# CHAPTER I

# A COMPARATIVE EVALUATION OF FIVE THATCH MEASUREMENT TECHNIQUES ON THREE TURFGRASS SPECIES

ABSTRACT

The objective was to evaluate the reliability of five methods for the quantitative measurement of thatch on Kentucky bluegrass, annual bluegrass, and creeping bentgrass. The five measurement techniques were (1) mm compression using a "thatchmeter," (2) physical depth, (3) verdure-thatch weight, (4) nonverdure-thatch weight, and (5) water displacement. An independent and multiple correlation-regression analysis was made with the "thatchmeter" as the dependent variable.

Based on repeatability values, the thatch weight technique (verdure or nonverdure depending on the species) was determined to be the preferred method. However, it is too time consuming to be practical for field conditions. The "thatchmeter" technique ranked intermediate in repeatability with thatch depth slightly less reliable. The water displacement method had poor repeatability for all three species.

Linear correlation and regression analysis on bentgrass showed a significant (1%) relationship between the "thatchmeter" and thatch depth and weight. Verdure and pseudothatch accounted for nearly all the variability in "thatchmeter" readings on Kentucky bluegrass. Ninety-eight

percent of the variation in the "thatchmeter" measurements on bentgrass was attributed to thatch depth.

Recognizing its limitations for accuracy, the thatch depth measurement is preferred for use by the specialist in the field. However, the "thatchmeter," with further evaluation by turf professionals to establish limits of high and low resilience for various environments and grass species offers potential value as a rapid means of monitoring year-to-year thatch accumulation and resiliency characteristics of greens turfs.

# INTRODUCTION

Turfgrass thatch is a tightly intermingled layer of dead and living sclerified vascular strands of stems, nodes of stems, crown tissue, mature leaf sheaths, and roots that develops above the soil line. This dense layer of organic debris should be distinguished from an upper layer of leaf remnants hereafter termed pseudothatch. Tissues comprising the thatch layer are the most resistant to decay, while those in the pseudothatch layer decompose more readily.

Excessive thatch accumulation remains a source of detriment to the aesthetic value and playing quality of established turfgrasses for golf courses, and particularly for lawns and recreational areas. Extensive damage to the sod may result if an excessive amount of thatch is allowed to develop. The need for monitoring year-to-year thatch accumulation is apparent, as is a reliable technique of thatch measurement to serve as a research tool.

Thatch measurement techniques that have been utilized include: physical depth using a scaled ruler, organic matter weight per unit area, and compressibility using a thatchmeter. The simplest and most frequently used technique is that of a physical depth measurement. Meinhold, Duble, Weaver, and Holt (1973) employed this technique in their nitrogen carrier studies by subtracting the mowing height (6.4mm) from all thatch depth measurements. Volk (1972) and Duble and Weaver (1969) simply removed the verdure and soil prior to measuring the thatch layer with a centimeter scale.

Two versions of the weight per unit area technique have been utilized. Meinhold, et al. (1973) washed and screened the thatch plugs to remove soil prior to weighing on an analytical balance. In contrast, Ledeboer and Skogley (1967) oven dried, weighed, and then ashed the thatch at 600 C. Total organic matter was calculated on the basis of weight lost upon ignition.

Recently, a thatch measurement technique for research and field conditions was proposed by Volk (1972). Using turf springiness as an indicator of thatch development, he constructed a "thatchmeter" to rapidly and effortlessly determine the compressibility of the surface. Volk found that thatchmeter regressions of compressibility on the rate of bermudagrass (Cynodon dactylon) shoot growth and on thatch weight and depth were statistically significant (.001).

There is no information in the literature concerning the comparative accuracy and reliability of turfgrass thatch measurement techniques as used by the professional turfman or researcher. Thus, the objective of this study was to evaluate five different methods for quantitatively measuring the thatch on Kentucky bluegrass (Poa pratensis L.), annual bluegrass (Poa annua L.), and creeping bentgrass (Agrostis palustris Huds.). These three species are commonly maintained on golf courses and sports fields throughout Michigan. The methods evaluated were:

(a) Thatchmeter - as a measure of resiliency or compressibility.

(b) Physical thickness measurement - non-compressed.

(c) Verdure - thatch weight (weight/unit area).

(d) Nonverdure - thatch weight (weight/unit area).

(e) Displacement of water (volume).

## MATERIALS AND METHODS

### Source of Thatch Samples

Three locations in the Southern Michigan area were selected for the comparative evaluation of thatch measurement techniques. The sites chosen represented mature turfgrass areas under which measurable amounts of uniform turfgrass thatch had developed. The description of the locations are as follows:

1) KENTUCKY BLUEGRASS TEE: The No. 5 golf tee, a par 4 hole, at Clio Country Club, Clio, Michigan, was chosen as the test site. The cultural practices applied to this turf were representative of golf tee conditions. The 'Merion' tee was established in 1965 on an unshaded, level, but well drained site that received light traffic and divoting. Thatch uniformity was not adversely affected by the minimal divoting. The soil was a sandy loam with a pH of 7.2 and soil phosphorus and potassium levels of 0.45 and 1.96 kg/are respectively (40 and 175 lbs./Acre). The cultural practices utilized included: (a) mowing at 3.8 cm (1.5 inches) three times per week with clippings returned; (b) a Milorganite[R] and $NH_4NO_3$ nitrogen

fertility level of 2.9 kg per are per year (6 lbs./ 1000 $ft^2$) applied in 4 applications; (c) fungicide applications as necessary, no insecticides, an annual coring and vertical mowing, and an annual topdressing at the rate of 0.59 cu m/1000 $ft^2$; and (d) irrigation as needed to prevent wilt. The thatch had accumulated to a depth of approximately 19 mm (0.75 inch) and was slightly intermixed with soil from topdressing and earthworm activity.

2) ANNUAL BLUEGRASS FAIRWAY: The No. 14 fairway at LochMoor Country Club in Grosse Pointe, Michigan, was chosen as the second sampling site. It was selected on the basis of estimated predominance (85 - 90%) of annual bluegrass (Poa annua var annua Timm.) and an accumulation of 19 - 25 mm (0.75 - 1.0 inch) thatch depth. Creeping bentgrass was the other species present. The fairway site was an unshaded, level, poorly drained area that was established in 1917. The soil was a compacted clay loam with a pH of 6.3 and soil P and K levels of 0.82 and 4.86 kg/are respectively (73 and 434 lbs./Acre). The area received moderate traffic but little divoting since it was not in a landing zone. Cultural practices used included: (a) mowing three times weekly at 1.9 cm (0.75 inch) with clippings returned; (b) nitrogen fertilization with urea and inorganic sources at

a rate of 1.5 kg per are per year (3 lbs./1000 $ft^2$) applied in 3 applications; (c) pest control as needed but no insecticides used; (d) twice annual coring with cores removed but no vertical mowing; and (e) irrigation 6-7 times weekly plus frequent, light syringing to prevent midday wilt.

3) CREEPING BENTGRASS PUTTING GREEN: The third sampling site was on a seldom used practice putting green, located at Lake O' The Hills Golf Club, a par-3 golf course near East Lansing, Michigan. The 'Toronto' green was established in 1969 on a loamy sand soil, pH of 6.7, with soil P and K levels of 0.34 and 1.82 kg/are respectively (30 and 162 lbs./Acre). Drainage from the putting surface was excellent. The site was unshaded and received only light traffic. The cultural practices applied to this green included: (a) mowing at 0.64 cm (0.25 inch) three times per week with clippings removed; (b) urea nitrogen fertilization at 2.9 kg per are per year (6 lbs./1000 $ft^2$) applied in 3 applications; (c) pest control as necessary but no insecticides used; and (d) irrigation 3-4 times weekly with occasional supplemental waterings. The area received an annual coring and light topdressing and had accumulated a thatch layer of 6 - 13 mm (0.2 - 0.5 inch) thickness.

This study was conducted during the months of June and July, 1974. Each of the three locations was divided into 8 equal sized plots. The Kentucky bluegrass tee and annual bluegrass fairway were sectioned into 2.4 x 2.4 m plots. The bentgrass green was divided into smaller (1.2 x 1.2 m) plots due to limited greens area. At random, 9 thatchmeter readings were obtained and recorded on each plot for each species. Each site was mowed immediately prior to thatchmeter measurements. Then 8.35 cm (3.3 inch) diameter sod plugs were harvested from the precise spot where each of the thatchmeter readings was taken. A prototype of the thatchmeter was provided by Dr. Gaylord Volk from which a new model was constructed for use in these studies (Figure I.1).

Sample Preparation and Measurement

Preparation of the thatch samples was similar for all three species. All excess soil was removed from the bottom and sides of the sod plug and the verdure (all green plant material) carefully clipped away and placed in plastic bags for refrigeration and prevention of moisture loss. The verdure fresh weight was recorded for each sample for purposes of correlation with the thatchmeter readings. The remaining thatch and pseudothatch layers were oven dried at 70 C for 24 hours. After drying, the pseudothatch (distinct upper layer of leaf remnants) was removed leaving only the denser thatch layer. The pseudothatch dry weight was then recorded.

The physical depth measurements were taken by first making a radial cut through the thatch using a sharp razor blade. The average of three depth measurements in millimeters, taken across the face of the cut, was immediately recorded for each sample. For the three remaining techniques, the nine samples from each plot were divided as follows:

(A) samples 1-3 for verdure - thatch weight determination.

(B) samples 4-6 for nonverdure - thatch weight determination.

(C) samples 7-9 for water displacement determination.

For (A) and (B) the samples were weighed, ashed at 600 C for 10 hours, and total organic matter (thatch) calculated on the basis of weight lost upon ignition. The previously clipped verdure and pseudothatch was ashed with the thatch for (A). For (C), the surfactant, Aqua Gro, was used to reduce the surface tension resulting from total moisture removal. The recommended rate of one ounce per gallon of water proved adequate for this purpose. The milliliter rise in volume of the solution within a 100 ml graduated cylinder was recorded for each sample. The readings were taken upon complete submergence of the thatch sample. All data was entered on Fortran data punch cards for computer analysis.

## Data Analysis

A completely randomized design with nested subsamples was used in this study. A one-way analysis of variance was conducted to determine the plot variance ($\hat{\sigma}_P^2$) and sample variance ($\hat{\sigma}_S^2$). Seventy-two observations were used in the analysis for the thatchmeter, depth, verdure, and pseudothatch measurements, and 24 observations for the organic matter and water displacement techniques. The repeatability quotient (R.Q.) of the 5 methods evaluated was based on the percentage of the total variability ($\hat{\sigma}_P{}^2 + \hat{\sigma}_S{}^2$) that was due to the sampling variability.

$$(R.Q.) = \frac{\hat{\sigma}_P}{\hat{\sigma}_P{}^2 + \hat{\sigma}_S{}^2}$$

The lower the R.Q. value the less the sampling variability, thus the more repeatable or reliable the technique.

A multiple factor approach was chosen to evaluate the influence of several independent variables on one dependent variable. By utilizing both simple and multiple regression - correlation analysis, the individual and combined influence of such parameters as thatch depth, thatch weight and volume, verdure weight, and pseudothatch weight on the thatchmeter response were evaluated. The thatchmeter was chosen as the dependent variable in an attempt to determine exactly which parameters it is measuring for the tee, fairway, and greens height turfs. Scatter diagrams were made of the significant relationships between the thatchmeter and the various other factors for all three species.

To test the relationship between the thatchmeter and the other techniques the following model was utilized:

$\hat{Y} = \overline{Y} + x_1 + x_2 + x_3 + x_4 + x_5 + x_6$, where $\hat{Y}$ is the dependent variable and $\overline{Y}$ is the constant. Three multiple linear regression and correlation analysis were accomplished. Simple correlation coefficients (r), and the square of the multiple correlation coefficient ($R^2$) were computed. $R^2$, also called the coefficient of determination, will be used in discussing the results of this investigation because its value shows the fraction of the total squared variation of a dependent variable which is related to a group of independent variables.

In conjunction with the multiple regression - correlation analysis, $R^2$ was calculated for selected subsets using the principle of variable selection. The method involves selecting the independent variable whose correlation with the dependent variable is greater than any of the other independent variables. This process is repeated until the addition of an independent variable results in an increase in the multiple $R^2$ which is less than 1%. The $R^2$ values calculated by this method give an indication of which factors are the most important in predicting the variation in the dependent variable.

## RESULTS AND DISCUSSION

### Comparisons of Measurement Techniques

The relative comparisons among the five thatch measurement techniques for three species are indicated in Table I.1. The comparisons are expressed as repeatability quotient values (R.Q.), with the lowest values indicating the highest degree of repeatability. There is a significant distribution of values among the five measurement techniques. R.Q. values ranged from as low as 0.05 to as high as 1.00 (the maximum), depending on the species.

The statistical analysis for Merion Kentucky bluegrass indicated that the nonverdure-thatch weight technique had the highest reliability. The thatchmeter, thatch depth, and the verdure-thatch weight techniques ranked in an intermediate grouping. The water displacement or volume measurement had the lowest reliability for all three species. For annual bluegrass thatch, the nonverdure-thatch weight measurement was again the most repeatable with the verdure-thatch weight method ranking a close second. The thatchmeter was intermediate again but thatch depth showed extremely low reliability. For Toronto creeping bentgrass both thatch weight techniques ranked highest in reliability with verdure-thatch weight being slightly better. The thatchmeter and thatch depth techniques were intermediate in repeatability.

The statistical results of this investigation indicate that the best overall technique for measuring thatch is the thatch weight technique. The decision of whether to measure verdure-thatch weight or nonverdure-thatch weight will depend on the turfgrass species involved. For instance, the verdure-thatch weight technique was not as repeatable for Merion Kentucky bluegrass as for the other two species. Presumably, this is attributable to a larger sample-to-sample variability caused by variations in verdure density between the three species. There is a significant increase in the repeatability of the verdure-thatch weight measurement as the cutting height was decreased from Kentucky bluegrass to annual bluegrass to creeping bentgrass. Cutting height also appears to influence the repeatability of the thatchmeter technique. The water displacement method was non-repeatable for all three species.

A possible reason that the thatchmeter and thatch depth techniques have only mediocre repeatability and the water displacement technique no repeatability is due to the inability of these methods to discriminate between organic matter and inorganic matter. The thatch layer for all three species was characterized by small but varying amounts of soil intermixed throughout due to topdressing and earthworm activity. The thatch weight techniques, employing ashing of the samples, separate these organic and mineral fractions. They are a more accurate measure of the organic fraction exclusive of all inorganic constituents.

Each measurement technique varied in time and equipment needs. The thatch depth and thatchmeter techniques were far less time consuming than the other three methods. Volk (1972) found that ten thatchmeter readings could be taken on a given green, recorded, and averaged in ten minutes. However, on the bentgrass green in this study, approximately 40 minutes were needed to complete 9 such readings. A four to five minute time period for each reading was necessary to allow for settling of the leaded weight into the thatch layer. Nevertheless, in terms of total time involved and equipment needs, the thatchmeter was comparable to the depth technique.

The water displacement technique, although simple in terms of equipment needs, was more time-consuming than either the thatchmeter or thatch depth methods. As much as 30 minutes for each sample was needed to submerge the thatch layer in the surfactant solution due to trapped air pockets.

The organic matter weight technique involved both extensive equipment needs and time-consuming procedures. Separating the thatch layer, weighing on the analytical balance, ashing for 10 hours in a muffle furnace, allowing to cool, and reweighing required approximately 15 hours per set of samples. Care was also taken to avoid weight fluctuations of the oven-dry thatch and pseudothatch by utilizing a dessicator jar to prevent accumulation of moisture from the air.

At present, thatch depth would be the preferred method for utilization by the professional turfman in the field, recognizing its limitations for accuracy. However, the researcher in a lab situation who is concerned with a greater degree of accuracy and precision and not restricted by time, should utilize the technique of organic matter weight calculated on the basis of weight lost upon ignition.

Independent and Multiple Correlation and Regression Analysis of Six Parameters on the Thatchmeter.

This part of the study attempted to evaluate the "thatchmeter" as an effective measurement of thatch on cool season turfgrasses. As stated previously, the thatchmeter was chosen as the dependent variable to determine exactly which parameters it is measuring for each of the three turfgrasses. The following independent parameters were selected for use in the statistical analysis:

TD - the physical depth of thatch; measured in millimeters.

TWV - the verdure-thatch weight; measured in $mg/cm^2$.

TWNV - the nonverdure-thatch weight; measured in $mg/cm^2$.

WD - the water displacement (volume) of thatch; measured in cc.

Vd - the verdure weight; measured in $g/cm^2$.

PsTh - the pseudothatch weight; measured in $g/cm^2$.

Correlation coefficients (r) for the six parameters with the thatchmeter are listed in Table I.2. Results for all three species indicate that three parameters are positively correlated at the 1% significance level with a fourth significant at the 5% level. Volk (1972) reported a 1% significance level for regression of the thatchmeter on thatch depth and weight on 0.64 cm cut bermudagrass. This was the case for the 0.64 cm cut creeping bentgrass tested in this study. The scatter diagrams (Figures I.2. and I.3.) for the linear correlation and regression analysis on creeping bentgrass show the highly significant relationship between the thatchmeter and the thatch depth and weight (TWV). The thatchmeter measurements on Kentucky bluegrass showed significant correlation and regression with verdure measurements and pseudothatch measurements (Figure I.4. and I.5.). Figure I.6. shows a 5% level of significance for thatch depth on annual bluegrass.

A stepwise least squares program using the principle of variable selection was utilized to estimate which factor was the most important in predicting variation in the dependent variable. For Kentucky bluegrass, verdure accounted for over 46% of the variation in the thatchmeter measurements (Table I.3.). The combined effects of verdure and pseudothatch accounted for 63% of the variation while the coefficient of determination, for all six variables, accounted for nearly 70% of the variation. This major influence of verdure and pseudothatch is further supported by the simple correlation coefficients in Table I.2.

Thatch depth of annual bluegrass accounted for 36% of the variation in the thatchmeter readings with only 39% accounted for by all six variables. Table I.2. substantiates this with a correlation coefficient ($r = .33$) significant at the 5% level. Nearly all of the thatchmeter variation (98%) was accounted for by the six independent variables in the analysis on creeping bentgrass (Table I.5.). Thatch depth accounted for most of this (97.5%) with the remaining variables failing to increase the $R^2$ significantly. Again, Table I.2. further supports this strong influence of depth ($r = .98$).

Based on these results, the thatchmeter cannot be utilized as an effective thatch measurement technique on turfs mowed higher than the range of recommended cutting heights (0.5 to 0.7 cm) for golf course putting greens. The thatchmeter, as it is now designed, does not have the capacity to exert a force sufficient to compress a thatch layer, irrespective of depth, through an abundance of shoot growth. The Kentucky bluegrass turf, mowed at approximately 3.8 cm, showed a significant correlation to the thatchmeter and a high coefficient of determination for verdure plus pseudo-thatch. However, the bentgrass turf, mowed at 0.64 cm (0.25 inch), showed no relationship between the two parameters and the thatchmeter. In view of the highly significant correlation between bentgrass thatch depth and the thatchmeter, the thatchmeter may offer the field turfman a relatively rapid means of monitoring year-to-year thatch accumulation and resiliency characteristics of greens turfs. Maintenance practices could then be adjusted accordingly.

Before this technique is to have value other than for research, further evaluation should be done by turf professionals to establish compression ranges (between excessive resilience and excessive hardness) for acceptable playing quality under various environments and turfgrass species.

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Table I.1. Repeatability quotients (R.Q.) for five thatch measurement techniques on three turfgrass species.

| Species | Measurement Techniques (R.Q.)[1] | | | | |
|---|---|---|---|---|---|
| | Thatchmeter | Thatch Depth | Thatch Weight (Verdure) | Thatch Weight (Nonverdure) | Water Displacement |
| Kentucky bluegrass | 0.51 | 0.55 | 0.74 | 0.29 | 1.00 |
| Annual bluegrass | 0.55 | 0.91 | 0.29 | 0.22 | 1.00 |
| Creeping bentgrass | 0.38 | 0.40 | 0.05 | 0.15 | 1.00 |

[1]R.Q. values: lowest values indicate highest degree of repeatability.

Table I.2. Simple correlation coefficients (r) of six independent parameters with the thatchmeter as the dependent variable for three turfgrass species.

| Species | Correlation Coefficients (r) | | | | | |
|---|---|---|---|---|---|---|
| | Thatch Depth | Thatch Weight (Verdure) | Thatch Weight (Nonverdure) | Water Displacement | Verdure Weight | Pseudothatch Weight |
| Kentucky bluegrass | 0.13 | 0.05 | -0.08 | -0.06 | 0.54** | 0.35* |
| Annual bluegrass | 0.33* | 0.28 | -0.05 | -0.21 | 0.11 | 0.28 |
| Creeping bentgrass | 0.97** | 0.74** | 0.33 | 0.22 | 0.15 | 0.10 |

*Significant at the 5% level.
**Significant at the 1% level.

Table I.3. The coefficients of determination for 'Merion' Kentucky bluegrass with the thatchmeter as the dependent variable.[1]

| Independent Variable | $R^2$ |
|---|---|
| Vd | 0.467 |
| Vd + PsTh | 0.633 |
| Vd + PsTh + TD | 0.687 |
| Vd + PsTh + TD + TWV | 0.698 |
| All 6 Variables | 0.699 |

[1]Kentucky Bluegrass: TM = TD + Vd + PsTh + TWV + TWNV + WD.

Prediction Equation for Kentucky Bluegrass: $\hat{Y}$ = 13.7089 TD + 0.1429 Vd + 0.0092 PsTh + 1.9525 TWV + 0.0055 TWNV - 0.0181 WD - 7.3154.

Table I.4. The coefficients of determination for annual bluegrass with the thatchmeter as the dependent variable.[1]

| Independent Variable | $R^2$ |
|---|---|
| TD | 0.363 |
| TD + PsTh | 0.381 |
| TD + PsTh + TWV | 0.391 |
| TD + PsTh + TWV + Vd | 0.392 |
| All 6 Variables | 0.393 |

[1]Annual Bluegrass: TM = TD + Vd + PsTh + TWV + TWNV + WD.

Prediction Equation for Annual Bluegrass: $\hat{Y} = 0.4169\ TD - 0.9628\ Vd + 0.0676\ PsTh + 0.0025\ TWV - 0.0303\ TWNV + 0.0090\ WD + 5.6482$.

Table I.5. The coefficients of determination for 'Toronto' creeping bentgrass with the thatchmeter as the dependent variable.[1]

| Independent Variable | $R^2$ |
|---|---|
| TD | 0.975 |
| TD + TWV | 0.977 |
| TD + TWV + Vd | 0.978 |
| TD + TWV + Vd + PsTh | 0.980 |
| All 6 Variables | 0.981 |

[1]Creeping Bentgrass: TM = TD + Vd + PsTh + TWV + TWNV + WD.

Prediction Equation for Creeping Bentgrass: $\hat{Y}$ = 1.0091 TD - 0.9628 Vd + 0.0676 PsTh + 0.0025 TWV - 0.0300 TWNV + 0.1082 WD - 3.2981.

Figure I.1. Thatchmeter. The base has a bearing pressure of 7.3 $g/cm^2$, and the lead cylinder is loaded to 570 $g/cm^2$. Compression is read in mm with 10X magnification.

Figure I.2. Correlation and regression of compressibility of thatch on thatch depth for 'Toronto' creeping bentgrass.

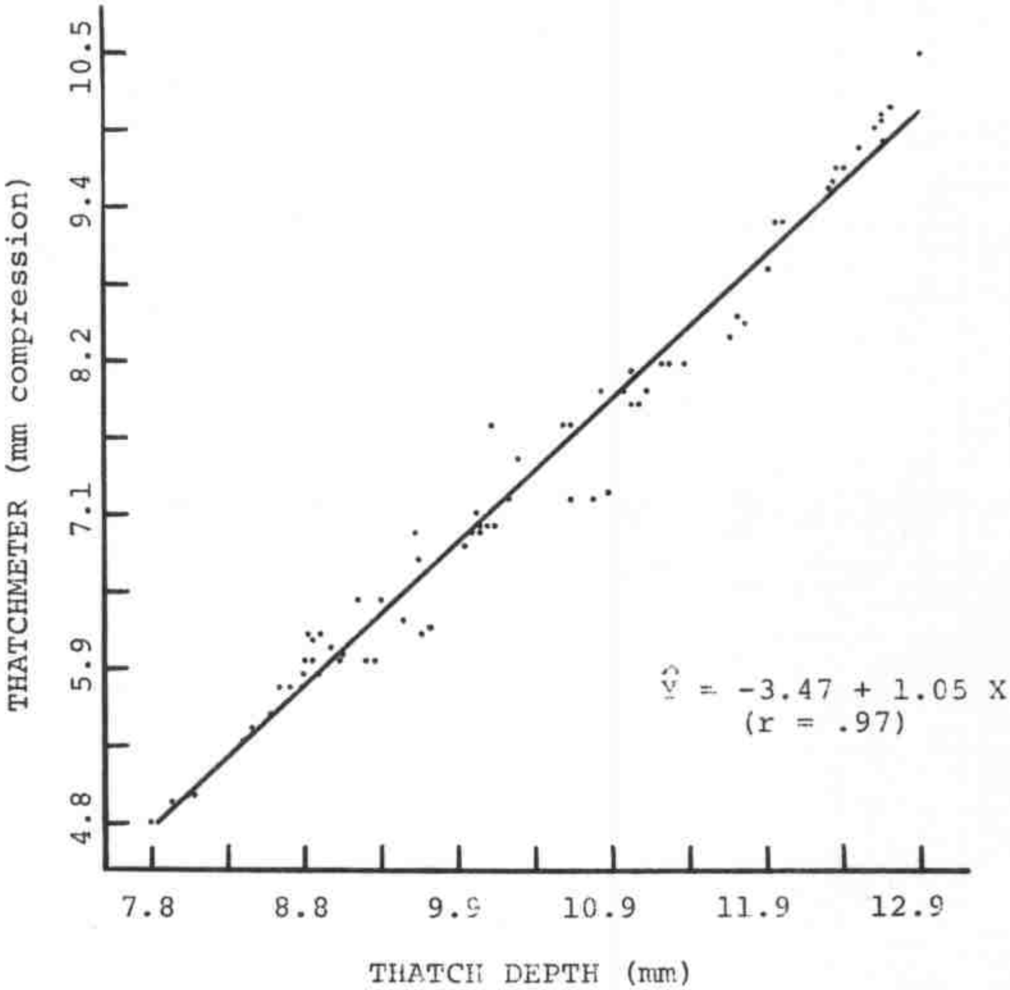

THATCHMETER (mm compression)
10.5
9.4
8.2
7.1
5.9
4.8
7.8
8.8
9.9
10.9
11.9
12.9
THATCH DEPTH (mm)
Ŷ = -3.47 + 1.05 X
(r = .97)

Figure I.3. Correlation and regression of compressibility of thatch on verdure-thatch weight for 'Toronto' creeping bentgrass.

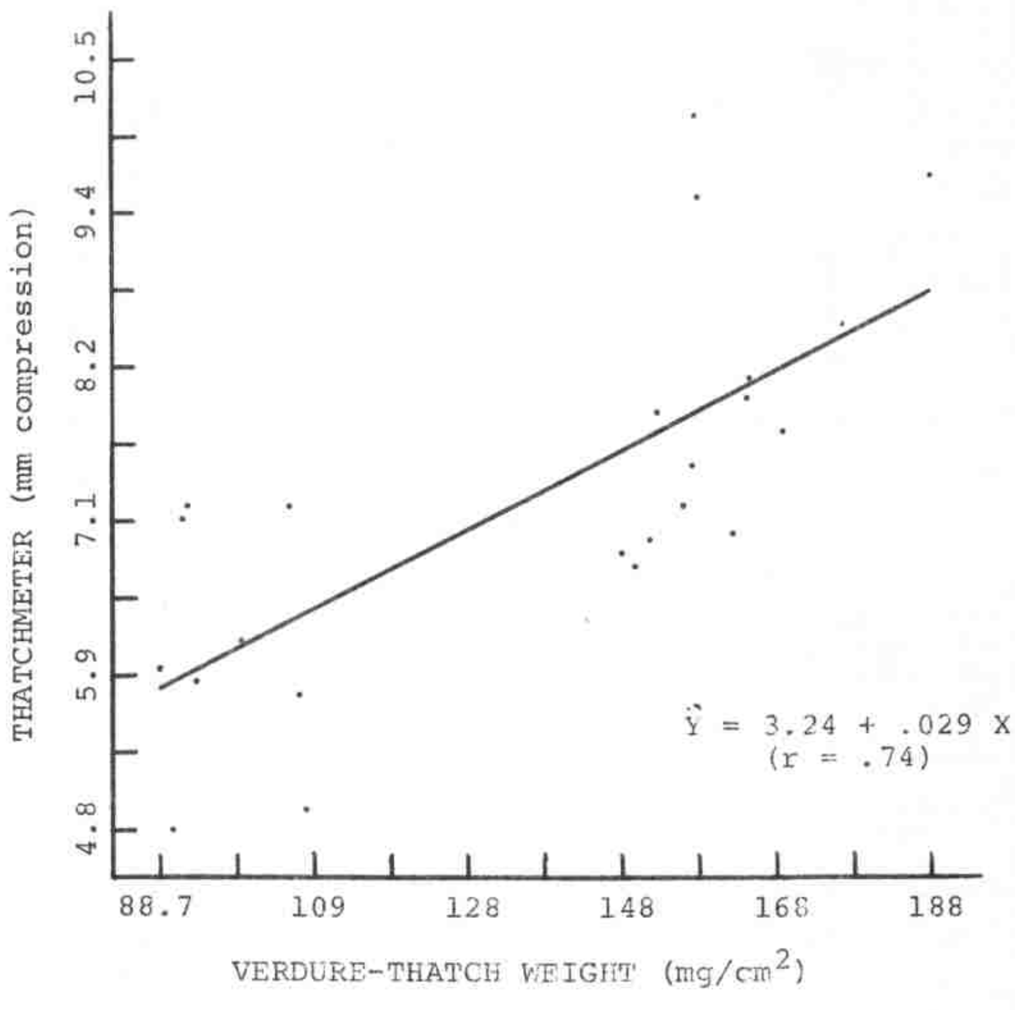

THATCHMETER (mm compression)
4.8
5.9
7.1
8.2
9.4
10.5
88.7
109
128
148
168
188
VERDURE-THATCH WEIGHT (mg/cm2)
Ŷ = 3.24 + .029 X
(r = .74)

Figure I.4. Correlation and regression of compressibility of thatch on verdure weight for 'Merion' Kentucky bluegrass.

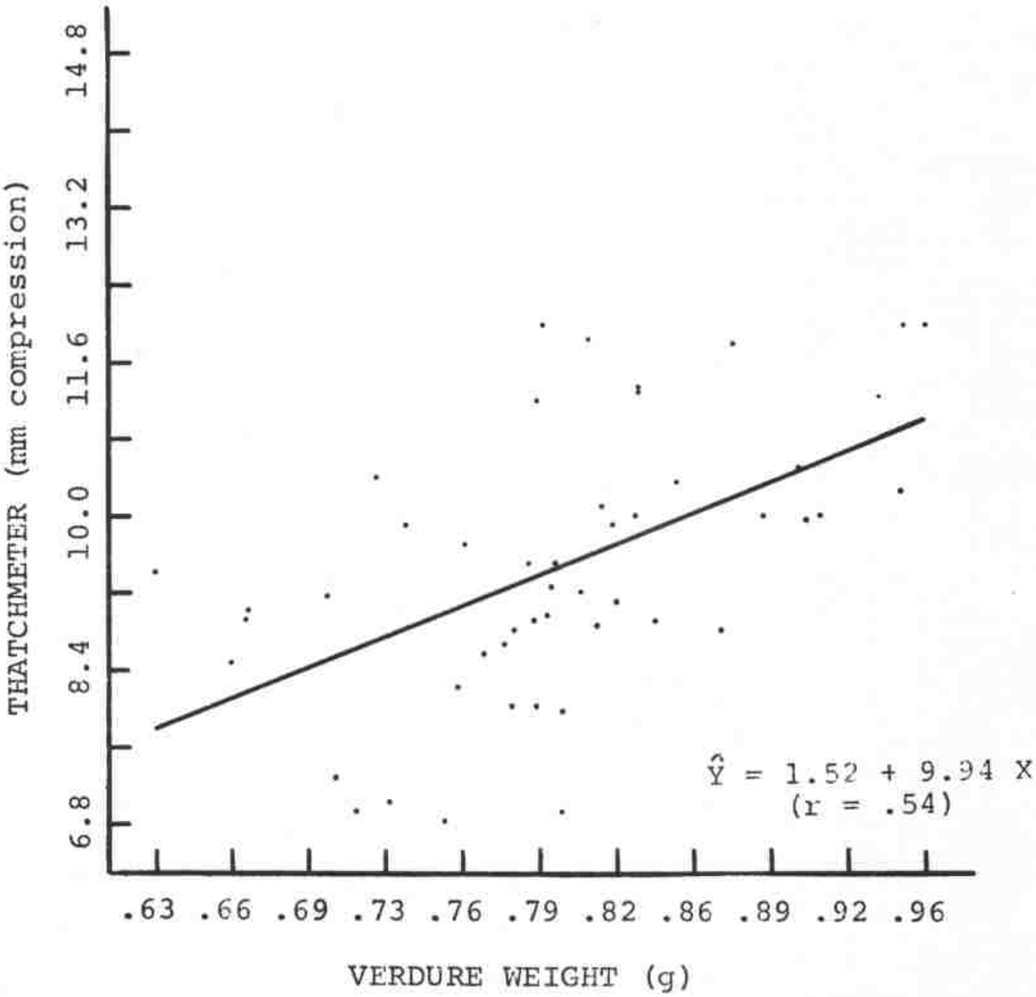

THATCHMETER (mm compression)
14.8
13.2
11.6
10.0
8.4
6.8
Ŷ = 1.52 + 9.94 X
(r = .54)
.63 .66 .69 .73 .76 .79 .82 .86 .89 .92 .96
VERDURE WEIGHT (g)

Figure I.5. Correlation and regression of compressibility of thatch on pseudothatch weight for 'Merion' Kentucky bluegrass.

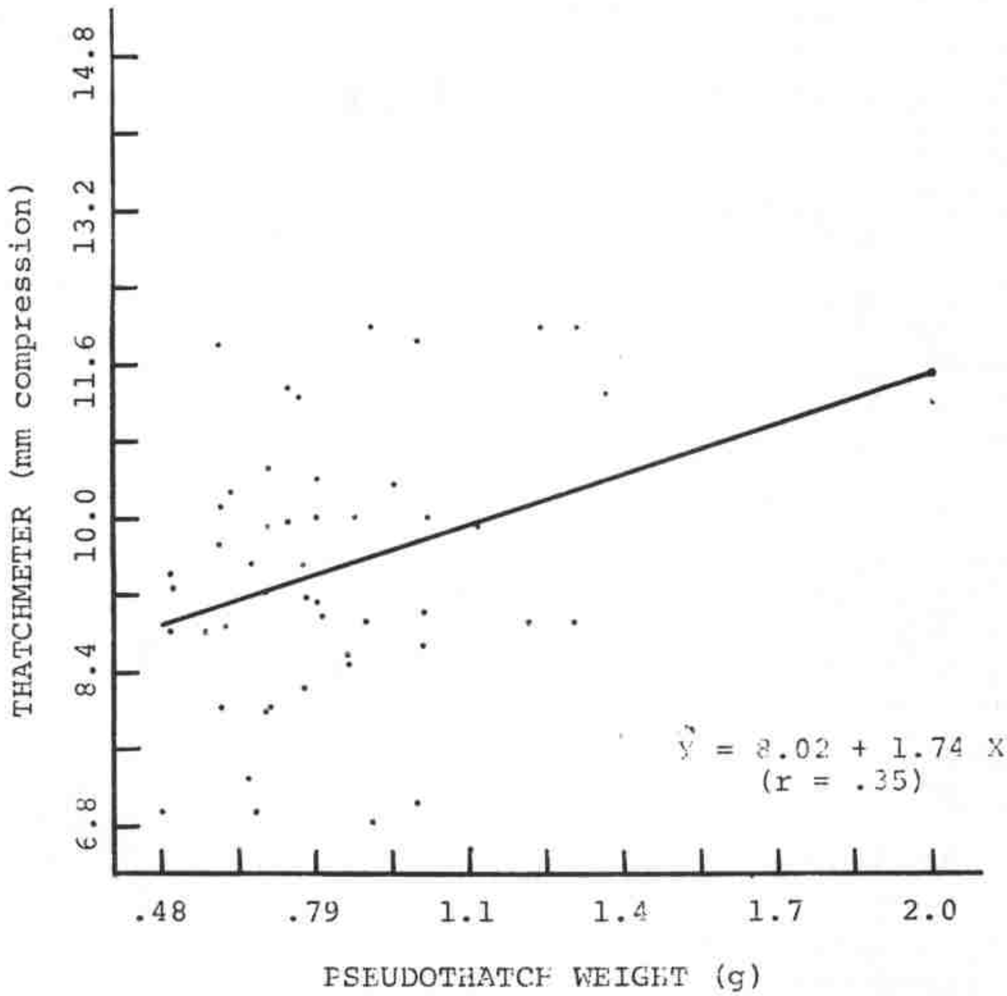
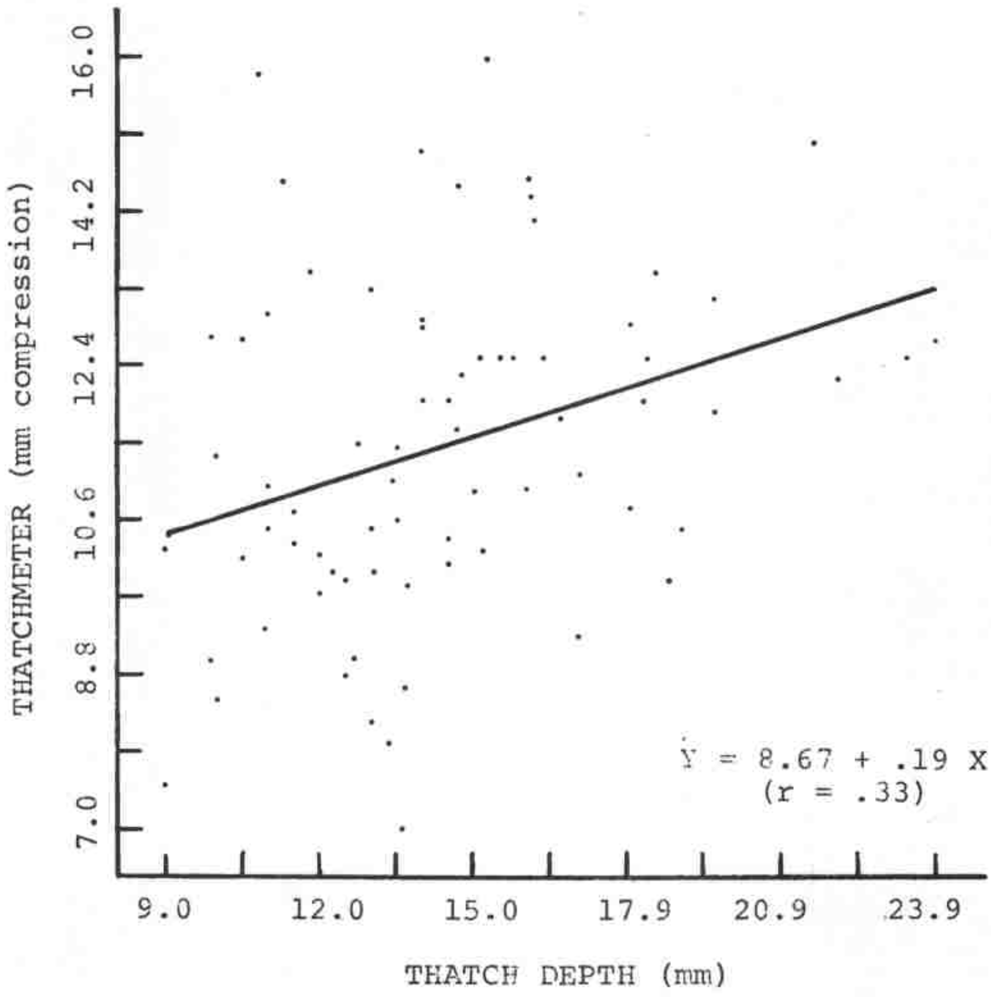

THATCHMETER (mm compression)
6.8
8.4
10.0
11.6
13.2
14.8
.48
.79
1.1
1.4
1.7
2.0
PSEUDOTHATCH WEIGHT (g)
Ŷ = 8.02 + 1.74 X
(r = .35)

Figure I.6. Correlation and regression of compressibility of thatch on thatch depth for annual bluegrass.


THATCHMETER (mm compression)
16.0
14.2
12.4
10.6
8.8
7.0
9.0
12.0
15.0
17.9
20.9
23.9
THATCH DEPTH (mm)
Y = 8.67 + .19 X
(r = .33)