10.1% water. It is possible that some water was added from the moist greenhouse atmosphere. There was no oven dry control.

These data indicate that water can move from a wet portion of the root zone up to a crown or stem area and back down into roots in a dryer area and be released into the soil. It also shows the maintenance of roots in dry soils may be species dependent, and that the implications for water management and fertilizer placement with regard to alternate row irrigation need evaluation.

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Comparison of Conventional and Mulching Mowers for Kentucky Bluegrass Maintenance

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Abstract. **The effects on Kentucky bluegrass (*Poa pratensis* L.) turf quality of mowing with either a mulching mower or a conventional rotary mower, having clippings removed or returned, were determined. Turf that received 0, 150, or 300 kg N ha^{-1} yr^{-1} was mowed at 5 cm either biweekly, weekly, or twice weekly. Turf quality, weed encroachment, and thatch buildup were monitored. Highest quality was found where turf was mowed twice weekly with a conventional rotary mower with clippings returned and received 300 kg N ha^{-1} yr^{-1}. Quality ratings for turf mowed with the mulching mower were equal to or significantly lower than ratings for turf mowed with a conventional rotary mower with clippings returned on 13 of the 17 rating dates. Thatch buildup and weed encroachment responded to N level, with more thatch and fewer weeds at the highest N level.**

In the last few years, public interest in mulching mowers has increased. Conventional rotary mowers typically are used with a bag attachment to catch turfgrass clippings. Clippings often are removed because they can be unsightly and are feared to contribute to thatch buildup. Clipping removal is time-consuming and results in nutrient loss (2, 3). The mulching mower does not require a bagging attachment, since an enclosed housing causes the clippings to be chopped into a fine debris. The "mulched" clippings are discharged underneath the mower. Because information related to the advantages and disadvantages of using these mowers was limited, this study was initiated to compare the effects of using a mulching mower versus a conventional rotary mower, with or without clipping romoval, on the quality of a Kentucky bluegrass turf. The influence of mowing frequency and nitrogen nutrition on turfgrass quality was also investigated.

The study was initiated on a 1-year-old stand of Kentucky bluegrass (*Poa pratensis* L. 'Baron') in April 1979. Plot size was 3 × 1.8 m. Treatments were arranged in a split-block design, with each treatment replicated 3 times. The horizontal strips consisted of nitrogen levels of 0, 150, or 300 kg ha^{-1} yr^{-1}. The mowing treatments were superimposed on the N levels in vertical strips. The 9 mowing treatments consisted of 3 mower types (mulching mower, conventional rotary mower with clippings returned, and conventional rotary mower with clippings removed), each used at 3 frequencies (biweekly, weekly, and twice weekly). All mowers were set at a 5-cm height of cut. Fertilizer treatments consisted of a water-soluble nitrogen source (33-0-0) divided into 3 equal applications made in April, June, and September. Weather permitting, mowing was performed on the same day(s) each week. The mowing schedule was followed without regard to the amount of leaf blade removed at each mowing. A Toro 21-inch "Mulcher Deluxe" was used for the mulching mower treatment. The conventional rotary mower was a Toro 21-inch "Rear Bagger". When clippings were returned, the bag was removed and the discharge chute closed. Clippings were discharged underneath the mower or a few inches from it. Clippings which were produced by the conventional mower were larger than those produced by the mulching mower, as reported previously (2).

Visual quality was evaluated on 17 dates,

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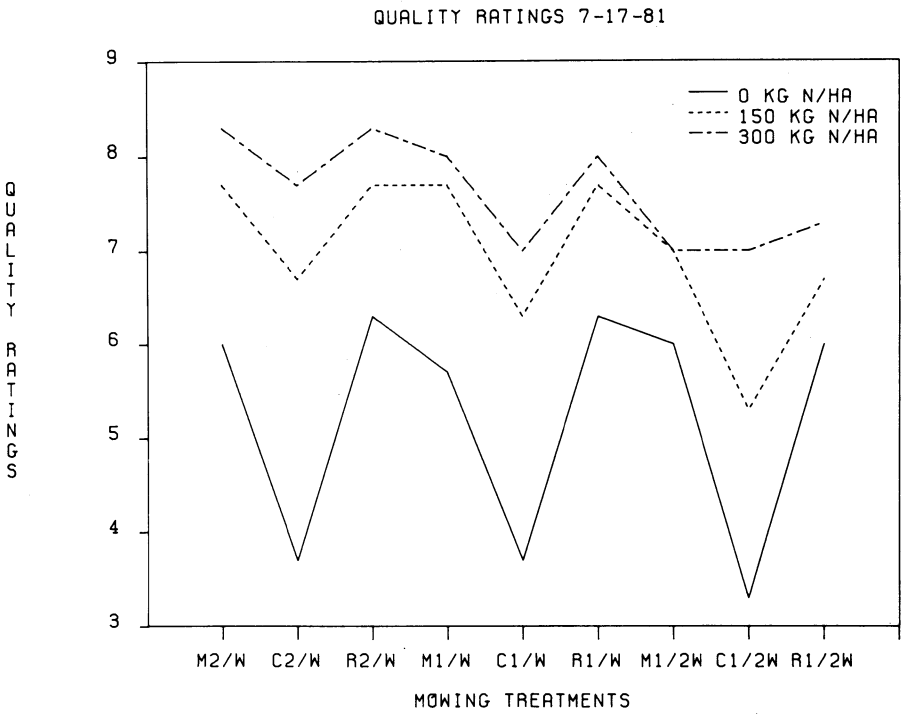

Fig. 1. Mowing treatment by fertility level interaction for quality ratings. M = mulching mower, C = rotary mower with clippings collected, R = rotary mower with clippings returned. Mowing frequencies 2/W, 1/W, 1/2W = twice per week, once per week, biweekly.

and turfgrass density and color on 8 dates, from 1979 to 1981. In all cases, a 1-to-9 scale was used — with 1 representing low quality, poor density, or brown turf, and 9 representing high quality, good density, or dark green color. Thatch was measured at the conclusion of the study by taking 3 samples per plot and measuring the noncompressed thickness of the thatch layer. Weed populations, predominately dandelion (*Taraxacum officinale*), were rated at the conclusion of the study using a 1-to-9 scale; 9 = 100% weeds and 1 = no weeds.

All data were subjected to an analysis of variance for spilt-block experiments. The sum of squares due to N level was partitioned in linear and quadratic effects. The mowing treatment sum of squares was partitioned using single degree of freedom contrasts as follows: linear and quadratic components of mowing frequency, mulching mower versus conventional mower with clippings returned, and returning clippings versus removal of clippings. The data were not transformed because the residuals from the analysis of variance followed a normal distribution.

The trends in turfgrass color and density paralleled the trends in the quality ratings, and for this reason only the quality ratings are presented. For 9 of the 17 quality ratings and the ratings for weed population, the N by mowing treatment interaction was significant. Graphs of the data on these dates revealed that the relative ranking of the mowing treatments at each fertility level remained relatively constant (Fig. 1), but the magnitude of change in the mowing treatment means between fertility levels varied. Since this was the probable cause for the significant interaction, no attempt was made to analyze the interaction further.

As expected, turf quality was influenced most drastically by N level (Table 1). Turf quality showed a linear response to N rate on 10 rating dates and a curvilinear response on 7 rating dates. Quality ratings for turf receiving the 150 kg ha^{-1} versus the 300 kg ha^{-1} rate reflected differences in N application timing in relation to data collection. Lack of serious disease, drought, or heat stress during this study meant that the turf receiving the high N rate did not suffer the quality reduction that might normally be expected with excessive N fertilization.

Mowing treatments had a significant ef-

Table 1. Quality ratings for Kentucky bluegrass fertilized at three rates and mowed with a mulching mower, rotary mower with clippings returned or a rotary mower with clippings removed. Turf was mowed at 5 cm 1 time/week, 2 times/week, or biweekly.

	1979					1980						1981					
Treatment	1 Jun	12 Jul	9 Aug	5 Sept	9 Oct	6 Apr	21 May	3 Jul	29 Jul	28 Aug	9 Oct	20 Apr	7 May	19 May	2 Jun	17 Jul	13 Aug
N level ($kg\ ha^{-1}\ yr^{-1}$)																	
0	5.0	5.4	6.3	6.2	5.9	4.4	4.4	4.6	5.0	4.7	5.3	3.3	4.4	4.6	3.7	5.2	5.2
150	6.0	6.5	6.6	6.6	6.4	5.9	5.8	8.1	6.9	5.5	7.1	4.7	6.4	6.3	7.6	7.0	7.0
300	6.8	7.3	7.0	6.9	6.9	6.2	6.3	8.3	7.0	5.9	7.0	6.6	7.0	7.2	8.3	7.6	7.7
Mowing treatment																	
Mulching twice/wk[z]	5.2	6.4	6.8	6.4	7.0	5.9	5.6	7.2	6.7	5.8	6.8	5.9	7.3	7.0	7.1	7.3	7.6
R. remove twice/wk	5.9	6.8	7.0	6.6	5.8	4.6	5.7	7.0	6.1	5.6	5.8	4.6	5.1	5.6	5.8	6.0	5.7
R. Return twice/wk	6.2	7.0	7.6	7.1	7.2	5.9	6.2	7.8	7.0	5.3	7.1	5.9	6.7	6.9	6.8	7.4	7.9
Mulching once/wk	5.1	6.2	6.3	6.0	6.6	5.4	5.1	6.4	6.4	4.8	6.4	5.4	6.8	6.8	7.1	7.1	7.3
R. Remove once/wk	6.2	6.9	6.3	6.7	6.0	3.7	5.7	7.2	6.2	5.5	6.4	3.7	4.8	4.7	5.9	5.7	5.7
R. Return once/wk	6.1	6.7	7.0	6.8	6.7	5.7	5.9	7.6	7.0	6.4	6.8	5.0	6.2	6.1	6.7	7.3	7.7
Mulching once/2 wks	5.0	5.8	6.0	6.4	5.4	5.7	4.8	5.8	4.1	4.1	6.4	5.1	6.9	6.9	7.3	6.7	5.7
R remove once/2 wks	7.0	5.8	6.2	6.2	6.2	4.4	5.1	7.2	6.2	5.3	6.0	3.3	4.1	4.7	5.4	5.2	5.4
R. Return once/2 wks	6.9	6.0	6.4	6.7	6.2	4.8	5.4	7.0	6.7	5.1	6.4	5.0	5.7	5.9	6.7	6.7	6.8
CV (%)	7.9	5.3	6.5	5.3	6.6	7.3	10.8	7.2	11.3	10.7	7.2	7.3	11.8	9.8	8.7	7.0	11.6
N_L[y]	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
N_Q	NS	NS	NS	NS	NS	*	**	**	*	NS	*	NS	NS	NS	**	*	NS
Mowing $freq_L$	**	**	**	NS	**	**	**	**	*	NS	NS	**	**	**	NS	**	**
Mowing $freq_Q$	*	**	NS	NS	NS	**	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	*
Mulch vs. Return	**	*	**	NS	NS	**	**	**	**	*	NS	NS	**	*	**	NS	*
Remove vs. Return	**	NS	NS	NS	**	**	NS	NS	NS	NS	*	**	**	**	**	**	**
N × Mowing Trt.	NS	NS	NS	*	NS	NS	**	**	**	**	*	*	NS	NS	NS	**	*

[z]Mulching = mulching mower, R. Remove = conventional rotary mower with clippings removed, R. Return = conventional rotary mower with clippings returned.

[y]L = linear component, Q = quadratic component.

[NS,*,**] = not significant, significant at 5% (*), or 1% (**) levels.

Table 2. Weed populations and thatch depth for Kentucky bluegrass fertilized at three rates and mowed with a mulching mower, rotary mower with clippings returned, or a rotary mower with clippings removed. Turf was mowed at 5 cm 1 time/week, 2 times/week, or biweekly.

Treatment	Weed population	Thatch depth (cm)
N level (kg ha^{-1} yr^{-1})		
0	3.8	1.2
150	1.3	1.7
300	1.0	2.0
Mowing treatment		
Mulching twice/wk[z]	1.8	1.5
R. Remove twice/wk	2.6	1.5
R. Return twice/wk	1.8	1.4
Mulching once/wk	1.8	1.4
R. Remove once/wk	2.8	1.6
R. Return once/wk	1.8	1.9
Mulching once/2 wks	1.6	1.8
R. Remove once/2 wks	2.6	1.5
R. Return once/2 wks	1.6	2.0
CV (%)	7.5	20.5
N_L[y]	**	**
N_Q	**	NS
Mowing $freq_L$	NS	**
Mowing $freq_Q$	NS	NS
Mulch vs. Return	NS	*
Remove vs. Return	**	NS
N × Mowing Trt	**	*

[z]Mulching = mulching mower, R. Remove = conventional rotary mower with clippings removed, R. Return = conventional rotary mower with clippings returned.
[y]L = linear component, Q = quadratic component.
NS, *, ** = not significant, significant at 5% (*), or 1% (**) levels.

fect on turfgrass quality. There was a linear response to increased mowing frequency on most rating dates with a curvilinear response on 5 rating dates. Turf quality suffered when mowing occurred only once in a 2-week period. The quality reducing was caused by large amounts of clippings left on the surface of the turf. This problem was most severe on turf fertilized with the high N rate and mowed with the mulching mower where excessive growth was cut into very small pieces that tended to stick together. On 12 rating dates, there was a significant difference in turfgrass quality between turf that had been mowed with a mulching mower and turf that had been mowed with a conventional rotary mower with clippings returned. On only 4 dates were the quality ratings for turf mowed with the mulching mower higher than those for turf mowed with a conventional rotary mower. The conventional rotary mower produced clippings that did not stick together, contrasting with those of the mulching mower. The quality comparison between turf that had clippings removed and turf that had clippings returned (combination of mulching mower treatments and conventional rotary mower with clippings returned treatments) indicated that quality on most dates was superior when clippings were returned. This effect was less apparent at the high N rate (Fig. 1).

The trends in weed populations (rated at the conclusion of the study) paralleled the trends in turfgrass quality (Table 2). Weed encroachment, which reflected poor turf density, was most severe in turf that received no N and that had clippings removed(1). Mowing frequency did not affect weed population.

Thatch measurements taken at the conclusion of the study revealed a linear response of thatch depth to N level. Thatch buildup is a result of excess organic matter production compared to decomposition. Although in some cases it can be influenced by fertility level (3), research has shown (5) that increased N does not always result in increased thatch. The largest difference in thatch depth occurred between turfs fertilized at 0 versus 300 kg N ha^{-1} yr^{-1}. The difference, however, was only 0.8 cm for the 3-year period of this study meaning that the difference in yearly accumulation was very small.

The differences in thatch buildup due to mowing treatments must be viewed in this light. There was a linear response of thatch depth to mowing frequency, with the thickest layers of thatch found on turf mowed once every 2 weeks. Decomposition of large deposits of clippings found on turf mowed biweekly may have been slowed because of reduced tissue surface area for microbial attack. There was less thatch found in turf where the mulching mower was used compared to the conventional rotary mower with clippings returned. There was no significant difference in thatch depth in turf where clippings were removed compared to turf where clippings were returned by the mulching mower or the conventional rotary mower. This result agrees with earlier reports (2,4) regarding the influence of clipping return on thatch buildup.

The N level by mowing treatment interaction for thatch depth was significant and is illustrated in Figure 2. At the O N rate, removing clippings resulted in less thatch than returning clippings. This effect diminished at the 150 and 300 kg N ha^{-1} levels, where adequate N overcame the effect of clipping removal.

Quality was acceptable on turf that was mowed 1 or 2 times per week, was fertilized with 150 or 300 kg N ha^{-1} yr^{-1}, and had clippings returned. Turf mowed with the mulching mower frequently received lower quality ratings than turf mowed with a conventional rotary mower with clippings returned. We found no advantages in using a mulching mower.

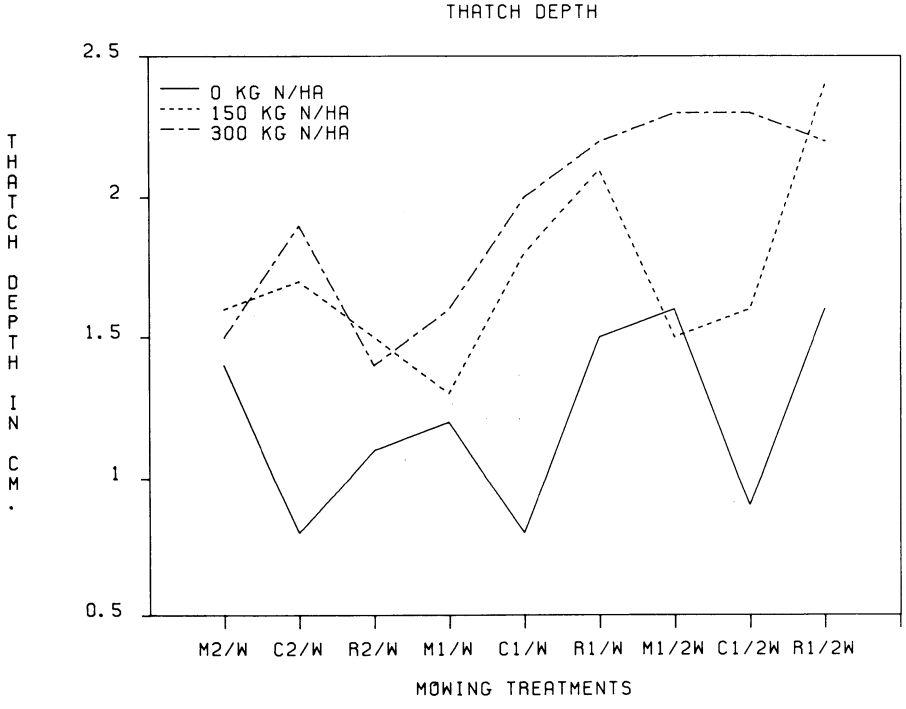

Figure 2. Mowing treatment by fertility level interaction for thatch depth. M = mulching mower, C = rotary mower with clippings collected, R = rotary mower with clippings returned. Mowing frequencies 2/W, 1/W, 1/2W = twice per week, once per week, biweekly.

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