

TURFGRASS TRENDS

Volume 7, Issue 9 • September 1998

AGRONOMICS

Thatch control in bentgrass greens

The influence of cultural & chemical controls on rootzone nutrients

By Lloyd M. Callahan, University of Tennessee

Thatch accumulation naturally occurs at many managed turfgrass sites, however if it accumulates excessively it can seriously impede the health and long-term survival of densely grown turfgrasses such as on putting greens, so controlling thatch buildup is important. Thatch is defined as a tightly intermingled layer of dead and living stems, leaves, and roots that accumulates between the green vegetation and the soil surface.

Accumulation of thatch is a direct result of intensive management which causes the rate of plant organic matter (OM) accumulation to exceed the natural degradation process. Thatch accumulation has been reported to be favored by acid soils except where calcium (Ca) was applied. Thatch accumulation rate was found to be approximately twice as great below pH 4.0 as above 5.0. The presence of Ca, applied as calcium hydroxide, and the suppressive effect it has been shown to have, suggests that Ca might be a major factor involved in thatch decomposition under acidic conditions.

There are considerable differences of opinion as to what cultural practices, chemical treatments, or treatment combinations are most effective in controlling thatch when highly maintained at sites like a golf course. These differences are broad-based and cover the spectrum of management strategies.

Some researchers have observed that mechanical practices like core aeration are effective in reducing thatch alone or in combination with either vertical mowing or limestone applications. Others have reported little or no benefit of coring on thatch levels. Vertical mowing has also been shown to effectively reduce thatch in some studies, but has been ineffective in others. Likewise, frequent topdressing with sand or a high sand content soil mixture reduced thatch when performed alone or in combination with coring and vertical mowing, while others have reported no effect of topdressing on thatch.

Limestone has been used in some studies to maintain a favorable thatch pH to enhance microbial activity to speed thatch decomposition, but in still other studies, limestone application had no effect on thatch. Even extra potassium (K) and wetting agent treatments have been tested, but were also reported to be ineffective in reducing thatch.

This variance in results was less surprising when you consider that all of these previous tests were conducted on a variety of grasses grown on soil rootzones under an assortment of management strategies - from six tests on bermudagrass greens and one lawn to three on bentgrass greens, one on a bentgrass fairway, and two on Kentucky bluegrass lawns.

To bring some semblance of order to this diversity of hosts, management practices, and

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Editor

Terry McIver
440-891-2709; 440-891-2675 (fax)
turfgrasstrends@advanstar.com

Production Manager

Karen Lenzen
218-723-9129; 218-723-9576 (fax)
klenzen@advanstar.com

Circulation Manager

Frank Christopherson
218-723-9271

Layout & Production

Bruce F. Shank, BioCOM
805-274-0321

Group Editor

Vern Henry

Group Publisher

John D. Payne
440-891-2786; 440-891-2675 (fax)
jpayne@advanstar.com

Corporate Office

7500 Old Oak Blvd.
Cleveland, OH 44130-3369

Editorial Office

7500 Old Oak Blvd.
Cleveland, OH 44130

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results we conducted a six-year study at the University of Tennessee. We compared the effectiveness of the most commonly used mechanical practices and certain chemical/nutrient treatments in controlling thatch on a creeping bentgrass green constructed to USGA specifications. Determinations were also included to assess the influence of these mechanical and chemical/nutrient treatments on the content of selected nutrients and the pH level of the USGA green rootzone.

Treatments Used

Cultural practices and chemical/nutrient control treatments were conducted on a Penncross bentgrass research green constructed at Knoxville, TN, expressly for the purpose of conducting these thatch control studies. The green was constructed to 1973 USGA specifications (9), except that the 1.5 inch thick intermediate coarse sand layer was omitted. An initial laboratory analyses of the 12-inch rootzone showed a composition of 95.3 percent sand (63 percent fractions between 0.25- and 0.5-mm diameters), 3 percent silt, 1 percent clay, and 0.7 percent OM by weight. Analysis of the rootzone mixture also showed 36 percent capillary and 16 percent noncapillary pores, a bulk density of 1.41 g cm³, and infiltration and percolation rates of 9 inches per hour.

Dolomitic limestone and a 6-12-12 analysis fertilizer were thoroughly mixed into the rootzone giving an initial soil test of the top 6 inches of a pH 6.6, 60 lb/A phosphorus (P), 190 lb/A K, and 3563 lb/A Ca. Nitrogen (N) was ammonium nitrate, P was superphosphate, and the K was muriate of potash. Limestone treatments were not made after the initial application.

The green was fumigated with methyl bromide to eradicate nematodes, fungi, insects and weed seed, and seeded with Koban treated Penncross bentgrass in September. The first research treatments were made the following March.

Maintenance fertilization and height of mowing was uniform across the green. Nitrogen rates and mowing height were not

used as treatment variables. Bentgrass annual maintenance fertilization (excluding extra K that was used as one of the main experimental treatments) totaled 263 lb/A N, 38 lb/A P, and 146 lb/A K.

Nitrogen applications were divided equally among March, April, May, September, October and November of each year. Annual phosphate and potash applications were divided equally among March, April, September, and October.

The green was mowed daily, Monday through Friday, with a greensmower at 6-mm-cutting height with clippings caught and removed. The green was irrigated with 1-inch of water Monday, Wednesday, and Friday, unless it rained, between June and September.

Fungicides and insecticides were applied as needed to control diseases and insects. No additional chemical or mechanical thatch control maintenance treatments were applied to the green throughout the entire period of these investigations except those applied as treatments.

Annual repeat test treatments, and their respective abbreviations in brackets, were:

- (1) vertical mowing, 4 times (VM 4x)
- (2) vertical mowing, eight times (VM 8x)
- (3) core (or coring) aerification, four times
- (4) vertical mowing plus coring, both four times (VM + core)
- (5) a wetting agent, seven times (Wet Ag)
- (6) extra K, four times (K)
- (7) hydrated lime, four times (L)
- (8) K plus lime, both four times (K+L)
- (9) vertical mowing plus extra K, both four times (VM+K)
- (10) vertical mowing plus lime, both four times (VM+L) and
- (11) vertical mowing plus extra K and lime, all applied four times per year (VM+K+L).

Three sub-plots crossed the main treatments and consisted of sand topdressing three (Tpd 3x) and six (Tpd 6x) times per year, and a no topdressing strip. Thus, each replication comprised a total of 36 individual plots.

Bentgrass stand density determinations were by monthly visual assessments in each sub-plot based on 0 to 100 percent. Main

plot treatments of vertical mowing were performed with solid blades spaced one inch apart, slicing just above the soil surface, and with the raised plant debris removed immediately with a power vacuum. VM treatments were done in March, May, September, and October. Treatments applied eight times per year were done in March, April, May, June, August, September, October, and November.

Coring was performed with a power core aerifier with 0.25 inch diameter tines, two inches apart, and cutting to a depth of approximately three inches. Cores were allowed to air-dry for several minutes and then removed with a power vacuum. Coring treatments were applied in April, May, September, and October.

A non-ionic Wet Ag (Aqua-Gro) was applied annually in March, April, May, June, September, October, and November in a water dilution. Extra K, as muriate of potash, was applied at 36 lb/A in March, April, September, and October to provide 144 lb/A K annually.

Hydrated lime was applied in March, April, September and October at 218 lb/A in a water suspension.

A soil test was conducted at the end of the six-year test period at the 0 to 3-inch and 3- to 6-inch rootzone depths for determinations of Ca, K, P, and pH. Topdressing treatments applied three times per year were done in April, May, and September. Topdressing applied six times per year were done in April, May, June, August, September, and October.

Thatch depth was measured with a thatchmeter in June, August, and November for all six years of the study. The thatchmeter was selected over the ruler and total OM by loss-on-ignition methods because it proved to be the most sensitive, consistent, reliable, and fastest of the three methods investigated in a previous comparative study (4). The thatchmeter used was the "Thatchmeter II" developed by Volk.

Earthworm counts, pesticide treatments, other than maintenance treatments, and variable N rates were not used. Furthermore, the potential for confounding influences from surface and soil feeding insects was removed from these studies with the use of three different insecticides.

Thatch development at the test site - All 13 individual and combination treatments for thatch control began approximately seven months (in March) after construction was completed and the green was seeded to Penncross bentgrass (the previous September). Depth of thatch was approximately 3.5 mm when treatments began.

Thatch accumulation was variable between replications as measured by both the ruler and thatchmeter during the first three years of the newly constructed green as thatch began its initial buildup. By year four, all ruler and thatchmeter readings appeared consistent among samples within plots and between replications. Thus, discussion of results will only be presented for the last three years of the six-year study. Ruler measurements are only shown for consistency from the start of the study. Thatch depth by ruler measurements in non-treatment control (check) plots in March was 10.2, 12.7, and 14.8 mm for years 4, 5, and 6 respectively.

Thatch depth measurement values were consistently higher in June for every main plot treatment than corresponding values taken in November. Moisture content of grass leaves and the thatch was low in August and resulted in erratic results, probably due to higher temperatures and drier conditions, hence August was judged a poor time to make accurate measurements (see Table 1).

Thatch Control

The results listed in Table 1 of measurements conducted in June show the most effective main treatment methods of reducing thatch level (5.68-6.21 mm) were:

- VM alone at both 4 and 8x/yr
- VM + core, both conducted 4x/yr.

Thatch reduction increased as frequency of Tpd increased, except under the three K treatments regimen (see Table 2). AT the higher amount of Tpd (6x), treatments

The University of Tennessee conducted a six-year study to compare the effectiveness of commonly used mechanical practices and selected chemical/nutrient treatments in controlling thatch on a creeping bentgrass green constructed to USGA specifications.

receiving extra K (VM+ K + L, K + L, K) appeared by visual observations to result in an increase in size, and possibly numbers, of stolons which may have resulted in an increase in thatch depth readings.

Least squares analysis showed no difference between VM 4x and 8x and VM + Core treatments under no Tpd. However, all main plot treatment effects exhibited lower values than untreated plots, except WetAg under 3x and 6x Tpd.

When lower amounts (3x) of Tpd was applied (April, May, and September) results were confounded and there were no differences among most main plot treatments, except for the individual treatments of Core, L, and Wet Ag (Table 2). Again there was no difference between VM 4x and 8x and VM + Core, but the confounding effect of K was removed and the non-significant main plot treatments included VM + L, instead of VM + K + L. Hydrated lime treatments did not influence thatch depth. The greatest decrease in thatch depth were observed on turf receiving large amounts of Tpd treatment (6x) plus VM (4x and 8x) and VM + Core (Table 2).

When comparing least squares analysis for Tpd frequency, both small (3x) and large (6x) amounts of Tpd significantly reduced thatch, as compared with no Tpd (Table 3). The largest amount of Tpd (6x) decreased thatch the most.

Lowest non-significant levels of thatch, or the highest level of thatch control, from cultural treatments resulted following VM 4x or 8x/yr and VM + coring. Tpd 3x or 6x/yr also effectively prevented thatch buildup.

Effects of Chemical/Nutritional Treatments on Thatch and rootzone nutrient levels The following discussions regarding levels of Ca, K, and P refer only to nutrient amounts in the rootzone reflected in the soil samples. No distinction is made as to what portion were removed by the plant nor what portion was lost through leaching. No leaf tissue analyses were conducted.

Potassium Effects

Several researchers reported that K did not influence thatch accumulation. However, they conducted their studies for only 1 year and indicated that K might affect thatch accumulation over a period of years. Extra K treatments were included in this study not only to determine if K contributes to either an increase or decrease in thatch buildup, but also to determine if K has any influence on bentgrass recovery following mechanical treatment thinning for thatch control.

The initial soil test K level was 190 lb/A, plus six years of annual maintenance fertilizer providing 873 lb/A, combined with six years of extra K treatments totaling 857 lb/A, ending with a grand total of 1,920 lb/A in extra K treatment plots. The grand total of K applications in plots not receiving extra K was 1,063 lb/A.

A soil sampling at the end of the study from the 0 to 3-inch depth of the main treatment plots showed a K range of 133 to 83 lb/A for plots receiving extra K and a range for all other main treatment plots of 87 to 57 lb/A (see Table 4). On average K at the extra K plots after six years was 110 lb/A and showed a loss of 94 percent K from leaching and clipping removal in the 95.3 percent sand content USGA green. An average of all other main treatments not receiving extra K was 67 lb/A and also showed a 94 percent loss. Loss of K appeared to be proportionate to the amount present. A soil test of available K in the extra K plots would rank in the mid-medium range and available soil K in all of the other main treatment plots ranked in the upper low range.

Soil test from the 3 to 6-inch depth of the main treatment plots showed a K range of 83 to 50 lb/A for plots receiving extra K and a range of all other main treatment plots of 44 to 40 lb/A (Table 4). An average of the extra K plots was 63 lb/A or a 97 percent loss and the average for all the other main treatments was 43 lb/A or a 96 percent loss. Again, K loss appeared to be proportionate to the amount present. Available K in the extra K plots ranked in the upper low level soil test and for all the oth-

ers, in the mid-low soil test range.

Previously it has been recommended that K levels in USGA specification greens be increased during the establishment period, and for the first few growth years, do to the high loss rate under the very low cation exchange capacity (CEC) sand-based conditions. Although the K loss was extremely high in this study, the bentgrass showed no deficiency symptoms. Apparently the grass was still able to satisfy its needs for K from the much higher measured K concentrations in the 0 to 3-inch rootzone depth (Table 4), which also is the depth containing the highest percentage of the grass's root system.

As mentioned under "Thatch Control", increasing Tpd (6x) generally resulted in decreased thatch, except with three of the four treatments involving extra K which exhibited increased thatch measurements (Table 2). Because of the longevity of this study, fungicides were used regularly throughout the six-year period to control all fungal activity to remove the confounding variability of disease incidence. Although K influence on disease resistance could not be determined, other physiological influences were observed. Bentgrass receiving extra K did not appear to maintain stand density, or influence rate of stand recovery following mechanical treatment thinning, any better than bentgrass mechanically thinned and not receiving extra K (Table 5). Thus, results of extra K treatments generally agreed with conclusions by other researchers.

Phosphorus Effects

The beginning soil test level of P was 60 lb/A, that plus six years of annual maintenance fertilizations which added 225 lb/A yielded total applications of 285 lb/A. The soil test at the end of the 6 years showed a P range of 83 to 38 lb/A in the 0 to 3-inch depth, an average of 55 lb/A, and 36 to 22 lb/A in the 3 to 6-inch depth, and average of 30 lb/A, for the main treatment plots (Table 4). Loss of P in the 0 to 3-inch depth was 81 percent and 90 percent in the 3 to 6-inch depth. Levels of P were significantly higher in the 0 to 3-inch depth in five of the six plots

receiving extra K and L (K, K + L, K + L + VM, L, L + VM). Levels of P in the 3 to 6-inch depth was almost half that occurring in the 0 to 3-inch depth. Both soil test showed levels classified as high available P. Although the average P loss from the top 6 inches of this very high porosity green was 86 percent, the residual P level was still more than ade-

TABLE 1. THATCH MEASUREMENT WITH THE THATCHMETER

Thatch Measurement Means and Standard Errors for Main Thatch Control Treatments in June and November for thatch measurements with the thatchmeter for the last three years of a six-year study.

Main Treatments	Thatch measurement means	
	June	November
	mm	
V + Core	5.68	5.04
VM 4x	6.20	5.07
VM 8x	6.21	4.99
VM + K	6.66	5.80
VM + K + L	6.75	5.23
K	6.80	5.72
VM + L	6.80	5.30
K + L	6.95	6.07
Core	7.36	5.64
Check	7.73	6.40
L	7.96	5.60
Wet Ag	7.99	5.99

Standard errors for least square means, as determined by general linear mixed models analysis, for all means = 0.36.

quate for plant needs. As were recommendations for K, recommends for increasing P levels in USGA greens during establishment to assure sufficient levels for root development and off-set leaching losses and plant removal have been made. There were no indications that P level played a significant role in the increase or decrease of thatch. Although mechanical treatments of VM 4x and 8x, Core, and the chemical treatment of Wet Ag did reduce P levels significantly in the 0 to 3-inch depth (Table 4), there were no significant detrimental effects evident in bentgrass sod density (Table 5).

Hydrated Lime, Calcium, and pH Effects

Researchers have conducted several studies to evaluate agricultural limestone (CaCO_3) for thatch control. In two studies, it was suggested that limestone may be effective in reducing thatch, but in other studies, limestone treatments were not effective. However, it was reported that the presence of Ca as hydrated lime ($\text{Ca}(\text{OH})_2$) suggested that Ca may be a contributing factor in thatch decomposition.

In this study, dolomitic limestone (CaCO_3 Mg CO_3) was incorporated into the rootzone just before bentgrass seeding. No limestone was used thereafter, only selective applications of hydrated lime were made four times per year for six years in four main treatment plots.

The initial level of Ca in the top six inches of the rootzone, following a dolomitic limestone incorporation, was 3563 lb/A. With the addition of Ca as hydrated lime four times per year for six years in four main treatment plots, total background plus

treatment Ca was 6,063 lb/A. The soil test at the end of six years showed an average level of Ca for main treatments in the 0 to 3-inch depth to be 2642 lb/A (Table 4), which was a 56 percent loss of Ca. Plots receiving L and extra K (L, K + L, L + VM, K + L + VM), with a pH 7.3, resulted in only a 53 percent Ca loss. The mean Ca level for main treatments in the 3 to 6-inch rootzone depth was 2980 lb/A, a 51 percent Ca loss.

However, plant needs for Ca is approximately 500 lb/A (12), thus more than adequate levels of Ca were available in the rootzone.

The starting pH of the top 6 inches of the rootzone was 6.6. The ending soil test pH after six years in the 0 to 3-inch depth showed a significant increase to 7.3 for the four main treatments involving lime (L, K + L, L + VM, K + L + VM) (Table 4). The pH for all other main treatments ranged from 6.8 to 6.4. Rootzone pH for all main treatments in the 3 to 6-inch depth ranged from 7.5 to 7.2, except for VM 4x which was significantly lower at 7.0 (Table 4).

TABLE 2. THATCH MEASUREMENT WITH THE THATCHMETER

Thatch measurement means and standard errors for main thatch control treatments by topdressing interactions for thatch measurement with the thatchmeter for the last 3 years of a 6-year study.

Main Treatments	Thatch depth for topdressing frequency		
	none	3x	6x
	mm		
VM + Core	6.06	5.32	4.70
VM 4x	6.43	5.56	4.90
VM 8x	6.62	5.44	4.75
VM + K + L	6.82	5.46	5.70
VM + L	6.95	5.87	5.33
VM + K	7.27	5.85	5.57
Core	7.45	6.40	5.66
K + L	7.47	5.97	6.09
K	7.58	5.20	6.01
L	7.80	6.63	5.91
Wet Ag	7.93	6.84	6.20
Check	8.29	6.76	6.14

Standard errors for least square means, as determined by general linear mixed models analysis, for all means = 0.40.

However, means of bentgrass stand density exhibited no visible effects which could be attributed significantly to these pH levels (see Table 5).

Bentgrass receiving L and no Tpd showed no evidence of reduced stand density that could be attributed to Ca deficiency after 5 and 6 years (Table 5) since Ca deficiency did not occur (Table 4). However, under both Tpd frequencies (3x and 6x), by year five, the lowest creeping bentgrass stand densities were recorded in the L plots (91 and 92 percent density), although by year six stand densities within Tpd frequencies were 99 and 100 percent. Results of L treatments indicate that L, at the rates used, had no significant benefits in controlling or reducing thatch, apparently because of the high soil pH levels which ranged from pH 6.4 to 7.3 in the 3 to 6-inch rootzone depth (Table 4).

Wetting Agent Effects

Two previous researchers used a Wet Ag and reported that it was ineffective in reducing thatch. The same non-ionic Wet Ag used in this study, but at a much higher rate than recommended by the manufacturer. Results indicated that Wet Ag increased thatch accumulation, regardless of whether Tpd was applied or not (Tables 1 and 2). It was previously suggested that Wet Ag treatments tend to promote quicker drying of the turf surface resulting in an interruption of the decay process thus enhancing thatch buildup. This may explain the deeper thatch layer observed

where Wet Ag was applied in our year five.

What part, if any, the high porosity green rootzone influenced Wet Ag effects could not be ascertained. However, bentgrass stand densities were 99 and 100 percent for year five and all were 100 percent for year six in untreated plots and in Tpd 3x and 6x plots (Table 5).

When combining mechanical and chemical methods with Tpd, lowest levels of thatch resulted following VM 4x or 8x/yr, VM + coring, and VM + L, all combined with Tpd 6x/yr. Extra K (VM + K + L, K + L, K) and Wet Ag actually resulted in increased thatch. Lime did not influence thatch depth. Loss of rootzone K was 94 percent and increased with mechanical and chemical treatments. Loss of rootzone P was 86 percent but extra K and L treatments reduced P loss, especially under pH 7.3 following L treatments. Loss of rootzone Ca was 56 percent but L and extra K treatments under pH 7.3 reduced this loss.

If managers have adequate soil nutrient levels (as measured by a soil test) and they can be maintained through normal nutrient management practices, then the 4 and 8 times per year mechanical treatments combined with 3 to 6 topdressing applications per year appear to offer the best change to significantly reduce accumulated thatch on highly maintained bentgrass USGA putting greens.

If soil tests reveal consistently low soil K levels requiring supplemental applications or the use of high K fertility practices to reduce disease pressure are used, then

TABLE 3. THATCH MEASUREMENT WITH THE THATCHMETER

Thatch measurement means and standard errors for topdressing frequency for thatch control measurements with the thatchmeter for the last 3 years of a 6-year study.

Topdressing Treatment	Thatch depth	
	June	November
	mm	
None	7.99	6.45
3x/yr	6.59	5.29
6x/yr	6.18	4.97

Standard errors for least square means, as determined by general linear mixed models analysis, for all means = 0.32.

higher thatch depths may result especially when measured in the usually more favorable fall months.

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TABLE 4. SOIL TEST LEVELS OF CALCIUM, PHOSPHORUS, POTASSIUM, PH

Means of main plot treatment soil test levels of calcium, phosphorus, potassium, and pH in the 0 to 3-inch and 3 to 6-inch rootzone depths after 6 years of thatch control treatments in a bentgrass green.

Main treatments	Nutrient means in two rootzone depths (in inches)							
	K		P		Ca		pH	
	0-3	3-6	0-3	3-6	0-3	3-6	0-3	3-6
	—lb/A—							
K	133	57	60	34	2672	2716	6.7	7.2
K + VM	130	83	38	28	2524	2530	6.6	7.2
K + L	94	60	83	29	2879	3850	7.3	7.5
Core	87	40	46	30	2445	2443	6.6	7.2
K + L + VM	83	50	73	36	2852	3827	7.3	7.5
Wet Ag	77	44	43	30	2645	2704	6.5	7.2
VM 4x	67	44	49	33	2484	2534	6.5	7.0
L	63	44	68	32	2838	3720	7.3	7.5
Core + VM	60	40	38	28	2435	2421	6.8	7.3
VM 8x	57	44	46	22	2471	2477	6.4	7.2
L + VM	57	44	54	25	2818	3555	7.3	7.5
Check	57	40	40	28	2550	2586	6.6	7.3
LSD (0.05)	52	12	23	12	208	300	0.41	0.33

Columns (down) are means of three replications, combining all Tpd treatments as one plot, and partitioned using LSD with alpha-risk set at 0.05.

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TABLE 5. PENNCROSS BENTGRASS STAND DENSITIES

Means of Penncross bentgrass stand densities in late June after 5 and 6 years of main plot treatments combined with sand topdressing treatments.

Main treatments	Topdressing (Tpd) frequencies					
	Year 5 Tpd			Year 6 Tpd		
	None	3x	6x	None	3x	6x
	----- % -----					
Core	100	100	100	100	100	100
VM + Core	100	100	100	99	98	97
Wet Ag	100	100	99	100	100	100
VM + L	100	96	94	98	99	97
K + L	100	92	99	100	100	99
L	100	92	91	100	100	99
VM + K + L	99	97	97	98	100	98
K	98	92	100	100	100	100
VM 8x	98	96	93	100	100	100
VM 4x	98	91	97	100	100	100
VM + K	98	92	93	99	99	98
Check	90	91	93	97	99	100
LSD (0.05)	3.9	2.7	2.7	1.3	1.2	1.2

Columns (down) are means of three replications and were partitioned using LSD with alpha-risk set at 0.05 for densities measured during the last 2 years of a 6-year study.