Exploring the hidden mysteries beneath our feet – Thatch

Martyn Jones explores the nature of thatch, its causes, and considers its management in various situations

Course Managers and greenkeepers are well aware of the deleterious aspects of excess thatch: Increased disease and insect problems, localised dry spots, chlorosis of the turf, proneness to scalping, foot printing, decreased heat, cold and drought hardiness, restricted rooting, nitrogen immobilization, reduced effectiveness of pesticides, a soft, spongy surface in wet weather, and the potential for black layer formation.

They are also conscious of the benefits of a limited depth (approximately 6mm) of thatch: Insulation of the soil surface, protection of the crowns of plants, buffer against surface soil compaction and smearing, recycling of nutrients, provision of a resilient surface, and absorption of chemical residues.

Continue to learn

Literature on turfgrass management prior to 1950 rarely, if ever, makes reference to the term 'thatch'. Allied terms such as 'matted turf', 'fibre', and 'litter' were sometimes fleetingly used when discussing other topics such as 'droughty turf' or 'neglected turf'.

A number of American authors between 1953 and 1973 proposed definitions of thatch. Beard (1973) produced one that became universally accepted: "A tightly intermingled layer of dead and living stems and roots that develops between the zone of green vegetation and the soil surface". He also defined 'mat' as "an organic layer buried and/or intermixed with soil from topdressings. It is partially decayed thatch that has become part of the soil profile". However, Shildrick (1985) in a comprehensive review of thatch expressed the view that 'mat' is a misleading term and should be avoided. He also distinguished two subdivisions of thatch:

"**Fibrous thatch** usually overlies dry soil, the turf becoming very dry indeed and difficult to re-wet under drought conditions. It is most commonly found in acidic conditions where the sward consists of Agrostis and Festuca spp."

"**Spongy thatch** is waterlogged throughout most of the year and is likely to smell strongly of decay and stagnation. It is yellow-brown in colour with black streaks showing the activity of anaerobic bacteria. The underlying soil is often wet and compacted, and usually of clay with restricted drainage." Further comments on spongy thatch suggest, "Poa annua usually predominates in the sward with perhaps some surviving Agrostis."

While these subdivisions are useful, they are more descriptive of differing environmental influences on accumulation, as opposed to the actual constituents of thatch.

WHAT ARE THE CONSTITUENTS OF THATCH?

Thatch is composed primarily of a mixture of partially decomposed stems, roots, stolons and rhizomes, each of which varies in its resistance to decay. Leaves are the least resistant to decay and, contrary to popular belief, do not appreciably add to thatch accumulation.

Resistance to decomposition increases in order through sclerified vascular strands of stems and leaf sheaths, stolons and rhizomes, roots, and nodes of stems and crown tissues, these being most resistant. Chemical analyses of thatch show an abundance of lignin, this being the most resistant to decomposition.

Fungi in the order Basidiomycete, the group of fungi that contain the familiar 'fairy ring fungi' and 'mushroom or toadstool fungi' are the primary decomposers of lignin. Cellulolytic fungi and bacteria, and many species of Ascomycetes and Fungi imperfecti decompose cellulose and hemicelluloses that are intermediate in decay rate. Rapidly decomposed organic compounds such as sugar and starch that are present in large quantities in leaf tissue are quickly decomposed by numerous species of bacteria, sugar fungi and shadow yeasts, as well as by a range of soil macrofauna.

▲ **Core cultivation is an effective means of physically removing thatch and, when accompanied by a sound topdressing programme, creates a favourable environment for decomposition**

WHAT ARE THE CAUSES OF THATCH?

A thatch layer develops in any situation where the accumulation rate of dead organic matter from the growing turf exceeds the rate at which it decomposes. Consequently, any cultural or environmental factor that promotes excessive shoot growth or impairs decomposition will encourage thatch accumulation.

▲ Sensitive use of a well-designed irrigation system is vital to successful thatch management

It has been estimated that about 8000 kg ha-1 of dry organic residues are returned to turfgrass soils each year. This comprises of approximately 3500 kg of roots, 2000 kg of clippings, and 2500 kg of other vegetative parts (Riem Vis 1981). Consequently, when clippings are removed, as in a golf green maintenance programme, the annual returns of organic residues will amount to around 6000 kg ha-1. These quantities vary to some degree depending on the turfgrass species studied but, surprisingly, the quantity of nitrogen fertiliser applied has little effect on the final figure as the nitrogen is utilized in the most part in leaf growth that is removed by mowing.

Certain turfgrass species and varieties with increased vigour and density such as Poa annua, Agrostis stolonifera, and, in a favourable environment, some cultivars of Poa pratensis are notorious for thatch production.

Species such as fine-leaved fescues that have high lignin contents are more resistant to decomposition and in these cases it is the slow rate of decomposition of the organic residues that contribute to thatch accumulation, rather than the turfgrass growth rate. Low growing, prostrate species such as creeping bentgrass tend to form more thatch than upright species. For this reason, although the upright-growing Lolium perenne is a vigorous species, it is not a major thatch producer.

Strongly acidic conditions will inhibit micro-organism activity and, consequently, decrease the decomposition rate. The majority of organic matter consumers and decomposers prefer neutral to alkaline soil conditions. Bacteria and actinomycetes are more abundant in such soils. Although many fungi are tolerant of pH's as low as 4.0, they are more numerous in soils with a pH range of 5.0 to 6.5. Optimum activity of species capable of decomposing cellulose and lignin occurs at pH 6.5 to 7.5. Many studies have shown that continuous and excessive use of acidifying fertilisers such as ammonium sulphate will favour the development of thatch (Edmund and Coles 1958, Smith 1979, and Potter et al. 1985).

A lack of earthworms will impair decomposition. They are major consumers of soil organic matter and their activities in soil mixing play a major part in increasing microorganism populations and enhancing organic matter decomposition. Their digestive tract contains large numbers of bacteria and these are deposited into the soil in their casts to continue the decomposition process. Decimation of an earthworm population will invariably result in an increase in thatch accumulation; hence its association with intensively managed golf turf where earthworm activity is unacceptable.

Poor soil aeration resulting from fine-textured rootzones, compaction, excessive wetness, be it due to poor drainage, an inclement climate or excessive irrigation, will decrease the decomposition rate of organic residues. The majority of beneficial microbes are strongly aerobic and restricted soil aeration will impair their activity. Many species of fungi are able to tolerate relatively low soil oxygen concentrations but the majority are unable to function in anaerobic conditions.

Excessive nitrogen nutrition stimulates rapid shoot growth and shallow rooting and, therefore, encourages thatch accumulation. An excess of nitrogen will also create an unfavourable carbon/nitrogen ratio for decomposition of the organic residues. The optimum C/N ratio range for bacterial decomposition is 25:1 to 30:1 and ratios greater or lesser than this range will slow down the decomposition processes. Heavy applications of nitrogen, even if applied infrequently, can impair rooting and create a temporary upset in the carbon/nitrogen ratio. Surface applications of phosphorus can stimulate rooting within the thatch layer, thereby further aggravating the thatch accumulation rate.

Irrigation practices that stimulate rapid shoot growth will increase the thatch accumulation rate and excessive irrigation that maintains high moisture contents to the detriment of oxygen availability within the thatch layer will decrease the decomposition rates.

Extremely dry conditions, in stark contrast, can be equally detrimental. Although most bacteria and fungi are able to survive drought conditions, they require water to be active decomposers and extremely dry conditions in the thatch will reduce the decomposition rates. Additionally, lack of water can result in turfgrass drought stress, greater pest and disease damage, and an increase in thatch accumulation.

The use of pesticides has often been reported as a contributing factor in thatch accumulation by adversely affecting decomposition rates. Whilst there may well be some merit in this argument when considering highly toxic chemicals that were quite widely used in the past, evidence that the modern range of pesticides directly affect microbe activity is highly debatable. Smiley et al (1985) and Smiley and Fowler (1986) concluded that increases in thatch accumulation where fungicides had been applied could be attributed to a greater rate of tissue production, rather than due to a reduction in the decomposition rate.

Topdressing materials high in organic matter will add to the accumulation of thatch, particularly if the organic source is high in compounds such as lignin that resist decomposition. Topdressings should be aimed at diluting the organic content in the surface horizon to produce a rootzone mixture with a maximum of four per cent by weight organic matter.

Fine-textured soils present a physical barrier to rooting, in addition to their inherent problems of impeded drainage and restricted aeration porosity. Consequently, there is an increase in the accumulation of organic matter near the surface. The anaerobic conditions that readily occur in such soils also accelerate root death whilst depleting microbe activity. The moisture retentive nature of such soils also makes them slow to warm up in spring and the low temperatures inhibit the activities of soil micro-organisms. The net result is an increase in thatch accumulation and decrease in decomposition rates.

Low temperatures reduce the metabolic rate of micro-organisms and thatch decomposition is greatly retarded during extended periods of cold weather. This is particularly relevant in northern Europe where temperatures remain below 10 degrees C for a large part of the year and, consequently, where fungal and bacterial activity is extremely restricted.

During the 1960s, thatch was a common problem on golf greens. This coincided with the wider introduction and misuse of automatic irrigation systems, excessive use of compound fertilisers, chlordane as a wormkiller, mercury-based fungicides, sterilised organic-rich topdressings and agricultural soils management policies. Little wonder that thatch developed so significantly. Those were the glory years for thatch but the Dark Ages for turf management.

MANAGEMENT OF THATCH

Management of thatch falls into two categories, curative or preventative, depending on the degree of thatch present. The former consists of a series of renovation procedures while the latter is a maintenance programme. Similar techniques are adopted for both categories but there are generally significant differences in intensity and frequency of operations. For example, scarification into a thatch layer would be considered a renovation or curative technique whereas Verti-cutting and grooming are maintenance or preventative operations. There are similarities in the actions of equipment but major differences in the severity of the treatment.

Scarification or hollow-tine cultivation will physically remove existing thatch. Coring may not remove as much material in a single operation but it has an advantage, in conjunction with a sound topdressing programme, of establishing capillary continuity with the underlying rootzone material, an important element in improving drainage and modifying the thatch environment for enhanced decomposition.

Topdressing is an essential part of both curative and preventative thatch management but incorporation into an existing thatch problem can pose difficulties. Creating layers of thatch/topdressing must be avoided by thorough and frequent cultivation. This is best achieved by coring but other cultivation techniques such as spiking and slitting can also be beneficial.

Course managers and greenkeepers with greens constructed to USGA recommendations must preserve the integrity of the construction by timely topdressings with compatible sand. A USGA rootzone recommendation suggests a maximum of three per cent by weight organic matter content in its construction; it follows then that a topdressing schedule should aim at maintaining this percentage by diluting any thatch accumulation to similar proportions (Carrow 2004). In most instances, this would necessitate annual topdressings of sand at 4.00 to 5.00 kg m-2, preferably divided into a number of small increments throughout the year.

Proper management practices will minimise thatch accumulation. Fertilisers should only be applied at rates that meet, but not exceed, the nutritional requirements of the turf. Similarly, irrigation must not be excessive and should not be applied before the desired turfgrasses shows signs of moderate moisture stress. Surface cultivation techniques to preserve drainage and adequate soil aeration should be appropriate to the site and soil type, and to the time of year.

All factors that contribute to thatch accumulation must be considered and management should be focused on enhancing decomposition rather than accumulation. Although the thatch may be beneath our feet and out of sight, it should never be out of mind.

Literature cited:

1. Beard, J. B. 1973. Turfgrass Science and Culture. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, USA.
2. Carrow, R. N. 2004. Surface organic matter in bentgrass greens. USGA Green Section Record 42(1).
3. Edmond, D. B. and S. T. J. Coles. 1958. Some long-term effects of fertilisers on a mown turf of Browntop and Chewing's fescue. N. Z. J. Agric. Res. 1.
4. Potter, D. A., B. L. Bridges, and F. C. Gordon. 1985. Effect of N fertilization on earthworm and microathropod populations in Kentucky bluegrass turf. Agron. J. 77.
5. Riem Vis, F. 1981. Accumulation and decomposition of organic matter under sports turf. In R. W. Sheard (ed.) Proc. 4th Int. Turfgrass Res. Conf., Guelph, ON, Canada.
6. Shildrick, J. P. 1985. Thatch: A review with special reference to UK golf courses. J. Sports Turf Res. Inst. 61.
7. Smiley, R. W., M. Craven Fowler, R. T. Kane, A. M. Petrovic, and R. A. White. 1985. Fungicide effects on thatch depth, thatch decomposition rate, and growth of Kentucky bluegrass. Agron. J. 77.
8. Smiley, R. W., and M. Craven Fowler. 1986. Turfgrass thatch components and decomposition rates in long-term fungicide plots. Agron. J. 78.
9. Smith, G. S. 1979. Nitrogen and aerification influence on putting green thatch and soil. Agron. J. 71.

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