited in the silt loam at the 3- to 6-inch depth compared to the zero- to 3-inch depth in response to an increase in soil strength and reduced aeration. Penetration resistance is closely associated with soil compaction and mechanical impedance to root penetration and was significantly greater in the compacted versus the non-compacted soil and in the silt loam versus the sand rootzone because of its greater soil strength.

Wear had no effect on penetration resistance.

Wear tolerance and recovery

There was significant wear injury noted immediately after wear was imposed in 2006 and 2007. Wear's main effect accounted for 87 percent to 90 percent of the total treatment variation in injury over both years (data not shown). The balance of variation was accounted for by compaction and soil type, which played a minimal role compared with wear.

During recovery in 2006, there was significant injury noted on all dates; however on the Aug. 29 rating, the plants had recovered with no observed bruising of the leaf tissue. In 2007, two of the five ratings during recovery were acceptable. On all other rating dates either some thinning and/or discoloration was observed.

Soil physical properties

There was a significant difference in air-filled porosity between the silt loam and sand rootzone corresponding to 7.6 percent and 20.1 percent, respectively.

Given the value for the silt loam of 7.6 percent, the value is below the cited minimum value of 10 percent, where aeration porosity can become deficient (Grable, 1971). Also, there was a significant decline in air-filled porosity due to compaction versus the non-compacted treatment across soils.

However, when comparing the values for compaction versus non-compaction on the sand rootzone (data not shown), the percent air-filled porosity for the compacted treatment is 16.8 percent, which is above the lower limit for air-filled porosity stated above.

The main effect for wear had no influence on air-filled porosity.

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