Experts Discuss Latest On Thatch at Nebraska

Latest Thatch Information Is Helpful But Controversial

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Thatch is a management problem on many turfgrass sites. The turfgrass manager is faced with maintaining turf on these areas under difficult and sometimes impossible conditions. In many cases, the turf manager is unaware of the integrated and complicated factors that are related to thatch accumulation and its influence on turfgrass stress and culture.

Considerable advances have been made in our knowledge about thatch during the past few years. We have learned new aspects about thatch, and its chemical and physical nature, causes, problems, benefits and prevention. Although considerable knowledge about thatch has been gained, more is needed and controversy exists over the knowledge we have gained so far. This is substantiated in the following articles included in this Symposium.

Thatch has been defined as "An intermingled organic layer of dead and living shoots, stems, and roots that develops between the zone of green vegetation and the soil surface." Careful examination of this definition indicates that emphasis is placed upon the intermingled layer of dead and living organic matter comprised of shoots, stems, and roots. In thinking this over, soil on a thatch-free, turfgrass site consists of living and dead organic matter comprised of shoots, and roots. The above definition of thatch therefore, is not entirely satisfactory. Thatch is a media located above the soil surface and is comprised of undecomposed and decomposed organic matter that is capable of supporting turfgrass plant growth. Mat is an additional term that adds confusion to the situation. Mat is not synonymous with thatch. Mat consists of a tightly intermingled layer of soil and decomposing organic matter. The added soil factor makes mat a more desirable growing media than thatch alone.

The chemical composition of thatch is mostly cellulose, hemicellulose, and lignin. Lignin is particularly prominent in the lower thatch where decomposition is more advanced. Turfgrass clippings contain very little lignin and decompose rapidly. As long as an adequate mowing frequency is maintained, clippings do not contribute significantly to thatch accumulation. Thatch may accumulate in intensively managed turfs such as creeping bentgrass or bermudagrass or it may accumulate in low maintenance turfs such as creeping red fescue or zoysiagrass. The cause of thatch accumulation, therefore, is not just the production of organic matter versus the rate of decomposition, but also the chemical composition of the plant materials comprising thatch.

The causes of thatch accumulation are equally as controversial as the definition of thatch. One can readily accept that if organic matter production exceeds the rate of decomposition then the net effect should be thatch accumulation. Factors that encourage organic matter production and discourage organic matter decomposition favor this accumulation. Cultural practices must be adjusted to avoid excessive organic matter production, and to provide an environment conducive to thatch decomposition. Earthworms and some insects are known to digest portions of the organic matter. They are important in relocating organic matter throughout the soil profile with their movement up and down in the soil. Certain pesticides reduce earthworm populations and induce thatch accumulation.

TABLE 1. Advantages and disadvantages of thatch in a turfgrass community.

Advantages (When present in moderate amounts):
1. Insulates the soil surface beneath the thatch layer
2. Reduces soil compaction
3. Increases the resiliency or cushioning effect of the turf
4. Increases turfgrass wear tolerance*

Disadvantages (When present in excessive amounts):
1. Increases turfgrass environmental stress
2. Reduces turfgrass tolerance to heat, cold, and drought
3. Increases disease incidence
4. Increases insect activity
5. Increases puffiness, scalping, footprinting, and spiking
6. Increases proneness to localized dry spots
7. Increases susceptibility to iron chlorosis
8. Reduces activity of certain pesticides
9. Increases phytotoxicity of certain pesticides

**Research at the University of Nebraska indicates that wear tolerance increases with thatch accumulation until a critical point is reached, when wear tolerance decreases.*

Contradictions also exist concerning the role of turfgrass cultivars, nitrogen, and mowing height in the accumulation of thatch. The turfgrass cultivar and mowing height may play a more important role in thatch accumulation then excessive nitrogen fertilization. Regardless of the cause of accumulation thatch is involved in beneficial and detrimental aspects in the turfgrass community (Table 1.). These factors are covered in detail in the subsequent articles.

In the past ten years we have gained considerably in our knowledge about thatch and its interaction with turfgrass culture and stress. As turfgrass managers we need to become more aware of the causes of thatch; its detrimental and beneficial aspects; its prevention; and perhaps most importantly, its modification to a more desirable growing media. The articles included in this Symposium will inform the reader of the present state of knowledge about thatch and will give the reader a better background for coping with this maintenance problem.

Influence of Thatch on Soil Is Both Positive and Negative

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Thatch is a frequently observed phenomenon in turf. It is generated by the plant community and, in turn, influences turfgrass response to environmental conditions and cultural practices. Its presence in a turf is considered to contribute both positive and negative influences toward turfgrass persistence and quality. Much confusion exists over factors contributing to thatch formation and the impact of thatch in turf; therefore, this paper will attempt to provide insights into the significance of thatch and its derivatives as edaphic features in turfgrass ecosystems.

Thatch has been defined in various ways depending upon the perspective of the observer. Ledeboer and Skogley (1967) simply referred to it as an "excessive accumulation of undecomposed surface organic matter." Beard (1973) defined thatch as "a tightly intermingled layer of dead and living stems and roots that develops between the zone of green vegetation and the soil surface."

The principal difference between these representative definitions is the role of living plant organs in the composition of thatch. Upon examining the thatch from a bentgrass turf profile, Ledeboer and Skogley (1967) reported that live roots, crowns, and stolons were found along with sclerified fibers from supporting tissues, and other undecayed organic residues. Others have interpreted this to mean that thatch is actually composed of living and dead plant material; thus, the contemporary definition offered by Beard (1973), and supported by the Crop Science Society of America, provides this perspective.

Examination of the surface soil layer of a thatch-free turf would show that it, too, is composed of live roots and stems from the plant community growing in it; yet, soil is usually not characterized the way thatch is. Soil analyses are typically conducted with the live plant community removed even though root and subsurface shoot growth undoubtedly influence soil physical and chemical properties.

Separation of live and dead components of a thatch layer is more difficult, so it usually is not attempted. In fact, the growth of plant organs within the thatch clearly shows that thatch is not simply a surface mulch; rather, it is a surface medium supporting the plant community and, as such, is analogous in function to the surface layer of soil from a thatch-free turf.

In the author's view, thatch is most appropriately defined as a layer of residual biomass generated by the turfgrass community, situated above the soil surface, and constituting an important portion of the edaphic medium supporting turfgrass growth.

Thatch Formation

The exact mechanism of thatch formation is not clear. Typical explanations of this phenomenon cite an imbalance between primary production (plant growth) and decomposition of organic residues. Thus, any factor which stimulates growth rates beyond decomposition rates, or which depresses the decomposition rate below that of plant production, leads to the formation of thatch. Of course, organic residues at the soil surface are not thatch.

A stable thatch layer must be stabilized by the plant community; otherwise, it can quickly become fragmented and decomposed, especially during winter in cold climates. Turfgrass-induced stabilization of thatch can occur in several ways: crowns can form from emerging rhizome terminals once light is intercepted near the thatch surface, existing crowns can continue to develop upwards into the thatch, and adventitious roots, rhizomes, and stolons emerging from these crowns can grow in the organic debris to form an interlocking network of live material.

Research at the University of Illinois has shown that certain pesticides, which inhibit earthworm and microbial activities, can induce thatch on sites where it otherwise would not form (Turgeon, Freeborg and Bruce, 1975; Cole and Turgeon, 1978). The amount of thatch which develops, however, is influenced by the turfgrass genotype and cultural practices. In field tests with over 50 cultivars of Kentucky bluegrass, the range in thatch depth, three years after establishment, was between 0.7 (Park) and 2.0 cm (Touchdown). In a cultural study comparing seven cultivars, two mowing heights (0.75 and 1.5 inches), and four fertilization programs (2, 4, 6, and 8 lb N/1000 sq ft/yr), only cultivar and mowing variables were found to influence thatch depth; higher mowing generally resulted in more thatch while increased use of nitrogen had no significant effect. Since the lack of any differential response to nitrogen in this study is inconsistent with many reports in the literature, it would seem that other conditions would have to exist in order to predispose the turf to nitrogen-induced thatch formation.

Edaphic Characteristics of Thatch

Since thatch constitutes an important growth medium for turfgrasses, attempts should be made to characterize it in much the same way as is done with soil media. Based upon work conducted at the University of Illinois, Hurto (1978) reported that "clean" thatch is a highly porous medium with a predominence of large (aeration) pores; therefore, its water-retention capacity is low compared to a well-structured Flanagan silt loam soil.

The cation exchange capacity (CEC) of thatch samples has averaged approximately 50 milliequivalents per 100 grams (me/100g) which is substantially higher than that of a Flanagan silt loam. As long as different media have similar bulk densities, comparisons of CEC's provide indications of relative nutrient-retention capacities.

Lighter colored material just beneath grass is sometimes referred to as "pseudo-thatch".

Bulk density (BD) determinations with clean thatch samples have yielded very low values, usually less than 0.25 g/cc. Since plants grow in a given volume of a medium, rather than in a given weight, CEC comparisons should be made only after multiplying by BD as in the following example:

Thatch CEC @ 50 me/100g and BD @ 0.25 g/cc yields 12.5 me/100 cc

Soil CEC @ 30 me/100g and BD @ 1 g/cc yields 30 me/100 cc.

In this comparison, the volumetric CEC of soil is actually over twice as much as that of thatch. Given the low BD, the very porous nature of thatch and, consequently, the rapid percolation rate of water and dissolved nutrients through its profile, retention of cationic nutrients (NH_4^+, Ca^{++}, Mg^{++}, K^+, Fe^{++}, etc.) by thatch would be low compared to many soils.

Another notable feature of thatch is its resiliency. With the application of a downward force, thatch compresses. Once that force is removed, the thatch springs back to its original state. Therefore, unlike many fine-textured soils, thatch resists compaction.

In summary, a thatch medium is well aerated and resistant to compaction, but is also characterized by poor nutrient- and water- retention capacities. When comparing the relative advantages and disadvantages of thatch to those of many fine- and medium-textured soils, it would be logical to conclude that an integrated medium, in which soil and thatch are blended together, would incorporate the desirable features of each component while compensating for various undesirable features. Integrated thatch-soil media will be discussed further under Thatch Control.

Influence of Thatch on Turfgrass Quality

Turfgrass quality is a function of genotypic and environmental conditions. Thatch, although reflecting in part some features of the turfgrass genotype, is an environmental (specifically, edaphic environment) feature in the turfgrass ecosystem. If a pure, coarse sand was used as the growth medium, sustaining the turf would require more frequent irrigation and fertilization than where a finer-textured soil were used. Thatch is, in some ways, analogous to coarse sand.

Field studies have shown that thatchy Kentucky bluegrass was more wilt prone, and had a higher irrigation requirement, under mid-summer stress than thatch-free turf in Flanagan silt loam (Turgeon, Freeborg and Bruce, 1975). Laboratory studies by Falkenstrom (1978) have shown that nitrogen retention by thatch is much less than in soil following applications of urea. This was due to rapid leaching of the nitrogen under moist conditions, and substantial volatilization of nitrogen as ammonia (NH_3) under dry conditions.

Other influences of thatch include higher disease incidence, reduced rooting, and lower water-infiltration capacities (Turgeon, Freeborg and Bruce, 1975). Jansen and Turgeon (1977) found that where water infiltration was lower in Kentucky bluegrass turf with a pesticide-induced thatch, the reduction was not due to the thatch layer but, rather, was associated with an altered physical condition of the underlying soil. Restriction of root and rhizome growth to the thatch layer and absence of earthworms in the underlying soil were factors accounting for higher soil bulk density, lower hydraulic conductivity, and reduced infiltration capacity in thatchy turf.

In herbicide studies, Hurto (1978) found that some preemergence herbicides were more phytotoxic when applied to thatchy than to thatch-free Kentucky bluegrass. He attributed this to greater downward mobility of the herbicides in thatch than in soil, and the inherent susceptibility of Kentucky bluegrass to herbicide injury when the herbicide is allowed to come into direct contact with the root system.

In a similar field study with non-selective herbicides for turf renovation, he found that paraquat residues in thatch were highly phytotoxic to overseeded perennial ryegrass. However, where soil was incorporated into the thatch or where the study was performed on a thatch-free site, little or no inhibition of ryegrass germination occurred from prior paraquat applications.

Thatch Control

Traditionally, thatch control has been synonymous with either mechanical removal, or topdressing (primarily greens) to favor decomposition. Results from recent and continuing research suggest that an alternative method should be considered. This involves thatch modification. A particular operation, or sequence of operations, which effectively blends soil and thatch into an integrated medium would almost immediately reduce many of the problems associated with thatch.

Although experience with topdressing greens has shown that soil inclusion favors decomposition of organic residues in thatch, this result is not immediate while many of the benefits of topdressing are apparent soon after the operation has been performed. On fairways in which core cultivation is practiced routinely, presumably to alleviate the effects of soil compaction, thatch is usually not a serious problem.

Again, soil inclusion in the thatch layer reduces thatch-associated problems and, eventually, favors thatch decomposition. In this case, soil from the

Relationship of Thatch to Disease and Insect Stress

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Most turf will remain trouble-free the first few years after establishment. A few problems may occur, but diseases and insects are actually minimal those first few years, especially on home lawns. The length of time from establishment to the time when problems begin appearing varies depending on such factors as soils, turfgrass variety, maintenance and environmental conditions.

One factor generally associated with older established turfgrass is thatch, but this does not imply that turfgrass without a thatch problem is always disease and insect free. Thatch free turfgrass may also have disease and insect problems but not to the same extent. A turfgrass with a severe thatch accumulation will generally have more disease and insect associated problems.

The influence of thatch accumulation on disease and insect problems actually makes sense when the condition of turfgrass and factors involved with disease and insect problems are considered. Heavy thatch accumulation causes the turfgrass to grow under a stress situation most of the time.

Heavy thatch often results in many of the turfgrass crowns and roots growing in the thatch layer rather than in the soil. Because thatch does not have the moisture holding capacity that most soils do, turfgrasses growing in it are more prone to drought stress. Since the turfgrass crowns and roots are elevated in the thatch layer, the turfgrass also becomes less tolerant to temperature extremes and more prone to traffic stress. In addition, the turfgrass will have fewer roots into the soil to receive nutrients it requires to remain vigorous. Pesticides applied to a "thatchy" turf are generally rendered ineffective by the thatch.

Turfgrass in a weakened condition is more susceptible to disease and insect problems, while vigorously growing and healthy turf is better able to resist insect invasion or an attack by a disease causing organism. Healthy turfs can also tolerate higher populations of disease-causing organisms and insects without showing damage and recover from the damage more rapidly. Therefore, disease and insect problems occur when there is a susceptible host, a favorable environment, and a causal organism.

Host

The host, of course, would be the turfgrass. For an attack by a disease causing organism or insect to occur the host must be susceptible to that attack. Most turfgrasses are tolerant or resistant to a disease or insect problem to a certain extent but certain turfgrass species and varieties are more tolerant or resistant than others. This tolerance is minimized, if the turfgrass is in a stress condition, or if populations of the disease causing organisms or insects accumulate to damaging levels.

Thatch accumulations may be involved with both factors, of creating stress conditions and providing a place for disease causing organisms or insects to thrive.

Environmental Conditions

The resulting environmental conditions of heavy thatch is ideal for many disease causing organisms and insects. This thatch environment provides an excellent place for the turfgrass

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same system is cycled while, with topdressing, a foreign soil source is used. Core cultivation, then, can be regarded as a comparatively efficient procedure for cycling soil and converting thatch to an integrated medium which is no longer thatch, but a derivative similar to what Beard (1973) describes as mat.

Depending upon the thickness and density of the thatch layer, once over with a core cultivator may not be sufficient to convert thatch to a mat-like derivative. In some cases, it may be necessary to remove a portion of the thatch and open up the remainder via vertical mowing before proceeding with core cultivation. Each site will have to be examined and a suitable procedure determined. However, the objective is clear; only the method for accomplishing the objective is site dependent.

Evidence to date suggests that the results are highly beneficial. Reduced disease, improved water relations and aeration, reduced pesticide-induced phytotoxicity, and generally superior turf are obtainable where thatch modification, rather than removal, is practiced.

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crowns, stems, roots and even the foliage to be attacked. The moisture, humidity, nutrition, and temperature of the thatch layer make conditions more favorable for the growth of certain organisms, but not ideal for the growth of turfgrass. Therefore, disease and insect problems may occur more readily on thatch stressed plants.

Pest (or Pathogen)

The third factor involved in a disease or insect problem would be the presence of a disease causing organism or insect that is capable of inciting a problem. The thatch layer may provide an ideal place for the growth and reproduction of the pest, allowing pest population to increase to a damaging level.

The thatch layer offers protection for the pest. This is especially true when considering chemical control because thatch forms a barrier to penetration of certain pesticides used to control disease or insect problems. The pesticide is either unable to penetrate the thatch layer, or it is absorbed by the organic matter of the thatch, making control of diseases or pests futile.

It is a generally accepted assumption that as thatch increases, disease and insect problems also increase, but research documentation is sparse. Perhaps the reason for this is the difficulty of working with thatch in trying to establish a cause and effect relationship. Let's look at a few examples in the literature dealing with thatch and disease and insect problems.

Disease

It is believed that many of the facultative parasitic fungi that cause disease on turfgrass are favored by a thatch accumulation. Apparently these fungi are capable of living on dead or decaying organic matter (thatch) as well as upon live turfgrass. Therefore, thatch is an ideal growth media for the establishment of this type of pathogen. Within this group are such fungal pathogens as *Fusarium, Rhizoctonia, Helminthosporium* and *Pythium* species. An increase in the incidence of the diseases caused by these pathogens has been noted with an increase in thatch accumulation.

Pythium Blight: Many turf specialists have associated *Pythium* blight with thatch accumulation. Research by Hall, Larsen and Schmitthenner (3) indicated that populations of *Pythium* species in the thatch increased approximately ten times over that of soil, indicating that there is a potential for increased *Pythium* blight with thatch accumulation.

Helminthosporium Leaf Spot: Several researchers have shown a relationship between thatch and leaf spot. Healy (4) has shown that *Helminthosporium* species can produce large quantities of spores (inoculum) while growing on thatch. Thatch accumulation favored greater incidences of *Helminthosporium* leaf spot in studies conducted by Murray and Juska (5). Work by Colbaugh and Endo (1) indicated that thatch accumulations may favor or inhibit the incidence of *Helminthosporium* leaf spot, depending on the moisture condition of the thatch.

Fusarium Blight: *Fusarium* blight is another disease that is often associated with thatch accumulation. There seems to be some correlation, as it occurs primarily on aged turfgrass (3 or 4 years old). The causal organism is also a fungus that can live off organic matter such as thatch. This disease has been shown to be more severe on turfgrass under a drought stress (2). Therefore, a greater potential exists for Fusarium blight to occur in turfgrass with a thatch accumulation. Recent research by Smiley (8) may indicate a somewhat different correlation between this disease and thatch. In this case, the thatch decomposition itself may be more important than the amount of thatch accumulation.

Control of Diseases: Disease control would depend on the pathogen and the chemical used. Some of the chemicals are held in the thatch layer, while others may leach through the thatch. The materials bound to the thatch may give better control to those organisms in the thatch, but, if the pathogen occurs on the foliage or within the soil, then these materials would not be as effective. So there could be differing effects depending on the specific disease and the type materials used. This is a relatively uninvestigated area which may explain some of the erratic fungicide responses.

Insect Problems

As with disease causing organisms, an increase in insect problems depends on the type of insect and how thatch may influence its activity. Thatch layers seem to make little difference on population of soil inhabiting insects. However, with surface inhabiting insects, thatch may have significant influence on their activity. Again, as with diseases, the turfgrass is better able to tolerate a population of insects when in a healthy condition. Therefore, if thatch is severe and causing stress, then the turf is more prone to insect damage.

Soil Inhabiting Insects: Thatch does not seem to affect the activity of soil inhabiting insects. These insects (grubs) cause problems on thatched turfgrass as well as thatch-free turf. Since these insects live in the soil, thatch does not affect their development.

Surface Inhabiting Insects: This group of insects includes the sod webworm, chinch bugs, adult billbugs, and army worms. Thatch provides an ideal habitat for the overwintering of these insects, as it gives protection from the low temperatures, which appears to be the only direct influence that thatch may have on these insects, with the exception of the sod webworm. Sod webworms survive best in the cover of thatch and are seldom a problem on thatch-free turfgrass. Sod webworms have real difficulty in surviving in bare soil, so thatch is very important to continued populations of these insects. Thatch does not appear to be as important with the other insects within this group.

Control: Control measures are affected by the thatch, as it inhibits the penetration of insecticides, not allowing the chemical to reach the soil below. Control of the soil inhabiting insects would definitely be less effective with a thick thatch cover (6). However, thatch may improve the effectiveness of control of insects that remain on the surface or within the thatch. Many of the insecticides are absorbed by the thatch, making them more likely to come in direct contact with the surface feeding insects (7).

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Changes in Management Needed Due to Thatch Accumulation

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The influences of thatch on turfgrass management are many. The effects of a layer of undecomposed organic matter no more than ¼ to ½ inch deep on irrigation practices and water availability can be noticeable. Also, serious disease and insect problems may be directly associated with thatch accumulation. Mowing, aerification and fertilization practices may be affected by thatch.

Thatch problems seem to become more evident when management is directed toward production of an excellent turf. In some instances thatch problems can be associated with low growing, dense, heavy organic matter producing cultivars. In other instances heavy thatch may be related closely to stoloniferous grasses or to those of a strong fiberous nature.

Heavy fertilization programs were thought to cause serious thatch problems. However, field observations do not necessarily bear this out. One fertility trial area that received up to 20 pounds of nitrogen per 1000 sq. ft. per year for several years developed no noticeable thatch. Thus, it became more and more evident that heavy thatch accumulation on many turf areas, even where management levels were high, was not "natural". Rather it resulted because of specific environmental conditions or management practices.

Turfs growing on soils that are wet and cold, very acid, sandy or heavy clay may have noticeable thatch accumulations. Whether such site conditions exist naturally or are caused by man - acid soils from use of acid-forming fertilizers, or use of "pure" sand medias for athletic fields — they may contribute to thatch build-up. It is apparent that where these factors exist to cause thatch build-up, management, topdressing, aerification, dethatching or treating with a wetting agent to counter the problem will be needed.

For many years pesticides were widely used in the turfgrass industry with almost total attention given to the control of specific pests. Ultimately, field observations began to suggest that thatch problems were sometimes severe where pesticides had been used. Such observations indicated that it was time to begin long-term field investigations of some commonly used pesticides to determine if they contributed significantly to thatch problems.

The role of microorganisms, especially bacteria and fungi, in organic matter breakdown indicate that the routine use of fungicides might greatly influence thatch build-up. This has been substantiated in a recent report (5) that indicates that long-term fungicide programs can materially influence thatch accumulation. This investigation reports that the physical depth of noncompressed thatch was significantly greater following application of certain fungicides, but not others.

Another factor, earthworms, should be considered as it influences thatch accumulation. Some early work (3) that influenced pesticide use and thinking was summarized as follows.

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Another important aspect of thatch and control relates to the various organisms that live in the thatch. The thatch layer is an ideal environment for organisms that may reduce insect populations. There are many predacious insects, mites, and other animals in the thatch that feed on insects.

Certain fungi living within the thatch may also be involved in reducing insect populations, therefore, the thatch may in some cases, be helping the turfgrass manager.

Conclusion

It is apparent that thatch and its affects on disease and insect problems is complicated. It is not simply an increase in thatch and an increase in problems relationship. There are other factors involved making this area very difficult to study. However, it can be said that there is often a relationship between disease and insect problems and thatch accumulation. It can be further stated, that if thatch is causing turfgrass stress then the turf is more prone to disease and insect problems.

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"Use of certain pesticides over a 3-year period caused a marked build-up of plant debris (thatch) of 'Kentucky' bluegrass (Poa pratensis L.) turf above the soil surface. Applications of the chlorinated hydrocarbon insecticides, dieldrin and chlordane, resulted in a thatch layer of 20 mm or more. The use of the carbamate insecticide, carbaryl, caused an average thatch thickness of 1.3 mm. The plots that received no insecticides or the mercuric fungicide, phenyl mercuric acetate (PMA), had no measurable thatch. The thatch depths were closely associated with plant debris weight.

In this study as the number of earthworm burrows increased, the amount of thatch decreased. Where earthworms were present to any extent, thatch was virtually non-existent. This research reitereated that earthworms are important agents in organic litter decomposition. Earthworms can influence decomposition in several ways. Among these are organic debris breakdown, giving greater surface area for increased microbal activity; they also mix organic litter with the soil.

It should be noted "that where earthworms flourish the amount of organic matter they consume is limited by the availability of supply rather than their capacity to ingest it" (4). Thus, it seems that increased organic matter production — through the use of more fertilizer and faster growing cultivars, may be offset by earthworms to the point that thatch build-up would be little, if any. Also, other benefits from earthworms such as their burrowing, which considerably improves soil aeration and drainage, should be noted.

In the early 1970's pesticide influence on earthworm populations and associated thatch problems began to be considered more often by turf professionals. Earthworm control recommendations were deleted from many published turf pesticide recommendation lists. A critical evaluation of whether or not earthworm control was necessary or desirable began to receive more attention. Earthworms on golf greens are often considered undesirable. However, many different kinds of earthworms and macrofauna occur in the soil, and many of these could be desirable, even on golf greens. Generally, a rough soil surface caused by earthworms ("night crawlers") is most common in areas of low soil fertility and shade. Proper fertilization, use of better cultivars and shade reduction are possible means of developing a better cover over the casts to reduce or elminate the rough surface problem.

Since research (3) had indicated that certain turf insecticides might induce thatch, it seemed possible that other type pesticides might also cause a thatch. A few turf pesticides, especially of the 1960's and early 1970's had dual use. For example, an insecticide might be used at a very heavy rate for crabgrass control. Also, long term pesticide use, often at high rates, might be expected to reduce earthworm populations and cause thatch accumulation. Consequently, investigations (6) were undertaken to study the influence of six preemergence herbicides (bensulide, calcium arsenate, DCPA, bandane, siduron and benefin: on thatch accumulation. This work revealed that in the fall following 2 successive spring applications, thatch had accumulated to a depth of 1.4 cm (.6 in) where calcium arsenate had been used, and to 2.1 cm (.8 in) where bandane had been used. No thatch had accumulated from the use of the other four herbicides. Also of interest in this study is the fact that "essentially no thatch accumulation was observed following the first series of herbicide treatments". This observation could help explain the lack of close association of pesticide use with thatch development.

In another report (7) it was noted that four annual applications of the six preemergence herbicides mentioned above had thatch accumulations only in bandane and calcium arsenate treated plots. Samples taken from the plots treated with bandane and calcium arsenate revealed no earthworms; whereas, there was no great difference in earthworm counts made in plots treated with the other materials or in areas not receiving treatment.

It has been reported (2) that "annual applications of insecticides to bluegrass turf over a three-year period did not create a thatch build-up. Diazinon, Gardona, trichlorfon (Dylox), fenthion (Baytex), and carbaryl (Sevin), were investigated in this study. It was also noted that when dieldrin and chlordane were applied 3 times a year over a 5 year period insecticide levels in the thatch layer were very high as compared to that in the soil.

It appears that adequate research has been done to demonstrate that certain pesticides may induce thatch. Also, thatch has been observed to accumulate rapidly where earthworms were not present. However, it has been noted (5) in a report that "thatch accumulation was not considered to be due to inhibitory effects of fungicides toward earthworms".

With these aspects in mind, it appears that thatch problems could sometimes be reduced or perhaps eliminated by using pesticides that have not demonstrated a significant influence on thatch development. More testing to determine the influence of existing and experimental turf pesticides on thatch development could provide useful management information for professional turfmen.

Some of the pesticides used in the past appear to cause long-term turf problems by influencing thatch accumulation. One area, where pesticides were applied some 20 years earlier, had distinct thatch accumulation; whereas, adjoining untreated areas had none. In this area, thatch was associated with a serious winter drought or desiccation problem.

Activated charcoal has been useful in inactivating certain pesticides, and certainly more research is needed on "turning-off" pesticides. Removal of thatch and working the soil might remove or dilute pesticides to the point where earthworms might reinfest, or be introduced into the soil. More work is needed on this possible means of thatch control. However, some work in this general area has already been done. It was reported (1) that where earthworms had been introduced the surface mat as a discrete layer disappeared.

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Integration of Control Methods Necessary to Prevent Thatch Buildup

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Excessive thatch accumulation results in degradation of turf and increases maintenance. Turfgrass cultural problems associated with thatch are: (a) greater susceptibility to heat, cold, and drought stress, (b) localized dry spots, (c) increased insect and disease incidence, (d) scalping, (e) reduced effectiveness and penetration of fertilizers and pesticides, (f) more wilt, (g) greater iron chlorosis, and (h) increased time, labor and money to maintain an acceptable turf.

Thatch control is not a once a year project. Instead it requires an integrated approach involving prevention, biological control, and mechanical removal. Each of these aspects requires a basic understanding of how thatch forms and how it is decomposed.

Prevention

Thatch develops in turfs because shoot growth results in organic matter accumulation at a faster rate than decomposition occurs. One approach to thatch control is to reduce accumulation by restricting excessive shoot growth. Factors which contribute to unnecessary shoot growth are discussed below.

Vigorous turfgrass cultivars: Turfgrass species and cultivars utilized for recreational turf are often vigorous. While this characteristic is important for persistence and recuperation from use, it also promotes rapid tissue production. Where feasible, the turf manager should use cultivars less prone to thatch development.

Excessive nitrogen fertilization: Thatch consists of an intertwined layer of living and dead stems, rhizomes, stolons, leaves and roots of grasses. Adequate nitrogen is required for acceptable turf quality and recuperative potential; however, excessive nitrogen increases shoot production which contributes to thatch accumulation.

Excessive irrigation: Applying excessive irrigation enhances shoot production and therefore results in thatch buildup.

Mowing and collection of clippings: Thatch accumulation can be reduced in bermuda and zoysia turfs by mowing closely. This retards total shoot production. For cool season turf, clipping removal has little influence on thatch accumulation since the leaf tissues easily degrade. Clippings contribute more to thatch buildup in bermuda and zoysia. Removal will aid in preventing thatch in these turfs; however, clippings only contribute 15-25% to the thatch.

Biological Control

The decomposition process for thatch normally involves digestion and mixing with soil by earthworm and insect activity. At the same time fungi, bacteria, actinomycetes and other microorganisms are active in decomposing various constituents within the thatch. Any factor which interfers with this natural decomposition pathway will enhance accumulation.

Promoting microorganism activity: Degradation will occur at a rapid rate if microenvironmental conditions within the thatch are suitable for a large, balanced microorganism population. The primary environmental variables influencing microorganisms are moisture, aeration, temperature, pH, organic matter, and inorganic nutrient supply. When a turf manager topdresses with a well-composted topdressing mix, he is adding microorganisms to the soil. However, more importantly he is changing the microenvironment to favor sustained microorganism activity. With topdressing soil well intermixed with thatch, moisture retention is improved. Also, due to a denser and moister environment temperature, variations are decreased. Thus, improved moisture and temperature conditions aid in maintaining an active microorganism population within the thatch.

Thatch and its decomposition products consist of a wide variety of organic compounds. To adequately degrade such a diverse assortment of compounds requires a very diverse microbial population including fungi and bacteria. Thatch tends to become acidic even if the underlying soil is alkaline. Exception to this would be if irrigation water is alkaline. When the thatch pH reaches 6.0 or less many bacteria involved in decomposing resistant components of thatch are no longer active. Thus, a light application of lime to keep the thatch

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Mechanical dethatching brings tnatcn to the surface for removal.

Damage to turf and shrubs caused by burning thatch as a method of removal.

pH at 6.0-7.0 will aid in maximum thatch breakdown. Generally, 5-10 lbs. CaCo,/1000 sq. ft. once a year on heavily irrigated turf is sufficient. Also, maintaining a soil pH of 6.0-7.0 will help insure a good natural microorganism population.

Cultivation practices, such as coring and grooving, improve moisture and temperature relations by mixing soil into the thatch. Improved soil aeration from cultivation — coring, grooving, slicing, spiking — will aid in the maintenance of an active microorganism population. Adequate irrigation also favors microbial activity.

Promoting earthworm activity: On golf greens earthworm casts are objectionable, they do not interfere to a great extent on higher cut turf. A good earthworm population is often the cheapest and most efficient control for thatch. Earthworms digest thatch, integrate soil into the thatch, and carry some of the organic matter down into the soil. Promoting earthworm activity is best achieved by avoiding pesticides detrimental to earthworms and maintaining a favorable pH range of 6.0-7.0. Cultivation on compacted soils will aid in creating a loose, friable physical condition for earthworms.

Biological dethatching materials: Several biological dethatching agents are commercially available which consist of a dry or liquid media inoculated with specific microorganisms. These are applied to the turf and when exposed to a favorable environment the microorganisms are activated and reportedly decompose thatch. Research studies conducted at several universities (Georgia, Hawaii, California, at Riverside, Nebraska, Michigan State) have not shown any beneficial affects from these materials. Innoculation with a specific microorganism population will have little affect if the microenvironment is unfavorable for sustaining the population. Natural, as well as added, microorganisms require correct moisture, aeration, pH, etc. conditions, if they are to persist at a high enough level to influence thatch decomposition.

Mechanical Removal

Vertical mowing is the most common method used to remove thatch. On golf greens or close cut turf, vertical mower attachments are available for riding greens mowers. This allows frequent, light vertical mowing without disruption of the playing surface. However, on higher cut turf vertical mowing is normally done once or twice a year, if thatch accumulation requires it. These can be severe and result in at least some disturbance of the turf surface.

When a severe vertical mowing is necessary, at least 3-4 weeks of good growing weather should follow in order for turf to recover. For example, with a cool season grass early fall would be a good time to verticut, while mid-spring would be acceptable for a warm season turf. Care should be taken not to severely verticut just prior to annual grass germination. If it is necessary to vertical mow at that time, a good preemergence herbicide for annual grasses should be applied to prevent severe weed encroachment. Do not verticut after applying a preemergence herbicide for annual grasses or the herbicide zone will be destroyed. Maintain good nutritional, moisture, and other growing condition after vertical mowing to insure rapid turf recovery.

Sometimes when a turf with rhizomes or stolons has developed a thick thatch, the turf can be stripped and allowed to recover from rhizomes or stolons that remain. Turning the sod under is generally not desirable since mixing it into the soil is difficult. This method is unsightly and requires several weeks for recovery.

Burning is sometimes used to remove thatch, particularly on bermuda. This method can reduce thatch but it is not without problems. If a thick thatch exists, the plant crowns may be elevated into the thatch. Burning can then result in high temperature kill of the crown, even on dormant turf. If burning is used it must be rapid and preferable with a moist soil. Burning should not be attempted around houses or where evergreen trees and shrubs are present.

Thatch is not a desirable turfgrass growing media. The turf manager should not consider mechanical removal as a routine maintenance practice. Instead he should give careful attention to preventing excessive shoot growth and promoting maximum decomposition. Mechanical removal is expensive and time consuming and should be used only as a last resort.