APPENDIX B

EFFECT OF CLIPPING MANAGEMENT ON NITRATE-N LEACHING, N UPTAKE, TURF QUALITY AND TURF GROWTH

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INTRODUCTION

Clipping management is an integral part of turfgrass management. Recommendations have long called for returning clippings to the grass to provide available nutrients and to improve organic matter. While this is a widely used practice in home lawn management, no known studies have been done on warm-season grasses to determine nutrient input for the grass and potential NO_3-N losses due to leaching. Clipping-return could provide at least part of a solution to this problem of human health or environmental pollution. Researchers working in cool-season grasses have reported that returning grass clippings can help maintain turf quality while reducing fertilizer use (Starr and DeRoo, 1981; Heckman et al., 2000; Kopp and Guillard, 2005).

The Florida Green Industries Best Management Practices (BMPs) have been developed to minimize nonpoint source pollution resulting from lawn management. Due to lack of information regarding the effect of clipping-return in warm-season grass, the objectives of this study were to determine the effect of clipping management on NO_3-N leaching and turf N nutritional status.

MATERIALS AND METHODS

The field experiment was conducted at the University of Florida Plant Science Research and Education Center in Citra, Florida on 'Empire' zoysiagrass (*Zoysia japonica* Steud.). The grass was established in March 2008 and the study was conducted from June to October 2008.

Clipping-management (CM) and nitrogen (N) fertilizer treatments were as follows:

- CM #1 consisted of clipping-return, in which clippings were left in the experimental field after mowing with a conventional rotary mower.

- CM#2 consisted of clipping-removal, in which clippings were taken from the field by attaching a collection bag to the same rotary mower. Mowing height was set at 6.3 cm (2.5 inches). The plots were mowed once a week during the growing season.

- Fertilizer treatments consisted of six levels of total N rates (equivalent to 0 lbs, 1 lbs, 2 lbs, 3 lbs, 4 lbs or 6lbs N 1,000 ft^{-2} or 0 kg, 49 kg, 98 kg, 147 kg, 196 kg, or 294 kg N ha^{-1}). Treatments were applied at 2-mo intervals for a total of two treatment applications. A 50% slow-release N fertilizer (SRF) with an analysis of 15-0-15 was used.

Leachate samples were collected weekly as previously described. Turf was evaluated visually for quality and color, which were rated immediately after mowing. A scale of 1 to 9 was used, in which 9 represents optimal, dark green color and 1 represents dead, brown turf. A rating of 6 is considered minimally acceptable for a home lawn.

Clippings were collected to determine shoot growth once a month from a known plot area and dried at 75ºC for 48h. They were ground in a Wiley mill and then weighed. The total N concentration was analyzed with 0.2 g of dried clippings and then analyzed by the total Kjeldahl nitrogen (TKN) procedure. Roots were sampled by taking three 1.9-cm diameter root cores per plot once a year. Root weight and length were measured after washing soil from them. Total N uptake (TNU) was also calculated from the TKN (%) and dry weight of clippings (DWC) (g m^{-2}).

□ TNU (mg m^{-2}) = DWC (g m^{-2}) × TKN (%) × 1000mg g^{-1} (Eq.2-1)

This experiment was arranged as a nested design by CM, with fertilizer treatments randomized within. There were three replications. Data were analyzed with the SAS procedure ANOVA (SAS institute Inc., Cary. NC). Significance was determined at the 0.05 probability level.

RESULTS AND DISCUSSION

Nitrate Leaching

Nitrate-N lost due to leaching did not differ in any month or for the season due to clipping management at the 0.05 probability level (Table 280). There were differences in NO_3-N lost to leaching due to N rate in June, July and September and for the seasonal total. Where these differences existed, leaching was higher only from the highest rate of applied N, with no differences due to the other rates.

Research data from cool-season grasses varies with respect to NO_3-N loss due to clipping management. Starr and DeRoo (1981) reported average NO_3-N concentrations of 2.0 and 1.9 mg L^{-1} from clippings returned and removed, respectively. They concluded that NO_3-N leaching losses were negligible regardless of clipping management. In contrast, Kopp and Guillard (2005) reported NO_3-N losses of 1.9 to 85.4 mg $L^{-1}$and 10.1 to 171mg L^{-1} with clippings removed and returned, respectively, from creeping bentgrass .

Clipping Yield and Root Weight

Clipping yields were influenced by N rate in each evaluation period (Table 281). Clipping management influenced clipping weights in July, Aug, and Sept only and the interaction of the main effects had differences at the 5% probability level in July and Aug, although means separation revealed differences due to the interaction in Sept as well. In July and Sept, higher yield was produced in plots clippings removed, with greater yield from clipping return in Aug. Root weights did not differ due to any treatment effects.

Table 280. NO_3-N leaching losses (kg ha^{-1}) from Empire Zoysiagrass in response to N rates and clipping management.

N Rate	June	July	Aug	Sept	Oct	Total
-------kg ha^{-1}------	----------kg ha^{-1}----------					
0	2.65 b	1.42 b	0.34 b	0.08 b	0.31 b	4.80 b
49	0.50 b	0.67 b	0.33 b	0.14 b	0.50 ab	2.14 b
98	4.19 b	3.96 b	0.35 b	0.39 b	1.3 ab	10.20 b
147	1.28 b	2.63 b	5.40 b	0.32 b	0.72 ab	10.36 b
196	5.63 b	1.85 b	1.01 b	0.37 b	1.29 ab	10.15 b
294	15.31 a	18.30 a	21.88 a	2.19 a	6.03 a	63.72 a
Clipping Management						
Return	20.06 a	17.67 a	23.28 a	2.69 a	8.56 a	72.27 a
Remove	9.50 a	11.15 a	6.04 a	0.81 a	1.60 a	29.08 a
ANOVA						
N rate (N)	*	*	NS[§]	*	NS	*
Clipping management (CM)	NS	NS	NS	NS	NS	NS
N x CM	NS	NS	NS	NS	NS	NS

* Significant at the 0.05 probability level.
** Significant at the 0.01 probability level.
*** Significant at the 0.001 probability level.
[§]NS= not significant

Table 281. Turf shoot and root weight in response to N rates and clipping management.

N Rate	July	Aug	Sept	Oct	Avg	Root Weight
-------kg ha^{-1}------	----------g m^{-2}----------					-------g-------
0	3.26 c	0.91 d	3.31 d	8.37 c	3.96 d	1.03 a
49	6.55 c	1.65 d	6.67 cd	17.18 bc	8.01 cd	0.62 a
98	7.83 c	2.38 cd	11.04 c	22.48 bc	10.93 bcd	0.80 a
147	23.13 b	3.77 bc	19.74 b	28.94 b	18.89 b	0.72 a
196	16.14 b	4.37 ab	19.52 b	27.72 b	16.94 bc	0.77 a
294	41.84 a	5.88 a	29.65 a	47.32 a	31.18 a	0.53 a
Clipping Management						
Return	11.11 b	4.52 a	12.42 b	24.39 a	13.11 a	0.69 a
Remove	21.81 a	1.80 b	17.55 a	26.29 a	16.86 a	0.80 a
ANOVA						
N rate (N)	***	***	***	**	***	NS[§]
Clipping management (CM)	***	***	**	NS	NS	NS
N x CM	*	**	NS	NS	NS	NS

* Significant at the 0.05 probability level.
** Significant at the 0.01 probability level.
*** Significant at the 0.001 probability level.
[§]NS= not significant

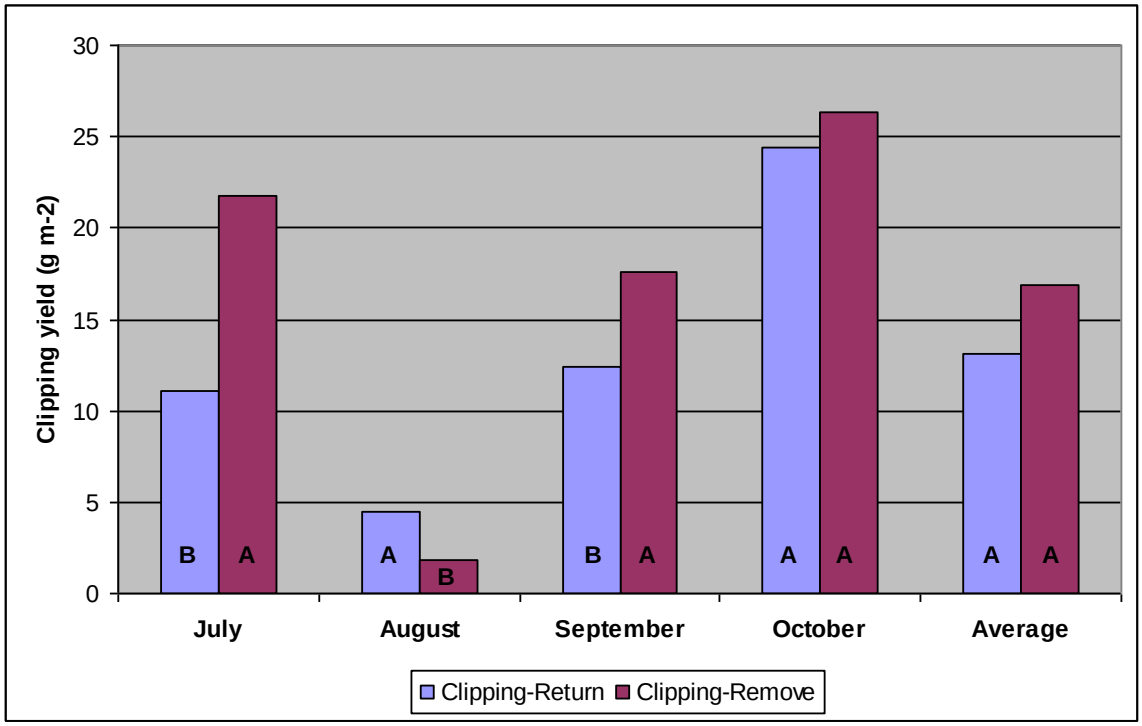

Figure 57. Total annual dry clipping yield (g m^{-2}) by clipping management of Empire Zoysiagrass in 2008.

Tissue N concentration and Total N Uptake

There was no significant difference in TKN due to any treatment effects (Table 281). Average N uptake, calculated as dry clipping yield x TKN differed only due to N rate, with higher uptake at higher N application rates. Clipping management did not affect the N uptake or concentration, and based on results of this trial, would not provide an offset for N application.

Visual Quality and Color

Clipping management and N rate had effects on turfgrass quality (Table 282). Higher N rates increased quality scores and clipping removal produced higher quality scores. Color was influenced only by N rate, with highest color scores at the three highest N rates.

Table 282. Tissue N concentration and N uptake[‡] in response to N rates and clipping treatment.

N-rate	TKN	N Uptake
kg ha^{-1}	%	g m^{-2}
0	1.54	0.06 c
49	1.58	0.13 bc
98	1.59	0.18 bc
147	1.57	0.30 b
196	1.65	0.28 b
294	1.70	0.53 a
Clipping Management		
Return	1.60	0.21
Removed	1.61	0.27
ANOVA		
N Rate (N)	NS	***
Clipping Management (CM)	NS	NS
N x CM	NS	NS

* Significant at the 0.05 probability level.
** Significant at the 0.01 probability level.
*** Significant at the 0.001 probability level.
[§]NS= not significant
[‡]N uptake (mg m^{-2}) = Dry clipping yield × TKN (%)

Table 283. Evaluation for quality and color (1-9) for 'Empire' Zoysiagrass in response to N rate and clipping management

N-rate (kg ha^{-1})	**N-rate (lbs N / 1000ft^2)**	**Quality (1 – 9)**	**Color (1 – 9)**
0	0	6.75 d	6.67 c
49	1.0	7.33 c	7.18 b
98	2.0	7.35 c	7.33 b
147	3.0	7.87 b	7.73 a
196	4.0	7.75 b	7.68 a
294	6.0	8.20 a	7.92 a
Clipping Management			
Return (CRT)		7.41 b	7.36 a
Remove (CRM)		7.67 a	7.48 a
ANOVA			
N-rate (N)		***	***
Clipping ©		**	NS[§]
N × C		NS	NS

* Significant at the 0.05 probability level.
** Significant at the 0.01 probability level.
*** Significant at the 0.001 probability level.
[§]NS= not significant

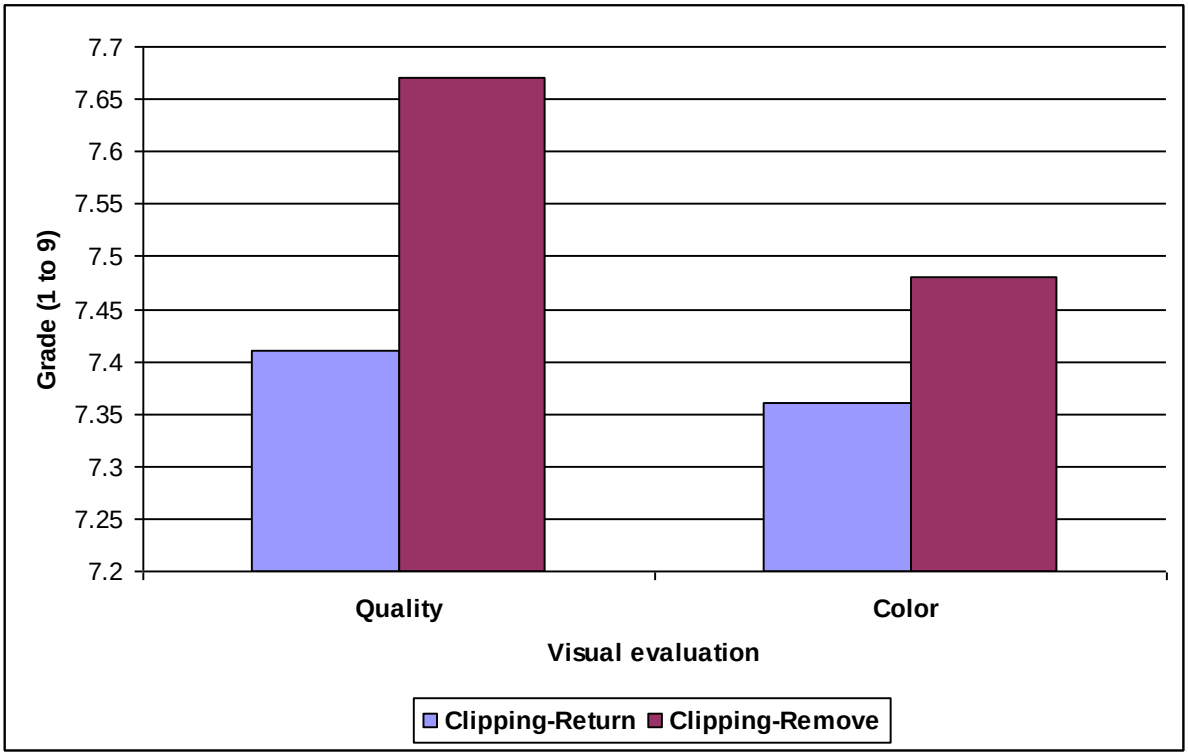

Figure 58.

CONCLUSIONS

Nitrogen rate influenced NO_3-N leaching in 3 of 5months and for the total trial period. There was no difference in NO_3-N leached due to clipping management. Clipping yield increased as N increased and differed in 3 of 4 months due to clipping management. There was an interaction of N rate and clipping management in July and August. Where these differences occurred, greater weights were from plots that received higher N and had clippings returned. There were no differences due to root weight to any treatment effects. Nitrogen uptake differed only in response to N rate. Turf quality and color increased with N rate and turf quality was higher when clippings were removed, only because visual ratings were taken after mowing.

Previous research has reported that clipping return may reduce fertilizer need in cool-season grasses. This research shows no effect in N uptake or tissue concentration due to clipping management and supports current fertilization recommendations that N should be applied at 196 kg ha^{-1} N or less annually to reduce leaching load while maintaining healthy, good quality Empire zoysiagrass in north central Florida.