Decomposition rates and nitrogen release of turf grass clippings

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Abstract

Decomposition rates and N release patterns of turfgrass clippings from lawns are not well understood. Litter bags containing clippings were inserted into the thatch layer of a cool-season turf. The experiment was arranged as a 2 ? 4 factorial in a randomized complete block design with three replicates. Treatments included four rates of N fertilizer (0, 98, 196, and 392 kg N ha^{-1} yr^{-1}) and two clipping treatments (returned vs. removed). Litter bags were removed periodically over the growing season and samples were analyzed for biomass, N and C concentrations, and C:N ratio on an ash-free basis. Percentage N loss from the clippings after 16 weeks ranged from 88% to 93% at the 0 and 392 kg N ha^{-1} rates, respectively, and from 86% to 94% when clippings were removed (CRM) or returned (CRT), respectively. Percentage C loss from the clippings ranged from 94% to 95% at the 0 and 392 kg N ha^{-1} rates, respectively, and from 92% to 96% with CRM and CRT, respectively. Cumulative N release was similar across N fertilization rates, (ranging from 131 g N kg^{-1} to 135 g N kg^{-1} tissue) but was higher for CRT (151 g N kg^{-1} tissue) than for CRM (128 g N kg^{-1} tissue). Grass clippings decomposed rapidly and released N quickly when returned to the turf thatch layer. This indicates the potential for reduced N fertilization when clippings are returned. Such rapid decomposition also suggests that the contribution of grass clippings to thatch development is negligible.

Media Summary

Returning clippings to managed turfgrass areas provides a significant source of nitrogen to the turf. Consequently, the application of synthetic fertilizers may be reduced.

Key Words

Turfgrass, clippings, decomposition, nitrogen fertilization, thatch

Introduction

Returning grass clippings provides a biodegradable source of organic N to the turfgrass ecosystem. The amount of mineralizable N available in such a system has a direct impact on the quality and vigor of the turf. By returning clippings, nutrients are recycled into the turfgrass system and N fertilization requirements may be reduced (Busey and Parker, 1992). However, literature reviewed on this topic indicated that there are few published, peer-reviewed studies that have examined the effects of returning grass clippings upon the turfgrass/soil system. In particular, there are no field studies that have examined decomposition of turfgrass clippings and the rate of release of clipping N in a turfgrass/soil system. Therefore, it was the objective of this research to determine decomposition rates and N release patterns of cool-season turfgrass clippings returned to turf managed as a residential lawn. It was a further objective to determine whether the practice of returning clippings affected a cumulative decomposition response in turfgrass with time.

Materials and Methods

The experiment was conducted at the University of Connecticut's Plant Science Research and Teaching Farm in Storrs, CT, USA and was arranged as a randomized complete block design with three replicates. Experimental treatments were N rate (0, 98, 196, and 392 kg N ha^{-1} yr^{-1}) with clippings either removed or returned to the plots. The site had been seeded with a bluegrass-ryegrass-red fescue mixture [35% common Kentucky bluegrass, 35% common creeping red fescue (*Festuca rubra* L. subsp. *rubra*), 15% 'Cutter' perennial ryegrass, and 15% 'Express' perennial ryegrass]. Fertilization and clipping treatments began during the growing season of 1997 and continued for two yrs prior to the initiation of the decomposition experiment. The soil at the site was a Paxton fine sandy loam (coarse-loamy, mixed, active, mesic Oxyaquic Dystrudrept). Before N application, first-cutting clippings were harvested from field plots and placed into litter bags for the determination of decomposition rates and N release patterns (20 g tissue per bag). Ten litter bags were placed into the thatch layer of each plot, including those on which clippings had always been removed, and the bags were retrieved from the field after 1, 2, 3, 4, 5, 7, 9, 11, 13, and 16 weeks. Samples were analyzed using a LECO FP-2000 Carbon/Nitrogen Analyzer (Leco Corp., St. Joseph, MI) for the determination of total N and C concentration. Initial and final N and C concentration data were analyzed on an ash-free basis using the GLM procedure of SAS (SAS Inst., 1990) for a randomized complete block design. The percentage initial N and C remaining at each sampling period were regressed on time using Deltagraph v. 4.0 software (Deltapoint Inc., 1990). A double, four-parameter exponential decay model (Weider and Lang, 1982) was used with the general form of the equation as follows:

$$Y = \Phi_0 e^{-k_1 t} + \Phi_1 e^{-k_2 t} + Error \quad [1]$$

where *Y* is the percentage of initial C or N remaining at sampling time *t*, Φ_0, is the easily decomposable fraction, Φ_1 is the recalcitrant fraction (100-Φ_0), k_1 and k_2 are C or N decomposition or N release constants, and *t* is the time in weeks. This double, four-parameter model describes a rapid, initial phase of decomposition followed by a slower phase (Isaac et al., 2000). Nitrogen release from clippings was calculated for N rate and clipping means by multiplying the initial N content by the percentage estimate of N release from the double exponential decay model equations (Isaac et al., 2000).

Results and Discussion

The effect of C:N ratios in the decomposition process is a regulatory one based upon the assumption that N concentrations commonly limit the activity of decomposer organisms (Swift, et al., 1979). In this experiment, however, C:N ratios for all treatments were less than the ratios that are typically considered limiting (>30:1). Therefore, we assumed that the decomposition of grass clippings would occur rapidly and limited the experiment to 16 weeks. Decomposition is also highly dependent on air temperature and soil moisture (Douglas and Rickman, 1992). Although we observed that most tissue was decomposed within 4 wks (approximately 70%), the hot and dry conditions that prevailed during our experiment may have slowed decomposition processes (Fig. 1A-H).

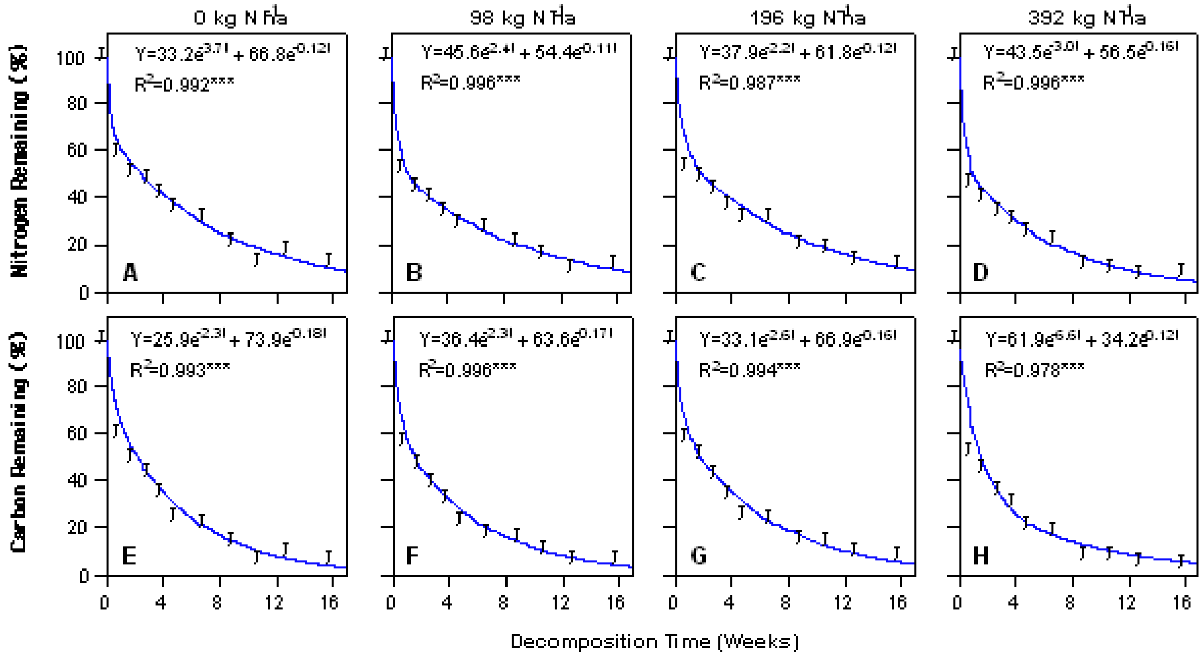

Figure 1. Percent nitrogen and carbon remaining in decomposing grass clippings across 4 N fertilization rates. •••Significance of model fit at *P*<0.001.

The double exponential decay model (Weider and Lang, 1982) suitably described percent N and C remaining in the grass clippings. Percentage N loss after 16 weeks averaged 90% and was greater when clippings were returned (Fig. 2A, B). Percentage C loss after 16 weeks averaged 94%. Percentage N and C loss was higher when clippings were returned (Table 1, Fig 2).

Prior to decomposition, initial tissue N concentration and C:N ratio exhibited a significant linear response to N rate (Table 1). Nitrogen rate effects observed before decomposition were likely due to carry-over from previous years' management. Following the decomposition experiment, final tissue N concentration averaged 2.1 g kg^{-1} and final tissue C content averaged 2.8 g kg^{-1} across N rates. In addition, final tissue N and C concentrations were significantly higher when clippings were removed (Table 1). Final C:N ratio exhibited a significant quadratic response to N rate but was unaffected by clipping treatment (Table 1). Considering both N fertilization rate and clipping treatment, marked release of N occurred within the first 4 wks of the experiment. After 16 weeks, cumulative N release was similar across N rates and averaged 133 g N kg^{-1} tissue. Cumulative N release was greater for CRT (150.7 g N kg^{-1} tissue) than for CRM (128.1 g N kg^{-1} tissue) after 16 weeks.

Table 1. Chemical characteristics of turfgrass clippings prior to and after decomposition (final loss of N and C is in relation to initial N and C contents).

Treatment	N concentration		C concentration		C:N ratio		Final loss	
	Initial	Final	Initial	Final	Initial	Final	N	C
kg N ha^{-1}		g kg^{-1}			g g^{-1}		%	

0	18.8	14.1	445	181	24.0	12.7	88.1	93.7
98	20.4	14.6	445	190	22.0	13.0	89.1	93.6
196	20.9	14.3	447	202	21.7	14.1	88.7	92.6
392	22.9	8.86	446	106	19.6	11.8	93.1	95.9
Linear	***	NS	NS	NS	***	NS	NS	NS
Quadratic	NS	NS	NS	NS	NS	*	NS	NS
Cubic	NS	NS	NS	NS	NS	NS	NS	NS
Clipping								
CRM†	19.9	17.6	446	228	22.7	13.0	93.7	96.0
CRT‡	21.6	8.42	446	112	20.9	12.8	85.7	91.9
***F* test**	NS	**	NS	**	NS	NS	**	*

*, **, ***, NS Significant at the 0.05, 0.01, and 0.001 probability level and nonsignificant, respectively. † CRM-clippings removed plots. ‡ CRT-clippings returned plots.

Direct comparisons of model parameters that we determined to those of other studies are difficult since we were unable to find published work on the decomposition of turfgrass clippings. Comparisons may be made, however, to decomposition studies of other grasses. K?chy and Wilson (1997) compared litter decomposition and nitrogen dynamics in aspen forest and mixed-grass prairie. Utilizing a three-parameter, exponential decay model, they determined a *k* rate of 0.03 wk^{-1} for mixed prairie grass. It is difficult to make direct comparisons to their study since we utilized a double exponential decay model, however, K?chy and Wilson's (1997) *k* rate was comparable to k_2 decay constants that we observed.

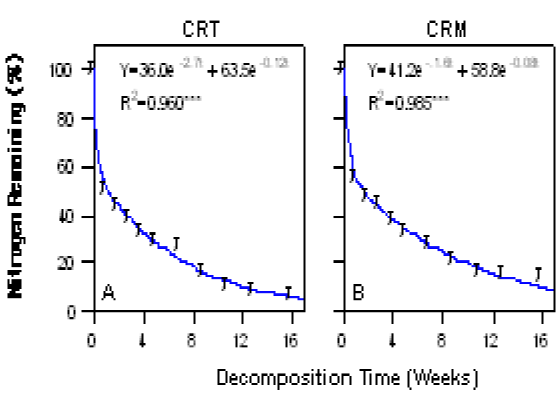

Figure 2. Percent nitrogen remaining from decomposing grass clippings when clippings were returned (A, CRT) or removed (B, CRM). ***Significance of model fit at *P*<0.001.

Douglas and Rickman (1992) also found that a two-stage decomposition model was appropriate for buried residues. We observed significant differences in both the k_1 and k_2 decay constants due to clipping treatment. In relation to clipping treatment, both the k_1 and k_2 decay constants were significantly greater when clippings were returned. The higher decay constants for CRT treatments indicate that the practice of returning clippings increased the rate of decay and N cycling of previously returned clippings during both phases of the decomposition process. The practice of returning clippings did not significantly affect the parameter estimates for decay models of C.

Hendrix and Parmelee (1985) examined the influence of herbicide upon decomposition of Johnsongrass [*Sorghum halepense* (L.) Pers.] in a fallow field. Dried Johnsongrass was treated with varying rates of different herbicide solutions and monitored for decomposition over time. Hendrix and Parmelee (1985) stated that they were unable to utilize double exponential decay models due to a lack of data during the initial, rapid decomposition phase, however, they were able to perform linear regressions upon data from the second phase of decomposition. Their observed k rates averaged 0.03 wk^{-1} and were comparable to the k_2 decay constants that we observed.

Conclusion

The rapid decomposition of grass clippings that we observed supports the conclusions of Beard (1976), Haley et al. (1985), and Johnson et al. (1987) that thatch accumulation is not increased by the practice of returning clippings to turfgrass. Further research is necessary, however, to determine decomposition and N release rates for different grass species under varying management conditions when clippings are returned. This study clearly shows, however, that the decomposition of grass clippings provides rapidly released N within the thatch layer of turfgrass. It is reasonable to assume that a portion of that N will become available to the turfgrass during the growing season. Therefore, N fertilization rates should be reduced when clippings are returned to turfgrass managed as a residential lawn.

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