CHAPTER II

THE COMPARATIVE EFFECTS OF FIVE LEVELS OF TURFGRASS MAT ON WEAR TOLERANCE OF BENTGRASS GREENS

ABSTRACT

The comparative wear tolerance of creeping bentgrass (*Agrostis palustris* Huds.) putting greens as affected by various amounts of mat accumulation was investigated using a wear simulator. Mat was defined as thatch in a state of further decomposition due to intermixing of soil from top-dressing and earthworm activity. The amount of turfgrass mat most desirable in terms of improved wear tolerance without creating detrimental effects associated with excessive mat was also assessed.

Mat depth and organic matter weight measurements were used in the selection of five greens ranging from zero to heavy mat (0, 5.6, 9.3, 21.0, 35.5 mm). Comparative wear tolerance was determined by the wear endpoint method. Verdure weight, tissue succulence, subsurface soil penetrability using a penetrometer, and total cell wall content were evaluated as potential contributing factors to wear tolerance.

The increase in mat accumulation, from zero to heavy mat, produced a 400% increase in the number of wear revolutions to reach the endpoint. The largest increase was induced by an increase in the mat from a light (5.6 mm) to a moderate (9.3 mm) level. The penetrability of the soil beneath the mat generally decreased as the wear tolerance

increased, suggesting a negative correlation. However, this was a minor response compared to the turfgrass wear aspects. Conversions of wear revolutions to time were utilized in ascertaining a desired range of mat accumulation. This study suggests the mat layer contributes to most of the wear differential on creeping bentgrass greens; and that a moderate level (8 - 10 mm or 200 - 220 mg/cm^2) of mat is most desirable.

INTRODUCTION

Wear on turfgrasses results from the direct pressure of concentrated foot and vehicular traffic causing a crushing of leaf, stem, and crown tissue of the plant. Beard (1973) reported wear tolerance to vary according to (a) turfgrass species and cultivar, (b) intensity of turfgrass culture, (c) intensity and type of traffic, and (d) the environment. Thatch accumulation, a secondary factor related to a high intensity of turfgrass culture, has also been reported to effect wear tolerance. Perry (1958) and Youngner (1961) observed that a small amount of thatch gave the turf greater wear tolerance. This is particularly desirable for golf course putting greens, bowling greens, and other heavily trafficked, close cut turfgrass areas that are without the benefit of abundant shoot growth.

Recently, several studies have been conducted involving the use of wear simulators. Except for the machine designed by Shearman et al. (1974), existing wear simulation machines are similar in that they fail to separate the effects of turfgrass wear and soil compaction. Shearman et al. (1974) designed their machine to simulate turfgrass wear while minimizing the effects of compaction during treatment. Shildrick (1971) and Wood and Law (1972) reported wear tolerance variations among Kentucky bluegrass (*Poa pratensis* L.) cultivars using their respective wear-compaction simulators. Intraspecies wear differentials were also determined for Kentucky bluegrasses by Anda and Beard (1975). Shearman and Beard (1975) reported on the relative wear tolerances of seven cool season turfgrass species determined by both sled (foot-like) and wheel (vehicular) wear injury.

This study involved the use of a wear simulator for accelerating the effects of traffic. The objectives were (1) to make a detailed assessment of the effects of various amounts of turfgrass mat on the wear tolerance of creeping bentgrass (*Agrostis palustris* Huds.) greens, and (2) to determine the amount of turfgrass mat accumulation most desirable for improved turfgrass wear tolerance. It was anticipated this information may provide the professional turfman with further insight into the importance and desirable quantity of mat for improved wear tolerance.

Mat, as defined in this study, is thatch in a state of further decomposition due to the intermixing of soil from topdressing and earthworm activity.

MATERIALS AND METHODS

Source of Mat

After an extensive search throughout the Southern Michigan area, five sites were chosen for use in this study. The sites selected represented creeping bentgrass golf course putting greens, ranging in mat depth from zero to approximately 35 mm and in organic matter weight from zero to 652 mg/cm^2. Due to the prevalent practice of topdressing putting greens for thatch control, accumulations of thatch (without soil interspersed) could not be found. Thus, this study utilizes various levels of mat accumulation. The description of the locations are summarized in Table II.1.

For the site selection process, four, 10 cm diameter plugs were sampled for determination of mat depth and organic matter weight. The aforementioned greens were chosen on the basis of a good distribution of mat depth and weight for comparison purposes.

Determination of Turfgrass Wear Tolerance

Each green was mowed at its respective cutting height just prior to the imposition of wear. The imposition of wear upon the turfs was accomplished with a wear simulator developed at MSU by Shearman, Beard, Hansen, and Apaclla (1973) through support of the USGA Green Section (Figure II.1). A wear endpoint similar to that reported by Youngner (1961) and Shearman and Beard (1975) was chosen to evaluate the mat-wear relationships. The wear tolerance was determined by the number of revolutions necessary to shread all leaf blades from the sheaths with only stems and bare soil or mat remaining. At this point the wear machine was stopped and the revolutions recorded. The procedure was repeated three times for each green and mat level. There was no moisture present on the leaves when wear treatments were imposed. No apparent disease activity was present at the time of the wear treatments which were conducted during the month of August, 1974.

Additional Parameters Measured

Not all factors affecting wear tolerance could be controlled or eliminated. The turfgrass tissue succulence was one such parameter measured at the time of wear imposition. Four leaf and stem samples from each green were placed in small (2.5 cm diameter) ground glass vials. The dry weight, obtained by oven drying at 70 C for 24 hours, was divided by the wet weight of the tissue samples. Resultant calculations were multipled by 100 to obtain a percentage value based on the wet weight of the verdure. The larger the value the more succulent the plant tissue.

Another factor measured was the relative subsurface soil compaction or resistance of the soil beneath the mat layer. This was accomplished with a penetrometer which measured the pressure in kg per cm^2 required to penetrate the soil. The penetrability of a soil zone 3.8 cm in depth, beneath the mat, was measured for this study by penetrating the device 3.8 cm beyond the mat depth. Six readings were taken per area and the pressures calculated by subtracting the mat depths from the total depths.

A third parameter, total cell wall (TCW), was determined using the method outlined by Goering and Van Soest (1970). Leaf clippings from each green were dried at 70 C for 24 hours, and ground in a Wiley Mill using a 1 mm screen. Four one-gram replicates from each green were then analyzed for TCW content using a neutral - detergent solution and a refluxing process. TCW content was then calculated on a grams TCW per gram of tissue basis.

The unworn verdure wet weights of the five greens, the fourth parameter, were determined by simply clipping the verdure from four 10 cm diameter plugs per green and weighing on a gram per unit area basis.

Data Analysis

A completely randomized block analysis of variance was made on each of the factors. Means were separated with the Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Results of the effects of various levels of creeping bentgrass mat on wear tolerance are shown in Table II.2. Wear tolerance was based on the number of revolutions to reach the predetermined endpoint. Ideally, more than three replications should be run due to the arbitrary nature of the comparable endpoint method. However, dependence on privately owned golf course putting greens dictated the extent of damage that could be imposed on these turfs. Fortunately, the variability among replications was not significant in this study.

The degree of wear tolerance differentiation among the five levels studied was significant ($r = .98$). A 650% increase, from zero, in the organic matter weight of the mat produced nearly a 400% increase, from an average of 86, in the number of revolutions required to reach the wear endpoint. The increase in organic matter weight from light (78.4 mg/cm^2) to moderate (210.5 mg/cm^2) and the increase in mat depth from 5.6 mm to 9.3 mm produced the largest percentage increase in wear tolerance (wear revolutions). Additional increments of mat caused a much slower rate of increase.

Of the additional parameters measured, the verdure weight, tissue succulence, and total cell wall content showed no significant differences among treatments. Thus, they had no significant influence on wear tolerance between or among the two cultivars (Toronto and Washington) in this study. However, the penetrability of the soil beneath the mat layer, measured with a penetrometer, showed significant differences (Table II.3.). The 20.8 kg/cm^2 measurement for zero mat accumulation is of the surface 3.8 cm and suggests a compacted soil condition due to the lack of a mat layer. The other four values are subsurface measurements which are significantly lower than the surface measurement. The general trend was for the penetrability of compaction values to decrease as the wear tolerance increased. This relationship suggests a negative correlation between the two factors ($r = -.41$). However, the decrease in penetrability by no means accounts for the very large (400%) increase in wear tolerance (simulator revolutions). Also, the difference in wear tolerance of the two cultivars was assumed insignificant based on their respective verdure wet weights and total cell wall contents. Thus, the mat layer is contributing to most of the wear differential. Based on the data presented in these two tables, the importance of mat in enhancing wear tolerance and minimizing soil compaction is evident. Although there is variability in soil and management conditions between the five greens evaluated, the large differences in mat accumulation are likely sufficient to mask this variability.

The second objective of this investigation was to determine the range of turfgrass mat accumulation (weight or depth) most desirable from a wear tolerance standpoint but not of a detrimental level. A detrimental accumulation of mat may cause proneness to mower scalping, foot printing, localized dry spots, chlorosis, increased disease and insect problems and generally poor putting quality. However, due to the intermixing of soil throughout the organic debris, problems from decreased heat, cold, and drought hardiness are essentially negated.

The average number of revolutions to reach the predetermined endpoint was converted to time (Table II.4.). The two lowest amounts of mat withstood only 10.8 and 26.5 minutes of concentrated wear, respectively. The third depth, 210.5 mg/cm^2 or 9.3 mm of mat, endured nearly 2.5 hours of simulated wear, representing the largest percentage increase. The fourth and fifth mat depths tolerated the most wear, nearly 6 and 7 hours respectively. But it is likely the point of diminishing returns was reached at the third mat depth. Rarely will a turf be subjected to concentrated traffic of such duration and intensity. However, the first two mat depths failed to provide the playing surface with adequate protection from such wear. The author also noted an incidence of foot printing and some mower scalping on the two greens with the heavier mat accumulations.

Based on these results and observations, a range of mat depth can be maintained between 8.0 mm and 10.0 mm, and mat weight in the range of 200 mg/cm^2 to 220 mg/cm^2, for improved wear tolerance without creating problems commonly associated with excessive mat accumulation on greens.

LITERATURE CITED

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Table II.1. Site descriptions summary for five creeping bentgrass putting greens utilized in the mat-wear study.

Location and Cultivar	Dunham Hills Pontiac, MI Toronto	Forest Akers E.Lansing, MI Toronto	Lake 'O The Hills Haslett, MI Toronto	Kearsley Lake Flint, MI Washington	Elks C.C. Grand Rapids, MI Washington
Mat Quantity (depth mm) (weight mg/ cm^2)	None	5.6 mm 78.4 mg/cm^2	9.3 mm 210.5 mg/cm^2	21.0 mm 450.0 mg/cm^2	35.5 mm 652.1 mg/cm^2
Date Established	1966	1970	1969	1950	1912
Soil Type and pH	Loamy sand pH 7.6	Loamy sand pH 7.6	Sandy loam pH 6.7	Loam pH 7.8	Loam pH 7.3
Traffic and Drainage	Intense Good surface and subsurface drainage	None Good surface and subsurface drainage	Light Good surface and subsurface drainage	None Good surface drainage	Light Good surface and subsurface drainage
P and K levels ($kg/100m^2$)	0.75 0.85	1.19 0.41	2.00 1.14	0.09 0.57	1.45 1.08
Mowing Culture	0.6 cm height 6 X weekly clippings removed	0.6 cm height 2 X weekly clippings removed	0.6 cm height 3 X weekly clippings removed	0.7 cm height 3 X weekly clippings removed	0.5 cm height 6 X weekly clippings removed

Table II.1. (Cont'd.)

Irrigation	As needed to prevent wilt	As needed to prevent wilt	As needed to prevent wilt, occasional mid-day syringing	As needed to prevent wilt	As needed to prevent wilt, occasional mid-day syringing
Nitrogen Fertility	Urea at 3.9 kg/100 m^2 in 8 applications	Milorganite and NH_4NO_3 at 3.4 kg/100 m^2 in 4 applications	Urea at 2.9 kg/100 m^2 in 3 applications	Milorganite, Urea and NH_4NO_3 at 5.8 kg/100 m^2 in 6 applications	Urea and Milorganite at 2.5 kg/100 m^2 in 3 applications
Pest Control	Fungicides as needed, No insecticides	Fungicides as needed, Diazinon for insect control	Fungicides as needed, No insecticides	Fungicides as needed, Chlorinated hydrocarbons for insect control	Fungicides as needed, Chlorinated hydrocarbons yearly for insect control
Cultivation and Topdressing	Annual coring with plugs removed, No topdressing, No vertical mowing	Annual coring with plugs removed, Annual topdressing at 0.59 cu m/9.3 m^2, Annual vertical mowing	Annual coring with plugs removed, Annual topdressing at 0.3 cu m/9.3 m^2, Annual vertical mowing	Annual coring with plugs retained, No topdressing, No vertical mowing	Annual coring with plugs removed, Twice annual topdressing at 0.3 cu m/9.3 m^2, Annual vertical mowing

Table II.2. Comparison of wear tolerance as influenced by five depths and weights of creeping bentgrass mat utilizing the wear machine operated until a comparable endpoint was achieved.

Organic matter* weight of mat (mg/cm^2)	Physical depth* of mat (mm)	Number of machine revolutions to reach the endpoint			
		Replication			Avg.
		I	II	III	
0	0	58	113	88	86 a**
78.4	5.6	235	221	180	212 b
210.5	9.3	1222	1176	1254	1217 c
450.0	21.0	2806	2900	2787	2831 d
652.1	35.5	3340	3301	3409	3350 e

*Values are averages of 4 replications.
**Values with the same letter are not significantly different at the 5% level, using Duncan's Multiple Range Test.

Table II.3. A comparison of penetrability as measured by a penetrometer with the wear tolerances of five levels of creeping bentgrass mat.

Levels of mat accumulation (mg/cm^2)	Avg number of revolutions to reach the endpoint	Pressure required to penetrate a zone 3.8 cm in depth beneath the mat layer (kg/cm^2)
0	86	20.8 a*
78.4	212	11.5 c
210.5	1217	14.9 b
450.0	2831	13.1 bc
652.1	3350	13.6 bc

*Values with the same letter or letters are not significantly different at the 5% level, using Duncan's Multiple Range Test.

Table II.4. Comparisons of time needed for the wear machine to reach the endpoint as influenced by five levels of creeping bentgrass mat.

Organic matter weight of mat (mg/cm^2)	Time to reach the endpoint* (minutes)
0	10.8
78.4	26.5
210.5	152.1
450.0	353.9
652.1	418.8

*Based on the average number of machine revolutions to reach the endpoint and eight revolutions per minute by the wear simulator.

Figure II.1. An overview of the wear simulator in operation. The pneumatic tire supply's a pressure of 7.2 kg dm^{-2} on the turf.