
THATCH DECOMPOSITION BY SYSTEMATIC SURFACE APPLICATIONS OF I-MOL™



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Introduction: Accumulation of thatch is generally undesirable yet inherent to intensively-managed turfgrass systems. Thatch accumulation has become a more serious concern with the increased use of new, high-density and aggressively-growing turfgrass varieties. Though thatch accumulation is traditionally mitigated through cultural practice, such as topdressing and/or physical cultivation techniques (e.g. verticutting and/or core aeration), these procedures are labor-intensive and disrupt playing quality. Moreover, the recognized long-term benefits of physical cultivation can be offset by increased susceptibility to tissue desiccation and/or cutworm infestation in the short-term, and/or intensified weed pressure through long-term surface redistribution of the soil seed bank.

For these reasons, there has long been interest in products that can effectively control thatch without causing the physical disruptions. Over the last several decades, products containing 'bioactive' ingredients like enzymes, active cultures, and/or plant hormones have been introduced for this purpose. Application of active culture, like most biological control methods, has not been proven sustainable under field conditions. Similarly, use of organically-fortified liquid meal has demonstrated mixed results. Following a 2-year study of regularly core-aerated and topdressed Crenshaw and Penn A-1 bentgrass putting greens, Willis et al. (2006) reported systematic application of several commercially-available biological thatch control products (Thatch-X, CPR, or molasses) to significantly reduce thatch layer depth (measured at 0.1-mm resolution with a ruler). Conversely, McCarty et al. (2005, 2007) reported exclusive use of Thatch-X, a biological thatch-control agent, to be an ineffective control of thatch-mat depth in respective L-93 and Penn A-1 creeping bentgrass putting greens. Research conducted on thatched bentgrass/annual bluegrass cohabited golf course putting greens did not show systematic application of two biological dethatching agents to effectively reduce thatch (Gibeault et al., 1976; Lancaster et al., 1977).

Undoubtedly, the best way to investigate accumulation or decomposition of thatch is by standardizing all contributing factors that share even a minor association with the treatments of interest. Edaphic factors and their influence on thatch are fairly straightforward. All things equal, and assuming a functional microbial population to be present, thatch decomposition rate correlates positively with: activity of macrofauna (primarily earthworms), pH level (up to slightly alkaline), temperature, and oxygen availability in soil. Likewise, the influence of certain cultural factors (species/cultivar selection, mechanical cultivation, fungicide/insecticide use, etc.) is relatively predictable. Effects of other cultural factors are more widely interpreted; i.e. mowing height and/or frequency, pre-emergent herbicide use, topdressing, and/or fertilization practice (particularly N). To better clarify the point at hand, and avoid reinventing the wheel, I paraphrase Waddington (1992):

In thatch studies, researchers may want to control certain factors to eliminate indirect effects. For instance, Potter et al. (1985) showed N fertilization rate increased thatch, while decreasing pH of soil and thatch, as well as earthworm activity. Since previous reports associate increased thatch

with both soil acidity and reduced earthworm populations, it is difficult to determine whether the increase in thatch was due to N-induced shoot growth (organic matter production), less decomposition due to lowering of earthworm and microbial activity caused by the low pH, or both. Thus, in future research, liming could be used to eliminate the variation in pH due to N rate and appropriate chemicals could be used to control earthworms.

Considering present accumulation of thatch and conditions governing its decomposition are spatially variable in the field, effective measure of any biologically-facilitated and subtle process requires careful planning. The most suitable approach that comes to mind is real-time laboratory measurement of the primary byproduct evolved from microbial thatch decomposition (CO₂). While this technique of measuring biological degradation of thatch was first reported over 30 years ago (Martin and Beard, 1975), it continues to provide a highly resolute measure of soil microbial activity. Evolution rates of 11 lbs C per 1000 ft² (500 ft³) over a 5- to 6-week period of room temperature incubation may appear excessive, yet have been measured in high-OM soils incubated under ambient conditions (Martinez and Tabatabai, 1997). Moreover, as most superintendents can attest, even ‘unbelievably’ high rates of soil OM decomposition are no match for the OM-deposition rates regularly occurring in managed turfgrass systems.

Use of nutrient-rich, labile, carbon substrate sources, a true cultural control method, has been shown to naturally enhance the population and activity of indigenous soil microbes. In a recent field study, these applications significantly increased decomposition rate of lignified, cellulose-rich organic residues (Boopathy et al., 2001). I-MOL™, From The Ground Up Inc.'s proprietary liquid blend of molasses and iron sulfate, is a non-living, labile carbon substrate containing numerous essential plant macro- and micro-nutrients that serve as a food source for microbial populations.

Experimental Objective: To accurately determine the effectiveness of systematic I-MOL™ treatments on thatch decomposition rate under controlled laboratory conditions, and to measure any influence of fungicide tank mixing on the overall effectiveness of I-MOL treatment.

Methods: Soil cores (8” by 4.25” diam.) were collected from a sand-based putting green nursery (Cape May County, NJ, USA; Sept. 2005) and a mineral soil fairway (Cumberland County, ME, USA; Nov. 2006), each exhibiting severe thatch accumulation layers. Following expedited

Table 1.	Experiment 1: Sand	Experiment 2: Mineral
Preliminary Soil Properties	Putting Green (NJ)	Soil Fairway (ME)
Turfgrass Species	<i>Agrostis palustris</i> cv. 'Penn A4'	<i>Agrostis palustris</i> / <i>Poa annua</i> mixture
Mowing Height (inches)	0.15	0.63
Years from Establishment	3.5	~28
Soil Taxonomic Subgroup Designations	Mesic, coated Lamellic Quartzipsamment	Fine, illitic, frigid Typic Epiquept
Soil pH (1:1 H ₂ O)	7.22	5.04
Bulk Density (g/cm ³)	1.54	0.84

transport to Penn State University, the core surfaces were treated with a 5% Roundup Ultra herbicide solution spray application (½ gal. / 1000 ft² or M). After a 2-week drying period, aerial tissues (leaves, tillers, shoots) were removed, and one core destructively sampled to characterize preliminary soil properties (Table 1). Three experimental units were randomly selected from the remaining NJ putting green soil cores (photo, top-right p. 3) and surface-treated with either 3 oz I-MOL / 1000 ft² (M), I-MOL + Daconil Ultrex (3 and 1 oz. / M, respectively), or a carbonless positive control containing mineral nutrient concentrations of I-MOL (3% Fe, K; 2% S; 0.5% N & Ca; others <0.2% by mass). Treatments were sprayed at 3 gal. / M volume and irrigated (0.04”).

Accurate thatch measurement is prone to spatial and sampling error that often renders data from field experiments inconclusive. A method of measuring thatch decomposition by encapsulating each treated plug in a respective flow cell (Soil Measurement Systems, AZ) was elected, enabling measurement of CO₂ evolution over 7-days at 0.1 mg-carbon accuracy (Strotmann et al., 2004). Cores in Exp. 1 were retreated by five weekly applications in each run. New plugs were randomly selected, prepared, and treated as described in subsequent Exp. 1 runs; totaling 3 replicated 6-wk runs.



The low-flux system used pressurized ultra-pure (CO₂-free) air to prevent anoxic and/or CO₂-rich conditions. Except the gaseous CO₂ residing within pores of the plug (assumed to be equal across all cores removed from the identical green on the same day), microbial respiration comprised the sole future source of CO₂



evolution from each plug. In soil devoid of viable root tissue, microbial respiration is a direct measure of microbial activity, which in turn relates to microbial assimilation of carbon. Under aerobic conditions, soil microbial respiration rate quantifies OM degradation. Considering treatments were all surface-applied, recorded levels of CO₂ evolution then correlate with microbial OM decomposition rate in the surface thatch/mat of the putting green. Further,

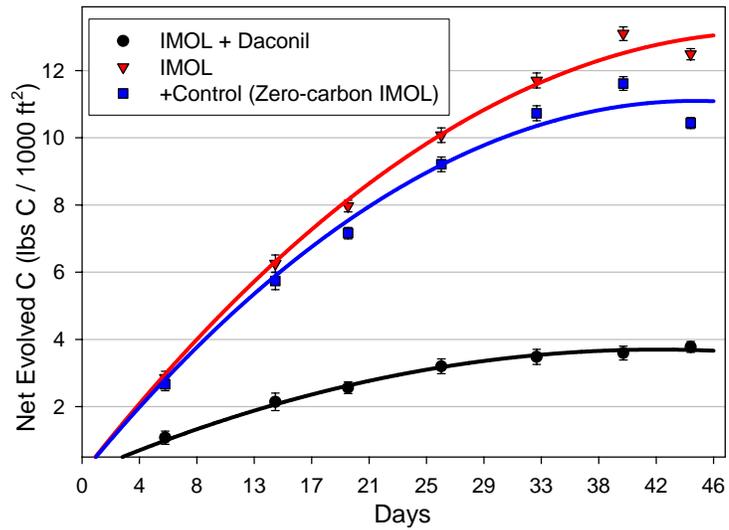
CO₂ evolution rates from I-MOL and I-MOL + Daconil cells were adjusted assuming total oxidation of weekly labile carbon substrate additions. Thus, results show 'net' treatment effects on decomposition of original thatch organic matter (OM) by indigenous soil microbiological agents.

In Experiment 2, three experimental units were randomly selected from the ME fairway soil cores (photo, right) and surface-treated by a 1 oz. / M application of Daconil in combination with; I-MOL (3 oz. / M), a 2X rate of I-MOL (6 oz. / M), or a positive control (carbonless nutrient analog of I-MOL). Weekly treatment applications were made as described in Exp. 1. Three 5-week experimental runs were conducted using fresh soil cores in Exp. 2. Following incubations, the upper 0.65" or 0.79" layers were systematically removed from Exp. 1

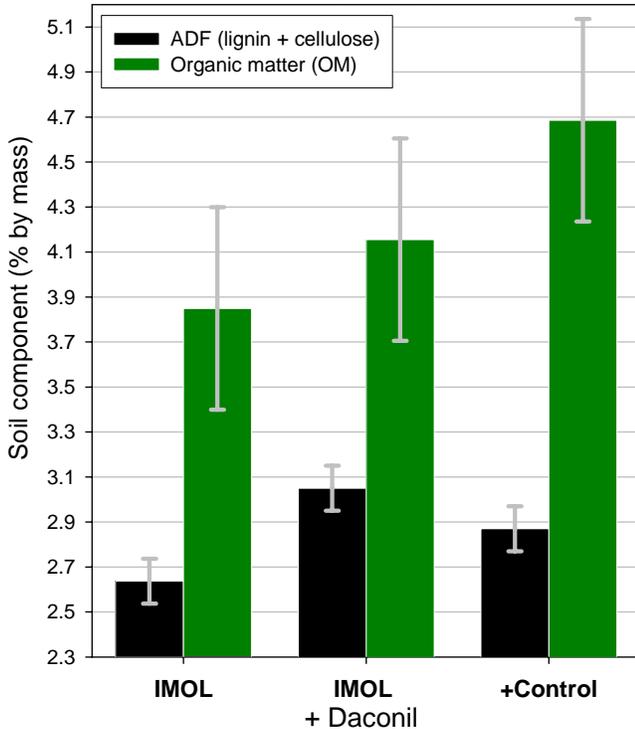


or 2 soil cores, respectively. Each of 2 core sub-samples were dried and ground, then submitted to Dairy-One Forage Quality Lab (Ithaca, NY) for determination of lignin + cellulose (acid-detergent fiber; ADF) and total organic matter (OM) content. No-intercept quadratic regression (PROC REG) was used to model CO₂ evolution by time, while experiment-end ADF and total OM data were analyzed by BLUE-weighted mixed models (SAS Inst., 1998). Flow cells and runs were included as experimental blocking factors. Moreover, inclusion of specific 5- or 6-wk mean cell temperatures as covariate factors proved effective in reducing residual error observed in each experiment model.

Experiment 1 Results: Microbial carbon evolution from the I-MOL treated-putting green cores (measured as CO₂) significantly exceeded that of the positive control cores by 17.6% (right). This difference amounted to 2 lbs C per 1000 ft² (M) over a 6-week period of use (each data point represents the mean value of three independent 6-week experiments). Average daily OM decomposition rate decreased with time elapsed from application (1 to 7 days) as well as over the experimental period (successive weekly applications). These observations likely resulted from a diminished soil OM pool (absence of fresh OM contributions) over the 6-week experimental period, and can be considered unique to the imposed conditions. Considering the observed



NJ USGA Sand Putting Green
Post Treatment Analysis (upper 0.65" surface)

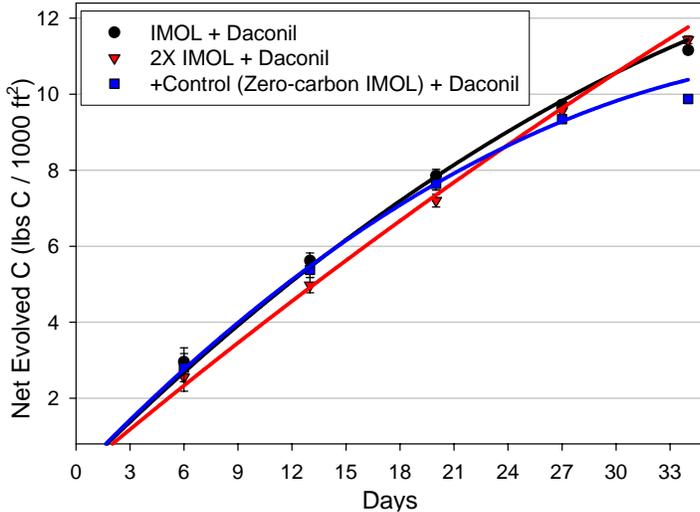


effect of Daconil on microbial activity in the sand-based putting green cores, soil fungi populations may play more significant roles in lignin and cellulose decomposition than bacteria, as reported in the literature (Holl et al., 2005).

Post-incubation analysis of the sand putting green thatch layer identifies the origin of evolved carbon (left). Resulting OM data show I-MOL treated cores retained 3.85 % OM (by mass), following 6 weekly applications at 3 oz. / M. The combined I-MOL + Daconil treatment shows similar soil OM levels (4.15 %) in the upper 0.65 inches of the putting green surface. The positive control treatment, or carbonless I-MOL analog, resulted in 4.7 % OM by mass in the upper putting green surface. Resulting acid-detergent fiber (ADF; lignin + cellulose content) was significantly reduced by I-MOL compared to the positive control.

Experiment 2 Results: In Experiment 2, carbon evolution rate was similar among the weekly treatment applications over the 35-day period (top left, page 4). Net evolved carbon accumulated to approximately 11 lbs C / M for all treatments. Initial upper soil surface OM content in the Maine fairway was extremely high, hardly an uncommon trait of mature and acidic turfgrass systems in the northern US. Although the climate of coastal Maine provides 5-6 months of turfgrass growing conditions, the period of elevated soil temperatures needed to support saprophytic decomposition of soil OM is brief. While all Exp. 2 treatments (I-MOL, 2X I-MOL, and the + Control) were made in

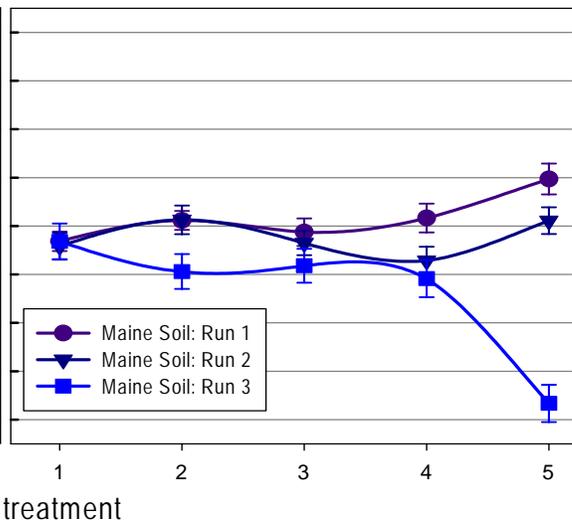
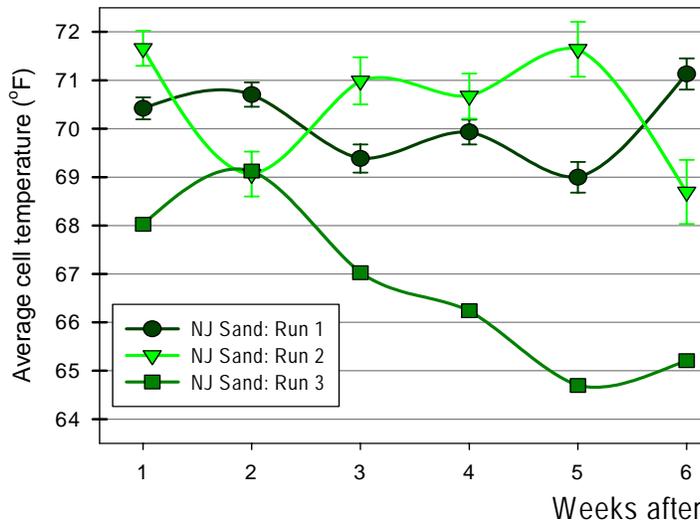
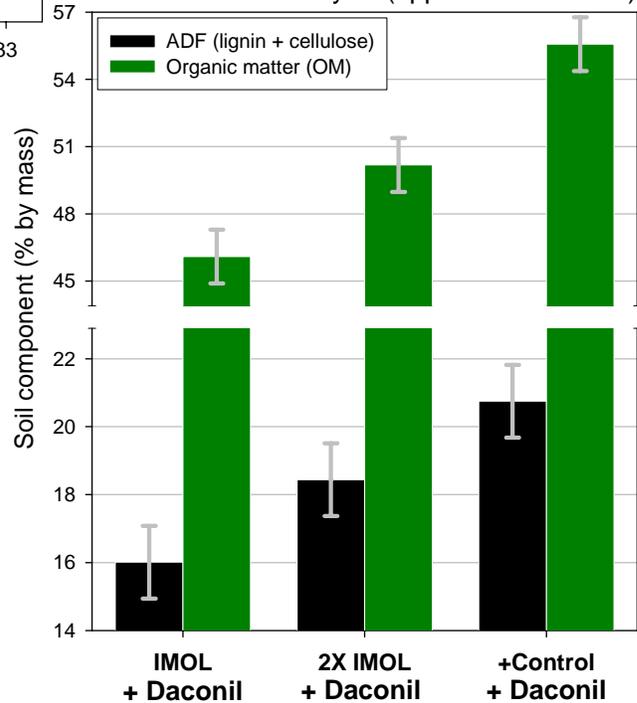
combination with Daconil fungicide, carbon evolution rates from Experiment 2 plugs were similar to rates observed from non-fungicide treated plugs in Exp. 1. This comparative-tolerance to



fungicide applications may be associated with greater OM content in the Experiment 2 cores. Likewise, the greater age/maturity of the Exp. 2 turfgrass system may correspond to a more robust and diverse microbial population. Holl et al. (2005) reported greater carbon substrate microbial utilization in soil-based turf systems than in newly-established sand-based systems.

Despite similar carbon evolution rates observed among treatments in Exp. 2, notable differences in upper soil surface OM quantity and quality resulted. As in Exp. 1, weekly applications of I-MOL significantly reduced the lignin + cellulose content of OM compared to the positive control (right). Effects of 2X I-MOL applications were intermediate to the positive control and label rate of I-MOL in reducing recalcitrant fiber content of OM. Label rate I-MOL applications significantly reduced total soil OM content compared to 2X or control treatments. These responses to I-MOL in Exp. 2 exceeded those observed in Exp. 1, yet occurred over a shorter incubation period (35- vs. 42-d) in which ambient laboratory temperatures were far cooler (below).

Portland ME Fairway Soil
Post Treatment Analysis (upper 0.79" surface)



Conclusions

Under the described laboratory conditions and relative to the positive control treatment:

- **Weekly reapplications of I-MOL (3 oz. / M) to thatch/mat enhanced microbial-activity, yet when applied in conjunction with a broad-spectrum fungicide (Daconil), the observed response was substantially reduced in the sand rootzone.**
- **Observed reductions in cellulose + lignin concentrations (acid detergent fiber; ADF) were 23 to 8% over respective 5- to 6-week periods of weekly I-MOL reapplications**
- **Weekly reapplications of I-MOL (3 oz. / M) significantly reduced total OM content by 17% in the upper 0.8” of a heavily-thatched soil turfgrass system, but had no effect on total OM content in the sand rootzone**
- **Arbitrary doubling of I-MOL application rate (3 to 6 oz. / M) did not enhance the described responses**

Discussion: As mentioned, the potential for effectively-preventing thatch accumulation through chemical and/or biological treatment is of inherent interest to turfgrass managers. Numerous ‘biochemical’ thatch control agents are currently available and advertised as effective alternatives to physical cultivation. Meanwhile, replicated field research results have shown mixed results. These reasons justified conducting the described research under controlled laboratory conditions.

Considering living turfgrass serves as both a sink and source of carbon dioxide, its influence on the collected data was eliminated. The same concern for standardization of influential factors served as justification for implementing a carbonless nutrient analog as the control treatment. Likewise, because thatch is hardly the most readily-decomposed carbon substrate available to microbes within cores of dead turfgrass systems, the concentrations of cellulose + lignin and total organic matter in the treated cores were analytically determined at experiment end. The decision to conduct research in the laboratory, rather than the field, was met with resistance. Ultimately, the research sponsors were convinced the laboratory approach was worthwhile—but not before we agreed upon the following mutually-satisfactory provision: If the laboratory experiments showed the treatment applications resulted in (1) increased CO₂ evolution, (2) decreased residual total organic matter, and (3) significant reduction of residual acid-detergent fiber content; then I was bound to further investigate treatment efficacy through replicated field trials in 2008. This field research is currently underway, and the results will be included in the 2008 PSU Turfgrass Research Reports.

In regard to the results and conclusions shown, it is imperative that I emphasize and each reader recognizes one very specific and important qualification. Under optimal field conditions, where mature leaf/shoot/root tissues regularly undergo senescence and replacement by fresh biomass, total OM and ADF fraction reductions of the magnitude described would be an unlikely—IF NOT IMPOSSIBLE—expectation of I-MOL treatment reapplications. This is because the described results were observed in a system purposely devoid of living vegetation, yet flush with vegetative detritus. The turfgrass vegetative detritus, often less-endearingly referred to as thatch, was generated in recent period by actual turfgrass living on an actual golf course; essentially the same thatch that

currently supports dynamic soil microbial populations anywhere. It is important to note the quantities of thatch that serve as the bases for every conclusion made in the described study were indeed static. The obvious follow-up question remains: Were the observations resulting from labile-carbon delivery by I-MOL real differences, or merely insignificant details on a backdrop rightfully obscured by the relentless biomass generation and deposition by intensively-managed modern turfgrass varieties? Field research results may help provide a definitive answer.

In summary, the described results are intriguing. The most common question I encounter from those whom read these associated reports is ‘Why does I-MOL facilitate thatch decomposition?’ Unfortunately I do not know the unequivocally-acceptable answer, but my best guess is the addition of the labile carbon stimulates microbial birth rate. In turn, the greater number of microbes increases production of extracellular enzymes. These persistent extracellular enzymes, synthesized in mass at the interface of assimilate and heterotrophic activity, may have made the measurable difference. I hope to have specific answers to all these questions before too long, and certainly appreciate your patience and continued interest in the meantime. Stay tuned and have a great summer!

Disclaimer: Trade and/or manufacturer’s names mentioned in this report are for information only and do not constitute endorsement, recommendation, or exclusion by the author or Pennsylvania State Univ.

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