205

KENTUCKY BLUEGRASS GROWTH AND SOIL RESPONSES UNDER LOW MAINTENANCE CULTURAL REGIMES

by

WARD S. UPHAM

B.S., Kansas State University, 1976

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Horticulture

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1982

Approved by:

Robert N. Carrow
Major Professor

TABLE OF CONTENTS

LIST OF TABLES

LITERATURE REVIEW

Introduction

Intensively utilized recreational areas require a very high cultural system in order to maintain a healthy, vigorous turf under adverse conditions. On other less used areas, the trend is to apply the least inputs possible but produce an acceptable quality turf. Thus, polarization of turfgrass management regimes has been increasing in recent years.

The goal behind a high maintenance system is to produce a vigorous, aesthetically pleasing turf in spite of intensive use. Athletic fields are a prime example with the turf placed under intense wear and compaction stresses but with the expectation of minimal deterioration. For Kentucky bluegrass (*Poa pratenses* L.), high maintenance culture in the transition zone typically requires a water input substantial enough to avoid water stress symptoms and fertilization rates of approximately 1.5 to 2.0 kg nitrogen (N)/100 m^2/yr (15). Adjustments to soil physical characteristics (e.g. core aeration) (10) and the use of pesticides (1) are frequently required to maintain adequate visual quality. Considerable research has been done on high maintenance regimes.

Low maintenance turf results from an attempt to minimize inputs with just enough fertilizer, irrigation, and weed control to produce and maintain a reasonably good stand of turf. It must be emphasized that a low maintenance turf cultural system implies limited inputs and not a no maintenance system.

Rapidly increasing input costs (e.g. fertilizer), as well as occasional unavailability of some inputs (e.g. water), are motivation factors behind the trend toward lower maintenance regimes.

There are many situations where a low maintenance turf would be feasible such as city parks, some home residences, cemeteries, and low use general grounds. However, other situations may demand higher maintenance. Recreational sites, for example, require vigorous, fast growing turf which is able to quickly recover from injury and continual wear. A low maintenance turf would not possess these qualities and would deteriorate rapidly.

Unfortunately, little research has been done to clarify the minimum level of inputs needed to produce an acceptable quality turf for usage situations allowing or requiring reduced maintenances. Such information would be useful for recommending to turf managers on how to carry a medium to high maintenance turf through a period of limited inputs as, for example, when a golf course superintendent is forced to curtail an irrigation program due to an inadequate water supply.

Previous studies at Kansas State University have identified Kentucky bluegrass cultivars which grow well under a low maintenance regime (15). It should be noted that these cultivars were not specifically bred for low maintenance. However, with the wide range of cultivars available there should be enough genetic variability in the species to make a low maintenance breeding program productive.

The objective of this study was to determine the relative influence of nitrogen, irrigation, and weed control on turf growth and soil nutrient status under a low maintenance culture regime for Kentucky bluegrass. This information would allow researchers to make cultural recommendations requiring fewer inputs, yet produce an acceptable quality turf.

Turfgrasses for Low Maintenance

A turfgrass adapted to low maintenance conditions, should possess certain attributes such as tolerance of environmental conditions, pest resistance, presence of rhizomes and/or stolons, quick recovery from injury if irrigation and fertilizer are applied, and the ability to produce an acceptable quality turf with a minimum of inputs. The major environmental conditions a low maintenance turf must tolerate are drought, heat, and cold. Pest resistance includes both diseases and insects. Rhizomes and stolons allow the turf to sqread quickly after injury when growth conditions are favorable.

Cool season grasses are often preferred for turf use in the transition zone because they green up much earlier in the spring than warm season grasses and also enter dormancy later in the fall. However, some warm season, native grasses are popular to use as turfgrasses under low maintenance conditions in the transition zone. Buffalograss [*Buchloe dactyloides* (Nutt.) Engelm.] and blue grama [*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.] are examples (1). Buffalograss thrives under very little rainfall and fertilization. If this trufgrass receives too much water and/or fertilization, it will deteriorate due to its inability to compete with weeds. Blue grama has excellent drought tolerance as well as good resistance to heat stress. The use of this turf is limited primarily to unirrigated, nonuse turfgrass areas such as roadsides.

The two cool season turfgrasses which can be used under low maintenance for fine turf sites include tall fescue (*Festuca arundinacea* Schreb.) and Kentucky bluegrass. Tall fescue is a coarse, bunch type grass which is drought and wear tolerant and exhibits a medium level of low temperature hardiness. Due to its bunch type growth habit, tall fescue does not spread if injured. Overseeding is the accepted method of recovering adequate shoot density.

Kentucky bluegrass produces a medium textured turf with good recuperative potential due to its vigorous rhizome development. It is able to survive relatively long periods of moisture and temperature stress by becoming dormant (4). After growth conditions improve, dormancy is broken.

Kentucky bluegrass was chosen for this study because it contained several very important characteristics. It is a cool season turfgrass offering a much longer growing period than any warm season grass. Kentucky bluegrass also has a major advantage over tall fescue in that it is highly polyploid and classed as a facultative apomictic (1). This genetic variability has allowed the development of a great many cultivars to date and should allow breeders to produce cultivars which are much better adapted to low maintenance conditions than current ones.

Kentucky bluegrass low maintenance cultivar trials were conducted at Kansas State University from 1978 to 1980 (15). Visual quality ratings on a scale of 1 to 9 were used to identify the cultivars best adapted to low maintenance. A visual quality rating of 9 equals an ideal turf, and a rating of 1 equals no live turf. A rating of 5 or above was considered acceptable under low maintenance conditions. At a 2 inch cutting height, 4 cultivars were acceptable; 'Arboretum', 'Park', 'Baron', and 'Merion'. With a 1 inch mowing height, only 'Arboretum' and 'Park' were acceptable. Based on this information, we chose 'Park' for this study.

Water

Studies on Kentucky bluegrass have shown that common types are more drought tolerant than many improved cultivars (4, 5, 13). Dernoeden (4) and Dernoeden and Butler (5) investigated the drought resistance of 25 Kentucky bluegrass cultivars by restricting water until the first cultivar developed dry blades of a blue-gray to brown color. Irrigation was then applied twice daily until the turf was green and turgid. 'Code 96' and 'Merion' (improved cultivars) were highly drought resistant as well as producing a dark green, dense stand (4, 5). 'South Dakota Common', Kenblue', and 'Arboretum' (common types) also had excellent drought tolerance as exhibited by survival but had poor color, texture, and density (4).

Dernoeden (4) and Dernoeden and Butler (5) noted that drought tolerance increased as the summer progressed. Early in the testing period, drought symptoms would appear 4 to 6 days after irrigation but later in the summer the turf was able to maintain "optimum turgidity and greenness" for 21 days.

Beard (1) has reviewed many of the morphological and physiological changes which occur as a result of a plant water deficit. These changes could account for the apparent adaptation observed as the turf remained under stress. Morphological alterations include increased rooting depth, thicker cuticle, and a decreased size and total area of leaves (1). An increase in rooting depth would allow the turf to obtain water from deeper in the soil profile. The thicker cuticle would help reduce cuticular transpirational water losses. A decrease in size and number of leaves would mean that less water would be required for aboveground plant parts per unit area of sod.

Physiological modifications include a higher osmotic pressure and increased bound water (1). The higher osmotic pressure would allow the plant to absorb water at a lower soil water potential than would otherwise be possible. Bound water is not as easily lost as free water because it is bound to protoplasmic protein.

Several researchers have noted that over-irrigation of turf is a common practice (4, 16, 26). With water supplies becoming more limited, turf managers will no longer be able to continue this practice.

Of course, too little water can also cause problems. Wilt occurs when transpiration losses exceed the rate of water absorbed by the roots. This leads to wilt which is a drooping, folding, or rolling of the turfgrass leaves. Plants in such a condition will close their stomates and reduce transpirational cooling which, during hot summer months, may lead to direct high temperature kill. A wilted turf is also sensitive to wear injury from traffic. Concentrated pressure, such as that imposed by vehicular traffic, frequently will cause death of the affected turf.

Kentucky bluegrass can undergo summer dormancy during periods of extreme soil drought. The leaves may die but buds present in the crown and rhizomes will survive and initiate new growth when favorable soil moisture conditions resume. If the drought persists, death of the turf can result as the plant depletes its carbohydrate reserves.

V. B. Youngner, et. al. (26) found that a turf under very limited irrigation suffered a decrease in density and an increase in fusarium blight purportedly caused by *Fusarium roseum* f. sp. *cerealis* (Cke.) Snyder and Hansen and *Fusarium tricinctum* f. sp. *poae* (Pk.) Snyder and Hanson. Both conditions would allow weed invasion and reduce the quality of the turf stand.

Nitrogen

Kentucky bluegrass is able to produce an acceptable quality turf with fewer nutritional inputs than is commonly utilized. Many growers utilize color rather than density when judging quality of a turf. Madison (11), however, identified shoot density as a better indicator of turf quality in response to nitrogen (N).

Schery (18) noted that a low maintenance turf would require 1 to 2 fertilizer applications per year with each containing approximately 0.5 kg N per 100 m^2. However, this would vary depending on site conditions. Returning clippings has been shown to aid in providing recycled nutrients (2, 7, 11, 18, 21), for growth (7, 25), and to intensity green color (30). Beard (1) noted that removal of 'Merion' Kentucky bluegrass clippings increased the amount of N needed by 0.10 to 0.15 kg per 100 m^2 per growing month.

Reducing N applications too extensively may lead to serious problems. Carrow (3) noted that turf is affected in two stages. First, rate of shoot growth is affected leading to a slower leaf appearance and elongation rates and second by decreased tillering, rhizome, and stolon production. This results in an open, slow growing turf with poor recuperative potential. A turf in this condition allows weed invasion (6, 10).

Drought tolerance increases under low N levels (24). Funk, et. al. (6) noted that drought recovery was higher under a 1.0 kg N per 100 m^2 per year regime than under a 2.0 kg N per 100 m^2 per year fertility level. Drought may also lead to increased available N since plant growth is inhibited at a higher soil moisture level than soil N mineralization and fixation. Madison (11) stated that, " . . . we found soil nitrate more than doubled between the 24th and 30th day of drought".

Slow release fertilizers have the ability to release nutrients over a long period of time. This is an advantage under low maintenance conditions because fewer applications are necessary to produce a uniform growth response. There is also evidence of carryover from one year to another especially with ureaformaldehyde (UF) (23). UF and other similar slow release materials, such as Milorganite (composted sewage sludge), depend on microbial degradation for N release. In studies on Kentucky bluegrass, these fertilizers produced a uniform growth response (22).

IBDU (isobutylidene diurea), another slow release N carrier, applied in the fall exhibited considerable low temperature release by slow dissolution and hydrolysis during the winter resulting in a pronounced spring greenup accompanied by peaks of early shoot growth (22, 23). SCU (sulfur coated urea) was not included in the above study but should give similar results because it is released under the same conditions as IBDU. IBDU provided greater efficiency than UF during the first two years of use but similar responses were found thereafter due to substantial carryover of UF (23). Delayed response to spring applications of IBDU was also noted (14).

Disease

Turgeon (20) noted that disease can have a major influence on turfgrass quality and is associated with mowing height and fertilization rate for each cultivar. Because low maintenance areas have limited inputs (including minimal or no applications of fungicides), turf is less able to recover from disease infestations due to slow growth.

Fertility level partially determines the susceptibility of a turf to specific diseases. A low fertility regime favors stem rust caused by *Puccinia spp.*, red thread caused by *Corticum fuciforme* (Berk.) Wakef., dollar spot caused by *Sclerotinia homeocarpa* F. T. Bennett, and anthracnose caused by *Colletotrichum graminicola* (Ces.) Wils. (syn. C. *cereale* Manns) (21) with dollar spot and rust being the most serious (12). High fertility favors pythium blight caused by *Pythium spp.*, brown patch caused by *Rhizoctonia solani* Kuhn, typhula blight caused by *Typhula spp.*, leafspot diseases caused by *Helminthosporium spp.*, and gray leaf spot caused by *Piricularia grisea* (Cke.) Sacc. (21) as well as stripe smut caused by *Ustilago striiformis* (Westend.) Niessl (8). Hull et. al. (8) found, for example, that stripe smut was 10 times as high on a high fertility turf as compared to one under low fertility. Fusarium blight is also favored under high fertility (1) but often requires additional stress (e.g. drought) before disease symptoms appear (21).

Due to slow recovery for low maintenance turf, limited fungicide use, and susceptibility to certain diseases, the selection of an adapted species and cultivar becomes critical. Cultivars that perform well under medium to high maintenance may do poorly under a low maintenance condition (15). Thus, disease susceptibility for low maintenance turf should be determined under low maintenance test conditions.

Mowing

Mowing has a significant effect on both disease and weeds. Turf weeds increase as mowing height was lowered (10). Schery (18), for example, found that Kentucky bluegrass maintained at 5 cm had only 10% of the weeds observed with a 2.5 cm mowing height. Schery (18) also noted that the 5 cm turf was deeper rooted, had greater recuperative potential, and was better able to recover from disease. A higher cut also increases shoot density (6).

Close cut and low fertility favors broadleaf weeds while close cut coupled with high fertility favors crabgrass (6). Low maintenance turf is most often maintained at the highest recommended height because it is rarely used as recreational turf. Exceptions include baseball outfields and unirrigated fairways. Busey and Burt (2) found that regular mowing also helped control weeds.

Soil Nitrogen Responses Under Low Maintenance

Nitrate nitrogen (NO_3^-) basically will follow soil water movement because anions are not adsorbed by most soils (19). Because of this, loss of NO_3^- is possible by leaching, especially under the following conditions of high annual N rates; infrequent, heavy applications of water soluble nitrogen carriers; intensive irrigation or rainfall; and porous, sandy soils (17). Only two of the above could apply to low maintenance conditions: high rainfall and porous, sandy soils.

Slow release carriers such as UF are much less subject to leaching than water soluble N carriers (17) because they slowly release small quantities of N over a long period of time. IBDU and especially UF have been shown to carry N over from one year to the next (22, 23). Fall applications of IBDU tend to result in early peaks of spring growth due to considerable N release in winter by slow dissolution and hydrolysis; however, because UF is dependent on microbial activity for breakdown (i.e. soil temperatures above 13 C), these spring "peaks" did not occur (22, 23). Waddington, et. al. (23) noted that the use of UF resulted in a greater increase of response with continued use than Milorganite, IBDU, Urex (extruded urea-paraffin matrix product), ADM (coated urea product), or complete fertilizers.

Drought can have a significant effect on soil NO_3^- levels because soil N is able to be fixed and mineralized at moisture levles too low for plant growth. Madison reported that soil NO_3^- levels more than doubled between the 24th and 30th day of drought.

Drought may also have a significant effect on the release of nutrients from some slow release carriers. For example, those carriers that depend on slow dissolution and hydrolysis, such as IBDU and SCU, would release very little N during extended periods of drought. Also, those carriers that depend on microbial activity for N release will have reduced N mineralization. In addition, lack of water slows plant growth, and therefore N use. These three factors of slowed plant growth, N fixation and mineralization, and carryover of N from slow release fertilizers insure that a plant resuming growth after a drought period would have more soil N available for growth than the same plant would have had if the drought did not occur.

Phosphorus and Potassium

Juska, et. al. (9) found that shoot growth was not affected by phosphorus (P) additions except under very deficient conditions. Root growth, however, was affected over a relatively wide range (0 to 21 kg $P_2O_5/100\ m^2$) with P enhancing root branching. Disease development is not affected by P as long as it is available (10).

Juska, et. al. (9) noted that potassium (K) only reduced shoot growth under very deficient levels. If these levels were reached, leaf elongation and appearance rates were reduced as well as rhizome and stolon development (3). Low K appeared to restrict root development, especially the degree of branching (3). K does not affect disease development except under very deficient conditions (10).

Thus, P and K would be expected to have less influence on turf quality than N, mowing, or irrigation. Unless soil levels are very low, growth responses would be minimal.

LITERATURE CITED

1. Beard, J. B. 1973. Turfgrass: science and culture. Prentice-Hall, Inc., Englewood Cliffs, N. J.

2. Busey, P., and E. O. Burt. 1979. Turf, energy, and the environment. Proc. Fla. State Hort. Soc. p. 92.

3. Carrow, R. N. 1981 Nutrition and turfgrass root and foliage growth. Proc. 19th Ann. Neb. Turf Conf. pp. 4-10.

4. Dernoeden, P. H. 1976. Cultivar tolerance to drought in Kentucky bluegrass. 22nd Ann. Rocky Mountain Reg. Turfgrass Conf. pp. 37-40.

5. Dernoeden, P. H., and J. K. Butler. 1978. Drought resistance of Kentucky bluegrass cultivars. HortScience. Vol. 13(6):667-668.

6. Funk, R., R. E. Engel, and P. M. Halisky. 1967. Performance of Kentucky bluegrass varieties as influenced by fertility level and cutting height. N. J. Agric. Expt. Station Bull. 816:7-21.

7. Gilbert, F. A., A. H. Bowers, and M. D. Sanders. 1960. Effect of nitrogen sources in complete fertilizers on bluegrass turf. Agron. J. 50:320-323.

8. Hull, R. J., N. Jackson, and C. R. Skogley. 1979. Influence of nutrition on stripe smut severity in Kentucky bluegrass turf. Agron. J. 7:553-555.

9. Juska, F. V., A. A. Hanson, and C. J. Erickson. 1965. Effects of phosphorus and other treatments on the development of red fescue, Merion, and common Kentucky bluegrass. Agron. J. 57: 75-78.

10. Madison, J. H. 1971. Practical turfgrass management. Van Nostrand Reinhold Company. New York, N. Y.

11. Madison, J. H. 1971. Principles of turfgrass culture. Van Nostrand Reinhold Company. New York, N. Y.

12. Meyer, W. A. 1982. Breeding disease-resistant cool-season turfgrass cultivars for the United States. Plant Disease 66(4): 341-344.

13. Miller, S., J. J. Wilkinson, and D. P. Martin. 1975. Kentucky bluegrass cultivars under low fertility. Ohio State Turf Field Day. pp. 16-18.

14. Moberg, E. L., D. V. Waddington, and J. M. Duich. 1970. Evaluation of slow-release nitrogen sources on Merion Kentucky bluegrass. Soil Sci. Soc. Amer. Proc. 34:335-339.

15. Pair, J. C., R. N. Carrow, L. D. Leuthold, and R. A. Keen. 1981. Kentucky bluegrass for turf: Keeping up with research 53. Kansas State University Extension Publications. Manhattan, Ks.

16. Pochop, L. O., and J. Borrelli. 1979. Water use by Kentucky bluegrass. Proc. Ariz. Turfgrass Conf. pp. 18-20.

17. Rieke, P. E. and B. G. Ellis. 1974. Effects of nitrogen fertilization on nitrate movements under turfgrass. Proc. of the 2nd Intern. Turfgrass Res. Conf.: E. C. Roberts, Ed., Amer. Soc. of Agron. pp. 120-130.

18. Schery, R. W. 1967. Minimum Maintenance turf. 8th Turfgrass Conf. Proc. at Univ. of Illin. pp. 8-9.

19. Snyder, G. H., E. O. Burt, and J. M. Davidson. 1977. Nitrogen leaching in bermudagrass turf: daily fertigation vs. tri-weekly conventional fertilization. Proc. of the Third Internat. Turfgrass Res. Conf. J. B. Beard, ed. pp. 185-193.

20. Turgeon, A. J. 1976. Kentucky bluegrass cultivar management. 17th Ann. Ill. Turfgrass Conf. pp. 13-20.

21. Vargas, Jr., J. M. 1981. Management of turfgrass diseases. Burgess Publishing Company. Minneapolis, Minn.

22. Waddington, D. V., J. M. Duich, and J. R. Turner. 1977. Turfgrass fertilization with isobutylidene diurea and ureaform. Proc. 1977 Controlled Release Pesticide Sym., R. L. Goulding, ed., pp. 319-334.

23. Waddington, D. V., E. L. Moberg, J. M. Duich, and T. L. Watschki. 1976. Long-term evaluation of slow-release nitrogen sources on turfgrass. Soil Sci. Soc. Am. J. 40:593-597.

24. Wehner, K. J. and T. L. Watschki. 1981. Heat tolerance of Kentucky bluegrasses, perennial ryegrasses, and annual bluegrass. Agron. J. 73:79-84.

25. Welton, F. A. and J. C. Carroll. 1940. Lawn experiments. Ohio Agric. Exper. Stat. Bull. 613. pp. 1-43.

26. Youngner, V. B., A. W. Marsh, R. A. Strohman, V. A. Gibeault, and S. Spaulding. 1981. Water use and turf quality of warm-season and cool-season turfgrasses. Proc. 4th Int. Turfgrass Conf. Huddleston and Barney Limited, Woodstock, Ontario. pp. 251-258.

MANUSCRIPT

This manuscript was written in the style
of and for publication in Agronomy Journal

Kentucky Bluegrass Growth and Soil Responses Under Low Maintenance Cultural Regimes

W. S. Upham and R. N. Carrow

ABSTRACT

Many turfgrass managers have become interested in low maintenance turfgrass culture due to the unavailability or high cost of inputs. This study was designed to investigate: a) plant growth and physiological responses to low maintenance culture and, b) soil responses over time under low maintenance conditions.

A two year old stand of Poa pratensis L. 'Park' on a fine, montmorillonitic mesic aquic arguidoll soil was used. A 3 x 2 x 2 (irrigation x nitrogen (N) x herbicide) factorial, randomized, complete block design was used with the irrigations consisting of no water, low water (2.5 cm every four weeks) and moderate water (2.5 cm every two weeks) with moisture supplied either by rainfall and/or irrigation. Annual N treatments consisted of low N (0.5 kg N/100 m^2) and moderate N (1.0 kg N/100 m^2) levels. Weed control treatments were no herbicide or preemergent annual grass herbicide applied in the spring plus a postemergent broadleaf herbicide applied in the fall.

Visual quality ratings increased with higher N levels and higher irrigation schedules during the hot, dry year of 1980. A 0.5 kg N/100 m^2 fertility level plus low irrigation resulted in an acceptable quality turf. During 1981, visual quality ratings were higher for turf receiving the higher N rate on the March, May, and June sampling dates with the turf receiving the high N rate averaging 6.3 and the turf receiving the low N rate averaging 5.9 (9.0 = ideal turf, 5.0 = acceptable quality, and 1.0 = no live turf). N carryover from 1980 under the no water and low irrigation schedules resulted in higher visual quality ratings for these schedules during 1981 compared to the moderate irrigated plots.

The nonirrigated treatments averaged 6.2 visual quality, while the moderate irrigation level averaged 5.8.

Shoot density ratings were 23% higher under the higher N level during 1981 (due to a greater availability of N for plant growth) but the low N treatments exhibited adequate density for low maintenance conditions. Percent turf cover was affected by irrigation levels for both the 1980 and 1982 sampling periods. Data from 1980 show percent turf cover 9% lower for the nonirrigated treatments than the moderate irrigation schedule, while in 1982 the nonirrigated treatment was 4% higher than the moderate treatment. The 1982 results can be explained by N carryover from 1980 under the nonirrigation schedule resulting in a healthier, more vigorous turf during the cool and moist year of 1981 with the effects continuing to be seen during 1982.

Both plant NO_3^- and total nonstructural carbohydrate levels showed only short-term differences resulting from recent applications of a water soluble N source. All plant NO_3^- levels were in the low range for Kentucky bluegrass.

Weeds did not significantly affect any plant growth parameters during the course of the study. However, by the spring of 1982, it was obvious that herbicides would be needed to control weed populations which began to affect visual quality ratings as the study was terminated.

Soil NO_3^- levels dropped after the first sampling period and remained low through the course of the study. The only significant differences observed were due to either N carryover from the previous year or recent applications of a water soluble N source. Phosphorus and potassium levels decreased with depth but increased substantially over time (i.e. from 1981 to 1982) at the 0 to 5 and 10 to 15 cm depths due to low mobility of these fertilizers in the soil and carryover from one year to the next.

Additional key words: Minimum maintenance, Poa pratensis L., irrigation, nitrogen, herbicides.

With inputs such as irrigation and fertilizer becoming either prohibitively expensive or unavailable (at least for short periods of time), many turfgrass managers have become interested in low maintenance culture. Much research has been conducted on cool season turf under a high or medium maintenance regime, but little work has dealt with low maintenance cultural programs. Research on low maintenance turfgrass responses has mainly focused on only one input at a time (i.e. nitrogen (N) or irrigation) or upon cultivar trials under a low maintenance regime (9).

The objective of a low maintenance cultural system is to produce a turf which persists and resists weed invasion. Supplemental N is needed to achieve this goal but rates are much lower and applications less frequent than for a higher level of maintenance (19). However, reducing N levels below the nutritional requirements of the grass will result in thin, slow growing turf with poor recuperative potential (3). When determining N needs, shoot density is a better indicator of quality than is color (9, 10) because dense turf resists weed invasion.

Slow release fertilizers can be used under low maintenance culture because nutrients are released over a long period of time and therefore require fewer applications (13). Certain slow release N carriers such as IBDU (isobutylidene diurea) and SCU (sulfur coated urea) release N by hydrolysis. When water is limiting for plant growth, the N released by these carriers is lowered and conserved for future use.

In the past, many turfgrass managers have over-irrigated turf (8, 17, 24). Under such conditions, some reduction in applied water will not cause a decrease in turf quality. If too little water is applied, a decrease in density will occur (24) allowing weed invasion. Extreme soil drought results in dormancy of the turf.

Turfgrass areas under low maintenance rarely are used as recreational sites and therefore turf can be maintained at the highest recommended mowing height. High mowing reduces weed populations (10, 19) and increases rooting depth, recuperative potential, and ability to recover from disease (19). A higher cut also reduces mowing frequency (3) resulting in a labor savings.

Many diseases are most severe under higher maintenance while others, such as stem rust caused by Puccinia spp. and dollar spot caused by Sclerotinia homeocarpa F. T. Bennett, are more serious under low maintenance conditions (21). The selection of an adapted species and cultivar becomes critical for low maintenance turf due to slow recovery, limited fungicide use, and susceptibility to certain diseases. Kentucky bluegrass (Poa pratensis L.) was chosen for this study because it is a cool season grass which is able to recover quickly from injury or stress due to a vigorous rhizomatious growth habit. Cool season grasses are preferred in the transition zone because they remain green for a much greater part of the year than warm season grasses. The common variety 'Park' was chosen because past research has shown common types of Kentucky bluegrass and especially 'Park' do better under low maintenance conditions than many improved cultivars (15).

This study was disigned to investigate the effect of a low maintenance cultural system on: a) plant growth and physiological responses and, b) soil responses over time. The knowledge gained should prove useful in delineating the minimum inputs needed to produce an acceptable quality turf.

MATERIALS AND METHODS

This experiment was conducted using a 2 year old 'Park' Kentucky bluegrass (Poa pratensis L.) grown on a Chase silt loam (fine, montmorrillonitic, mesic Aquic Arguidolls) composed of 19.0% sand, 58.9% silt, 19.1% clay, pH 7.3 and 3% organic matter. The study site was located at the Kansas State University turf research plots in Manhattan, Kansas. Measurements were begun on 15 July, 1980 and continued through 26 March, 1982.

Plots measured 1.2 x 2.4 m with three replications per treatment in a 3 x 2 x 2 (irrigation x N x herbicide) factorial, randomized complete block design. All treatments were mowed as needed at 6.3 cm with clippings returned. Treatments and dates of application are listed in Table 1.

Three irrigation levels were used: a) water consisting of precipitation with no irrigation (actual moisture = 0 or higher at 4 wks); b) low water consisting of precipitation + irrigation = 2.5 cm or precipitation = 2.5 cm or higher at 4 wks; and c) moderate water consisting of precipitation + irrigation = 2.5 cm or precipitation = 2.5 cm or higher at 2 wks. Irrigation, when needed, was applied by wave sprinklers. Rainfall consisted of 49 cm, 91 cm, and 15 cm for April through December 1980, January through December 1981, and January through April 1982, respectively.

The growing season of 1980 was extremely dry and water was provided from late July to mid-October according to treatment schedules. Low and moderate irrigation schedules received water on July 24 and October 8 at the rate of 3.8 cm and 2.5 cm respectively. The moderate irrigation schedule also received 2.5 cm on August 6. Adequate rainfall fell during 1981 until late summer, when 1.9 cm applications were applied on August 24 and September 26 for the low and moderate schedules.

Both the low and moderate fertilizer levels (0.5 and 1.0 kg N/100 m^2, respectively) were applied as split applications. One-half of the total amount of N was applied in the spring as IBDU (isobutylidene diurea) and the other half applied in the fall as 12-12-12 (Table 1). IBDU is a slow release carrier while the N in 12-12-12 is water soluble.

Herbicide treatments were no herbicide and herbicide applications of the preemergent annual grass herbicide siduron [1-(2-methylcyclohexyl)-3-phenylurea] as Tupersan® applied by hand sprayer in the spring plus a postemergent broadleaf herbicide consisting of 2,4-D (2,4-Dichlorophenoxyacetic acid) + dicamba (3,6-Dichloro-o-anisic acid) + MCPP [2-(2-Methyl-4-chlorophenoxy) propionic acid] as Trimec® applied in the fall (Table 1).

Shoot density, verdure, and total nonstructural carbohydrate (TNC) were determined from two 5.4 cm diameter plug samples per plot. Sampling dates for shoot density and verdure are in Table 3 and TNC sampling dates are in Table 4. Samples were collected before 1000 hours, oven dried at 100 C for 1 hr, then 60 C for 24 hours. TNC levels were determined by the method by Morris (4). Visual quality ratings (9.0 = ideal turf, 1.0 = no live turf) were based on color, turf density, and uniformity of the entire plot. Percent turf cover was based on visual observations.

Percent N of tissue was determined from clippings dried at 65 C for 24 hours, weighed, and analyzed from a micro-Kjeldahl digestion (3) using a selective, NH_3^- ion electrode (1). Soil NO_3^- was measured at depths of 0 to 5, 10 to 15, and 20 to 25 cm from two cores (2.0 cm diam) per plot. Samples were separated by depth, air dried, and then sieved to pass through a 20 mesh screen. A 7 g sample was analyzed using a selective NO_3^- electrode (1).

Root weights were determined by combining 4 cores (2 cm diam x 20 cm) per plot. Samples were divided into 0 to 10 and 10 to 20 cm zones, washed, dried at 60 C for 24 hours, and weighed. Results for the upper and lower zones were statistically similar and therefore were consolidated for this report.

Disease ratings were conducted during August 1981. Weed counts were made later in the fall as weeds per plot.

RESULTS AND DISCUSSION

Herbicide treatments did not significantly affect any plant growth parameter measured except weed counts so therefore only N and water effects will be presented. Irrigation and N responses were able to be averaged over herbicide levels due to the absence of any interaction responses.

Plant Responses

Shoot Growth. Visual quality was often higher under the 1.0 kg N/100 m^2 rate but not on all dates (Table 2). This was especially apparent late in the summers of 1980 and 1981 when the bluegrass did not respond to higher N during periods of limited rainfall. This indicates that using higher N would not improve turf quality if water was limiting. Both Madison (10) and Beard (3) have noted that turfgrass cannot utilize N if soil moisture levels are too low. This results from the inability of fertilizer ions to diffuse to the root area without water as a medium (3). Madison (10) also found that mineralization and fixation of soil

N continued at soil moisture levels too low for plant growth. Therefore, turf resuming growth after a drought may have more soil N available for plant growth than would be expected from carryover of previous fertilizer applications.

Significant differences in turf quality among irrigation treatments occurred on all dates in 1980 (Table 2). The months April through September were hot and dry and turf quality increased with increasing irrigation level. The nonirrigated treatment went dormant in July to mid-August of 1980 and under the low irrigation level the turf was dormant for short periods.

In 1981 and 1982 differences were apparent among irrigation treatments on most dates but with higher visual quality exhibited for the no water and low irrigation levels (Table 2). This could not have been due to irrigation applications because no water was applied until late August 1981. Since the previous year was extremely dry, N carryover into the spring and early summer of 1981 seems likely as the cause. The soil NO_3^- levels in the 20 to 25 cm zone for April 1981 revealed a trend for higher N with decreasing irrigation ($P < 10\%$) (Table 6).

Nitrogen carryover has been noted on agronomic crops during periods of low leaching and low crop production (2). Slow release N carriers may carry N from one year to the next even without drought conditions (13). Considering the fact that N release from IBDU is by slow dissolution and hydrolysis (13, 23), carryover into 1981 appears likely on the plots that received less irrigation. Nitrogen also may have accumulated under the lower irrigation schedules because plant growth, and therefore N use, are inhibited at a higher soil moisture level that are soil N mineralization and fixation (10).

The only disease considered severe enough to rate was fusarium blight purportedly caused by Fusarium roseum f. sp. cerealis (Cke.) Snyder and Hansen and Fusarium tricinctum f. sp. poae (Pk.) Snyder and Hanson (7). Visual symptoms (typical "frog-eye" patterns consisting of circular areas of dead grass with center tufts of living grass was observed) were considered sufficient for disease determination. The etiology of this disease is still uncertain because the associated Fusarium spp. have not been shown to reproduce field symptoms in controlled inoculation experiments (7, 20). Furthermore, other microorganisms may be the actual causal agents (16).

In the late summer of 1981, fusarium blight was most severe under the moderate irrigation level (Table 3). The presence of this disease under this cultural system was surprising because fusarium blight is often associated with high N, heat stress, and drought (20). None of the plots received irrigation water during 1981 until after the disease had abated and therefore this could not have been a direct response to irrigations. Data for August 1981 showed verdure (dry weight of all aboveground live tissue) to be significantly lower for the nonirrigated plots. Solar radiation striking the nonirrigated plots could have resulted in greater heat stress to the turf, thereby predisposing it to greater damage from fusarium blight than the other two irrigation regimes. Also, since the visual quality of the turf was better for the nonirrigated plots, these may have been better able to recover.

Shoot density was significantly greater at the higher N level for April and June 1981 as well as March 1982 (Table 3). The spring dates most likely reflect N carryover from the previous year while the June response was due to the IBDU application in May. There were no consistent shoot density responses to irrigation level.

Verdure (dry weight of all aboveground live tissue) responses were similar to shoot density results (Table 3). The higher N level produced more tissue on April, June, and October sampling periods due to the availability of more N for plant growth and favorable growing conditions. During August, the lack of response may have been due to lack of water for growth or soil NO_3^- reaching low levels (Table 6). The April and August 1981 data also showed that verdure increased as irrigation level decreased. The April response appeared to be due to carryover of N from the previous year, while the August response could be due to the incidence of fusarium blight.

Percent cover ratings were taken during October 1980 and March 1982 (Table 3). The only difference noted in the October rating was that the nonirrigated plots had a lower percent cover than the low or moderate irrigation level. By April 1982 the nonirrigated regime was rated significantly higher than either the low or moderate levels.

Root density. Root density measurements were taken for the 0 to 10 and 10 to 20 cm depths but were consolidated because results were statistically similar.

Root density was not significantly affected by any of the treatments except in March of 1982 where the higher N treatment produced a greater density of roots due to the availability of more N for plant growth (Table 4).

Plant NO_3^-. Roberts (18) found that N rate affected plant NO_3^- levels with 2.8% N for low (plant exhibits N deficiency symptoms) fertility grass, 3.5% N for moderate (N adequate for growth and color) fertility grass, and 4.4 to 4.9% for grass receiving excessive (produces excessive growth) N. Plant NO_3^- levels in this study were in the low range due to the limited N applied (Table 4). No significant differences between treatments were noted except that increased N application produced a higher plant NO_3^- reading during October of 1981. This is understandable because NH_4NO_3 (in a 12-12-12 fertilizer) was applied during September and would be immediately available for plant uptake.

TNC. During October 1981, the low N regime resulted in a significantly higher TNC level (Table 4). Greatest accumulation of TNC's has been noted under conditions of slow shoot growth and high light intensity (3). A fertilizer containing NH_4NO_3 was applied during September 1981. The higher N rate resulted in comparatively more shoot growth which caused a decrease in TNC levels. There was a similar trend of lower TNC levels under the 1.0 kg N/100 m^2 rate on the first three sample dates but these were significant at $P < 10\%$.

Weeds. The postemergence broadleaf herbicide Trimec® applied during the fall of 1980 did not effectively control weeds through the following August since most of the dandelion population developed after the fall application (Table 5). Fall treatment for broadleaf weeds in 1981 resulted in good control of dandelions the following spring. The higher N rate resulted in over 40% fewer weeds than the lower N rate probably due to more verdure as revealed in the October rating period. Irrigation treatments did not produce any significant differences in dandelion populations by the spring 1981 sampling period. A N-herbicide interaction was also noted during April 1982 with the nonirrigated plots which did not receive herbicide applications containing a significantly higher dandelion population.

The preemergent annual grass herbicide Tupersan® applied during the spring 1981 did aid in controlling crabgrass but the nonirrigation treatment showed less control than the other two irrigation levels

(Table 5). The reason for this is not clear considering that the first irrigation treatment was not applied until August 19.

The data show that weeds are definately a problem under low maintenance conditions and that during most years herbicides will be needed to maintain an acceptable quality turf.

Soil Responses

Soil NO_3^-. Except for April 1981, all soil NO_3^- levels were low (Table 6). This was expected due to the low levels of N fertilizer applied.

N rate had a significant effect on soil NO_3^- levels on only two dates; April and September 1981 (Table 6). Residual N from the previous year could explain the April data and the September sampling period (September 26) occurred approximately 2 weeks after an NH_4NO_3 fertilizer was applied. The rather uniform soil NO_3^- from May through August would be expected since the N applied in April was as IBDU. IBDU is a slow release N carrier which releases only a small quantity of N at any one time.

The soil NO_3^- levels in April 1981 also reveal a trend (P   10%) for the nonirrigation treatments to have higher soil nitrate levels than the low or moderate treatments. This additional N could explain the higher visual quality ratings noted for the nonirrigation treatment during the spring and early summer of 1981.

Phosphorus (P) and potassium (K). Phosphorus samples were taken in the spring of both 1981 and 1982 (Table 7). Levels of P were highest at the 0 to 5 cm depth and decreased by 39% for the 10 to 15 cm depth and by 84% for the 20 to 25 cm depth. P is relatively immobile in the soil and so data reflect previous fertilizer applications. P levels were in the high to very high range (5) for the 0 to 5 and 10 to 15 cm depths. An increase in P of 31 to 38% was found from 1981 to 1982 in the 0 to 5 and 10 to 15 cm depths, respectively, due to carryover from previous fertilizer applications.

Data in 1981 show the nonirrigation level had a significantly higher P level in the 10 to 15 and 20 to 25 cm soil depths that the other two irrigation regimes (Table 7). Irrigation applied the previous fall to the low and moderate regimes may have resulted in greater uptake of soil P due to greater plant growth. Data in 1981 revealed higher P levels at the 20 to 25 cm depth for the nonirrigated treatment as compared to the moderate irrigation level (Table 7). Irrigation was applied twice to the moderate schedule after application of fertilizer but only once under the low regime.

Potassium was sampled at the same time as P. Native soils at the test site contain very high levels of K. Levels of K at the 10 to 15 and 20 to 25 cm depths were only 72 and 60 percent respectively of the K level at the 0 to 5 cm depth. Increases in K were observed from 1981 to 1982 for all depths due to carryover from previous fertilizer applications with a 29% increase noted in the 0 to 5 cm soil zone. Data from 1982 showed significantly higher K at the higher N level at the 0 to 5 cm depth (Table 7). This is easily understood considering that 12-12-12 was applied the previous fall and twice as much K was applied under the 1.0 kg N/100 m^2 N regime.

Organic matter and pH. Organic matter and pH exhibited only one minor significant difference each due to treatment. Both differences occurred at the 20 to 25 cm depth during the 1981 sampling period with organic matter increasing and pH decreasing with an increase in N rate[1].

[1]Measurements are contained in Appendix B.

Summary and Conclusion

In this study, the low N rate (0.5 kg N/100 m^2) provided enough shoot density to maintain visual quality ratings above an acceptable level of 5.0 if water was not limiting. However, N carryover from 1980 appears to have provided significant amounts of N during 1981 under the low and nonirrigated treatments. Further sampling may be needed to verify that the low N rate will continue to be adequate. This would indicate that soil N in a plant available form may accumulate during a dry period and have significant influence in the following year. Under higher maintenance situations such carryover responses may be masked by high inputs of water and N. Slow release N carriers did appear to release N for plant growth over a relatively long period of time.

The year of 1980 was hot and dry and therefore provided a good test of irrigation needs. The nonirrigated turf became dormant in July to mid-August and therefore was considered unacceptable. The low irrigation treatment (rainfall + irrigation to equal 2.5 cm every 4 weeks) maintained the turf in a semi-dormant condition and was therefore deemed acceptable for low maintenance conditions. Rainfall during 1981 was well distributed through much of the summer and supplemental irrigation needs were minimal and turf quality was acceptable.

A preemergent annual grass herbicide applied during the spring of 1981 only affected weed counts and not turf growth. The broadleaf herbicide applied during the fall of 1981 showed striking differences due to dandelions infesting non-treated plots the following April. It is expected that herbicides will be needed to maintain acceptable quality except during dry years.

Under the conditions of this study, soil N responses were minimal.

Soil NO_3^- levels remained low except when N carryover or recent applications of a water soluble N source occurred.

Soil P and K levels demonstrated a 31 and 29% increase, respectively, within one year even though applied rates were low. This would suggest that soil levels of these nutrients could increase rapidly under a low maintenance regime where plant removal and leaching losses would be low. When soil test recommendations are made on low maintenance turf, these factors should be considered. Recommended rates may need to be adjusted downward because recommendations often assume a medium level of maintenance.

LITERATURE CITED

1. Anonymous. 1978. Analytical methods guide. 9th ed. Orion Res., Inc., Cambridge, Mass.

2. Ankerman, K., and R. Large. 1981. Soil and plant analysis. A & L Agricultural Laboritories, Inc.

3. Beard, J. B. 1973. Turfgrass: science and culture. Prentice-Hall, Inc., Englewood Cliffs, N. J.

4. Busey, P., and E. O. Burt. 1979. Turf, energy, and the environment. Proc. Fla. State Hort. Soc. p. 92.

5. Carrow, R. N. 1981. Nutrition and turfgrass root and foliage growth. Proc. 19th Annual Neb. Turf Conf. pp. 4-10.

6. Carrow, R. N. 1982. Fertilization investigation on a high sand creeping bentgrass golf green. CPTF and Kansas State University Turf Field Day. pp. 37-43.

7. Couch, H. B. 1966. Fusarium blight of turfgrasses. Phytopathology 56:781-786.

8. Dernoeden, P. H. 1976. Cultivar tolerance to drought in Kentucky bluegrass. 22nd Ann. Rocky Mountain Reg. Turfgrass Conf. pp. 37-40.

9. Lukens, R. J., P. M. Miller, and G. S. Walton. 1975. Performance of bluegrass cultivars under a low maintenance program. Conn. Agricult. Exper. Stat.-Bull. 753.

10. Madison, J. H. 1971. Practical turfgrass management. Van Nostrand Reinhold Company. New York, N. Y.

11. Madison, J. H. 1971. Principles of turfgrass culture. Van Nostrand Reinhold Company. New York, N. Y.

12. Mitchell, H. L. 1972. Microdetermination of nitrogen in plant tissues. J. Assoc. Offic. Anal. Chemists. 1:55.

13. Moberg, E. L., D. V. Waddington, and J. M. Duich. 1970. Evaluation of slow-release nitrogen sources on Merion Kentucky bluegrass. Soil Sci. Soc. Amer. Proc. 34:335-339.

14. Morris, D. L. 1948. Quantitative determination of carbohydrates with Dreywood's anthrone reagent. Science 106:254-255.

15. Pair, J. C., R. N. Carrow, L. D. Leuthold, and R. A. Keen. 1981. Kentucky bluegrass for turf: Keeping up with research 53. Kansas State University Extension Publications. Manhattan, Ks.

16. Pennypacker, B. W., P. L. Sanders, and J. Cole, Jr. 1982. Basidiomycetes associated with a patterned midsummer wilt of bluegrass. Plant Disease 66:419-420.

17. Pochop, L. O., and J. Borrelli. 1979. Water use by Kentucky bluegrass. Proc. Ariz. Turfgrass Conf. pp. 18-20.

18. Roberts, E. C., and R. M. Pellett. 1964. Potassium helps bluegrass face hot summer. Better Crops 48(2):2-7.

19. Schery, R. W. 1967. Minimum maintenance turf. 8th Turfgrass Conf. Proc. at Univ. of Ill. pp. 8-9.

20. Smiley, R. W. 1980. Fusarium blight of Kentucky bluegrass: new perspectives. Advances in Turfgrass Pathology: P. O. Larsen and B. G. Joyner, eds. pp. 155-178.

21. Vargas, Jr., J. M. 1981. Management of turfgrass diseases. Burgess Publishing Company. Minneapolis, Minn.

22. Waddington, D. V., J. M. Duich, and J. R. Turner. 1977. Turfgrass fertilization with isobutylidene diurea and ureaform. Proc. 1977 Controlled Release Pesticide Sym., R. L. Goulding, ed., pp. 319-334.

23. Waddington, D. V., E. L. Moberg, J. M. Duich, and T. L. Watschki. 1976. Long-term evaluation of slow-release nitrogen sources on turfgrass. Soil Sci. Soc. Am. J. 40:593-597.

24. Youngner, V. B., A. W. Marsh, R. A. Strohman, V. A. Gibeault, and S. Spaulding. 1981. Water use and turf quality of warm-season and cool-season turfgrasses. Proc. 4th Int. Turfgrass Conf. Huddleston and Barney Limited, Woodstock, Ontario. pp. 251-258.

Table 1. Application dates for N, irrigation water, and herbicide treatments.

Treatment	Year and date applied 1980	1981
Nitrogen (kg/100 m^2/yr.)		
0.5	5/29	5/20
	9/26	9/5
1.0	5/29	5/20
	9/26	9/5
Irrigation water (cm)		
none	--	--
low	7/24 (3.8 cm)	9/26 (2.5 cm)
	10/8 (2.5 cm)	--
moderate	7/24 (3.8 cm)	8/24 (1.9 cm)
	8/6 (2.5 cm)	9/12 (1.9 cm)
	10/8 (2.5 cm)	9/26 (2.5 cm)
Herbicide (a.i./100 m^2)		
Siduron (112 g)	--	5/27
Trimec	--	9/19

Table 2. Visual quality ratings in 1980-82 for low maintenance Kentucky bluegrass.

Visual quality† by date	N-rate (kg N/100 m²/yr) 0.5	1.0	Irrigation level none	low	moderate	LSD (.05)‡ N	I
1980							
July 15	5.7	5.8	5.1	5.8	6.5	ns	0.28
Aug. 29	5.9	5.8	4.9	6.2	6.4	ns	0.42
Oct. 31	6.1	6.7	6.0	6.8	6.5	0.30	0.37
1981							
March 20	5.2	5.6	5.5	5.5	5.3	0.20	ns
May 22	6.1	6.6	6.6	6.4	6.1	0.26	0.31
June 30	6.4	6.7	6.7	6.6	6.4	0.13	0.16
July 28	6.4	6.5	6.6	6.6	6.4	ns	0.13
Aug. 25	5.7	5.7	6.0	5.8	5.4	ns	0.18
Sept. 26	5.5	5.5	5.9	5.6	5.1	ns	0.32
Oct. 19	5.8	6.0	6.0	6.0	5.7	ns	ns
1982							
April 13	4.3	5.4	5.2	4.8	4.5	0.25	0.31
May 29	5.7	6.5	6.3	6.1	5.9	0.20	0.24

†Visual quality scale: 9 = ideal turf, 1 = no live turf.
‡No significant N x I interactions. N = nitrogen, I = irrigation.

Table 3. Fusarium blight, shoot density, verdure, and turf cover for 1981 and 1982.

Measurement and date	N-rate (kg N/100 m^2/yr) 0.5	1.0	Irrigation level none	low	moderate	LSD (.05)† N	I
Fusarium blight (0 = none, 5 = 80%+ kill of plants)							
Aug. 81	2.7	2.4	2.0	2.6	3.0	ns	0.64
Shoot density (plants/100 cm^2)							
April 81	123	178	159	145	148	19	ns
June 81	124	181	148	171	140	16	19
Aug. 81	107	124	123	120	103	ns	ns
Oct. 81	96	101	100	94	102	ns	ns
March 82	98	146	127	122	117	14	ns
Verdure (g/100 m^2)							
April 81	1.38	1.81	1.67	1.71	1.41	0.21	0.26
June 81	1.81	2.10	2.02	2.05	1.79	0.21	ns
Aug. 81	1.44	1.58	1.69	1.58	1.27	ns	0.22
Oct. 81	0.85	1.25	1.04	0.93	1.17	0.12	ns
Turf cover (%)							
Oct. 80	94	94	87	97	96	ns	4
March 82	89	90	92	89	88	ns	3

† See footnote in Table 2.

Table 4. Root weights, plant nitrate, and plant total nonstructural carbohydrates in 1981-82.

Measurement and date	N-rate (kg N/100 m^2/yr)		Irrigation level			LSD (.05)†	
	0.5	1.0	none	low	moderate	N	I
Root density (mg/cm^3) in 0-20 cm depth)							
April 81	8.88	7.77	8.60	8.38	8.00	ns	ns
June 81	4.77	4.75	4.72	4.77	4.80	ns	ns
Aug. 81	3.57	3.43	3.51	3.33	3.66	ns	ns
Oct. 81	3.29	3.36	3.32	3.34	3.32	ns	ns
March 82	3.18	3.61	3.65	3.43	3.11	.35	ns
Plant nitrate (% dry wt. basis)							
April 81	1.84	2.11	1.93	2.08	1.92	ns	ns
June 81	2.67	2.72	2.72	2.68	2.69	ns	ns
Aug. 81	1.62	1.58	1.64	1.56	1.60	ns	ns
Oct. 81	1.93	2.42	2.19	2.25	2.09	0.11	ns
March 82	0.95	0.99	0.96	1.03	0.92	ns	ns
Plant total nonstructural carbohydrates (% dry wt. basis)							
April 81	39.0	35.8	35.6	38.5	38.0	ns	ns
June 81	27.3	25.1	25.3	26.0	27.4	ns	ns
Aug. 81	24.3	22.6	24.1	24.1	22.2	ns	ns
Oct. 81	32.9	25.0	28.3	28.6	29.9	2.3	ns
March 82	52.8	50.9	52.5	48.6	54.4	ns	ns

†See footnote in Table 2.

Table 5. Weed populations (weeds per plot, 1.2 x 2.4 m) in 1981-82.

N-rate (kg/100 m^2)	Irrigation level	Weed control	Aug. 81 Dandelion	Aug. 81 Crabgrass	Aug. 81 Spurge	April 82 Dandelion
0.5	none	no	18	19	5	20
0.5	low	no	28	17	6	17
0.5	mod.	no	28	27	24	26
0.5	none	yes	21	18	12	0
0.5	low	yes	18	5	1	1
0.5	mod.	yes	34	5	5	1
1.0	none	no	18	12	5	11
1.0	low	no	13	20	3	15
1.0	mod.	no	13	27	8	10
1.0	none	yes	16	12	11	0
1.0	low	yes	8	2	0	1
1.0	mod.	yes	19	6	5	0
LSD (.05)† N =			ns‡	ns	ns	3.2
LSD (.05) I =			ns	ns	ns	ns
LSD (.05) H =			ns	5.7	ns	3.2
LSD (.05) I x H =			ns	9.8	ns	ns
LSD (.05) N x H =			ns	ns	ns	4.5

† LSD values are for mean comparisons. H = herbicide.
‡ Significant at a F-test of 0.10.

Table 6. Effects of N applications and irrigation on soil nitrate levels in 1981-82 at three soil depths.

Date and soil depth (cm)	N-rate (kg N/100 m^2/yr)		Irrigation level			LSD (.05)†	
	0.5	1.0	none	low	moderate	N	I
	ppm soil NO_3^-						
April 81							
0-5 cm	6.6	6.3	6.8	6.2	6.3	ns	ns
10-15 cm	6.5	6.7	6.7	6.8	6.2	ns	ns
20-25 cm	5.7	6.9	6.6	6.2	6.2	0.43	ns
May 81							
0-5 cm	0.94	0.89	0.94	0.93	0.88	ns	ns
10-15 cm	0.90	0.82	0.90	0.89	0.79	ns	ns
20-25 cm	0.91	0.81	0.83	0.86	0.88	ns	ns
June 81							
0-5 cm	0.63	0.66	0.64	0.63	0.68	ns	ns
August 81							
0-5 cm	0.79	0.85	0.81	0.85	0.80	ns	ns
10-15 cm	0.76	0.77	0.79	0.75	0.76	ns	ns
20-25 cm	0.76	0.77	0.80	0.76	0.73	ns	ns
September 81							
0-5 cm	0.91	1.39	1.08	1.34	1.03	0.36	ns
October 81							
0-5 cm	1.03	1.52	1.04	1.65	1.13	ns	ns
10-15 cm	0.72	0.88	0.72	0.93	0.74	ns	ns
20-25 cm	0.59	0.61	0.58	0.63	0.59	ns	ns
March 82							
0-5 cm	0.48	0.48	0.48	0.47	0.49	ns	ns

† See footnote in Table 2.

Table 7. Soil phosphorus and potassium levels by depth in 1981-82 under low maintenance conditions.

Measurement, date and soil depth (cm)	N-rate (kg N/100 m^2/yr)		Irrigation level			LSD (.05)	
	0.5	1.0	none	low	moderate	N	I
	gm/m^2						
Phosphorus 81							
0-5 cm	11.1	11.1	11.8	10.8	10.8	ns	ns
10-15 cm	7.3	6.8	7.9	6.6	6.6	ns	1.2
20-25 cm	2.0	2.0	2.6	1.8	1.8	ns	0.6
Phosphorus 82							
0-5 cm	14.7	14.5	16.1	13.8	13.7	ns	ns
10-15 cm	10.2	9.1	11.0	8.7	9.2	ns	ns
20-25 cm	1.8	2.4	2.8	1.5	1.9	ns	0.8
Potassium 81							
0-5 cm	89.3	92.4	94.0	90.5	88.0	ns	ns
10-15 cm	68.4	68.7	70.1	67.8	67.6	ns	ns
20-25 cm	53.4	59.5	58.6	58.6	58.2	ns	ns
Potassium 82							
0-5 cm	113.5	121.4	121.3	115.5	115.5	7.4	ns
10-15 cm	82.0	81.7	81.7	82.4	82.2	ns	ns
20-25 cm	66.9	67.4	67.4	67.6	66.8	ns	ns

See footnote in Table 2.

TABLE CAPTIONS

APPENDIX A

Precipitation Records

Month	Year and Amounts (cm)		
	1980	1981	1982
January	2.87	0.18	2.87
February	2.59	1.60	2.97
March	12.62	2.92	5.69
April	3.50	5.61	3.07
May	4.57	17.93	--
June	7.13	16.61	--
July	3.05	14.20	--
August	7.47	7.01	--
September	6.40	3.53	--
October	8.71	5.92	--
November	0.28	13.36	--
December	7.75	1.83	--
Total	66.95	90.70	

Appendix B. Organic matter (%) and pH by depth in 1981-82.

Measurement, date, and soil depth (cm)	N-rate (kg N/100 m^2/yr)		Irrigation level			LSD (.05)†	
	0.5	1.0	none	low	moderate	N	I
Organic Matter 81							
0-5 cm	2.84	2.73	2.82	2.72	2.83	ns	ns
10-15 cm	2.64	2.48	2.62	2.52	2.54	ns	ns
20-25 cm	2.03	2.30	2.20	2.07	2.22	0.25	ns
Organic Matter 82							
0-5 cm	3.63	3.65	3.60	3.73	3.59	ns	ns
10-15 cm	3.32	3.23	3.33	3.26	3.24	ns	ns
20-25 cm	2.58	2.50	2.67	2.43	2.52	ns	ns
pH 81							
0-5 cm	7.57	7.53	7.52	7.54	7.58	ns	ns
10-15 cm	7.59	7.53	7.50	7.52	7.67	ns	ns
20-25 cm	7.57	7.43	7.49	7.45	7.57	0.10	ns
pH 82							
0-5 cm	7.60	7.56	7.59	7.58	7.58	ns	ns
10-15 cm	7.68	7.71	7.70	7.68	7.71	ns	ns
20-25 cm	7.77	7.79	7.78	7.77	7.79	ns	ns

†No significant N x I interactions. N = nitrogen, I = irrigation.

ACKNOWLEDGEMENTS

The writer wishes to express sincere thanks to Dr. R. N. Carrow for his guidance and the use of his laboratory facilities throughout this study.

Thanks are also extended to Dr. P. Jennings and Dr. F. Crowe for their guidance and support.

KENTUCKY BLUEGRASS GROWTH AND SOIL RESPONSES UNDER
LOW MAINTENANCE CULTURAL REGIMES

by

WARD S. UPHAM

B.S., Kansas State University, 1976

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Horticulture

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1982

Many turfgrass managers have become interested in low maintenance turfgrass culture due to the unavailability or high cost of inputs. This study was designed to investigate: a) plant growth and physiological responses to low maintenance culture and, b) soil responses over time under low maintenance conditions.

A two year old stand of Poa pratensis L. 'Park' on a fine, montmorrillonitic mesic aquic arguidoll soil was used. A 3 x 2 x 2 (irrigation x nitrogen (N) x herbicide) factorial, randomized, complete block design was used with the irrigations consisting of no water, low water (2.5 cm every four weeks) and moderate water (2.5 cm every two weeks) with moisture supplied either by rainfall and/or irrigation. Annual N treatments consisted of low N (0.5 kg N/100 m^2) and moderate N (1.0 kg N/100 m^2) levels. Weed control treatments were no herbicide or preemergent annual grass herbicide applied in the spring plus a postemergent broadleaf herbicide applied in the fall.

Visual quality ratings increased with higher N levels and higher irrigation schedules during the hot, dry year of 1980. A 0.5 kg N/100 m^2 fertility level plus low irrigation resulted in an acceptable quality turf. During 1981, visual quality ratings were higher for turf receiving the higher N rate on the March, May, and June sampling dates with the turf receiving the high N rate averaging 6.3 and the turf receiving the low N rate averaging 5.9 (9.0 = ideal turf, 5.0 = acceptable quality, and 1.0 = no live turf). N carryover from 1980 under the no water and low irrigation schedules resulted in higher visual quality ratings for these schedules during 1981 compared to the moderate irrigated plots. The nonirrigated treatments averaged 6.2 visual quality, while the moderate irrigation level averaged 5.8.

Shoot density ratings were 23% higher under the higher N level during 1981 (due to a greater availability of N for plant growth) but the low N treatments exhibited adequate density for low maintenance conditions. Percent turf cover was affected by irrigation levels for both the 1980 and 1982 sampling periods. Data from 1980 show percent turf cover 9% lower for the nonirrigated treatments that the moderate irrigation schedule, while in 1982 the nonirrigated treatment was 4% higher than the moderate treatment. The 1982 results can be explained by N carryover from 1980 under the nonirrigation schedule resulting in a healthier, more vigorous turf during the cool and moist year of 1981 with the effects continuing to be seen during 1982.

Both plant NO_3^- and total nonstructural carbohydrate levels showed only short-term differences resulting from recent applications of a water soluble N source. All plant NO_3^- levels were in the low range for Kentucky bluegrass.

Weeds did not significantly affect any plant growth parpmeters during the course of the study. However, by the spring of 1982, it was obvious that herbicides would be needed to control weed populations which began to affect visual quality ratings as the study was terminated.

Soil NO_3^- levels dropped after the first sampling period and remained low through the course of the study. The only significant differences observed were due to either N carryover from the previous year or recent applications of a water soluble N source. Phosphorus and potassium levels decreased with depth but increased substantially over time (i.e. from 1981 to 1982) at the 0 to 5 and 10 to 15 cm depths due to low mobility of these fertilizers in the soil and carryover from one year to the next.