LATE SEASON NITROGEN FERTILIZATION

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Turf fertilization programs traditionally begin with an early spring application of 1.0 lb N/1000 ft^2 or more to induce rapid color restoration and growth after winter dormancy. This is typically followed by a lower rate mid-summer N application and an equal or greater amount of N in early fall.

Research indicates that this traditional N fertilization has several unfavorable consequences. The early spring application occurs as air temperatures are approaching the optimum of about 70°F for turfgrass growth and rainfall is typically plentiful. The result is a flush of top growth at the expense of below-ground growth of roots, rhizomes, or stolons (Koski, 1990). This reduces tolerance to mid-summer moisture stress and causes thinning of the turfgrass stand.

Early fall N has effects very similar to that of early spring N. A surge in fall growth sends the turfgrass into winter dormancy in a weakened state and with low carbohydrate reserves. This limits early season root growth and slows recovery the following spring.

An improved N fertilization program for turfgrass is one that avoids early spring and fall surges in top growth and ensures late season production and storage of carbohydrates. Under these circumstances, the expectations are better below-ground growth, a denser turf and faster recovery in spring without excessive top growth and loss of roots (Portz, 1978; Snow, 1982).

Research by Wilkinson and Duff (1972) provided information key to the development of an improved N fertilization strategy. They observed that when Kentucky bluegrass is fertilized with N in fall after mean daily air temperatures are 50°F or less, there is color enhancement without an increase in top growth. Fertilization with N at this time of year also brings turfgrass out of dormancy earlier the following spring (Wehner et al., 1988). Color enhancement late in the season without an increase in top growth suggests more production of carbohydrates that are available for underground growth (Powell et al., 1967).

From these observations and suggestions has evolved the idea that late season N application is the key to an improved N fertilization schedule for turfgrass. Many claims have been made for the virtues of late season N application. Some have been documented in research while others are more a matter of speculation. The main claims for a late season based N fertilization program are (Hall, 1984; Koski, 1990):

1. Better root growth;
2. Denser turf;
3. Faster spring greenup without a surge in top growth;

4. Better turfgrass color and quality throughout the season;
5. Increased summer tolerance to heat and moisture stress

A variant of fall N application that is practiced on Wisconsin golf courses is dormant application of N. In this instance, N is applied after the turfgrass has gone dormant or just before snowfall. In either instance, there is no time for turfgrass color response to the N that season. The main justification for dormant N is more rapid spring recovery from dormancy and a delay in the time when N must be applied the following year (Wilkinson and Duff, 1972).

The purpose of the present study was to determine whether or not turfgrass N programs involving fall and/or dormant N applications are superior to the traditional schedule for N application. Specific objectives were:

1. To verify that fall and dormant N applications hasten spring greenup without causing a surge in top growth;

2. To verify that fall N favors turfgrass root growth; and

3. To verify that an N fertilization program involving late season N application leads to better turfgrass quality throughout the season.

METHODS

The N fertilization programs used in this study are summarized in Table 1. A season N rate variable was included because spring greenup is affected by seasonal N rate as well as the time of N application (Nelson, 1977). The fall and dormant N schedules were modified in 1990 in an attempt to optimize full=season color ratings.

The two sites for the study were an old stand of 'Pennlawn' fine fescue dominated turf at the Yahara Hills Golf Course and a 10-month-old stand of 'Penncross' creeping bentgrass at the Cherokee Country Club. All treatments were repeated four times in a randomized complete block experimental design.

Nitrogen sources used in the study were predominantly slow release materials. In 1988 and 1989, a small particle CIL SCU, 32-0-0, was applied May through September at both sites. Urea was used for the fall N application in 1988 and IBDU (31-0-0 Fine) in 1989. The small particle 32-0-0 SCU was not available in 1990. A larger particle 37-0-0 SCU was used on the fescue and IBDU on the bentgrass. Urea once again served as the fall N source. Milorganite was used as the dormant N source throughout the duration of the study.

For the first 2 years of the study, the plots were color rated on a bi-weekly schedule and clippings removed for N analysis. During the third and final year, color rating and clipping collection were intensified and clipping weights recorded. Root samples were collected on seven dates during the 3-year period. The normal depth of sampling was 6 inches. In 1990, the sampling depth was increased to 12 inches. Measurements of turfgrass verdure were made at both sites mid-way through the study. No significant treatment differences were observed. In 1990, the turfgrass at both sites became infected with dollar spot and plots were rated for extent of infection.

RESULTS AND DISCUSSION

By happenstance rather than design, routine maintenance practices were much higher on the bentgrass site than the fescue-Kentucky bluegrass site. Improper mowing and non-uniform, erratic irrigation had a decided influence on the fescue-Kentucky bluegrass responses to the N treatments. Therefore, results from the two sites have to be examined separately.

LOW MAINTENANCE FESCUE DOMINATED TURF

Late Season Color

At the N rate employed (1, 2 or 3 lb/M season), late season color differences between the traditional and fall N schedules were slight and confined to the first two to three weeks in November (Figure 1). On the other hand, the dormant N schedule failed to sustain reasonable color after mid-October. Theoretically, then, we should not expect to see much difference between the traditional and fall N programs with regard to root development while the dormant program should provide the lease amount of roots the following spring.

Early Season Color

The effects of late season N on early season color development were rather dramatic (Figure 2). When averaged over three seasons, application of fall N led to color ratings of 7.0 or greater by the end of the second week in April. Rate of greenup was somewhat slower in the dormant N treatments and did not achieve the same level as in the fall N treatments until the first week in May. In the traditional N program, color ratings of 7.0 or greater were not attained until 7 to 10 days after the spring (May 15) N application.

The durations of the early season color responses to fall and dormant N were too short to allow withholding of next-season N applications until June 15 (Figure 2), a time when higher air temperatures might suppress shoot growth response. Additional N had to be applied no later than June 1 to avoid development of unsatisfactory color ratings.

Early Season Chipping Weights

One of the virtues often cited for late season N applications is early greenup without a corresponding surge in clipping weight. We found this not to be the case. During the latter part of May of each season, fescue-Kentucky bluegrass clipping weights in the fall and dormant N plots exceeded those in the traditional N schedule plots by a fair amount (Figure 3).

Full Season Color

Differences among the three N schedules with respect to full season turfgrass color were confined primarily to early spring and late fall (Figure 4). Mid-fall color, from about September 10 to October 15, was best for the traditional N schedule.

Root Weight Density

Prior to initiation of this study, the fescue-Kentucky bluegrass turf had received little or no N for the past 15 years. During the first year of the study, application of N according to any schedule dramatically increased late season root weight densities (Figure 5). During the second year root growth declined sharply and then stabilized. At no time during these large fluctuations in root weight densities were we able to discern a consistent influence of N schedule. Significant treatment effects were present on only three of the seven root sampling dates and these were almost entirely confined to comparisons between N rates rather than N schedules.

Summary Responses

When averaged over the three seasons, differences in color and shoot and root growth responses of the fescue-Kentucky bluegrass to N schedule at even the highest N rate were seldom significant (Table 2). Average color ratings were the same for the no late season (traditional), fall and dormant

N schedules. The traditional and fall N schedules did provide satisfactory color ratings a higher percentage of the time. This was primarily attributable to rapid loss of color in fall for the dormant N schedule (Figure 1).

Clipping weights were higher for the fall and dormant N treatments than for the traditional N schedule (Table 2). This arose primarily because of the surge in mid-May growth observed for the fall and dormant N schedules (Figure 3).

Root weight densities, when averaged over the three seasons, were not significantly influenced by N schedule (Table 2). As a general rule, higher clipping weights were associated with lower root weight densities.

HIGH MAINTENANCE CREEPING BENTGRASS

Late Season Color

With higher N rates and proper maintenance, N scheduling effects on late season color of the bentgrass were more pronounced (Figure 6) than for the fescue-Kentucky bluegrass (Figure 1). In addition, the time during which fall N provided superior color was approximately two weeks longer in duration than for the traditional N schedule. Thus, the period of color enhancement from fall N encompassed the last two weeks in October as well as much of the month of November.

Early Season Color

In the presence of fall or dormant N, development of satisfactory color in the bentgrass occurred 30 to 40 days earlier than where no late season N was applied (Figure 7). The duration of this early season color enhancement by the dormant N exceeded that of the fall N by nearly two weeks.

The argument has been made that fall N should be applied as urea rather than a slow-release form of N (Wehner, et al, 1988). We experimented with urea and IBDU and could see no difference in terms of spring greenup. In another of our studies, we fall applied fine Milorganite (FM) and regular Milorganite (RM) as well as urea and IBDU and found that April color of bentgrass was primarily a function of rate of application rather than the N carrier (Figure 8). Nelson (1977) reported similar results for fall applications of N on Kentucky bluegrass.

Early Season Clipping Weights

Just as in the case of the fescue-Kentucky bluegrass, late season N applications caused an early season surge in bentgrass clipping weights (Figure 9). In the case of fall N, enhancement of clipping weights persisted from the time of the first mowing (May 1) to approximately June 1. Dormant N did likewise, but also increased growth response to the June 1 to 15 N application.

Late season N effects on bentgrass clipping weights were not evident during the month of July and early August, but surfaced again in mid-August and persisted until late October (Figure 10). I have no plausible explanation for these late summer effects of late season N applications on bentgrass clipping weights except some type of general improvement in turfgrass quality.

Root Weight Density

Out of the seven dates when the bentgrass roots were sampled, significant N scheduling effects were observed only once, in November, 1989 (Figure 11). On that date, root weight densities were higher for the traditional and fall N treatments than for the dormant N schedule. The only consistent effect of N on root weight density was an average decrease of about 25% when going from the 2 to the 6 lb N rate (data not shown).

Summary Responses

Average responses of the bentgrass for the full three years of the study are given in Table 3 for the 4 lb N rate. This N rate is close to that found to be optimum in the study.

Average color ratings for the five N schedules tested did not differ significantly (Table 3). However, time of satisfactory color (ratings of 7 to 8) was significantly higher for the fall N schedule than for the traditional and dormant schedules. This improvement in time of satisfactory color was almost entirely attributable to more rapid spring greenup and better last season color retention (Figure 12). Dormant N application did not increase the time of satisfactory color despite spring greenup comparable to that achieved with fall N. There are two reasons for this. The first is the rapid decline in color in the dormant N treatment after about the first week in October. The second reason is that dormant N enhanced color response to the June N application to the extent that ratings in excess of 8.0 were frequently observed.

Average clipping weights, recorded in 1990 were significantly greater for the dormant N program than for the traditional or fall N schedules (Table 3). This is likely a consequence of the influences of dormant N on color response to June N as well as early season color. Had bentgrass clipping weights been recorded all three years and averaged over those years, chances are that significant N schedule effects would not have been observed. The reason for this is indicated in Figure 13. Annual average color responses to the dormant N program progressively increased from the first year, 1988, to the final year, 1990. Clipping weights logically followed this same trend. There were no significant N schedule effects on 3-year average bentgrass root weight densities (Table 3).

CONCLUSIONS

When low rates of N are applied on turf subjected to periodic moisture stress and poor mowing practices, the benefits arising from late season N applications are minimal. Other than more rapid early spring greenup and a delay to late May the time when spring N is required, there are no other justifications for applying fall or dormant N.

Even for high maintenance turf the major advantages of a fall vs. a traditional turfgrass N fertilization schedule are the opportunity to achieve better color throughout the season and to extend the period of satisfactory color by approximately 4 weeks in early spring and 2 or more weeks in late fall. To realize these benefits, annual N rates for creeping bentgrass grown under golf tee or fairway conditions need to be in the range of 4 to 5 lb per season properly distributed among four applications of slow release N. The first application needs to be no later than June 1 and followed by applications in mid-July, mid-September, and when mean daily air temperatures drop to 50°F in fall (about October 15 in southern Wisconsin).

Dormant application of Milorganite is comparable to fall N in terms of early season color development, but has no effect on late season color. Consequently, the percent time that a dormant N schedule produces satisfactory bentgrass color is intermediate between fall and traditional N application schedules.

Application of fall and dormant N causes an early season surge in turfgrass top growth that results in higher total season clipping weights than for a traditional N program. Total season clipping weights are further increased in a dormant N program because of residual turfgrass response to the first N application of the season.

Late season N applications do not increase turfgrass root development. This observation is consistent with that of Koski and Street (1988) and Koski (1990), but contrary to popular opinion. Reasons that root development was not increased may be: (1) the intensity and duration of late fall color enhancement were insufficient to lead to significant increases in net carbohydrate production; (2) periodic chilling temperatures severely curtailed photosynthesis for several days at a time (Moon, et al, 1990); or (3) any increases in storage carbohydrates supply were rapidly consumed by an early spring surge in top growth.

Table 1. Nitrogen Fertilization Programs Employed

N program designation	Percent of season N* applied							
	05/15	06/01	06/15	07/15	08/15	09/15	10/15	11/15
			1988 and 1989					
Traditional	40			20		40		
Fall			40		20		40	
2/3 Fall, 1/3 Dormant			40		20		26	14
2/3 Fall, 2/3 Dormant			40		20		14	26
Dormant			40		20			40
			1990					
Traditional	40			20		40		
Fall		30		20		20	30	
2/3 Fall, 1/3 Dormant		30		20		20	20	10
1/3 Fall, 2/3 Dormant		30		20		20	10	20
Dormant		30		20		20		30

* Season N rates	lb/M
Fine fescue-Kentucky bluegrass	1, 2, 3
Creeping bentgrass	2, 4, 6

Table 2. Fescue-Kentucky Bluegrass Responses to Late Season Nitrogen

3-year averages for 3.0 lb N rate.

Late Season Nitrogen	Color Rating Scale 1-9	Satisfactory Color % Time	Clipping Weight* lb/M	Root Density Mg/cc Soil
None	7.3	72	42	2.2
Fall	7.3	70	46	2.0
2/3 Fall, 1/3 Dormant	7.1	61	36	2.4
1/3 Fall, 2/3 Dormant	7.2	62	45	2.3
Dormant	7.3	60	47	2.1

*1990 only.

Table 3. Creeping Bentgrass Responses to Late Season Nitrogen

3-year averages at 4.0 lb. N rate

Late Season Nitrogen	Color Rating Scale 1-9	Satisfactory Color % Time	Clipping Weight* lb/M	Root Density Mg/cc Soil
None	7.6	59	25	1.2
Fall	7.7	80	28	1.2
2/3 Fall, 1/3 Dormant	7.7	76	30	1.2
1/3 Fall, 2/3 Dormant	7.6	70	31	1.2
Dormant	7.7	65	34	1.3

*1990 only

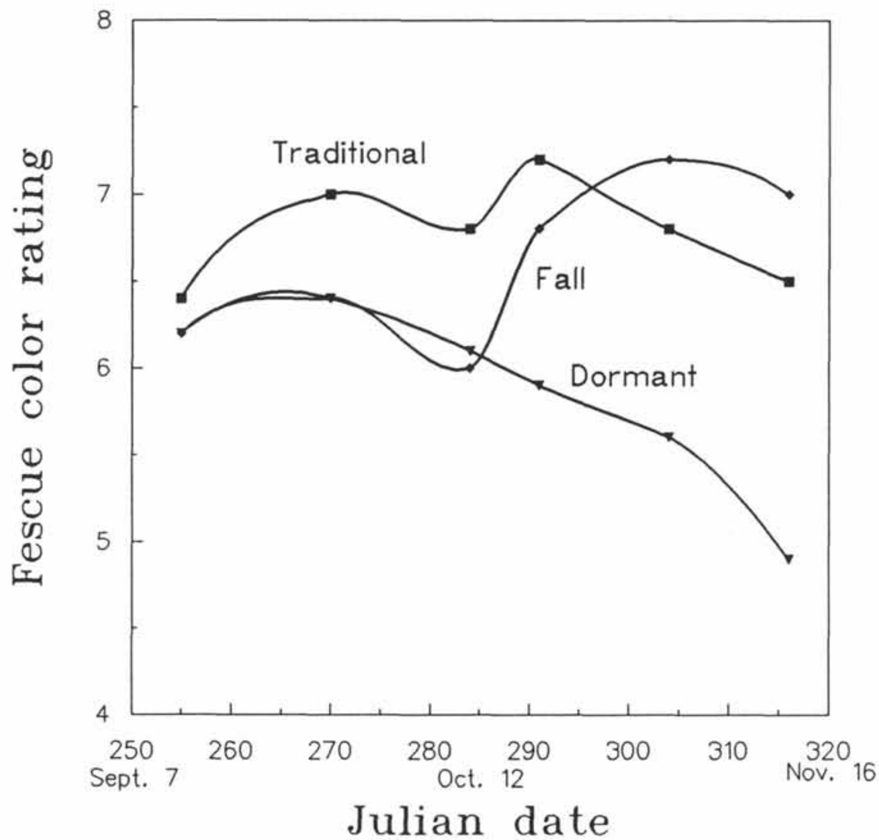

Figure 1. Late season color response of fescue-Kentucky bluegrass to late season N at an annual N rate of 3 lb/M.

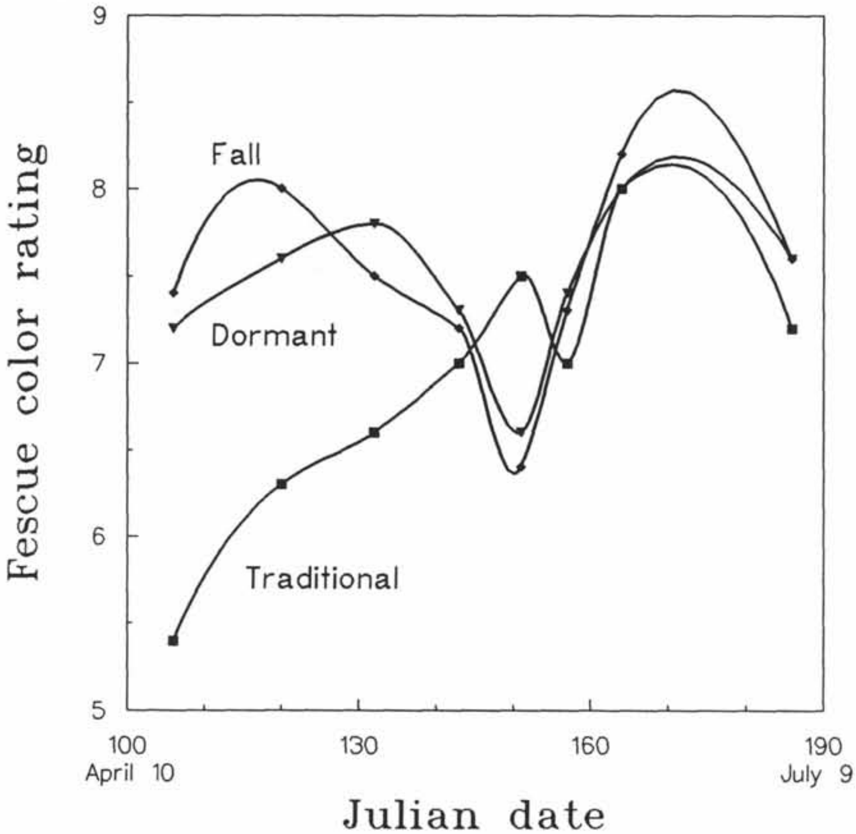

Figure 2. Early season color response of fescue-Kentucky bluegrass to late season N at an annual N rate of 3 lb/M.

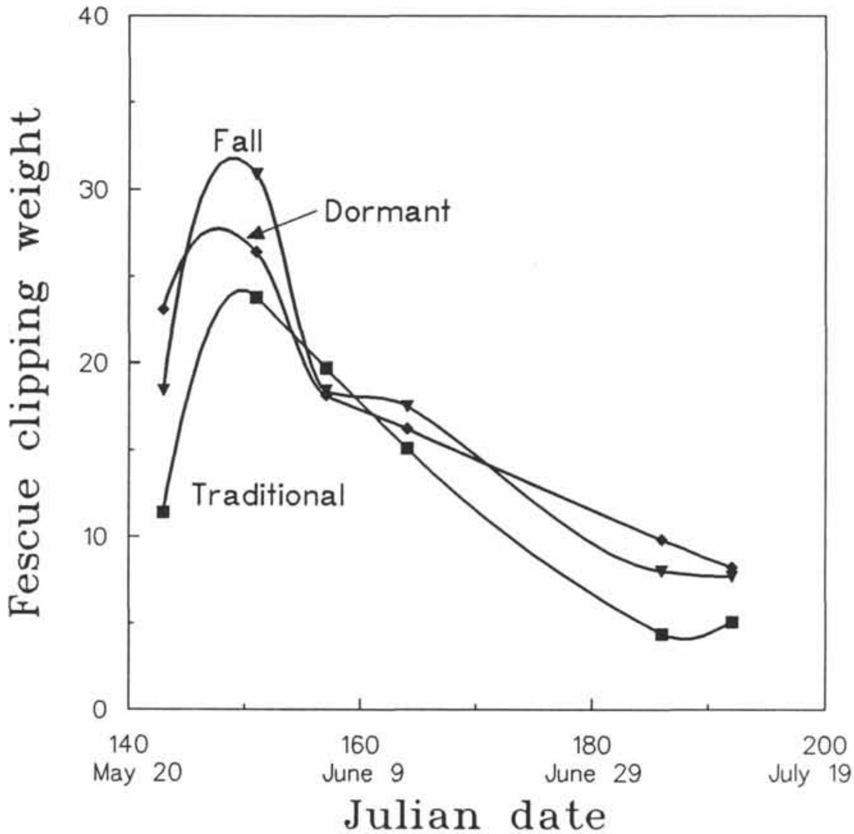

Figure 3. Early season growth response of fescue-Kentucky bluegrass to late season N at an annual N rate of 3 lb/M.

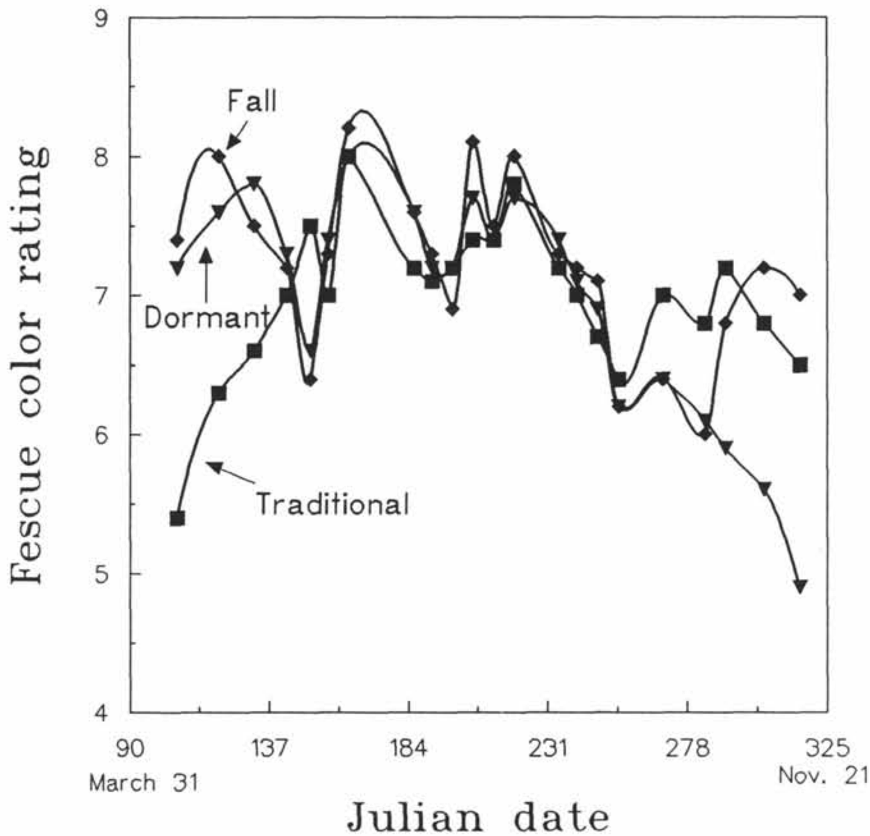

Figure 4. Full season color response of fescue-Kentucky bluegrass to three different N schedules at an annual N rate of 3 lb/M.

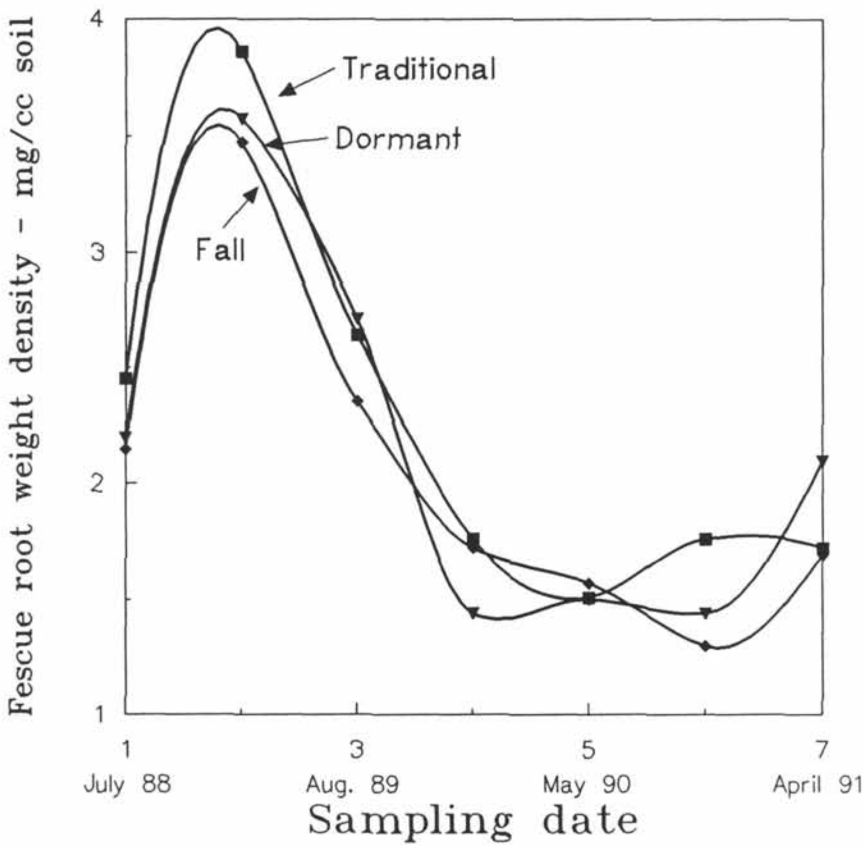

Figure 5. Effects of three N schedules on the root weight densities to a 6-inch soil depth of fescue-Kentucky bluegrass at an annual N rate of 3 lb/M.

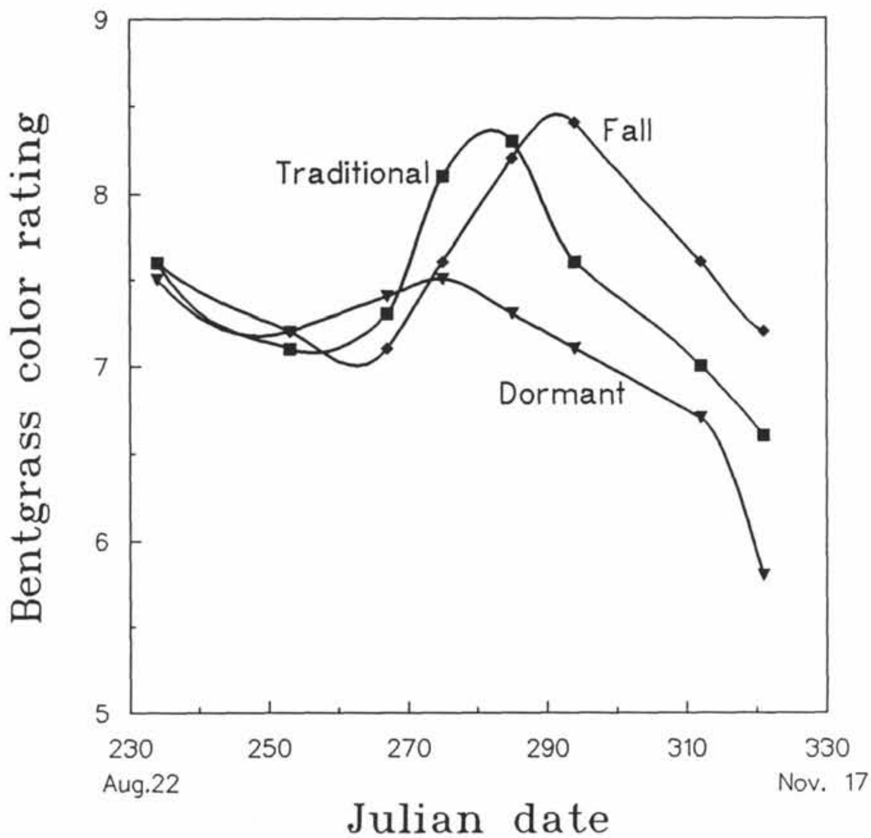

Figure 6. Late season color response of creeping bentgrass to late season N applications at an annual N rate of 4 lb/M.

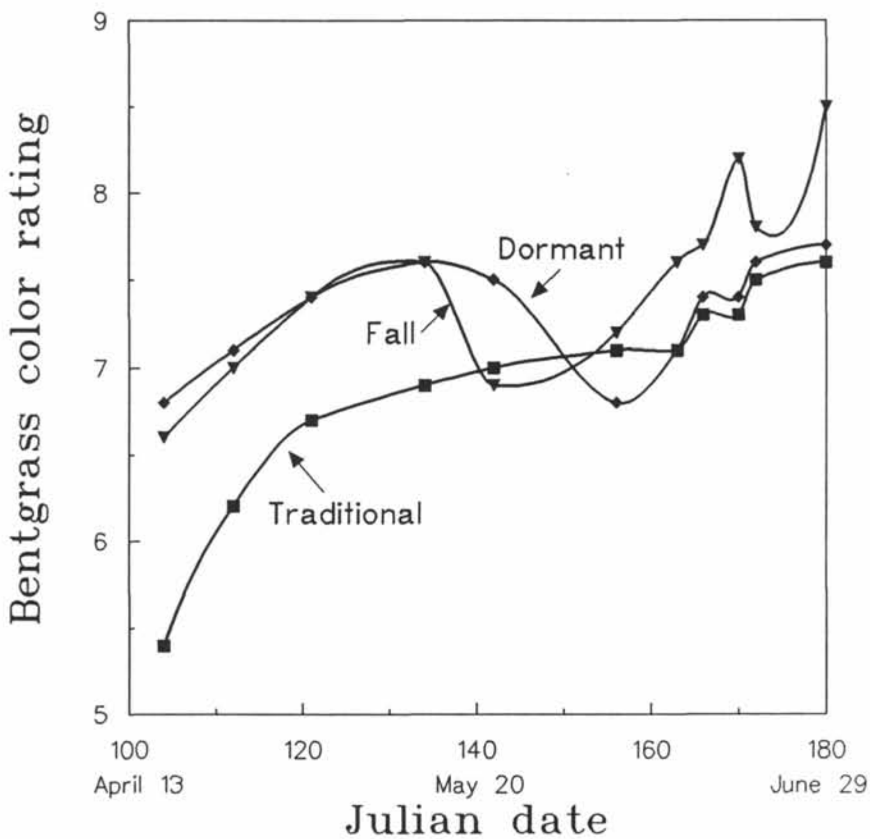

Figure 7. Early season color response of creeping bentgrass to late season N applications at an annual N rate of 4 lb/M.

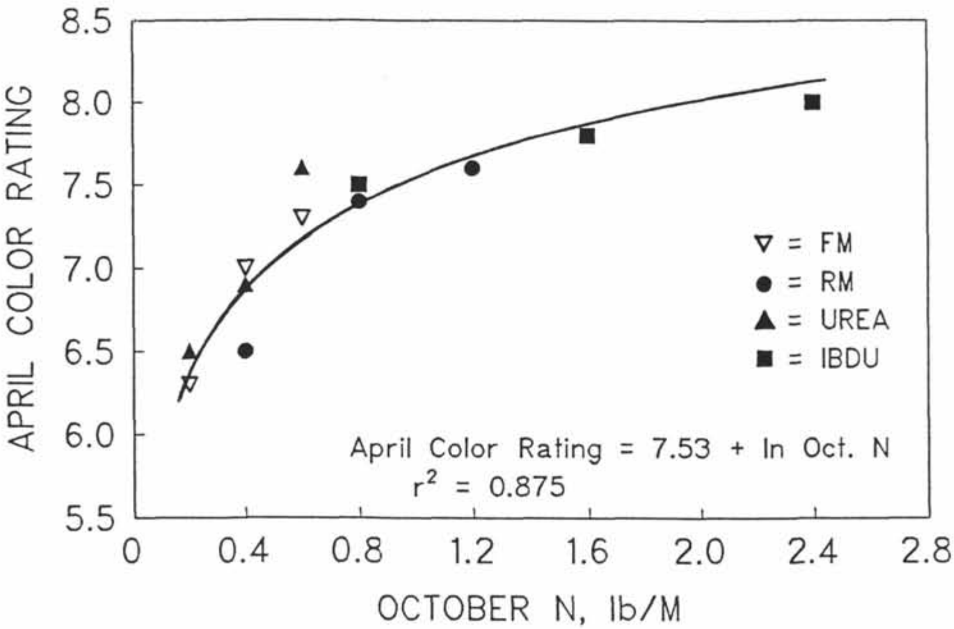

Figure 8. Influences of N carrier and rate on creeping bentgrass April color response to fall N applications (FM = fine Milorganite, RM = regular Milorganite).

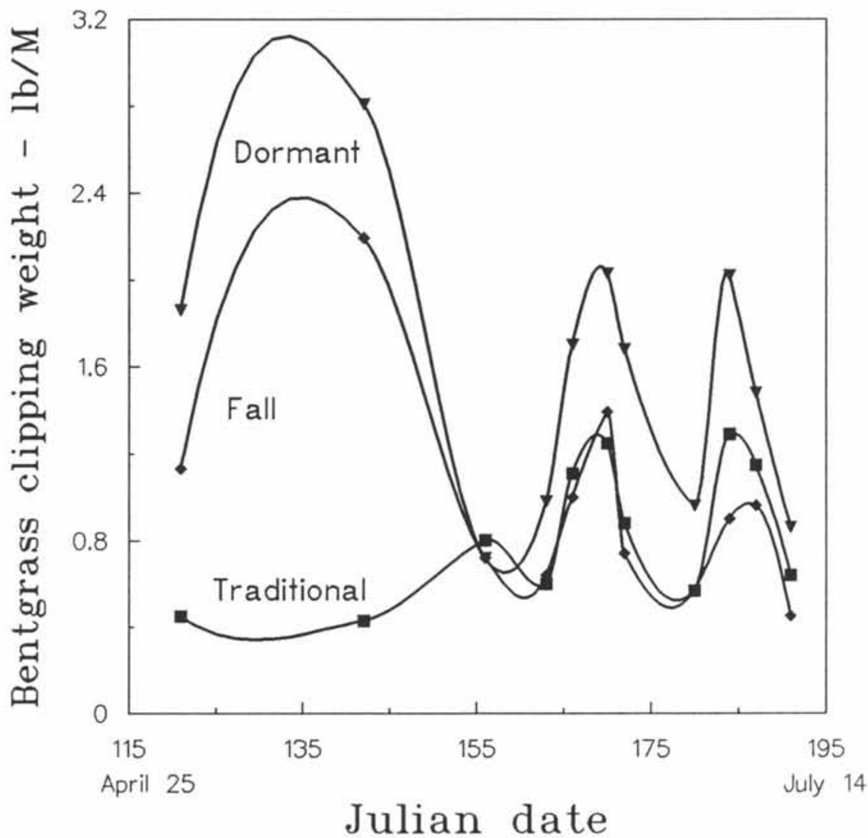

Figure 9. Early season growth response of creeping bentgrass to fall and dormant N applications at an annual N rate of 4 lb/M.

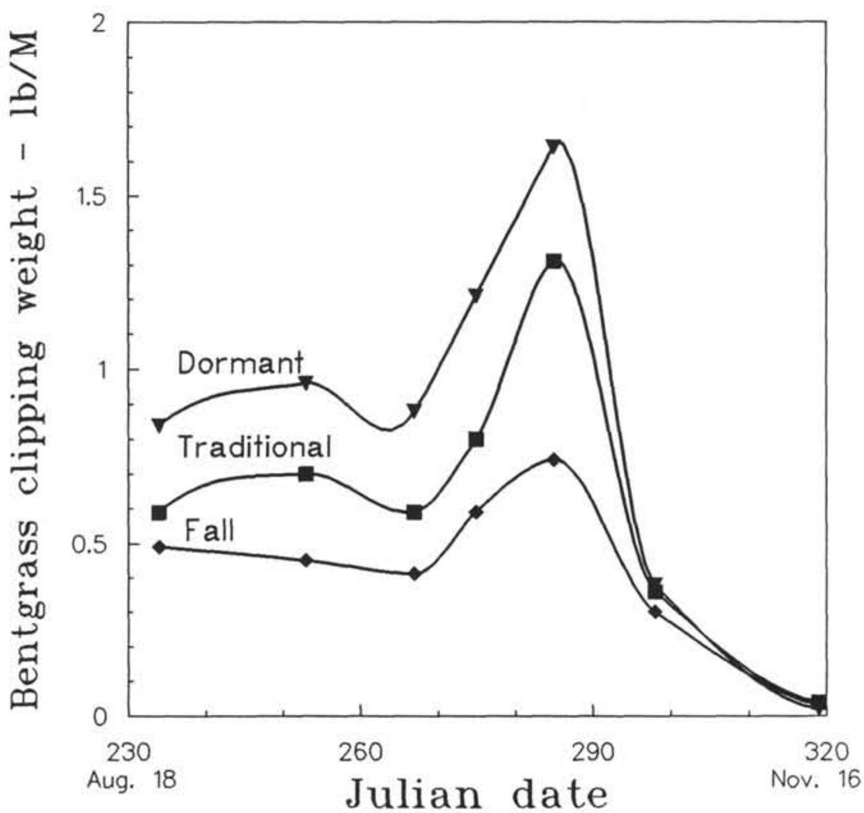

Figure 10. Late season growth of creeping bentgrass for three different N schedules at an annual N rate of 4 lb/M.

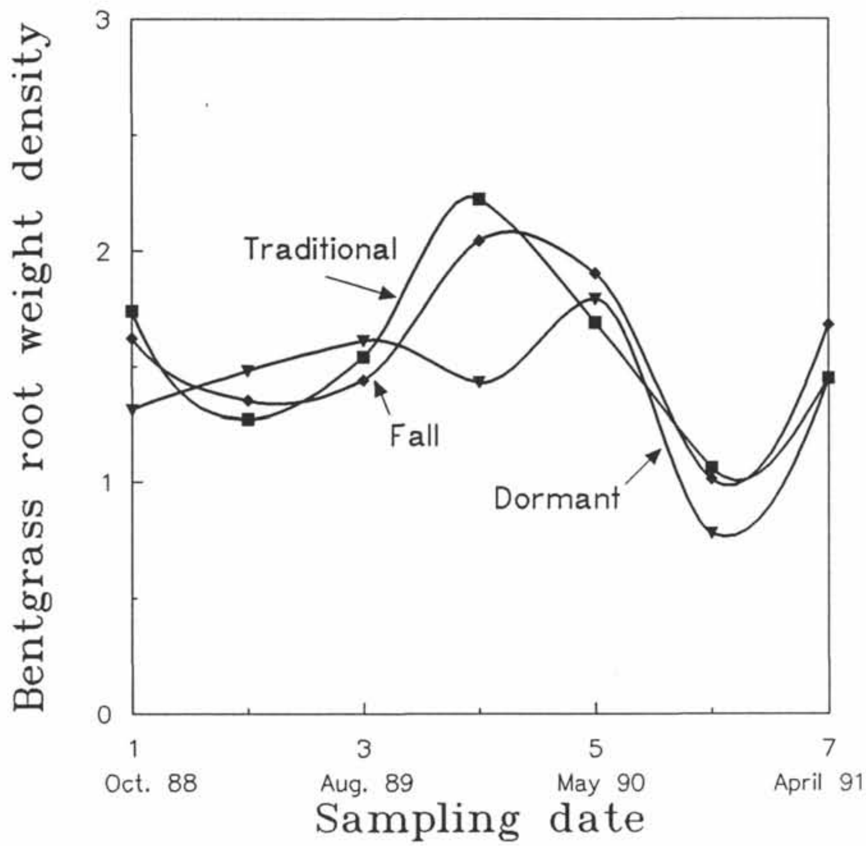

Figure 11. Effects of three N schedules on the root weight densities to a 6-inch soil depth of creeping bentgrass at an annual N rate of 4 lb/M.

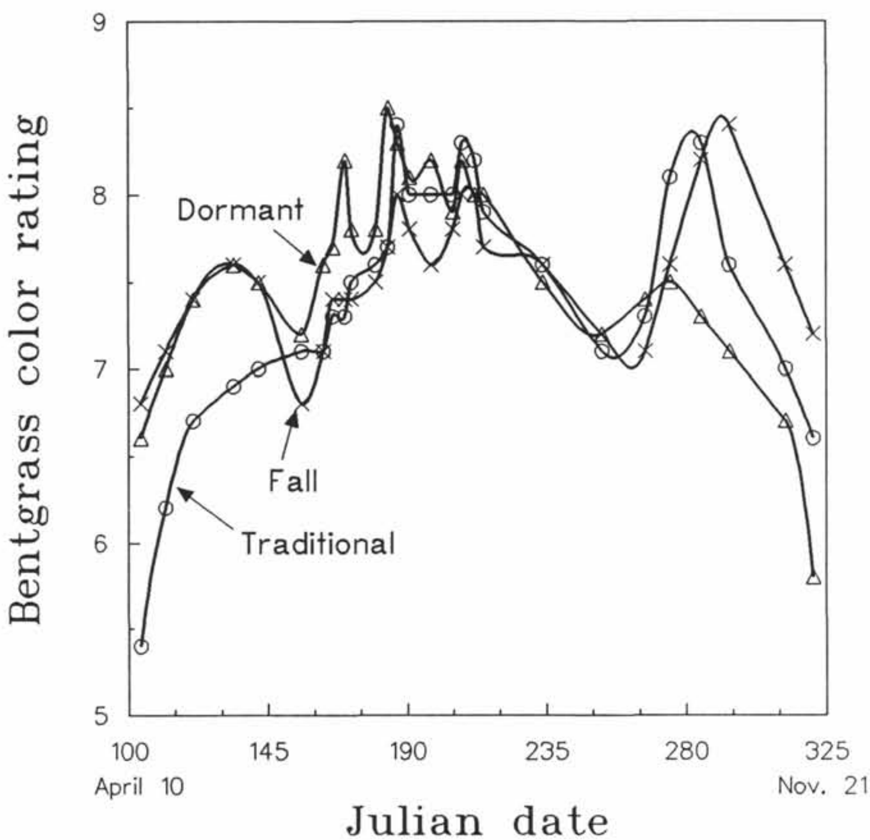

Figure 12. Full season color response of creeping bentgrass to three N schedules at an annual N rate of 4 lb/M.

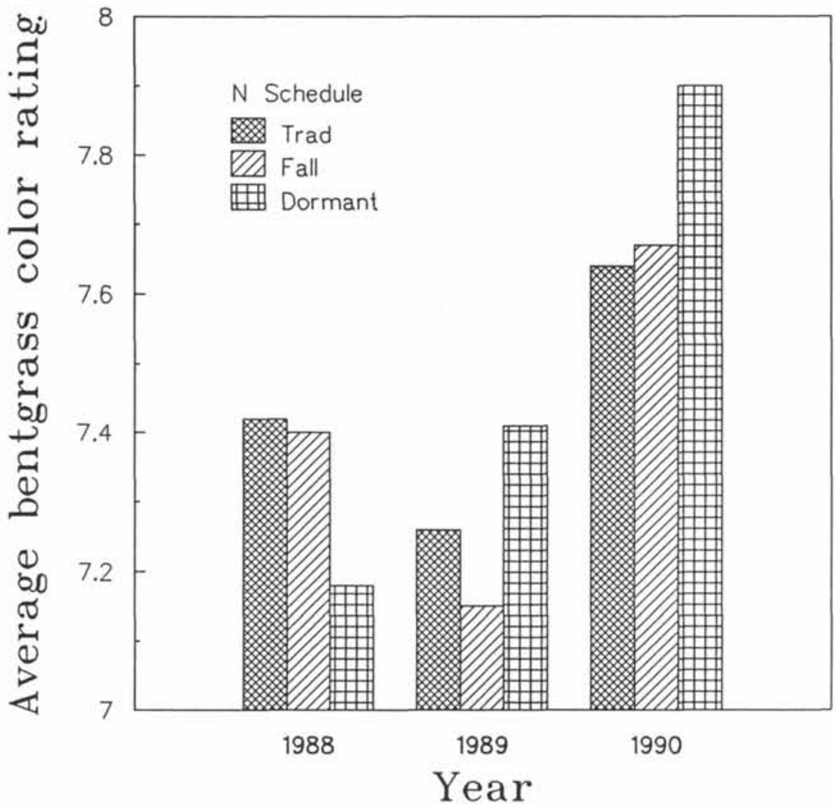

Figure 13. Season average color responses of creeping bentgrass for three successive years to 4 lb/M/season applied according to three different schedules.

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