Golfdom's PRACTICAL RESEARCH DIGEST FOR TURF MANAGERS

TURFGRASS TRENDS

WEAR AND COMPACTION STRESS

Soil Compaction Prolongs Establishment

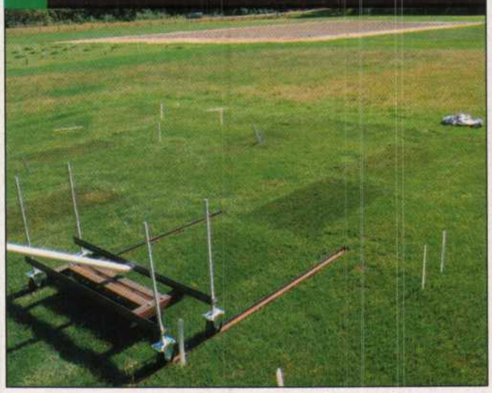
Specifications should steer seedbed preparation and construction projects

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

Wear and soil compaction are the major cause for turfgrass stress under intense traffic typical of golf courses and athletic field turf. That traffic can be broken down into two separate stresses, wear and soil compaction (Carrow and Petrovic, 1992).

Wear stress affects the shoot system of turfgrass plants resulting in crushing and bruising injuries. Compaction alters the physical properties of the soil affecting water and air movement, seedling emergence and root penetration, which in turn affects shoot vigor. While there have been numerous studies to evaluate these factors separately, few studies have been conducted to assess which of these two factors have the greatest influence on plant stress and what is the effect of their interaction.

PHOTO 1



Using a wear simulator on silt loam plots, wear was applied to shoot tissue by adjusting a steel brush into a frame to reduce the influence of wear on soil compaction.

The objectives of our research were, first, to differentiate between the influence of wear and soil compaction and their interaction on turfgrass stress, and second, to compare the effects of soil compaction between a native soil and sand rootzone on their physical properties conducted in the field.

Materials and methods

Field studies were established on a native silt loam and sand rootzone in 2004 at the Joseph Troll Turf Research Center, University of Massachusetts Amherst. The treatments were set out in a randomized block design with three replications on each soil.

Plot size was 4 feet by 4 feet. The compaction treatments were applied using a

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TABLE 1

Mean percent turfgrass cover for main effects of soils and compaction treatments from fall 2004 to spring 2005.

	2004		2005				
Treatments	Oct. 7	Nov. 4	Jan. 4	Apr. 20	May 19	June 7	June 29
	% cover+						
Soils							
Silt loam	48.3	80.0	80.0	99.5	99.2	95.8	99.0
Sand rootzone	24.2	24.6	32.1	49.6	72.8	89.2	99.5
Significance	**	**	**	**	**	*	NS
Compaction-treatments							
Compaction	33.3	43.3	49.6	71.6	82.5	90.7	99.0
Noncompaction	39.2	61.2	62.5	77.6	89.5	94.3	99.5
Significance	*	**	**	NS	*	*	NS

**, **, NS Significant at $P < 0.05$, 0.01, and non significant ($P > 0.05$) respectively.*

+ Visual estimate for percent cover 0 = no cover, 100 = 100 percent cover.

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Vibro-Tamper prior to seeding the plots to insure that the soil was compacted to at least a 6-inch depth below the surface.

Plots were sown with a seed mixture comprised of 25 percent Kentucky bluegrass (*Poa pratensis L.*), America and Touchdown and 75 percent perennial ryegrass (*Lolium perenne L.*), Fiesta 3, Express, Cutter on Sept. 14, 2004. The plots were visually rated for percent cover beginning Oct. 7, 2004 through June 29, 2005. Turfgrass quality was rated visually beginning in June 2005 on a scale from 1 to 9 (9=best, 6=minimum acceptable).

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 and to compensate for mowing height (Photo 1, page 75).

The number of oscillations on the wear plots ranged from 75 on Sept. 13, 2005, to as many as 200 on Aug. 24, 2006. Wear ratings were taken immediately after treatments using a scale of 1 to 9 (1 = severe wear with 50 percent bare ground showing, better than 6 was the minimum acceptable, 9 = no injury). Recovery from injury was rated several days after the wear treatments using the same 1 to 9 scale (6 = minimum acceptable, 9 indicating complete recovery). A light reflectance meter (Spectrum Technologies, CM 1000 Chlorophyll Meter, Plainfield, Ill.) also was used to assess injury one day after injury ratings were taken.

Penetration resistance was measured using a Proving Ring penetrometer with a cone point having a base of 0.98 square inches and a conical base area of 1.9 square inches. Leaf turgidity was determined on all available non-senescing, fully developed leaves using the formula [(fresh weight-dry weight)/(turgid weight-dry weight)] times 100. Turgid weight was measured after soaking leaves in distilled water for 12 hours. Leaf strength was defined as a measure of the tension (in grams) required to reach the breaking point and tear a leaf blade in half.

Leaf strength was determined on five randomly chosen, fully developed leaf samples per plot for Kentucky bluegrass and perennial ryegrass. Leaf strength is reported averaged across species. Leaf strength was measured using Shimpo Digital Force Gauge (Model FGS-50H; Nidec-Shimpo America Corp., Itasca, Ill.). Five 0.9-inch diameter plugs were taken from each plot and stand count by species was determined and expressed as percent Kentucky bluegrass. Shoot growth was measured as five days of cumulative growth collected above the 1.25-inch mowing

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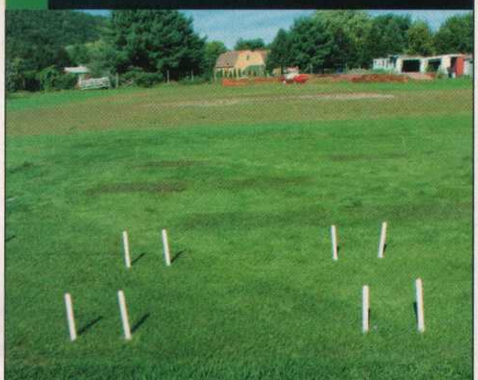
PHOTO 2



Wear injury on sand plots the day of wear treatment, Aug. 24, 2006.

TABLE 2

Mean turfgrass injury ratings, chlorophyll index and recovery ratings for wear and nonwear treatments over soils for September 2005.

	Injury+		Chlorophyll index++		Recovery+++	
Treatment	Sept. 13	Sept. 22	Sept. 14	Sept. 28	Sept. 22	Sept. 28
Wear	5.00	4.50	364	217	6.75	5.17
Nonwear	7.50	7.08	409	254	6.75	7.25
Significance	**	**	**	**	NS	**

***, NS significant at P<0.01 and non-significant, respectively.*

+ Injury rating 1 = severe with 50% bare ground, >6 = no injury from wear, 9 = no injury, excellent quality.

++ Chlorophyll measurement taken one day after wear.

+++ Recovery rating taken 9 and 6 days after wear respectively; rating > 6 indicates no wear injury; 9 = no injury, excellent quality.

TABLE 3

Means for wear rating and recovery from wear for main effects of soils, wear and compaction treatments for 2006.

	Wear			Recovery		
Treatments	June 19	July 6	Aug. 24	June 21	July 10	Aug. 29
	------------1 to 9, 9=no injury, 6=minimum acceptable------------					
Soils						
Silt loam	5.83	5.83	6.58	6.08	6.96	7.92
Sand	5.42	5.83	5.79	6.00	7.04	7.50
Significance	†	NS	*	NS	NS	NS
Wear						
Wear	4.17	4.42	4.38	4.83	5.00	6.43
Nonwear	7.08	7.25	8.00	7.25	9.00	9.00
Significance	***	***	**	***	***	***
Compaction						
Compacted	5.58	5.79	6.38	5.96	7.38	7.92
Noncompacted	5.67	5.88	6.00	6.13	6.63	7.50
Significance	NS	NS	NS	NS	†	NS

*†, *, **,***, NS Significant at P <0.10, 0.05, 0.01,0.001 and nonsignificant, respectively.*

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height, oven dried for 48 hours at 70 degrees Celsius and then expressed as gram dry weight per square meter per day.

Results

The rate of stand establishment was significantly faster in the silt loam than the sand rootzone on all dates that ratings were taken through June 7, 2005 (Table 1, page 76).

Plants growing on the sand rootzone received 7.2 pounds of nitrogen, 2.8 pounds of phosphorous, and 4.6 pounds of potassium per 1,000 square feet. The silt loam plots received 4.2 pounds of nitrogen, 1.4 pounds of phosphorous and 2.8 pounds of potassium per 1,000 square feet during the same time period. There was no difference in grass cover by June 29, 2005 (Table 1).

Soil compaction significantly reduced the rate of stand establishment over both soils through the fall/winter and into June 7, 2005, in all but one of the dates visual estimates for cover were made (Table 1). Most of the reduction in percent cover was associated with the sand rootzone. The data suggests that soil compaction as a result of construction activities and during seedbed preparation can have a profound effect on turfgrass establishment. Our experience has been that soil compaction from construction activities is a major problem that needs to be addressed since it can significantly postpone establishment and in turn delay the start of scheduling sporting events.

There was a significant compaction by soil interaction on penetration resistance on three out of the four dates that penetration measurements were taken. Greater penetration resistance is closely associated with greater compaction and potentially mechanical impedance to root penetration. Penetration values were significantly greater on the compacted versus the noncompacted treatments within soils, likely a result of an increase in soil strength due to an increase in bulk density. Penetration resistance was also significantly greater in the silt loam versus the sand rootzone due to the silt loam's cohesive property. Sands rely largely on frictional properties for soil strength.

There was significant wear injury noted on the wear treatments over the two soils

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immediately after wear was imposed on Sept. 13 and Sept. 22, 2005 (Photo 2, page 76; Table 2, page 78).

The chlorophyll index taken the day after wear treatment also showed the extent of bruising from wear. There was a highly significant correlation between visual ratings and the chlorophyll index on Sept. 14 and Sept. 23, 2005. The turf had fully recovered from the Sept. 13, 2005, wear treatment when compared to the non-wear treatment shown by the Sept. 22, 2005, ratings (Table 2).

However, turf had not fully recovered from the second wear treatment taken on Sept. 28, 2005. This may be a result of the greater number of oscillations imposed at the second wear treatment or because the ratings were taken within a shorter time frame than in the first wear treatment.

The compaction and wear treatments had little effect on turfgrass quality during the 2006 season. However, turfgrass quality was affected by soil type. Turfgrass quality was significantly better on sand compared to silt loam plots during the spring. Conversely, superior turfgrass quality was observed in the silt loam during the summer months (July, August and early September) compared to the sand plots.

There was significant wear injury observed on wear-treated plots over the two soils immediately after wear was imposed on June 19, July 6, and Aug. 29, 2006 (Table 3, page 78). There was significantly more wear injury on the sand plots compared to silt loam plots on the Aug. 24 rating. Compaction had no effect on wear injury. During recovery (Table 3), there was significant injury noted on all dates. However, on the Aug. 29 rating, there was no leaf injury observed from bruising although plots were still thin.

Kentucky bluegrass decreased significantly in the population relative perennial ryegrass in wear-treated plots and in compacted plots compared to noncompacted treatments.

The data at the time of collecting samples suggests that perennial ryegrass exhibited greater wear and compaction tolerance than Kentucky bluegrass. Lower leaf turgidity and greater leaf strength have been shown to be associated with greater wear tolerance (Brosnan et al., 2005). However, there was little difference observed with leaf strength and leaf turgidity between soil and compaction treatments. No difference was observed in dry weight over all treatments in 2006.

Conclusions

Stand establishment was reduced significantly by the compaction treatment indicating the need to minimize soil compaction during construction activities and seedbed preparation by setting strict specification.

Penetration resistance was increased due to compaction with the larger increase occurring on the native silt loam than on a sand rootzone largely due to its greater soil strength. There was significant injury from wear on both soils. However, there was significantly less injury from wear in the silt loam plots compared to the sand rootzone.

Turfgrass quality was better in spring on sand plots while silt loam plots afforded superior quality in summer. Kentucky bluegrass populations in mixture with perennial ryegrass decreased significantly as the result of soil compaction. There was little effect from compaction and wear treatments on dry weight, leaf strength and leaf turgidity. This study will continue into 2007 to evaluate the influence of wear and compaction and their interaction on turfgrass stress.

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