There were few effects of treatments on soil tests on this sand green (Table 11). The most marked effect was on soil pH. Sand topdressing caused pH to drop slightly while coring increased pH. Differences in pH were small but consistent. There were no effects on soil tests which were considered meaningful.

A similar study was established on a Penncross creeping bentgrass green growing on a loamy sand at the Hancock Turfgrass Research Center in 1985. While Sand Aid treatments at higher rates had higher quality ratings than at lower rates or where no Sand Aid was applied, differences were small and not significant (Table 12). Turf color ratings (not shown) were not affected by treatment.

Topdressing consistently increased the thickness of the thatch/sand layer compared to other treatments (Table 13). And coring treatments increased this measurement compared to the untreated check. As with other observations when treatments were applied on the sand green (Table 11) there was no difference in the total amount of organic matter in the "thatch" layer in this study with the numbers being remarkably consistent. In this study the untreated plot had a high percent (36%) of organic matter in the thatch layer.

Rooting data taken from samples obtained August 14 (Table 14) and September 16 gave evidence that sand topdressed plots had higher root weights in the "thatch layer" than cored or untreated plots, but there was little effect of Sand Aid treatment on rooting on either date.

As on the sand green, sand topdressing caused a small, but consistent, lowering of pH (Table 15). There was a tendency for plots receiving coring treatments to have higher levels of available nutrients, particularly for calcium and magnesium. This may result from bringing soil to the surface with cultivation which has a higher nutrient level than exists in untreated plots or where sand has been applied which contains essentially no available nutrients.

Another Sand Aid topdressing study has been conducted since 1985 on Penncross creeping bentgrss growing on a native soil (heavy sandy loam). No meaningful differences have been observed on this green as caused by treatments.

It is our opinion that the benefits of use of a product like Sand Aid will likely become apparent over the long term. In this third year of the study some responses have appeared indicating benefit from the use of Sand Aid, particularly when applied with sand topdressing. At this time the nature of the cause for these positive responses is not clear.

Long Term Fertilty Studies

The long term nitrogen fertility study on Penncross, Penneagle and Emerald creeping bentgrasses maintained under greens conditions was established in 1982. The treatments applied are outlined in Table 16. Plot size was 4 feet by 6 feet. Note that treatments 7 and 8 include late fall nitrogen applications for urea and Milorganite, respectively. The higher nitrogen treatments had higher turf quality ratings (Tables 17-19) and color ratings

Table 16. Long-term nitrogen fertility program treatments which have been applied to Penncross, Penneagle or Emerald creeping bentgrass turfs mowed at 3/16 inch. Treatments initiated in 1982. All plots receive 2 pounds K_2O per 1000 sq ft annually. Hancock Turfgrass Research Center. 3 replications.

Treatment No.	Carrier	N Rate	Month of Application: Apr	May	June	July	Aug	Sept	Nov
		lbs/1000							
1	Urea	1	-	0.5	-	-	-	0.5	-
2	Urea	2	-	1.0	-	-	-	1.0	-
3	Urea	3	-	1.0	0.5	0.5	-	1.0	-
4	Urea	4	-	1.0	1.0	-	1.0	1.0	-
5	Urea	6	1.0	1.0	1.0	1.0	1.0	1.0	-
6	Urea	8	1.25	1.25	1.25	1.25	1.25	1.25	-
7	Urea	4	-	-	1.0	0.5	-	1.0	1.5
8	Milorganite	4	-	-	1.0	0.5	-	1.0	1.5
9	Ammonium nitrate	4	-	1.0	1.0	1.0	-	1.0	-

* Means in columns followed by the same letter are not significantly different from each other using Duncan's Multiple Range Test (5%).

Table 17. Effect of long-term nitrogen fertility program on turfgrass visual quality ratings on Penncross creeping bentgrass turf mowed at 3/16 inch. Hancock Turfgrass Research Center. Averages of 3 replications. See Table for description of treatments.

Treatment No.	N Rate	Turfgrass Quality Rating (9 = best): 5/11	6/1	6/11	7/6	7/30	8/18	9/8	10/8
	lb/1000								
1	1	5.5e	5.0b	4.5d	5.8d	5.0e	5.2d	4.2e	5.5e
2	2	5.8de	5.0b	4.8cd	6.7cd	6.2d	5.7d	4.7de	7.0d
3	3	5.8de	5.0b	5.2c	6.7cd	7.5bc	7.0c	5.3cd	7.3cd
4	4	6.3b-e	5.3b	5.3c	7.2c	6.7cd	6.5c	8.0a	7.8bc
5	6	6.8b-d	8.2a	7.5a	8.3ab	8.8a	8.8a	8.7a	8.8a
6	8	7.0bc	8.3a	7.2a	9.0a	9.0a	8.7a	8.8a	8.3ab
7	4	8.0a	7.7a	6.2b	7.5bc	8.3ab	8.8a	6.5b	8.3ab
8	4	7.3ab	7.5a	7.2a	7.0c	7.7b	7.7b	6.5b	6.0e
9	4	6.0c-e	6.0b	5.0cd	7.0c	8.3ab	8.5a	5.8bc	8.0b

* Means in columns followed by the same letter are not significantly different from each other using Duncan's Multiple Range Test (5%).

Table 18. Effect of long term nitrogen fertility program on visual turfgrass quality rating of Penneagle creeping bentgrass mowed at 3/16 inch. Hancock Turfgrass Research Center. Treatments initiated in 1982. See Table for description of treatments. Averages of 3 replications.

Treatment No.	N Rate	Turfgrass Quality Rating (9 = best) 4/10	5/11	6/1	6/11	7/6	7/30	8/18	9/8	10/8
	lbs/1000									
1	1	5.0d	5.7bc	4.5d	4.7d	5.0f	5.0d	5.2c	4.0e	6.0d
2	2	5.7cd	5.8bc	4.8d	4.8d	5.3ef	5.0d	5.7c	4.8de	6.8c
3	3	6.8bc	5.8bc	5.3cd	5.0d	6.8cd	7.5b	7.2b	5.5cd	8.0b
4	4	6.3cd	5.5c	4.7d	4.7d	7.2bc	6.5c	7.2b	7.8a	7.7b
5	6	6.8bc	6.3bc	7.2ab	6.8b	8.5a	8.8a	8.8a	8.7a	8.0b
6	8	7.7ab	5.8bc	8.2a	7.0ab	8.7a	9.0a	8.8a	8.7a	7.8b
7	4	8.3a	8.0a	7.2ab	7.5a	7.8ab	8.5a	8.8a	6.2bc	8.7a
8	4	6.8bc	6.7b	6.2bc	5.8c	6.2de	6.0c	7.8ab	6.5b	6.2cd
9	4	6.7bc	6.0bc	5.7cd	5.7c	8.0ab	8.3ab	8.2ab	6.8b	8.7a

* Means in columns followed by the same letter are not significantly different from each other using Duncan's Multiple Range Test (5%).

Table 19. Effect of long term nitrogen fertility program on turfgrass visual quality rating of Emerald creeping bentgrass mowed at 3/16 inch. Hancock Turfgrass Research Center. Treatments initiated in 1982. See Table for description of treatments. Ave-ages of 3 replications.

Treatments No.	N Rates	Turfgrass Quality Rating (9 = best) 4/10	5/11	6/1	6/11	7/6	7/30	8/18	9/8	10/8
	lbs/1000									
1	1	5.0d	5.0d	4.0e	4.0d	5.0d	5.3cd	5.0d	4.0e	5.8de
2	2	5.2d	5.8cd	4.3e	4.2d	5.5d	4.5d	5.7c	4.0e	6.5cd
3	3	5.5cd	6.0c	5.0d	5.0c	7.7a-c	7.7a	6.8b	4.7d	7.0a-c
4	4	6.3bc	6.5bc	5.0d	5.2c	8.0a	6.2bc	6.7b	7.3b	6.8a-d
5	6	7.2ab	7.2ab	7.3bc	7.5a	8.2a	8.2a	7.8a	8.0a	7.5a-c
6	8	7.3ab	7.2ab	8.0a	7.0b	7.8a-c	8.0a	8.2a	8.2a	7.8a
7	4	8.0a	8.0a	7.8ab	7.0b	6.8c	8.0a	7.7a	5.0d	6.7b-d
8	4	7.2ab	7.2ab	6.7c	7.0b	7.3ac	7.2ab	7.0b	5.7c	5.5e
9	4	5.7cd	6.2bc	5.0d	5.2c	7.0bc	8.2a	7.7a	5.5c	7.7ab

* Means in columns followed by the same letter are not significantly different from each other using Duncan's Multiple Range Test (5%).

(not shown) for Penncross, Penneagle and Emerald, respectively. The late fall applications ranked well much of the year considering the rate of nitrogen application.

The thickness of the "thatch" layer tended to be higher at higher rates of nitrogen but there was sufficient variability in the data (Tables 20-22) that differences were not significant. Similarly the amount of organic matter in the thatch tended to increase with the higher nitrogen levels, depending on the grass. Higher nitrogen levels reduced dollarspot numbers for Penncross and Penneagle but were not consistent on the Emerald plots.

Table 23 gives soil test information for two treatments from samples taken in Fall, 1987. Higher nitrogen decreased available phosphorus and potassium levels in both thatch and soil while calcium was reduced somewhat and magnesium was not affected. Levels of available nutrients in soil samples taken from below the thatch layer were markedly lower than in thatch. This may be due to fertilizers being applied on the surface (concentrating the nutrients at the surface) and to the lower density of the thatch layer as mentioned previously.

Another long-term nitrogen fertility study initiated in 1982 was completed on a Penncross creeping bentgrass green at the Hancock Turfgrass Research Center. Emphasis was on nitrogen carriers and timing. Carriers included IBDU, sulfur-coated urea, urea, ammonium nitrate, Milorganite and a greens quality commercial fertilizer, 18-4-10, provided by the Lebanon Chemical Company.

Numerous turf quality and color ratings taken during the year revealed no unusual responses to treatments. Those plots receiving 1 pound nitrogen as a late fall treatment (after growth ceases, about November 5 in central Michigan most years) ranked well throughout the year. Lower rates on greens might be advisable (1/2 to 3/4 pound N). As nitrogen rate was increased from 1 to 7.5 pounds per 1000 sq ft annually, the thickness of the thatch layer increased from 4.5 mm to 10.6 mm.

Soil tests on selected plots revealed few differences among nitrogen carrier effects. Those products not containing P had available soil P levels of 35-39 pounds per acre at the conclusion of the study while plots receiving P had higher soil test levels. Plots treated with 18-4-10 have received 6.2 pounds P_2O_5 over the 7 year period while those treated with Milorganite received 9.3 pounds P_2O_5, assuming the analyses of Milorganite is 6-2-0. The soil P tests at the conclusion of the study were 86 and 116 pounds per acre, respectively for 18-4-10 and Milorganite treated plots. Thus the soil P levels increased dramatically as a result of the continued use of P containing fertilizers.

Phosphorus Needs On Sodded Turfs

Turfs established on subsoils frequently suffer from a lack ofnutrients, especially nitrogen and phosphorus which are naturally very low in subsoils. A study to evaluate phosphorus response on a sodded Kentucky bluegrass lawn in Novi growing on a compacted subsoil was established in 1985. Treatments applied are outlined in Table 24. These treatments have not been repeated. Turf quality ratings in 1986 indicated response to applications of 1 pound of

Table 20. Effect of long-term nitrogen fertility program on thatch and dollarspot on Penncross creeping bentgrass mowed at 3/16 inch. Hancock Turfgrass Research Center. Treatments initiated in 1982. See Table for description of treatments. Averages for 3 replications.

Treatment No.	N Rate	"Thatch" thickness	Organic Matter in Thatch %	Organic Matter in Thatch Grams	Dollarspot (8/18) No of spots
	lbs/1000				
1	1	8.7bc*	12.4ac	1.21ab	38a
2	2	7.9c	10.0c	1.15b	12ab
3	3	9.4ac	12.1ac	1.25ab	13ab
4	4	9.3ac	14.6ab	1.19ab	10b
5	6	9.9ab	15.7ab	1.25ab	11b
6	8	10.7a	14.2ac	1.34ab	5b
7	4	10.7a	16.3a	1.26ab	15ab
8	4	8.7bc	16.1ab	1.36a	9b
9	4	9.2ac	11.8bc	1.22ab	9b

* - Means in columns followed by the same letter are not significantly different from each other using Duncan's Multiple Range Test (5%).

Table 21. Effect of long-term nitrogen fertility program on thatch and dollarspot on Penneagle creeping bentgrass mowed at 3/16 inch. Hancock Turfgrass Research Center. Treatments initiated in 1982. See Table for description of treatments. Averages for 3 replications.

Treatment No.	N Rate	"Thatch" thickness	Organic Matter in Thatch %	Organic Matter in Thatch Grams	Dollarspot (8/18) No of spots
	lbs/1000				
1	1	8.2a*	9.5c	1.01c	51a
2	2	8.2a	13.9b	1.29ab	36ab
3	3	8.0a	14.4b	1.24b	24b
4	4	10.0a	14.0b	1.18bc	31b
5	6	9.0a	16.1ab	1.19bc	22b
6	8	8.6a	14.5b	1.15bc	18b
7	4	11.0a	18.1a	1.10bc	16b
8	4	10.7a	16.7ab	1.46a	32ab
9	4	10.3a	15.5ab	1.20bc	28b

* Means in columns followed by the same letter are not significantly different from each other using Duncan's Multiple Range test (5%).

Table 22. Effect of long-term nitrogen fertility program on thatch and dollarspot on Emerald creeping bentgrass mowed at 3/16 inch. Hancock Turfgrass Research Center. Treatments initiated in 1982. See Table for description of treatments. Averages for 3 replications.

Treatment No.	N Rate	"Thatch" thickness	Organic Matter in Thatch %	Organic Matter in Thatch Grams	Dollarspot (8/18) No of spots
	lbs/1000				
1	1	6.5b*	8.7a	.95d	80ab
2	2	10.1ab	8.9a	.99d	82ab
3	3	9.4ab	9.9a	1.11bc	103a
4	4	9.3ab	10.6a	1.14b	76ab
5	6	10.0ab	9.3a	1.02cd	56b
6	8	10.4a	9.8a	1.04bc	48b
7	4	8.5ab	9.0a	1.13b	100a
8	4	11.3a	10.6a	1.27a	85ab
9	4	8.1ab	8.9a	.94d	69ab

* Means in columns followed by same letter are not significantly different from each other using Duncan's Multiple Range test (5%).

Table 23. Effect of long term fertility treatments on soil tests of thatch and soil on a Penneagle creeping bentgrass green grown on loamy sand. Treatments initiated in 1982. Averages for 3 replications. N applied as urea.

Annual N Rate lbs/1000 sq ft		pH	Available Nutrient, lbs/A P	K	Ca	Mg
Thatch	1	7.3	65	346	3063	348
	8	-	30	284	2541	379
Soil	1	7.6	53	80	1473	282
	8	7.4	21	45	1360	236