CHAPTER III

THE EFFECTS OF SELECTED CULTURAL PRACTICES ON THATCH ACCUMULATION

ABSTRACT

The objective was to determine the effects of long-term turfgrass cultural practices on thatch accumulation. Three long-term studies were located and utilized in this evaluation: (a) a nitrogen-mowing height study on Wintergreen chewings fescue (Festuca rubra var. commutata) with five nitrogen levels and two mowing heights, and on Merion Kentucky bluegrass (Poa pratensis L.) with four nitrogen levels and two mowing heights; (b) a nitrogen carrier-rate-time of application study on Merion Kentucky bluegrass; and (c) a calcium arsenate study on Anhauser Kentucky bluegrass.

Sod plugs were harvested at random within each treatment, oven dried at 70 C, and the verdure and pseudothatch removed. The thatch layer was then analyzed for total organic matter on a mg/cm^2 basis.

Increased nitrogen rates from 0 to 5.8 $kg/100\ m^2$/year and higher mowing heights from 1.9 to 3.8 cm produced significant increases in thatch accumulation for both species. In the case of nitrogen, thatch differences may be largely attributed to an increase in the growth rate of the plants. Increased carbohydrate synthesis causing increased root and rhizome growth can explain the increase in thatch at higher mowing heights.

Comparisons between three nitrogen carrier classifications showed that Milorganite® was not significantly different than NH_4NO_3 in altering thatch accumulation on a long-term basis. This response likely resulted from leaching of soluble nitrogen due to heavy irrigation of the NH_4NO_3 treatment. Uramite®, a synthetic organic carrier, had an average of 25% less thatch than the other two categories.

The calcium arsenate treatment resulted in a 39% increase in thatch accumulation above the control. Herbicide inhibition of earthworm and microorganism activity in the soil and/or eradication of weedy species that would otherwise increase substrate concentration is likely causing this response.

INTRODUCTION

Cultural practices required to maintain high quality turfs are also usually conducive to increased thatch accumulation. Practices reportedly contributing to thatch problems are the use of vigorous growing cultivars, an acidic soil environment, intensive irrigation, excessive nitrogen fertilization, infrequent or excessively high mowing, and the use of certain pesticides (Beard 1973).

Many sources refer to increased thatch problems associated with high rates of nitrogen fertility. Engel and Alderfer (1967) and Engel (1967), after a 10 year study, attributed the puffiness in bentgrass (Agrostis palustris Huds.) putting greens to excessive nitrogen rates. Higher nitrogen levels increased thatch accumulation 30% on a bermudagrass (Cynodon dactylon Pers.) putting green in a short-term study by Meinhold, Dueble, Weaver, and Holt (1973). Schery (1966), on the other hand, made the general observation that fertilizer rates had little effect on thatch accumulation for Kentucky bluegrass (Poa pratensis L.) turf.

The question of whether the thatch accumulation: decomposition ratio is altered by mowing height has yet to be satisfactorily answered. Beard and Rieke (1964) reported and Schery (1966) observed a greater thatch development of Kentucky

bluegrass with a higher mowing height; however, these results could be attributed to the increased residue or pseudothatch rather than the thatch itself.

Application of certain pesticides also appears to alter this ratio by reducing fungal populations in the soil and thus perhaps affecting the rate at which thatch is decomposed (Domsch and Gams 1969). The use of the fungicides zinc ion plus manganese ethylene bisdithiocarbamate (Fore®) and tetramethylthiuram disulfide (Tersan 75) at preventive rates resulted in significant thatch increases. The same compounds, when used at lower rates, had a shoot growth retardant effect, increased microbial activity 30%, and resulted in a 16% decrease in thatch accumulation (Meinhold et al. 1973). Chlordane acts by reducing small animal, earthworm, and soil insect populations, thus decreasing the thatch decomposition rate (Beard, Eaton, and Yoder, 1973).

The nitrogen source has also been reported to influence thatch accumulation. Engel (1967) reported that urea encouraged puffiness more than activated sewage sludge or ureaformaldehyde. Meinhold et al. (1973) found similar results in their studies. Milorganite® treatments decreased thatch accumulation and lignin 12% while increasing microbial activity 3% as compared to a water soluble, $(NH_4)_2SO_4$, source of nitrogen.

The objective of this study was to locate existing, long-term turfgrass cultural studies and determine the effects of selected cultural factors on thatch accumulation.

MATERIALS AND METHODS

A search throughout the states of Michigan, Indiana, Ohio, and Illinois produced only three long-term cultural practices studies that had potential for altering the thatch accumulation: decomposition ratio. Two of these studies were located at Michigan State University's turfgrass research facilities in East Lansing and Traverse City, Michigan. The third was at Purdue University, West Lafayette, Indiana. The three studies investigated for thatch content were: (1) a nitrogen rate - mowing height study on two species; (2) a nitrogen carrier - rate - time of application study; and (3) an arsenic study.

NITROGEN RATE - MOWING HEIGHT EFFECTS

Wintergreen Chewings Fescue

The East Lansing experimental area located on a Hodunk fine sandy loam soil with a pH of 7.3 was seeded to Wintergreen chewings fescue (Festuca rubra var. commutata Gaud.) in September, 1966. Internal soil drainage was good. Soil phosphorus and potassium levels were adequate so no P or K was applied at establishment. The experimental design was a split-plot randomized block with three replications using 1.5 x 2.1 m plots. Cultural treatments utilized on the site

included: (a) mowed twice weekly with reel mowers at mowing heights of 1.9 and 3.8 cm with clippings removed; (b) nitrogen fertility levels of 0, 1.0, 1.9, 3.9, and 5.8 kg N per are per year applied as ammonium nitrate, 20% during each month of April, May, August, and September, and 10% each in June and July of each year. General cultural practices used included: (a) deep irrigation as needed to prevent wilt; (b) no topdressing or cultivation; (c) applications of 2,4-D and dicamba at the recommended rate for control of broadleaf weeds in May, 1972 and September, 1973; and (d) no fungicides or insecticides.

Merion Kentucky Bluegrass

This study was also located at an East Lansing site that was unshaded and seeded to Merion Kentucky bluegrass (Poa pratensis L.) on September 29, 1965, on a Hodunk fine sandy loam soil with a pH of 7.3. Nitrogen treatments were initiated in April 1967. The experimental design had three replications with a split-plot randomized block arrangement using 1.5 x 2.1 m plots. No phosphorus or potassium was applied at establishment since both levels were considered adequate. Internal drainage was good. The specific cultural treatments employed on this site were identical to those utilized in the study on Wintergreen with two exceptions. The 1.0 kg N per are rate was not sampled in this study; and applications of herbicide were in May of 1973 and 1974.

NITROGEN CARRIER - RATE - TIME OF APPLICATION EFFECTS

The Northern Michigan MSU Turfgrass Research Area, located on a Rubicon sand soil, pH of 6.4, at Traverse City, Michigan, was the site for this investigation. Plots, 1.5 x 2.1 m, were established from Merion Kentucky bluegrass seed on May 5, 1963, utilizing a randomized block design with two replications. Treatments were initiated in April, 1964. The cultural practices utilized were (a) heavy irrigation; (b) mowing with a reel mower twice weekly at a 2.5 cm height with clippings returned; (c) 2.4-D and dicamba applied once per year at the recommended rate for broadleaf weed control, but no fungicides or insecticides; (d) phosphorus and potassium applied as needed based on soil tests; and (e) no cultivation or topdressing. The nitrogen source - rate - time of application treatments are listed in Table III.1.

ARSENIC EFFECTS

The turfgrass research facility at Purdue University was the site for this study covering the effects of a pesticide on the thatch accumulation: decomposition ratio. Three plots, 3.6 x 18.0 m, were seeded to Anhauser Kentucky bluegrass on April 5, 1965 on a well-drained sandy loam soil. Treatment with calcium arsenate (2.4 kg/100 m^2) was initiated at establishment on two of the plots. The third plot served as a control. In 1966, 2.1 kg/100 m^2 of calcium arsenate were applied. In 1967, 68, and 71, 1.0 kg/100 m^2 was applied with the plots receiving .7 kg/100 m^2 in 1972, 73, and 75. No treatments were made in

1969, 70, and 74. Soil phosphorus and potassium levels were 1.0 kg/100 m^2 and 3.9 kg/100 m^2 respectively for treated plots, 0.7 kg/100 m^2 and 3.4 kg/100 m^2 respectively for the control plot, and a pH of 7.1 for all plots. The cultural practices employed on this site were (a) mowing height of 1.9 cm three times weekly with clippings returned; (b) nitrogen fertilization of 1.9 kg/100 m^2 per year; (c) irrigation as needed to prevent wilt; and (d) coring in the fall of the year but no topdressing.

Thatch Sampling and Evaluation

All studies were collected the last two weeks of September, 1974, and analyzed within 30 days. Two sod plugs, 8.3 cm in diameter, were collected with a cup cutter randomly from each replication of each treatment. Four samples were collected from each treatment for the arsenic study. The samples were oven dried at 70 C for 24 hours, excess soil removed, and the verdure plus pseudothatch clipped away. The separated thatch layer was then analyzed for total organic matter. The weight per unit area was recorded for each sample. Additionally, soil samples were taken from all treatments for pH, phosphorus, and potassium determinations.

Data Analysis

A completely randomized block analysis of variance was made on each of the studies. The means were separated by either LSD or Duncan's Multiple Range Test. Planned comparisons were made of several subsets of the nitrogen carrier study to better determine the treatment effects.

RESULTS AND DISCUSSION

Nitrogen Rate-Mowing Height Study

WINTERGREEN CHEWINGS FESCUE

The results of the long-term (8-year) effects of five nitrogen rates and two mowing heights on thatch accumulation are presented in Table III.2. An increase in the nitrogen rate resulted in a significant increase in thatch weight over the 8-year period. Thatch accumulation increased nearly 200% from the lowest (0 kg/are) to the highest (5.8 kg/are) nitrogen rate at both mowing heights.

MERION KENTUCKY BLUEGRASS

Thatch accumulation in the Kentucky bluegrass turf was also increased by higher nitrogen rates and mowing height (Table III.3.). The increase in thatch weight was significant for each increase in main plot and subplot treatments. A nitrogen rate increase from 0 to 5.8 kg/are resulted in 180% increase in thatch weight at the lower (1.9 cm) mowing height, and 160% at the higher (3.8 cm) height.

These data on chewings fescue and Kentucky bluegrass are similar to the results of Engel and Alderfer (1967) and Meinhold et al. (1973) whose studies on creeping bentgrass and bermudagrass, respectively, supported the concept that increased

thatch problems are associated with high rates of nitrogen fertility. In each case, these results have been attributed to a general increase in the total growth rate of the turfgrass plant. Results of the soil pH analysis conducted on these plots perhaps indicate an additional factor attributing to increased thatch weight at the 5.8 kg/are nitrogen level. The soil pH values at this rate were 6.0 and 5.7 for Wintergreen chewings fescue and Merion Kentucky bluegrass respectively. The pH values increased sharply as the nitrogen rates decreased from the 5.8 kg/are level. Increased soil acidity is associated with a higher nitrogen rate when acidifying nitrogen carriers are used. An acidic soil environment is conducive to thatch accumulation (Engel and Alderfer 1967).

The reason for increased thatch accumulation at higher mowing heights is not as readily evident. Engel (1969) reports that at higher mowing heights the "so called" thatch often appears trash-like rather than thatch-like in nature. Recognizing the validity of this observation, this trash-like material (pseudothatch) was removed prior to the organic matter determination. Increased thatch accumulation still occurred. The increase at higher mowing heights can be largely explained by the increased leaf area available for carbohydrate synthesis which, in turn, results in increased root growth rate and total root production, plus increased rhizome growth. Lateral stems, roots, leaf sheaths, nodes, and crown tissues are reported to be the most decay resistant; and thus comprise the major portion of the physical structure of thatch (Ledeboer and Skogley - 1967).

Nitrogen Carrier - Rate - Time of Application Study

Thatch accumulation comparisons among 12 nitrogen treatments are shown in Appendix Table 1. Among the carriers with one, two, and three applications per year at the same nitrogen rate, there appears to be no significant relationship between frequency of application and thatch accumulation with one exception (Table III.4.). The plot treated with Uramite®, one application per year, accumulated more thatch than either the two or three applications per year treatment. A greater flush of growth with only one application of Uramite® would explain this differential. The three applications per year treatment had the least thatch.

A planned, orthogonal comparison was made on the three nitrogen carrier classifications - synthetic inorganic, natural organic, and synthetic organic - as to their effect on thatch accumulation (Table III.5.). It was necessary to pool the three means of 1, 2, and 3 applications per year for each carrier to make this comparison. Contrary to expected results, the natural organic carrier, Milorganite®, was not significantly different than the inorganic carrier, ammonium nitrate, in effecting thatch accumulation. Meinhold, et al. (1973) reported Milorganite® treatments on a bermudagrass green reduced thatch accumulation significantly as compared to the inorganic carriers. The leaching of soluble nitrogen due to heavy irrigation of the plots is a possible explanation for the low response of thatch weight to the inorganic carrier (NH_4NO_3) in this study. The response of the synthetic organic

carrier, Uramite®, was lowest (25%) of the three nitrogen sources. Presumably, this response results from a decreased growth stimulation during cooler weather associated with water-insoluble, temperature-activated nitrogen carriers. The low efficiency of Uramite® may also be a contributing factor.

Arsenate Study

The long-term effects of calcium arsenate on thatch accumulation are shown in Table III.6. Calcium arsenate is responsible for a significant increase (39%) in thatch weight compared to the untreated control. Apparently, the pesticide is either inhibiting small animal (earthworm) and microorganism activity in the soil, or increasing the substrate concentration via eradication of weedy grasses, thus enabling the desirable species to proliferate above that of the untreated control plot.

LITERATURE CITED

Beard, J.B. 1973. Turfgrass: Science and Culture. Prentice Hall, Inc., New York. 658 pp.

Beard, J.B. and P. Rieke. 1964. Management factors in thatch formation in Merion. MSU Turf Field Day Report, p. 8.

Beard, J.B., W.J. Eaton, and R.L. Yoder. 1973. Physiology research: chemical growth regulators, water use rates, thatch causes, and low temperature kill. Fourty-third Annual Michigan Turfgrass Conf. Proc. 2:27-33.

Domsch, K.H. and W. Gams. 1969. Variability and potential of a soil fungus population to decompose pectin, xylan, and carboxymethylcellulose. Soil Biol. Biochem. 1:29-36.

Engel, R.E. 1967. A note on the development of puffiness in 1/4-inch bentgrass turf with varied nitrogen fertilization. Report on Turf Res. at Rutgers Univ. - N.J. Ag. Exp. Sta. Bulletin 818, pp. 46-47.

_____. 1969. Thatch, cultivation, and topdressing of closely-cut turf. Proc. First Intern. Turfgrass Res. Conf. pp. 496-501.

Engel, R.E. and R.B. Alderfer. 1967. The effect of cultivation, topdressing, lime, nitrogen, and wetting agent on thatch development in 1/4-inch bentgrass over a 10-year period. Report on Turf Res. at Rutgers Univ. - N.J. Ag. Exp. Sta. Bulletin 818, pp. 32-45.

Ledeboer, F.B., and C.R. Skogley. 1967. Investigations into the nature of thatch and methods for its decomposition. Agron. J. 59:320-323.

Meinhold, V.H., R.L. Duble, E.W. Weaver, and E.C. Holt. 1973. Thatch accumulation in bermudagrass turf in relation to management. Agron. J. 65:833-835.

Schery, R.W. 1966. Remarkable Kentucky bluegrass. Weeds, Trees and Turf. 5:16-17.

Table III.1. Traverse City fertility study on Merion Kentucky bluegrass.

Nitrogen Source	Total Kg N per are per year	Applications per year	Kilograms of Nitrogen per are					
			4/15	5/15	6/15	7/15	8/15	9/15
NH_4NO_3	1.9 (4)[1]	6	0.32	0.32	0.32	0.32	0.32	0.32
NH_4NO_3	3.9 (8)	6	0.65	0.65	0.65	0.65	0.65	0.65
NH_4NO_3	5.8 (12)	6	0.96	0.96	0.96	0.96	0.96	0.96
NH_4NO_3	3.9 (8)	1	3.90					
NH_4NO_3	3.9 (8)	2	1.95				1.95	
NH_4NO_3	3.9 (8)	3	1.30		1.30		1.30	
Milorganite®	3.9 (8)	1	3.90					
Milorganite®	3.9 (8)	2	1.95				1.95	
Milorganite®	3.9 (8)	3	1.30		1.30		1.30	
Uramite®	3.9 (8)	1	3.90					
Uramite®	3.9 (8)	2	1.95				1.95	
Uramite®	3.9 (8)	3	1.30		1.30		1.30	

[1]Number in parenthesis equals total lbs/1000 ft^2/year.

Table III.2. Long-term (7-year) effects of nitrogen and mowing height on the accumulation of thatch in Wintergreen chewings fescue.

Nitrogen Rate (kg/are/year)	Mowing Height (cm)	Thatch Weight (mg/cm^2)
0	1.9	42.0*
	3.8	51.8
1.0	1.9	55.9
	3.8	74.6
1.9	1.9	71.7
	3.8	84.8
3.9	1.9	90.4
	3.8	109.7
5.8	1.9	105.5
	3.8	123.0

LSD .05 = 27.46**
LSD .05 = 18.65***

*Values are means of 3 replications with 2 subsamples per treatment.
**LSD for comparison between main plot nitrogen treatments.
***LSD for comparison between subplot mowing height treatment.

Table III.3. Long-term (7-year) effects of nitrogen and mowing height on the accumulation of thatch in Merion Kentucky bluegrass.

Nigrogen Rate (kg/are/year)	Mowing Height (cm)	Thatch Weight (mg/cm^2)
0	1.9	60.9*
	3.8	72.1
1.9	1.9	81.7
	3.8	94.8
3.9	1.9	130.3
	3.8	144.4
5.8	1.9	171.7
	3.8	187.1

LSD .05 = 8.38**
LSD .05 = 7.34***

*Values are means of 3 replications with 2 subsamples per treatment.
**LSD for comparison between main plot nitrogen treatments.
***LSD for comparison between subplot mowing height treatments.

Table III.4. Long-term (10-year) effects on thatch accumulation from three nitrogen carriers at 3.9 kg N per are and 1, 2, or 3 applications per year.

Nitrogen Carrier	Applications/ year	Thatch Weight (mg/cm^2)
Uramite^R	1	157.5 ab*
	2	148.1 a
	3	142.3 a
NH_4NO_3	1	169.3 abc
	2	196.5 bc
	3	177.5 abc
Milorganite^R	1	181.7 abc
	2	183.2 abc
	3	201.5 c

*Values with the same letter in a column are not significantly different at the 5% level, using Duncan's Multiple Range Test. Values are means of 4 observations.

Table III.5. The long-term (10-year) effects on thatch accumulation from three nitrogen carrier classifications pooled over 1, 2, and 3 applications per year at 3.9 kg N per are.

Classification (Carrier)	Thatch Weight (mg/cm^2)
Synthetic organic (Uramite^R)	147.3 a*
Inorganic (NH_4NO_3)	180.9 b
Natural organic (Milorganite^R)	188.8 b

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

Table III.6. The long-term (9-year) effect of calcium arsenate on the accumulation of thatch in Anhauser Kentucky bluegrass.

Treatment	Thatch Weight (mg/cm^2)
Control	130.4 a*
Arsenate	180.9 b

*Values with the same letter in a column are not significantly different at the 5% level, using Duncan's Multiple Range Test. Values are means of 8 observations.

Appendix Table 1. Long-term (10-year) effects of 12 fertility treatments on Merion Kentucky bluegrass thatch accumulation.

Nitrogen Carrier	Nitrogen Rate (kg/are/year)	Applications/ year	Thatch Weight (mg/cm^2)
Uramite^R	3.9	1	157.5
	3.9	2	148.1
	3.9	3	142.3
NH_4NO_3	1.9	6	153.1
	3.9	6	160.7
	5.8	6	197.8
	3.9	1	169.3
	3.9	2	196.2
	3.9	3	177.5
Milorganite^R	3.9	1	181.7
	3.9	2	183.2
	3.9	3	201.5