Turfgrass Soil Management Research: 1989

P. E. Rieke, M. T. Saffel and D. K. Lee
Crop and Soil Sciences, MSU

Nitrogen Carrier Evaluations

Several nitrogen carrier evaluation studies were conducted at the Hancock Turfgrass Research Center in 1989. Nitrogen carriers which were evaluated included the following. Sustane is a turkey manure natural organic fertilizer which is available in several particle size ranges (from the Sustane Corporation). The PCUs are experimental plastic coated urea fertilizers from Canadian Industries Limited (CIL). The sulfur coated ureas (labelled SCU in the tables) are also from CIL. The Andersons fertilizers are natural organic products from The Andersons. The Sierra fertilizers and Agriform are plastic coated products from the Sierra Co. Turf Restore and Greens Restore are natural organic based products from Ringers. Scotts fertilizers are methylene urea carriers as is the Nor-Am fertilizer. N-Sure is a liquid product containing triazones and urea from the Arcadian Corporation. Nitro 26 is a liquid fertilizer containing various methylene ureas from Growth Products. IBDU was provided by Estech, ureaformaldehyde by Nor-Am, Milorganite by the Milwaukee Sewerage Commission, 18-4-10 by the Lebanon Co., LESCO Elite by LESCO, Iron-S by Scotts, GS-1 by Emerald Isle, and Ferromec by PBI Gordon.

The first study was conducted on Challenger Kentucky bluegrass. Plot size was 4 feet by 12 feet with 3 replications. One pound of N was applied per 1000 sq ft on June 25, 1989. Turfgrass quality ratings were taken on seven dates during the growing season (Table 1). Clipping weights were collected on three dates from an area 22 inches wide by 10 feet, 2 inches long on each plot. Clippings were dried and weighed (Table 2).

Challenger Kentucky bluegrass has an inherently dark green color. As a result of this and the fact that most of the carriers performed well, there were few meaningful differences noted among carriers through much of the study (Table 1). Five months after application in November, the plastic coated fertilizers from Sierra and CIL seemed to have a little better residual effect than other carriers although all plots had lost significant color that late in the year.

Clipping weight data (Table 2) were somewhat variable so consistent conclusions were not evident. Some necrotic ring spot disease appeared randomly in the plot area in September.

A second nitrogen carrier study was established July 14, 1989 on Palmer and Citation II perennial ryegrasses. Nitrogen was applied at 1 or 3 lbs per 1000 sq ft. Plot size was 4 feet by 12 feet with 3 replications. Quality ratings were taken on six dates (Table 3) and clipping weights determined on two dates (Table 4).

One week after application (July 21) several products performed well including, among others, N-Sure, Nitro 26, Scotts 38-0-0, Lawn Restore, Andersons 9-3-6, Sustane and PCUI. Three weeks after applicaton (August 4) good performers included Lawn Restore, Andersons 9-3-6, IBDU, Scotts 35-0-0,

Table 1. Effects of nitrogen on turfgrass quality ratings of Challenger Kentucky bluegrass. Hancock Turfgrass Research Center. Nitrogen applied at 1 lb. N per 1000 sq. ft. on June 26, 1989. Averages of 3 replications.

	Turfgrass Quality Rating (9 = Ideal)							
Carrier	7/10	7/18	8/3	8/15	9/19	10/3	11/26	average
Sustane Med 5-2-4	8.2a*	7.7a	7.3ab	6.2 c	6.5 c	6.8 c	5.5abc	6.8 c
Sustane Fine 5-2-4	8.3a	7.7ab	6.7 b	6.2 c	7.0abc	7.1 bc	5.5abc	7.0 bc
CIL PCU1 44.6%	8.5a	7.7ab	7.7a	6.5 c	7.0abc	7.2 bc	5.3 bc	7.1 bc
CIL PCU 2 44.2%	8.5a	7.7ab	8.0a	6.8abc	7.3abc	7.7ab	5.5abc	7.4ab
CIL SCU 32%	8.5a	8.0a	7.5ab	6.8abc	7.0abc	7.3 bc	6.2ab	7.3ab
CIL SCU 37%	8.5a	7.2a	7.7a	6.7 bc	6.8abc	7.0 bc	5.5abc	7.0 bc
Anderson 9-3-6	8.5a	7.5ab	7.3ab	6.7 bc	7.2abc	7.5abc	5.7abc	7.2abc
Anderson 10-2-4	8.2a	7.5ab	7.2ab	6.5 c	7.2abc	7.2 bc	5.7abc	7.0 bc
Sierra 34-0-7	8.3a	7.7ab	8.0a	7.3a	7.7ab	7.5abc	6.3a	7.6a
Sierra 25-0-0	8.3a	7.5ab	7.8a	7.2ab	7.8a	8.2a	6.2ab	7.6a
Scott's 38-0-0	8.5a	8.0a	7.7a	6.8abc	6.7 bc	7.0 bc	5.3 bc	7.3abc
Turf Restore 10-3-4	8.2a	7.5ab	7.7a	6.8abc	7.0abc	6.9 bc	5.2 c	7.0 bc
Nor-Am Methylene Urea	8.3a	7.3ab	7.3ab	6.3 c	7.2abc	7.5abc	5.7abc	7.1 bc
N-Sure 28%	8.5a	7.8ab	7.7a	6.7 bc	7.0abc	7.3 bc	5.5abc	7.4ab
Urea 46%	8.5a	7.0 b	7.7a	6.8abc	7.5abc	7.3 bc	5.8abc	7.2abc

* - Means followed by the same letter are not significantly different at the 5% level using Duncan's Multiple Range Test.

Table 2. Effect of nitrogen carriers on dry clipping weights of Challenger Kentucky bluegrass. Hancock Turfgrass Research Center. Nitrogen applied at 1 lb. N per 1000 sq. ft. on June 26,1989. Averages of 3 replications.

Carrier	Clipping weight, grams meter^{-2}		
	7/28	8/23	9/26
Sustane Med 5-2-4	22.8a*	9.7 cd	32.5abc
Sustane Fine 5-2-4	31.8a	10.4 bcd	29.1 bc
CIL PCU1 44.6%	43.8a	19.0a	41.2abc
CIL PCU2 44.2%	30.6a	20.8a	35.2abc
CIL SCU 32%	46.6a	13.9abcd	40.6abc
CIL PCU 37%	30.6a	22.2a	42.5ab
Anderson 9-3-6	18.6a	13.9abcd	45.3a
Anderson 10-2-4	50.7a	12.7abcd	34.8abc
Sierra 34-0-7	31.1a	13.4abcd	33.6abc
Sierra 25-0-0	50.3a	19.6ab	32.4abc
Scott's 38-0-0	43.7a	13.2abcd	34.0abc
Turf Restore 10-3-4	30.8a	8.6 d	29.8 bc
Nor-Am Methylene Urea 40%	28.9a	15.2abcd	27.8 c
N-Sure 28%	41.4a	19.6ab	40.2abc
Urea 46%	50.7a	17.3abcd	39.1abc

* - Means followed by the same letter are not significantly different at the 5% level using Duncan's Multiple Range Test.

Table 3. Effect of nitrogen carrier and rate on turfgrass quality rating of perennial ryegrass. Hancock Turfgrass Research Center. Nitrogen applied at 1 or 3 lbs per 1000 sq. ft. on July 14, 1989. Averages of 3 replications.

Treatment	Rate (lbs N/M)	Turfgrass Quality Rating (9 = Ideal)					
		7/21	8/4	8/15	9/14	10/3	11/26
CIL PCU1 44%	1	5.5ghi*	5.2ghi	6.0efghi	6.5hijkl	6.7cdef	5.8cd
CIL PCU1 44%	3	6.7abcd	7.2abcd	7.3ab	7.2defghij	6.7cdef	6.0bcd
CIL PCU2 44.2%	1	5.5ghi	5.5ghi	6.2defg	7.2defghij	6.7cdef	5.7d
CIL PCU2 44.2%	3	5.8efgh	6.8abcdef	7.3ab	9.0a	7.7ab	5.8cd
CIL SCU 32%	1	5.0ij	5.2ghi	5.2ijkl	7.2efghij	6.3def	5.8cd
CIL SCU 32%	3	5.8efgh	6.8abcdef	7.5a	8.5ab	7.3abc	6.2bcd
CIL SCU 37%	1	5.2hji	5.3ghi	6.0efghi	7.0efghijk	6.5cdef	6.0bcd
CIL SCU 37%	3	6.2defg	6.8abcdef	7.7a	8.2abcd	6.5cdef	6.0bcd
Sustane Medium	1	5.2hij	5.5ghi	5.3hijkl	5.8l	6.0f	5.8cd
Sustane Medium	3	6.5bcde	6.8abcdef	6.2defg	6.7ghijkl	6.2ef	5.7d
Sustane Fine	1	5.5ghi	5.5ghi	5.0jkl	6.3ijkl	6.2ef	5.8cd
Sustane Fine	3	6.5bcde	7.0abcde	6.5bcdef	6.8fghijkl	6.5cdef	5.8cd
Sustane Super Fine	1	5.5ghi	5.3ghi	5.2ijkl	6.3ijkl	6.0f	5.8cd
Sustane Super Fine	3	6.3cdef	6.3bcdefg	6.3cdefg	6.8fghijkl	6.2ef	5.8cd
Sierra 24-6-10	1	5.2hij	5.3ghi	4.7l	6.0kl	6.3def	6.0bcd
Sierra 24-6-10	3	6.5bcde	7.5ab	7.2abc	7.7bcdefg	7.0bcde	6.5b
Sierra 25-0-0	1	5.5ghi	5.0hi	5.3hijkl	6.8fghijkl	7.0bcde	6.0bcd
Sierra 25-0-0	3	6.3cdef	5.7fghi	6.5bcdef	8.0bcde	8.0a	7.2a
Agriform 34-0-7	1	5.2hij	5.3ghi	5.8fghij	7.0efghijk	6.3def	5.8cd
Agriform 34-0-7	3	5.8efgh	6.0defghi	7.0abcd	7.5cdefgh	7.3abc	6.3bc
Anderson 9-3-6	1	5.7fghi	5.8efghi	5.3hijkl	6.2jkl	6.3def	6.0bcd
Anderson 9-3-6	3	7.2ab	7.2abcd	6.2defgh	7.0efghijk	6.5cdef	5.7cd
Anderson 10-2-6	1	5.0ij	4.8i	4.7l	6.2jkl	6.0f	5.8cd
Anderson 10-2-6	3	6.2defg	6.2cdefgh	6.0efghi	7.0efghijk	7.2abcd	6.0bcd
Lawn Restore	1	5.7fghi	6.3bcdefg	5.5ghijkl	6.3ijkl	6.2ef	6.2bcd
Lawn Restore	3	7.0abc	7.3abc	6.8abcd	7.3defghi	6.2ef	6.0bcd
Scott's 35-0-0	1	5.3hij	5.8efghi	5.7fghijk	7.0efghijk	6.8bcdef	5.8cd
Scott's 35-0-0	3	6.5bcde	7.2abcd	7.5a	8.3abc	7.3abc	6.5b
Scott's 38-0-0	1	6.2defg	6.2cdefgh	5.5ghijkl	6.3ijkl	6.2ef	6.0bcd
Scott's 38-0-0	3	7.0abc	7.0abcde	6.8abcde	7.7bcdefg	6.2ef	6.0bcd
IBDU 31-0-0	1	4.7j	6.3bcdefg	5.5ghijkl	6.3ijkl	6.2ef	5.8cd
IBDU 31-0-0	3	5.2hij	7.2abcd	7.5a	7.2efghij	6.7cdef	5.8cd
Nor-Am M.U. 40%	1	5.5ghi	5.5ghi	5.2ijkl	7.0efghijk	6.2ef	5.8cd
Nor-Am M.U. 40%	3	6.2defg	7.3abc	7.0abcd	7.8bcdef	6.5cdef	6.0bcd
U.F. 38-0-0	1	5.2hij	6.3cdefg	4.7l	6.2jkl	6.5cdef	5.8cd
U.F. 38-0-0	3	5.7fghi	5.8efghi	6.0efghi	7.2defghij	6.5cdef	6.0bcd
N-Sure 28-0-0	1	5.7fghi	5.7fghi	5.3hijkl	6.2jkl	6.2ef	5.8cd
N-Sure 28-0-0	3	7.3a	7.7a	7.3ab	7.0efghijk	6.8bcdef	6.0bcd
Nitro-26 26%	1	6.3cdef	6.0defghi	5.7fghijk	6.5hijkl	6.5cdef	5.8cd
Nitro-26 26%	3	7.0abc	7.3abc	6.8abcde	6.7ghijkl	6.3def	5.8cd

* - Means followed by the same letter are not significantly different at the 5% level using Duncan's Multiple Range Test.

Table 4. Effect of nitrogen carrier and rate on dry clipping weights of perennial ryegrass. Hancock Turfgrass Research Center. Nitrogen applied at 1 or 3 lbs per 1000 sq. ft. on July 14, 1989. Averages of 3 replications.

Treatment	Rate (lbs N/M)	Clipping weights, grams meter^{-2} 7/31	9/20
CIL PCU1 44%	1	30.5abcdef*	13.0 cdef
CIL PCU1 44%	3	31.8 bcde	23.8ab
CIL PCU2 44.2%	1	18.6 ef	12.3 cdef
CIL PCU2 44.2%	3	31.2 bcdef	18.1abcdef
CIL SCU 32%	1	18.8 ef	14.8abcdef
CIL SCU 32%	3	29.0 bcdef	19.8abcde
CIL SCU 37%	1	25.4 cdef	11.2 def
CIL SCU 37%	3	32.7 bcdef	22.4abc
Sustane Medium	1	27.7 bcdef	11.1 def
Sustane Medium	3	37.9abcdef	15.8abcdef
Sustane Fine	1	20.5 ef	11.7 def
Sustane Fine	3	48.8abc	11.9 def
Sustane Super Fine	1	25.8 cdef	9.6 f
Sustane Super Fine	3	25.6 cdef	15.7abcdef
Sierra 24-6-10	1	25.2 cdef	12.4 def
Sierra 24-6-10	3	37.3abcdef	11.7 def
Sierra 25-0-0	1	18.9 ef	12.6 cdef
Sierra 25-0-0	3	27.0 bcdef	18.7abcdef
Agriform 34-0-7	1	16.8 f	13.7 cdef
Agriform 34-0-7	3	24.2 def	20.7abcd
Anderson 9-3-6	1	30.4 bcdef	13.5 cdef
Anderson 9-3-6	3	41.5abcde	17.2abcdef
Anderson 10-2-6	1	14.1 f	13.1 cdef
Anderson 10-2-6	3	30.6 bcdef	24.3a
Lawn Restore	1	31.9 bcdef	12.7 cdef
Lawn Restore	3	58.6a	20.0abcde
Scott's 35-0-0	1	23.0 ef	14.8abcde
Scott's 35-0-0	3	36.2abcdef	19.5abcdef
Scott's 38-0-0	1	35.6 bcdef	18.9abcdef
Scott's 38-0-0	3	50.0ab	22.4abc
IBDU 31-0-0	1	20.2 ef	11.7 def
IBDU 31-0-0	3	36.4abcdef	15.3abcdef
Nor-Am M.U. 40%	1	30.4 bcdef	11.2 def
Nor-Am M.U. 40%	3	47.7abcd	18.4abcdef
U.F. 38-0-0	1	19.4 ef	16.4abcdef
U.F. 38-0-0	3	19.4 ef	14.6abcdef
N-Sure 28-0-0	1	26.4 bcdef	14.0 bcdef
N-Sure 28-0-0	3	37.7abcdef	15.8abcdef
Nitro-26 26%	1	30.4 bcdef	12.3 def
Nitro-26 26%	3	31.4 bcdef	15.4abcdef

* - Means followed by the same letter are not significantly different at the 5% level using Duncan's Multiple Range Test.

Scotts 38-0-0, Nor-Am methylene urea, N-Sure and Nitro 26.

One month after application (Aug 15) good performers included the plastic coated ureas (PCU) from CIL, sulfur coated urea, Agriform, Scotts 35-0-0, IBDU and N-Sure. After two months (Sept. 14) the best performers were one of the experimental plastic coated ureas (PCU2), sulfur coated ureas, the Sierra plastic coated ureas, Scotts 35-0-0, and Nor-Am methylene urea. After almost three months (Oct 3) most of the plastic coated fertilizers performed well, along with sulfur coated urea and Scotts 35-0-0. After four and a half months (Nov. 26) differences were small with some of the coated materials showing a bit better quality ratings.

Clipping weight data were again somewhat variable (Table 4) but trends similar to those for quality ratings were still evident. Two weeks after application higher clipping weights were observed for Scotts 38-0-0, Lawn Restore, Anderson 9-3-6, Nor-Am methylene urea and some of the Sustane products. After two months (Sept. 20) products giving higher clipping weights included Scotts 38-0-0, Scotts 35-0-0, Andersons 10-2-6, and Agriform.

A late fall nitrogen fertilization study was initiated November 11, 1988 on a Penncross creeping bentgrass green at the Hancock Turfgrass Research Center. Plot size was 4 feet by 6 feet with three replications. In late January, Scotts Iron-S performed best while in early March Greens Restore, Scotts Iron-S and GS-1 performed well. A similar trend was still apparent in mid-April although other treatments were improving. By early May differences were small although Greens Restore and GS-1 still ranked highest. After that time there were no meaningful differences.

In this late fall study the performance of the Iron-S when applied at 1/2 lb N per 1000 sq ft was better than or equal to other materials applied at a full pound of N. This reflected the presence of iron in the fertilizer giving good turf color through late winter and early spring. A similar trend occurred for GS-1. Greens Restore provided good turf ratings during early spring.

Based on studies conducted several years ago, it was surprising that urea and 18-4-10 did not perform better in this study applied in early November. For most slow release carriers an earlier application date would be preferred for best late fall uptake and utilization of nitrogen. Thus most of the slow release carriers did not perform especially well in this study. If later fall applied nitrogen is to be taken up by the turf and utilized in building up carbohydrates through photosynthesis, it should be applied in late October to early November. Our recommendations at this point are to use a carrier which has soluble nitrogen (60-80% soluble) during this time period. Apply at the rate of 1/2 to 1 pound nitrogen per 1000 sq ft on grass which is green and has been properly fertilized earlier in the fall (September). On sandy soils use caution to limit the potential for leaching of nitrates by using lower N rates, more slow release N or eliminating this application entirely. A late fall application should be timed to be made about the time fall growth stops when roots are still active. Do not apply in the late fall if the grass is totally dormant or brown.

Table 5. Effect of late fall fertilization on quality ratings of a Penncross creeping bentgrass green. Treatments applied November 11, 1988. Averages of 3 replications.

Treatment		Turfgrass Quality Rating (9 = Ideal)				
Carrier	Rate					
	lb N/M	1/27	3/5	4/17	5/9	6/8
Urea	1.0	5.0ab*	5.0 c	5.0 c	5.0 c	5.0a
Milorganite	1.0	5.0ab	5.0 c	5.0 c	5.0 c	4.0 b
Sustane Medium	1.0	4.5 b	5.0 c	5.5 bc	6.0ab	4.0 b
Sustane Fine	1.0	4.5 b	5.0 c	5.5 bc	6.0ab	4.0 b
Anderson 9-3-6	1.0	4.0 b	4.0 d	5.0 c	5.5 bc	4.5ab
Emerald Isle GS-1	0.5	5.0ab	6.0 b	6.0 b	6.5a	4.5ab
Lebanon 18-4-10	1.0	5.0ab	4.0 d	5.5 bc	5.5 bc	4.5ab
IBDU Fine	1.0	4.0 b	4.5 cd	5.5 bc	6.0ab	4.5ab
Lesco Elite	1.0	5.0ab	4.5 cd	5.5 bc	5.5 bc	4.5ab
Scott's Iron-S	0.5	7.0a	6.0 b	6.0 b	6.0ab	5.0a
Ferromec	0.1	4.0 b	4.5 cd	5.0 c	5.0 c	4.5ab
Ferromec + Urea	0.1+0.5	5.0ab	5.0 c	5.5 bc	6.0ab	4.0 b
Greens Restore	1.0	3.0 b	7.0a	7.0a	6.5a	4.5ab

* - Means followed by the same letter are not significantly different at the 5% level using Duncan's Multiple Range Test.

Coated potassium fertilizer study

Two studies were established on sandy soils in western Michigan to evaluate the benefits of the use of coated potassium carriers. The studies were located on Kentucky bluegrass roughs at the Spring Lake Country Club in Spring Lake and the Grand Haven Golf Club at Grand Haven. Applications were made at Spring Lake as outlined in Table 6 on May 11, June 15 and September 5. The fertilizers were provided by the Sierra Chemical Co. The potash carrier was potassium sulfate with 0-0-45, 0-0-46 and 0-0-47 being coated products and 0-0-50 is uncoated. A similar study was established at Grand Haven but no further applications were made beyond the May 11 treatments. There was no visually observed turf response to these treatments at either location.

Soil samples were collected to a 3 inch depth on June 28, September 5 and December 8. Available potassium was extracted with neutral normal ammonium acetate. Soil potassium tests (Table 6) were relatively low on the June 28 sampling date while all tests increased for the September sampling date. This increase remains unexplained. The variability in the data reduce any significance in the data although the untreated plot was consistently lower for the June and September samplings. The data from the December sampling were quite variable and are not included. Although we expected to find more K in the plots which had been treated with the coated product, that was not apparent in this study. On sandy soils it would be desirable to have a slow release potassium carrier since the cation exchange capacity is so low the postassium can be leached readily from sands.

Mowing height study

A study was initiated March 31, 1989 on a sodded Kentucky bluegrass alley at the Hancock Turfgrass Research Center. The turf was still dormant with no green shoots and a high density of brown plants. A bagging rotary mower was used to mow at 1, 1.5 or 2.0 inches along with an unmowed treatment. Clippings were removed from the plot area. Nitrogen applications were made across the mowing treatments at 0, 1 or 2 pounds per 1000 sq ft subsequent to the mowing treatment. After the treatment date all plots were mowed at the normal height of 2 inches.

Upon mowing it was apparent that green tissue was exposed with the shorter mowing heights (Table 7). Turf quality ratings revealed that the short mowing resulted in improved turf color for about 3 weeks when no nitrogen was applied. After that time there were few meaningful differences due to initial mowing height.

When nitrogen was applied at the time of mowing turf quality ratings were better for closer mowing for about a month. Few differences occurred through May. But in June the plots which were mowed shorter again had higher quality ratings.

While more research is needed to evaluate these responses more fully, it appears that if the turf has a high density of dead leaf tissue in the spring there would be benefit in mowing the grass short to remove some of this debris. It is thought this would permit more rapid warming of the crown tissue and the soil resulting in quicker growth. There could be physiological

Table 6. 1989 Coated potassium study. Spring Lake Country Club, Spring Lake, Michigan. Treatments applied May 11, June 15 and September 5, 1989.

Treatments (lbs K2O/M)				Soil Tests, lbs/A	
	5/11	6/15	9/5	6/28	9/5
0-0-45	3.5	0	0	103.7 bc*	176.0abc
0-0-45	5.0	0	0	115.7abc	213.0ab
0-0-46	3.5	0	0	91.7 c	179.0abc
0-0-46	5.0	0	0	118.7abc	177.0abc
0-0-47	3.5	0	0	115.3abc	193.3abc
0-0-47	5.0	0	0	139.0ab	266.7a
0-0-50	3.5	0	0	153.7a	188.0abc
0-0-50	1.17	1.17	1.17	124.3abc	169.7 bc
Check	0.0	0.0	0.0	86.0 c	106.7 c

* - Means followed by the same letter are not significantly different at the 5% level using Duncan's Multiple Range Test.

Table 7. Mowing height by nitrogen interaction effects on Kentucky bluegrass quality ratings. 1989 mowing height by nitrogen study. Treatments applied March 31, 1989. Hancock Turfgrass Research Center.

Mowing Height	Nitrogen Rate	Quality Ratings (9 = Ideal)													
		4./5	4/17	4/21	4/24	4/28	5/5	5/15	5/22	5/25	6/5	6/9	6/20	7/3	7/11
1.0 inch	Check	4.9b	5.8d	5.9de	5.8e	5.6ef	5.6de	5.8d	6.2e	6.0e	6.2e	6.7ef	6.9bcde	7.8ab	6.4a
1.0 inch	1 lb N/yr	5.2a	6.5ab	7.1bc	7.3c	7.4c	7.3bc	8.5ab	8.0c	8.1ab	8.2bc	8.0b	7.3abc	7.7bc	6.3a
1.0 inch	2 lb N/yr	5.4a	6.8a	7.8a	8.0a	9.0a	8.8a	9.0a	9.0a	8.5a	9.0a	8.5a	7.7a	8.0a	6.3a
1.5 inch	Check	4.4c	5.3e	5.8de	5.0f	5.2ef	5.0e	6.2cd	6.3e	6.1e	6.1e	6.8ef	6.5efg	7.2d	6.3a
1.5 inch	1 lb N/yr	4.6c	6.0cd	7.0bc	7.1bc	7.3c	7.7bc	8.2ab	8.1bc	7.6bc	7.9bc	7.6cd	6.8cdef	7.3d	6.3a
1.5 inch	2 lb N/yr	4.5c	6.4b	7.2b	7.6ab	8.3b	8.8a	8.7ab	9.0a	7.8bc	8.3b	7.8bc	7.6a	7.3cd	6.4a
2 inch	Check	4.0d	5.1ef	6.0de	5.0f	5.8e	5.7d	6.7c	6.8d	6.3e	6.3e	6.8ef	6.7defg	7.2d	6.5a
2 inch	1 lb N/yr	4.0d	5.8cd	6.2d	6.4d	6.9cd	7.8bc	8.4ab	8.4b	7.2c	7.7cd	7.3d	7.0bcd	7.3cd	6.3a
2 inch	2 lb N/yr	4.1d	6.2bc	6.7c	7.0c	8.1b	8.6a	8.2b	9.0a	7.2c	7.9bc	7.6cd	7.3ab	7.4bcd	6.5a
Check	Check	3.0e	4.0g	5.2f	4.2g	5.0f	5.2de	6.5cd	6.8d	6.5de	6.2e	6.4f	6.3g	7.1d	6.2a
Check	1 lb N/yr	3.0e	q4.7f	5.5ef	6.1de	6.4d	7.3c	7.9b	8.4b	7.1cd	7.2cd	6.9e	6.4fg	7.3cd	6.1a
Check	2 lb N/yr	3.1e	5.0ef	6.0de	6.3d	7.1cd	7.9b	8.3ab	9.0a	7.4c	8.1bc	7.3d	7.3ab	7.4cd	6.5a

* - Means followed by the same letter are not significantly different at the 5% level using Duncan's Multiple Range Test.

effects which accompany this practice as well. It is not known if this practice would expose the turf to greater potential for turf loss due to winter injury should crown hydration occur in the early spring followed by a hard freeze. Any benefit from mowing short the first time would not likely occur if the grass is already green.

Topdressing studies on greens

The long range topdressing study on the Penneagle creeping bentgrass green was concluded at the end of the 1989 growing season. This study was initiated in 1982. Topdressing treatments as outlined in Table 8 were: no topdressing treatment (check); 3 cubic feet of sand applied per 1000 sq ft at 3 week intervals (3 WK sand); 6 cubic feet of sand applied at 6 week intervals (6 WK sand); 12 cubic feet of sand applied spring and fall (12 WK Sand); and 12 cubic feet of a sandy soil based mix applied spring and fall (12 WK mix). Each topdressing treatment received either 3 lbs N or 6 lbs N per 1000 sq ft annually. Plot size was 4 feet by 12 feet with 3 replications.

The turfgrass quality rating data taken from these plots in 1989 (Table 8) were quite consistent with those observed in previous years. The light and frequent topdressing programs ranked higher than the infrequent topdressing treatments on a few dates. As expected plots receiving higher nitrogen rates (6 lbs N/1000 sq ft annually) ranked higher than when treated with the lower rate (3 lbs N annually). On a few dates the opposite effect was observed. After topdressing application turf quality ratings improved for a few days then the ratings stabilized. One key observation was turf quality on the non-topdressed plots ranked consistently lower compared to topdressed plots. Those plots which were not topdressed developed a significant thatch layer making the turf susceptible to scalping and lower turf quality ratings. These plots receive maintenance traffic only so would be more susceptible to thatch accumulation than when turf routinely received intense traffic.

In August plots were sampled to determine effects of treatment on the physical properties of the "thatch" layer, that layer of thatch (nontopdressed plots) or thatch mixed with topdressing material. The "thatch" like layer was separated from the original underlying soil. Measurements taken in this layer were measured for percent organic matter as determined by ashing and thickness and bulk density of the "thatch" like layer (Table 9).

The percent organic matter in the thatch layer was much higher for the nontopdressed plots as would be expected since no topdressing material diluted the thatch. Thickness of the "thatch" like layer was greatest for plots receiving less frequent sand topdressing, lowest for the check plots and intermediate for the light, frequent sand topdressed plots and those topdressed with the soil based mix in spring and fall. The bulk density of the topdressed plots was quite uniform. Sand and organic matter mixed together had a higher density (close to 1.0 gm/cubic centimeter). Clearly topdressing resulted in more uniform turf and "thatch" conditions than when no topdressing was done.

The topdressing study on the Penncross creeping bentgrass green which began in 1986 was continued in 1989 (Table 10). Soil mixes applied were: sand alone; 80% sand, 20% peat; and 60% sand, 20% soil, 20% peat. Topdressing programs were either 3 cubic feet of soil material per 1000 sq ft applied

Table 8. *Effect of topdressing program and nitrogen treatment on turfgrass quality ratings on a Penneagle creeping bentgrass putting green. Treatments initiated 1982. Hancock Turfgrass Research Center. Averages for 3 replications.*

		1989 Turfgrass Quality rating (9 = Ideal)												
Topdressing	Nitrogen	4/24	5/9	6/1	6/14	6/20	7/6	7/17	7/27	8/3	8/14	8/29	9/19	10/3
Check	3 lb N/yr	4.3d*	4.3d	5.0h	5.5d	6.0e	6.7d	6.2c	5.3c	6.0d	5.5d	6.7abc	6.3d	6.0d
Check	6 lb N/yr	6.0ab	5.8abc	5.8g	6.5c	6.2de	7.3c	7.2b	5.5c	6.7ab	6.0cd	5.3d	6.7cd	6.3d
3 WK Sand	3 lb N/yr	5.3bc	5.5bc	6.3f	6.8bc	6.8bc	7.2c	7.0b	7.3ab	7.3ab	7.0ab	7.7a	7.8b	7.2bc
3 WK Sand	6 lb N/yr	6.3a	6.5a	7.2cd	7.3ab	6.5cde	7.8ab	8.0a	7.0ab	6.7ab	7.3ab	7.7a	8.2ab	7.8a
6 WK Sand	3 lb N/yr	5.7abc	5.5bc	6.7ef	7.0bc	6.8bc	7.5bc	7.2b	8.0a	7.0ab	7.2ab	7.3a	8.0b	7.0c
6 WK Sand	6 lb N/yr	6.5a	6.5a	8.0a	7.8a	6.7bcd	8.2a	8.3a	7.7ab	7.7a	8.0a	7.7a	9.0a	7.8a
12 WK Sand	3 lb N/yr	5.0cd	5.2c	7.0cde	6.8c	7.5a	7.3c	7.0b	7.0ab	6.7ab	7.0abc	7.2ab	7.7b	7.0c
12 WK Sand	6 lb N/yr	6.5a	6.0abc	7.7ab	7.5a	7.2ab	8.0a	7.3b	6.7b	6.4ab	6.7bc	5.8cd	7.3bc	7.0c
12 WK Mix	3 lb N/yr	4.8cd	5.2c	6.8de	6.7c	7.7a	7.3c	6.8b	7.0ab	7.0ab	7.2ab	7.3a	8.0b	7.3abc
12 WK Mix	6 lb N/yr	6.5a	6.3ab	7.3bc	7.7a	7.2ab	8.0a	7.3b	6.8b	7.7a	7.3ab	6.0bcd	7.7b	7.7ab

* - Means followed by the same letter are not significantly different at the 5% level using Duncan's Multiple Range Test.

Table 9. Effect of topdressing program and nitrogen treatment on percent organic matter in the "thatch" layer, thickness and bulk density on a Penneagle creeping bentgrass green. Hancock Turfgrass Research Center. Study initiated 1982. Averages of 3 replications.

Treatments		Percent Organic Matter	Thatch Thickness(cm)	Bulk Density(g/cm^3)
Topdressing	Nitrogen lbs/N/yr			
Check	3	26.8 b	2.0 e	0.5 b
Check	6	29.3a	2.2 e	0.4 b
3 WK Sand	3	4.8 c	4.5 bcd	1.0a
3 WK Sand	6	5.2 c	4.2 cd	1.0a
6 WK Sand	3	4.4 c	4.9abc	1.1a
6 WK Sand	6	4.9 c	5.5a	1.1a
12 WK Sand	3	4.6 c	5.1ab	1.0a
12 WK Sand	6	4.9 c	5.1ab	1.0a
12 WK 2:1 Mix	3	6.2 c	4.4 cd	1.0a
12 WK 2:1 Mix	6	5.9 c	4.2 d	1.0a

* - Means followed by the same letter are not significantly different at the 5% level using Duncan's Multiple Range Test.

Table 10. Effects of topdressing mix and program on quality ratings of a Penncross creeping bentgrass green. Treatments initiated 1986. Hancock Turfgrass Research Center.

Treatments			1989 Turfgrass Quality Ratings (9 = Ideal)								
Topdressing	Rate (ft^3)	Frequency	4/17	5/9	6/1	6/9	8/14	8/29	9/7	9/19	10/3
Sand	3	3 Weeks	4.5c*	7.0a	6.7bc	7.2abc	6.5bc	7.2b	8.0bc	7.7a	6.5bc
Sand	12	Spring/Fall	5.0bc	7.0a	6.3c	6.7c	5.3d	7.0a	6.7d	6.7b	6.8abc
80 Sand: 20 Peat	3	3 Weeks	4.8bc	7.0a	7.0abc	7.3abc	7.0b	7.8ab	8.7ab	7.8a	6.7abc
80 Sand: 20 Peat	12	Spring/Fall	5.8a	7.0a	8.0a	7.8a	6.2c	7.0b	7.2cd	7.0ab	7.2ab
60 Sand: 20 Peat: 20 Soil	3	3 Weeks	4.7bc	7.0a	7.0abc	7.5abc	8.0a	8.7a	9.0a	7.7a	6.8abc
60 Sand: 20 Peat: 20 Soil	12	Spring/Fall	5.8a	6.7ab	7.7ab	7.7ab	6.8bc	7.8ab	7.5cd	7.2ab	7.3a
Check	--	----------	5.0bc	6.3bc	6.5bc	6.8bc	6.8bc	7.7ab	7.7c	6.7b	6.3c
Sand (Cored)	12	Spring/Fall	5.2b	6.0c	7.3abc	7.3abc	7.7a	7.7ab	7.3cd	7.0ab	7.0abc

* - Means followed by the same letter are not significantly different at the 5% level using Duncan's Multiple Range Test.

every 3 weeks or 12 cubic feet applied spring and fall. Also included were an untreated check and a plot which received 12 cubic feet of sand spring and fall after cultivating with 1/2 inch hollow tines.

Turfgrass quality ratings (Table 10) reflect the improvement observed after topdressing as observed previously. For that reason the light frequent topdressing program ranks better through much of the season than when topdressed only in spring and fall. But following spring and fall topdressings at high rates these plots freqently outranked the light, frequent topdressing program for a period of time.

Plots receiving the soil based mix outranked those receiving sand alone on several dates. This has been observed previously. We are still of the opinion that a soil based topdressing material is preferred if the soil mix in the green is no finer textured than the topdressing mix. Try to match the original soil if it is acceptable. If not, use a sandier mix but be sure the topdressing mix is sandy enough to permit good infiltration and will resist compaction. If a quality, consistent source of a soil based mix is not available, then sand can be used. It is essential to use light rates (2-4 cubic feet per 1000 sq ft except when applied after core cultivation) at intervals which are adjusted to the growth rate of the grass (an approximation of the rate of thatch accumulation). This means more frequent topdressing in spring and fall when growth is greater and traffic is lower, perhaps at 2 week intervals. By contrast, in the summer with greater stress and traffic it may be possible to stretch the interval to as much as 4 weeks. This must be determined on a site by site basis requiring careful observation by the superintendent.

Wetting agent study

The wetting agent treatments shown in Table 11 were applied to a Penncross creeping bentgrass green at the Hancock Turfgrass Center on June 26, 1989. Repeat treatments were made on July 25 and August 16. This study was designed to evaluate the effect of these wetting agents on prevention of localized dry spots. As was the case in 1988 we observed no significant development of localized dry spots on these plots. The soil is a modified loamy sand. Heavy irrigation of adjacent plots utilized for another study likely prevented localized dry spot development on these plots.

Significant differences in dew formation occurred on several dates, however (Table 11). Effects on dew suppression tended to be short term (2 to perhaps 4 days) for the sprayable wetting agents. Granular materials have a less dramatic effect short term but tend to provide dew suppression over a longer period.

Control of moss with Safer

A study to evaluate the effect of Safer in controlling moss in a shaded Kentucky bluegrass lawn in Okemos was established June 9, 1989. Safer was applied at 4 oz per 1000 sq ft. The degree of moss control was very good as observed by the relative ratings taken 1 week after treatment and at 1 and 2 month intervals. There was some short term phytotoxicity observed but this was limited in effect and duration. This product seemed to work very effectively but should be applied carefully according to label instruction to

Table 11. Wetting agent effects on dew formation observed on a Penncross creeping bentgrass green. 1989 treatments applied 6/26, 7/25 and 8/16. Hancock Turfgrass Research Center.

Treatment	Rate	Dew Ratings (1 = heavy dew; 9 = no dew)							
Wetting Agent	ounces per 1000 sq. ft.	6/28	7/7	7/26	8/7	8/17	8/23	8/24	Yearly Average
Naiad/Fertilizer	1	2.0e	5.5abcd	1.2f	1.0c	1.0h	4.0ab	1.0c	2.3h
Naiad	1	4.3d	7.0a	4.7f	1.0c	2.0fgh	5.7ab	1.0c	3.2fg
Aqua-Gro	8	8.0ab	4.2d	8.3ab	1.0c	8.0ab	6.3ab	1.7c	5.4abc
Aqua-Gro S	56	6.0bcd	5.5abcd	6.0de	1.0c	2.7fgh	3.7ab	1.0c	3.7ef
Hydrozyme	12	5.0cd	5.5abcd	2.3f	1.0c	3.3defg	3.0b	1.0c	3.0fgh
LescoWet II	8	7.3ab	6.8ab	9.0a	1.0c	8.0ab	6.3ab	1.0c	5.6ab
Hydraflo-G	56	6.7bc	6.0abcd	5.3e	2.3b	3.0efgh	6.7a	3.0b	4.7bcd
Hydraflo-G	112	7.7ab	6.7abc	6.3cde	5.0a	4.0efg	6.7a	4.0a	5.8a
Hydraflo	4	8.3ab	4.3d	8.3ab	1.0c	8.7a	5.0ab	1.7c	5.3abc
Hydraflo	8	9.0a	7.0a	9.0a	2.3b	4.3cdefg	5.0ab	2.0c	5.5ab
Peneturf	8	6.7abc	4.7cd	7.3cd	1.0c	5.7bcde	4.7ab	1.3c	4.5cde
Surfside 19A	16	5.0cd	6.7abc	7.0cd	1.0c	6.0abcd	5.3ab	1.0c	4.6cde
Surfside 37A	16	7.0abc	4.8bcd	7.3bc	1.0c	4.7cdef	3.3ab	1.0c	4.2de
HydroWet	8	7.0abc	5.8abcd	9.0a	1.0c	7.0abc	5.0ab	1.0c	5.1abc
Check	-	2.0e	5.3abcd	1.3f	1.0c	1.7gh	4.7ab	1.0c	2.4gh

* - Means followed by the same letter are not significantly different at the 5% level using Duncan's Multiple Range Test.

Table 12. Effects of applications of Safer on moss control in a shaded Kentucky bluegrass lawn. Safer applied at 4 ounces per 1000 sq. ft. on June 9, 1989.

Treatment	Moss Control (1 = no control)			Phytotoxicity(1=none)	
	6/15	7/12	8/11	6/15	8/11
Safer	8.0a	8.7a	8.0a	3.0a	1.0a
Check	1.0 b	1.3 b	1.3 b	1.0 b	1.0a

* - Means followed by the same letter are not significantly different at the 1% level using Duncan's Multiple Range Test.

Table 13. Effects of cultivation on force required to lift rooting boxes.[1] Study V. Treatments initiated 8/1/88.

Treatments	Mean Lifting Force - Kg*		
	8/31/88	9/30/88	6/8/89
Check	27.4 b**	41.5 b	67.9 c
Compacted	26.5 b	33.9 c	66.2 c
Hollow tine coring	30.7ab	48.3a	79.6ab
Solid tine coring	33.0ab	51.0a	84.8a
Rototilling	35.2a	52.6a	73.5 bc

* - Extraction of rooting box at 10 to 11% soil moisture by weight.
** - Any two means followed by the same letter are not significantly different at p=.05 by Duncan's Multiple Range Test.
1- From, Lee, Douglas Kwai-Keng. 1989. "Effects of soil cultivation techniques on rooting of Kentucky bluegrass sod." M.S. Thesis. Michigan State University.

prevent significant injury to the turf. It is especially important to utilize adequate water when making application.

Sod Rooting Studies

The study on the effects of cultivation techniques on sod rooting was concluded in 1989. The objective of this study was to determine the effect of utilizing vertical operating tine (VOT) cultivation as a means of soil preparation for sod establishment. The treatments compared were untilled, rototilling and cultivation with half-inch diameter hollow or solid tines. One treatment consisted of compacting the soil before sodding. VOT treatments were made with the Toro greens aerifier. One of the means used to evaluate how quickly the sod roots into the underlying soil was the sod lifting device. This involves placing the sod in a 1 sq ft rooting box. This box has plastic screen attached to the bottom of the box. A wire hook on each corner of the box permits lifting the box. A lifting device which measures the force required to lift the box was designed and constructed. Sod was placed on the appropriately treated soils and maintained as a lawn. At three times after sodding (about 1 month, 2 months and 10 months) sod rooting boxes were lifted for each time interval.

As was reported in 1988, VOT cultivation is a viable means of preparing soil for sodding. Data in Table 13 point out there was no difference among the cultivation treatments in the force required to lift the sod at 1 and 2 months after sodding. After 10 months, solid tine coring was superior to rototilling, however, and all three cultivation treatments were better than the untilled or compacted plots.

Other observations were that solid tine coring was more beneficial as a cultivation practice if the soil was very dry. Significant loosening of the soil occurred with solid tine treatment when the soil was dry but was somewhat less effective when the soil was wet. Under more wet soil conditions rototilling was somewhat better than VOT coring. All cultivation treatments gave improvement in loosening the soil over the one to two month period but by ten months later (after a winter season) much of the benefit of cultivation was lost in terms of soil physical property measurements. However, it was clear that soil preparation by these cultivation methods did improve sod rooting. For long term rooting and stress tolerance we feel proper soil preparation is essential. The addition of a soil amendment, such as desirable topsoil or peat could improve the stability of the improved soil properties gained with cultivation.

Financial support for this project was provided by the Michigan Turfgrass Foundation. Sod utilized in this study was provided by Halmich Sod Nurseries of East Lansing. This support is gratefully acknowledged.

Acknowledgements

The research reported here was supported in part by the Michigan Turfgrass Foundation, the Michigan Agricultural Experiment Station and several companies which provided financial support or fertilizers and chemicals. This support is gratefully acknowledged.