TURFGRASS SOILS RESEARCH REPORT - 1988

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NITROGEN FERTILIZER EVALUATIONS

Several nitrogen fertilizer evaluation studies were initiated in 1988. One was established on Challenger Kentucky bluegrass at the Hancock Turfgrass Research Center. Treatments shown in Table 1 were applied at the rate of 1 pound nitrogen per 1000 sq ft on July 8. Plot size was 4 feet by 12 feet with 3 replications.

Fertilizers were provided by the following companies: N-Serve--Triazon Corporation; Sustane--Sustane Corporation; CIL--Canadian Industries, Limited; Anderson's--The Andersons; Turf Restore and Green Restore--Ringer Corporation; IBDU--Estech; Milorganite--Milwaukee Sewerage Commission; Lesco--LESCO; 18-4-10--Lebanon Chemical.

Turf quality ratings shown in Table 1 indicate IBDU and N-Sure responded somewhat more slowly than some other materials 12 days after application. IBDU continued to respond more slowly than several other carriers 21 days after application (July 29) but by August 16 all materials resulted in excellent turf quality. No practical differences occurred during August. By late October IBDU and two of the CIL experimentals ranked highest while most other materials performed well.

Clipping weights were taken in late July from this study on Challenger Kentucky bluegrass (Table 2) which demonstrated some differences in growth responses but there was enough variability to reduce the significance of differences which occurred. By late August all treatments gave similar clipping weights indicating there was little difference among treatments. This was consistent with the observations on turf quality ratings in Table 1.

Another nitrogen fertilizer evaluation study was established on two perennial ryegrasses at the Hancock Turfgrass Research Center. Treatments outlined in Table 3 were applied July 5. Plot size was 4 feet by 12 feet with 3 replications. Turf quality ratings are given in Table 3. At the .5 pound rate of nitrogen application, all materials demonstrated a relatively quick response except Milorganite, Turf Restore and Ward fertilizer. At the 1 pound rate of application, IBDU-coarse was a bit slower to respond than others which is to be expected. These plots were watered to prevent wilt but very little rainfall occurred during this study, especially over the first few weeks. Several carriers demonstrated good longevity of response in August but by October essentially all differences had disappeared.

In Table 4 clipping weights taken from the study on perennial ryegrass are given. While there are few significant differences among clipping weights for a given rate of nitrogen application, several materials resulted in longer term effects.

A third nitrogen fertilizer study was established on a Penncross creeping bentgrass putting green at the Hancock Turfgrass Research Center. Treatments as outlined in Table 5 were applied on June 21 and August 21. Plot size was 4

Table 1. 1988 Challenger Kentucky Bluegrass Nitrogen Carrier Study Quality Ratings. Hancock Turfgrass Research Center. Treatments applied as 1 pound of N per 1000 square feet on July 8, 1988. Numbers are averages of three replications.

Treatment	Date of Rating (1988)y				
	7/20	7/29	8/16	8/30	10/26
N - Sure	7.7c*	8.0abc	8.3ab	9.0a	7.3abcd
Sustane-Medium	9.0a	8.3ab	8.0ab	9.0a	7.3abcd
Sustane-Fine	8.3abc	7.7bc	8.3ab	9.0a	6.7bcd
Sustane-Superfine	8.3abc	7.7bc	8.0ab	9.0a	6.0d
CIL Experimental 1	9.0a	9.0a	9.0a	9.0a	7.7abc
CIL Experimental 2	8.7ab	8.7ab	8.3ab	8.7a	8.7a
CIL Experimental 3	9.0a	9.0a	8.7ab	8.7a	7.7abc
Pursell-Sulfur Coated Urea	8.0bc	8.0abc	8.3ab	9.0a	7.7abc
CIL Experimental 4	8.0bc	8.0abc	9.0a	9.0a	8.7a
CIL Sulfur Coated Urea	9.0a	8.3ab	8.7ab	9.0a	8.0ab
Andersons 9-3-6	9.0a	8.7ab	8.0ab	9.0a	6.7bcd
Andersons 20-0-0	9.0a	8.7ab	7.7b	8.7a	6.3cd
Turf Restore	8.3abc	8.7ab	8.7ab	9.0a	7.7abc
IBDU-Coarse	7.7c	7.0c	8.0ab	9.0a	8.3a
Milorganite	8.3abc	8.3ab	8.7ab	9.0a	8.0ab

* - numbers followed by the same letter are not significantly different at the 5% level using Duncan's Multiple Range Test.
y - 9 = excellent 1 = poor

Table 2. 1988 Challenger Kentucky Bluegrass Nitrogen Carrier Study Clipping Yields. Hancock Turfgrass Research Center. Treatments applied as 1 pound N per 1000 square feet on July 8, 1988. Numbers are averages of three replications.

Treatment	Date of Clipping Collection(1988)y	
	7/29	8/30
N-Sure	10.69ab*	16.27a
Sustane-Medium	11.41ab	14.88a
Sustane-Fine	9.15b	14.86a
Sustane-Superfine	8.39b	13.96a
CIL Experimental 1	12.82ab	17.66a
CIL Experimental 2	15.23a	16.84a
CIL Experimental 3	12.55ab	14.02a
Pursell-Sulfur Coated Urea	8.68b	14.29a
CIL Experimental 4	9.00b	16.29a
CIL Sulfur Coated Urea	11.46ab	14.51a
Andersons 9-3-6	9.78ab	15.02a
Andersons 20-0-0	12.29ab	15.57a
Turf Restore	11.83ab	14.55a
IBDU-Coarse	7.67b	15.08a
Milorganite	13.08ab	15.31a

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

y Clipping yields expressed as grams per square meter.

Table 3. 1988 Effects of fertilizer treatments on perennial ryegrass quality ratings. Quality rating scale 9 = best. Hancock Turfgrass Research Center.

Treatment					
Material	Rate (N/M)	Quality Ratings			
	7/12	7/29	8/15	10/26	
Sustane Medium	.5	7.0abcd*	6.7cd	6.3bc	6.2abc
Sustane Fine	.5	7.3abcd	7.3abcd	7.0abc	5.3c
Sustane Superfine	.5	6.3cd	7.0bcd	6.7abc	6.0abc
Milorganite	.5	6.0d	7.3abcd	6.7abc	5.3c
Turf Restore	.5	6.0d	7.0bcd	6.7abc	6.2abc
CIL Experimental 1	.5	6.6bcd	7.4abcd	6.7abc	5.7bc
CIL Experimental 2	.5	7.7abc	8.0abc	7.7ab	6.3ab
CIL Experimental 3	.5	8.0ab	7.7abc	7.3abc	6.2abc
Pursell-Sulfur Coated Urea	.5	6.7bcd	7.3abcd	7.0abc	6.3ab
CIL Experimental 4	.5	6.7bcd	7.3abcd	7.3abc	6.3ab
CIL Sulfur Coated Urea	.5	7.0abcd	7.3abcd	6.7abc	5.8abc
Andersons 9-3-6	.5	7.3abcd	7.3abcd	6.7abc	6.5ab
Andersons 20-0-0	.5	7.3abcd	7.3abcd	7.3abc	5.8abc
N-Sure	.5	6.3cd	7.3abcd	7.3abc	6.0abc
Sustane Medium	1.0	8.0ab	7.3abcd	7.0abc	5.8abc
Sustane Fine	1.0	7.7abc	7.3abcd	6.7abc	6.2abc
Sustane Superfine	1.0	7.7bcd	7.7abc	7.3abc	6.2abc
Milorganite	1.0	6.7bcd	8.0abc	7.3abc	6.5ab
Turf Restore	1.0	7.3abcd	8.0abc	7.3abc	6.3ab
CIL Experimental 1	1.0	8.3a	8.3ab	7.7ab	6.5ab
CIL Experimental 2	1.0	8.3a	8.3ab	7.7ab	6.7a
CIL Experimental 3	1.0	8.4a	8.5a	8.0a	6.5ab
Pursell Sulfur Coated Urea	1.0	6.9abcd	8.1abc	8.0a	6.7a
CIL Experimental 4	1.0	6.3abcd	7.7abc	8.0a	6.5ab
CIL Sulfur Coated Urea	1.0	7.3abcd	7.3abcd	7.0abc	6.0abc
Andersons 9-3-6	1.0	8.0ab	7.3abcd	6.7abc	5.8abc
Andersons 20-0-0	1.0	8.3a	7.7abc	6.7abc	6.0abc
IBDU - Coarse	1.0	6.3cd	8.3ab	7.3abc	6.2abc
IBDU - Fine	1.0	6.7bcd	7.3abcd	7.0abc	5.8abc
IBDU - Sprayable	1.0	7.0abcd	7.7abc	6.7abc	6.3ab
N-Sure	1.0	8.0ab	8.3ab	7.3abc	6.2abc
Urea	1.0	7.7abc	7.7abc	6.7abc	6.3ab
Ward	.5	6.3cd	6.0d	6.3bc	6.2abc
Ward	1.0	7.3abcd	7.0bcd	6.0c	5.8abc
Check	0.0	6.3cd	7.0bcd	6.3bc	6.3ab

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

Table 4. 1988 Effects of fertilizer treatments on perennial ryegrass clipping weights in grams per square meter. Hancock Turfgrass Research Center.

Treatment Material	Rate (N/M)	Clipping Yield 8/1	Clipping Yield 8/25
Sustane Medium	.5	2.45abcde*	1.36cdefg
Sustane Fine	.5	2.19abcde	1.20defg
Sustane Superfine	.5	1.96abcde	1.40cdefg
Milorganite	.5	2.12abcde	1.17defg
Turfrestore	.5	1.85bcde	1.38cdefg
CIL Experimental 1	.5	2.07abcde	1.09defg
CIL Experimental 2	.5	2.40abcde	1.58abcdefg
CIL Experiental 3	.5	2.53abcde	1.96abcde
Pursell-Sulfur Coated Urea	.5	2.18abcde	1.49bcdefg
CIL Experimental 4	.5	2.63abcde	1.69abcdef
CIL Sulfur Coated Urea	.5	3.08ab	1.99abcd
Andersons 9-3-6	.5	2.97abc	1.84abcdef
Andersons 20-0-0	.5	2.15abcde	1.74abcdef
N-Sure	.5	2.38abcde	1.47bcdefg
Sustane Medium	1.0	2.93abcd	1.61abcdefg
Sustane Fine	1.0	2.28abcde	1.61abcdefg
Sustane Superfine	1.0	2.06abcde	1.42cdefg
Milorganite	1.0	2.74abcde	2.42a
Turf Restore	1.0	2.61abcde	2.01abcd
CIL Experimental 1	1.0	2.51abcde	1.69abcdef
CIL Experimental 2	1.0	3.14ab	1.90abcdef
CIL Experimental 3	1.0	2.92abcde	2.26abc
Pursell-Sulfur Coated Urea	1.0	2.80abcde	1.56abcdefg
CIL Experimental 4	1.0	2.62abcde	1.31defg
CIL Sulfur Coated Urea	1.0	2.76abcde	1.65abcdef
Andersons 9-3-6	1.0	2.46abcde	1.63abcdef
Andersons 20-0-0	1.0	2.17abcde	1.61abcdefg
IBDU - Coarse	1.0	3.48a	2.34ab
IBDU - Fine	1.0	2.68abcde	2.23abc
IBDU - Sprayable	1.0	2.35abcde	1.34cdefg
N-Sure	1.0	3.01abc	2.00abcd
Urea	1.0	2.36abcde	1.82abcdef
Ward	.5	1.36e	1.07efg
Ward	1.0	1.40de	1.00fg
Check	0.0	1.51cde	0.71g

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

Table 5. 1988 fertilizer quality effects on a Penncross bentgrass green. Treatments applied June 21 and August 11, 1988. 9 = highest quality. Hancock Turfgrass Research Center.

Treatment	Rate (lbs N/M)	Date of Rating (1988) 6/24	6/30	7/8	7/26	8/11	8/23	10/26
Milorganite	1	4.5hji*	4.0k	6.3bcd	6.7cd	6.3cd	5.3f	5.8bcd
Sustane-Medium	1	6.7bc	4.8ij	6.0cd	6.3cd	6.0d	6.0ef	4.3e
Sustane-Fine	1	5.7ef	5.0hi	5.7d	6.0d	6.0d	5.7ef	4.7de
Sustane-Superfine	1	6.2cde	4.8ij	6.0cd	6.3cd	6.3cd	6.3de	4.3e
IBDU-fine	1	4.5hji	6.2efg	7.7ab	8.7ab	7.3ab	8.0b	7.0ab
IBDU-sprayable	1	4.7hi	5.7gh	7.7ab	7.3bcd	6.3cd	8.0b	6.8ab
Lesco-SCU-Elite	1	6.0def	5.8fg	6.7bcd	7.0cd	6.7bcd	7.0cd	6.0bcd
Andersons 9-3-6	1	5.7ef	5.0hi	6.0cd	6.0d	6.0d	6.3de	5.2cde
N-Sure 28%	1	4.0j	5.7gh	6.3bcd	6.3cd	6.0d	6.3de	5.0cde
Milorganite	2	5.0gh	6.5def	7.7ab	8.7ab	7.8a	7.8bc	7.0ab
Sustane-Medium	2	8.0a	7.7ab	6.7bcd	6.7cd	6.7bcd	8.0b	6.3bc
Sustane-Fine	2	7.2b	7.2bcd	6.7bcd	6.3cd	6.7bcd	7.8bc	6.0bcd
Sustane-Superfine	2	7.2b	6.7cde	7.0bcd	7.3bcd	6.7bcd	7.7bc	5.7bcde
Green Restore	1	4.3ij	4.2jk	6.7bcd	7.0cd	7.0abc	7.0cd	5.7bcde
Green Restore	2	4.5hji	7.7ab	8.3a	9.0a	7.5ab	9.0a	8.0a
Andersons 9-3-6	2	6.3cd	7.3abc	7.3abc	7.7abc	7.0abc	8.0b	6.7b
N-Serve 28%	2	4.0j	8.0a	8.3a	7.7abc	7.0abc	7.8bc	6.0bcd
18-4-10	1	5.5fg	4.5ijk	5.7d	6.0d	6.0d	5.7ef	4.3e

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

feet by 6 feet with 3 replications. Sustane, an organic fertilizer produced from turkey waste, gives a quicker response than Milorganite but the length of response was of shorter duration than Milorganite. IBDU responded slowly as expected but provided excellent longevity.

The study outlined in Table 6 was initiated on July 6. Turf quality ratings for the Kentucky bluegrass turf indicated considerable variability in the data caused reduced significance in the data taken July 19 and August 5. On August 15 and September 26 turf quality reflected the effect of nitrogen rate with few differences caused by carrier. Roots were washed from soil samples taken in September, then dried and weighed. Samples were also taken in September to determine the amount of thatch in each plot. Data are shown in Table 7. There was a tendency for lower root weights with higher rate of nitrogen application and with higher rate of potassium application but differences were not consistent. No differences occurred in the amount of thatch as a result of these treatments.

WETTING AGENT EVALUATIONS

Several wetting agent treatments were applied to a Penncross creeping bentgrass putting green at the Hancock Turfgrass Research Center to evaluate effects on localized dry spots, dew and frost formation and phototoxicity. Plot size was 4 feet by 6 feet. Plots were not irrigated to determine the potential for phytotoxicity. Data in Table 8 indicate Hydroflo L (liquid) and LescoWet were more phytotoxic than AquaGro liquid. While some minor injury was detected with the higher rate of Hydro Wet this proved the safest of the liquid materials evaluated. The Hydroflo and AquaGro granular materials resulted in no injury to the turf. LescoWet II was considerably less injurious than LescoWet. In terms of dew reduction the order of effectiveness was Hydroflo L > LescoWet > AquaGro > HydroWet = LescoWet II > AquaGro granular = Hydroflo G.

A second wetting agent study was begun October 6 to evaluate wetting agent effects on formation on dew and frost. Data are given in Tables 9 and 10 for dew and frost ratings, respectively. Generally, Hydroflo was most effective in reducing dew formations followed by LescoWet and AquaGro. Other materials reduced dew compared to the check on some dates. Granular wetting agents responded slowly and over the month of this study did not prove of longer effect than liquid applications. Effects of wetting agents on frost formation (Table 10) were less clearly defined although good differences occurred on the October 20 rating date.

One of the objectives of these studies was to evaluate the effect of wetting agents on preventative or curative effects on localized dry spots on putting greens on sandy soils. Although treatments were applied, no significant development of localized dry spot developed adequately to permit separation of treatment effects. A modest problem with localized dry spot began to develop in mid-July but rains promptly corrected the condition.

GREENS TOPDRESSING STUDIES

The long term sand topdressing study begun in 1982 was continued through 1988. Treatments shown in Table 11 give the quality ratings taken during the year. As observed in the past the higher nitrogen (6 pounds N per 1000 sq ft

Table 6. 1988 Kentucky Bluegrass fertility study quality ratings. Hancock Turfgrass Research Center. Treatments applied in equal amounts July 6, July 25, August 18 and September 26, 1988. Averages for three replications.

Treatment	Rate	Rate	Date of Rating (1988)y			
	Lbs N/M/YR)	(K2O/M/YR)	7/19	8/5	8/15	9/26
Urea	2.0	0	8.3a*	8.0a	7.0b	7.0d
Urea	4.0	0	9.0a	9.0a	8.3a	8.7ab
Andersons 9-3-6	1.8	0	6.7a	7.0a	6.0c	7.2d
Andersons 9-3-6	3.6	0	8.3a	8.0a	6.3bc	8.3ab
Urea/KCl	4.0	1	7.3a	7.0a	8.7a	8.3ab
Urea/KCl	4.0	2	8.3a	8.3a	8.3a	8.5ab
Urea/K2SO4	4.0	1	6.7a	6.3a	8.7a	8.8a
Urea/K2SO4	4.0	2	8.0a	7.7a	8.0a	8.5ab
Andersons 20-0-0	2.0	0	8.0a	8.0a	7.0b	7.0d
Andersons 20-0-0	4.0	0	6.7a	6.3a	8.0a	8.0bc
Sustane-Medium	4.0	0	6.7a	7.0a	7.0b	7.5cd

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

y - 9 = excellent 1 = poor

Table 7. 1988 Kentucky bluegrass fertilizer effects on root and thatch weights. Root weights expressed as kilograms per cubic meter of soil. Thatch weights expressed as kilograms per square meter. Fertilizer treatments were applied in equal amounts on July 6. July 25, August 18 and September 26, 1988. Hancock Turfgrass Research Center.

Treatment	Rate	Rate	September 1988		
	(Lbs N/M/YR)	(K2O/M/YR)	Root Weights 0-2"	Root Weights 2-8"	Thatch Weights
Urea	2.0	0	2.69ab*	0.26ab	2.24a
Urea	4.0	0	2.19abc	0.25ab	2.12a
Andersons 9-3-6	1.8	0	2.64ab	0.31a	2.22a
Andersons 9-3-6	3.6	0	2.42abc	0.24ab	2.00a
Urea/KCl	4.0	1	2.15bc	0.23ab	2.05a
Urea/KCl	4.0	2	1.87bc	0.31a	1.76a
Urea/K2SO4	4.0	1	1.76c	0.22ab	2.13a
Urea/K2SO4	4.0	2	1.88bc	0.14b	2.15a
Andersons 20-0-0	2.0	0	3.04a	0.32a	2.00a
Andersons 20-0-0	4.0	0	2.42abc	0.34a	2.38a
Sustane-Med	4.0	0	2.51abc	0.30a	2.12a

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

Table 8. Phytotoxic and dew accumulation effects of wetting agents on a Penncross bentgrass green. Hancock Turfgrass Research Center. Wetting agents applied August 4, 1988. Averages for three replications.

Treatment	Rate (oz/1000)	Dew Rating (1=No Dew)	Phytotoxicity Rating (9=Severe Burn)		
		8/4	8/4	8/10	8/23
Hydraflo 15G	32	6.8a*	1.0f	1.0e	1.0d
Hydraflo 15G	48	6.5ab	1.2ef	1.0e	1.0d
Hydraflo 15g	64	6.3ab	1.0f	1.0e	1.0d
Hydraflo 15 g	112	6.5ab	1.0f	1.0e	1.0d
Hydraflo L	8	2.0h	2.8d	2.7d	1.7bcd
Hydraflo L	16	1.0i	5.0c	5.0b	2.0bc
Hydraflo L	32	1.0i	7.8a	7.3a	5.3a
LescoWet	8	2.8g	2.3def	1.7de	1.0d
LescoWet	16	1.2i	6.5b	5.7b	2.0bc
LescoWet II	8	4.7d	1.5def	1.2e	1.0d
LescoWet II	16	4.0ef	1.5def	2.5d	2.3b
HydroWet	8	4.3de	1.3def	1.3e	1.0d
HydroWet	16	4.3de	2.8d	2.0de	1.0d
AquaGro	8	3.7f	2.0def	1.7de	1.0d
AquaGro	16	2.0h	2.7de	3.7c	1.3cd
AquaGro g	32	5.7c	1.0f	1.0e	1.0d
AquaGro g	64	6.2bc	1.0f	1.0e	1.0d
Check	-	6.8a	1.0f	1.0e	1.0d

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

Table 9. 1988 wetting agent effects on dew accumulation on a Penncross creeping bentgrass green. Hancock Turfgrass Research Center. Treatments applied October 6, 1988. Averages for three replications.

Treatments	Rate (oz/M)	Date of Rating (1988)y				
		10/7	10/11	10/17	10/19	11/4
Hydraflo 15G	32	5.0DEF*	5.3DEFG	5.7DEF	5.3EFG	6.0DEF
Hydraflo 15G	64	5.7CDE	6.0BCDE	6.3CDE	7.3BCD	7.3BCD
Hydraflo 15G	128	6.0CDE	7.3B	8.0AB	9.0A	8.0AB
Hydraflo L	4	8.7A	7.0BC	7.0BC	8.0AB	6.7BCDEF
Hydraflo L	8	9.0A	8.7A	8.7A	9.0A	7.7ABC
Hydraflo L	12	9.0A	9.0A	9.0A	9.0A	9.0A
LescoWet	4	7.7AB	5.7CDEF	6.3CDE	6.7BCDEF	6.0DEF
LescoWet	8	8.7A	7.3B	7.3BC	7.7ABC	7.2BCDE
LescoWet II	4	6.0CDE	4.3FG	4.7F	5.7DEF	6.0DEF
LescoWet II	8	5.7CDE	5.7CDEF	5.7DEF	6.0DEF	5.7EF
AquaGro	8	8.3A	6.7BCD	6.7CD	7.0BCDE	6.7BCDEF
HydroWet	8	6.3BCD	5.0EFG	5.7DEF	5.2FG	5.7DEF
AquaGro D	64	5.0DEF	5.7CDEF	5.0F	5.7DEF	6.3CDEF
Naiad	2	4.7EF	4.7EFG	4.3F	4.0GH	5.3F
SurfSide 19A	8	5.3CDEF	4.7EFG	4.7F	5.3EFG	6.0DEF
SurfSide 37	16	6.7BC	5.0EFG	5.7DEF	5.8DEF	5.8DEF
SurfSide 9	64	5.0DEF	5.3DEFG	5.3EF	6.3CDEF	6.5BCDEF
Check	0	4.0F	4.0G	3.0G	3.0H	5.3F

* - Means followed by the same letter are not signficantly different at the 1% level, using Duncan's multiple range test.
y - 9 = least dew, 1 = heavy dew

Table 10. 1988 Wetting agent effects on frost formation on a penncross creeping bentgrass green. Hancock Turfgrass Research Center. Treatments applied October 6, 1988. Averages for three replications.

Treatments	Rate (oz/M)	Date of Rating (1988)y 10/12	10/20	11/3
Hydraflo 15G	32	6.8 ABC*	4.3 EFG	4.0 A
Hydraflo 15G	64	6.0 ABC	5.5 CDE	3.0 C
Hydraflo 15G	128	7.3 A	6.3 ABC	2.0 D
Hydraflo L	4	4.8 C	5.8 BCD	4.0 A
Hydraflo L	8	6.0 ABC	6.7 AB	4.0 A
Hydraflo L	12	5.2 BC	7.0 A	3.7 B
LescoWet	4	6.3 ABC	4.8 DEF	4.0 A
LescoWet	8	5.3 A	5.3 CDEF	4.0 A
LescoWet II	4	6.8 ABC	4.5 EFG	4.0 A
LescoWet II	8	5.5 ABC	4.5 EFG	3.7 B
AquaGro	8	6.0 ABC	4.5 EFG	4.0 A
HydroWet	8	5.3 ABC	4.2 FG	4.0 A
AquaGro D	64	5.7 ABC	3.3 GH	4.0 A
Naiad	2	6.2 ABC	3.3 GH	4.0 A
SurfSide 19A	8	5.3 ABC	3.3 GH	4.0 A
SurfSide 37	16	6.3 ABC	4.2 FG	4.0 A
SurfSide 9	64	6.7 ABC	4.5 EFG	4.0 A
Check	0	7.2 AB	2.3 H	4.0 A

* - Means followed by the same letter are not significantly different at the 10% level, using duncan's multiple range test.

y - 9 = no frost 1 = heavy frost

Table 11. Effect of topdressing and nitrogen fertility programs on the turfgrass quality ratings of a Penneagle creeping bentgrass green. Treatments initiated in 1982. Hancock Turfgrass Research Center. Averages for three replications.

Topdress Treatment	N Rate (lbs/1000)	Date of Rating (1988)y			
		7/12	8/8	9/26	10/26
12 cu. ft. Spring/Fall 2:1 Sand Soil Mix	3	6.0cde*	6.0c	5.0de	7.0bc
12 cu. ft. Spring/Fall Sand	3	5.7de	6.0c	5.3de	6.7c
3 cu. ft. every 3 weeks Sand	3	6.7bcd	7.0b	5.7cd	6.3c
6 cu. ft. every 6 weeks Sand	3	7.0abcd	7.0b	6.0bcd	7.0bc
Check	3	5.0e	5.0d	4.0e	4.0d
12 cu. ft. Spring/Fall 2:1 Sand Soil Mix	6	8.0ab	8.0a	7.0abc	8.3ab
12 cu. ft. Spring/Fall Sand	6	7.3abc	8.0a	7.3ab	8.3ab
3 cu. ft. every 3 weeks Sand	6	8.0ab	8.0a	8.0a	9.0a
6 cu. ft. every 6 weeks Sand	6	8.3a	8.0a	7.3ab	8.3ab
Check	6	7.3abc	6.7b	6.0bcd	6.3c

* - Means followed by the same letter are not significantly different at the 1% level using Duncan's Multiple Range Test.
y - 9 = excellent 1 = poor

annually) resulted in higher quality ratings than the lower N rate (3 pounds). The non-topdressed plots (check) ranked significantly lower than where topdressing treatments were applied. The check plots have developed a significant thatch layer which results in a lower quality turf. Using the surface hardness tester developed by John N. Rogers, III at Pennsylvania State University with Don Waddington, the non-topdressed plots were found to be considerably harder than where topdressing was applied. The impact readings were in the range of 71-74 on topdressed plots compared to an average value of 86 on the check plots. In spite of the thatch layer on non-topdressed plots, the soil below the thatch has become highly compacted while topdressed plots exhibit more resilience.

After three years of topdressing with sand or sand mixes it has become apparent that putting green turf quality ratings are improved after topdressing (Table 12). Peak turf quality occurs on plots topdressed in spring and fall after these treatments have been applied while those plots topdressed every 3 weeks tend to have a more consistent quality throughout the growing season. On a few dates topdressing with sand mixes (80% sand, 20% peat or 60% sand, 20% peat, 20% loam topsoil) turf quality ranked better than when sand was used alone. All topdressed plots consistently ranked better than non-topdressed plots.

Applying Sand Aid with sand when topdressing on a Penncross bentgrass putting green resulted in improved turf quality on certain dates during the growing season. Data are given in Tables 13 and 14 for studies established in 1985 on a modified loamy sand and dune sand, respectively. This was particularly evident on the green growing on sand. Interestingly, plots which were cored had less dew on October 17 than plots which were sand topdressed or not treated. This rating was taken during a period of frequent rainfall and low evapotranspiration so differential soil moisture was not considered a factor in the differential in dew formation.

SOIL TEST RESPONSES TO PHOSPHATE AND POTASH

Ongoing studies on Penncross bentgrass putting greens have been continued in 1988. Phosphorus and potassium applications outlined in Tables 15 and 16 have been applied since 1982. On the soil green (loamy texture) in Table 15 it is apparent that 2 pounds of P per 1000 sq ft annually are needed to increase P soil test over the check on this soil that had a very high P level at the beginning of the study in 1982. At such high P levels (375 pounds per acre) it is apparent that P has moved down into the 2-4 inch depth (194 pounds per acre) compared to lower P levels applied. Potassium also accumulates in this loamy soil as indicated by the K soil tests in Table 15.

On the green established on a 80% sand, 20% peat mixture (Table 16) there is some residual potassium in the 0-2 inch depth from applications made during establishment. Some potash has accumulated in the 0-2 inch depth but only at the higher rates of application has much potassium moved into the 2-4 inch depth.

Phosphorus applied to a Penncross creeping bentgrass growing on sand (Table 17) corrected a phosphorus deficiency with as little as 1 pound P applied annually. However, the P soil test of 11 pounds per acre is still considered deficient for good stress tolerance of the turf. It is clear that phosphorus does leach in the sand which has no organic matter added other than what the turf contributes. Regular, light application of phosphorus should

Table 12. Effect of topdressing a Penncross creeping bentgrass green with Great Lakes Minerals topdressing mixes on turfgras quality ratings. Study initiated spring 1986. Hancock Turfgrass Research Center. Averages for 3 replications.

Treatment			Overall Quality Ratings (9 = best)						
Mix[y]	Rate	Frequency	4/26	7/14	7/20	8/8	8/26	10/3	11/1
	cu ft/1000								
TDS-50	3	3 weeks	6.2d	7.7a	7.3c	8.3ab	8.7a	6.7bc	6.7b
	12	Spring/Fall	7.0ab	7.7a	7.3c	8.7a	7.3cd	7.0ab	7.0b
80:20	3	3 weeks	6.3cd	7.7a	8.7ab	8.7a	8.3ab	7.7a	6.7b
	12	Spring/Fall	7.2a	8.0a	7.3c	7.7ab	7.0d	6.7bc	8.3a
60:20:20	3	3 weeks	6.5bcd	8.0a	9.0a	8.7a	8.7a	7.3ab	7.0b
	12	Spring/Fall	6.8abc	7.7a	7.7c	8.0ab	7.7bcd	7.0ab	8.7a
TDS-50 (cored)	12	Spring/Fall	6.2d	7.3a	8.0bc	8.0ab	8.0abc	7.0abc	7.0ab
Check	-	-	4.8e	6.0b	6.3d	6.0d	7.2cd	6.0c	5.0c

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

[y] TDS-50 is 100% sand; 80:20 is 80% sand, 20% peat; 60:20:20 is 60% sand, 20% peat and 20% loamy topsoil.

Table 13. Effect of Sand Aid treatments on turfgrass quality and dew ratings of a Penncross creeping bentgrass green grown on loamy sand. Hancock Turfgrass Research Center. Treatments initiated in 1985. Quality rating scale of 1-9 with 9 = highest quality turf. For dew ratings 9 = no dew. Averages for three replications.

Treatment		Dew	Quality Rating		
Sand Aid	Auxiliary	10/17	4/26	10/4	11/1
5%	Sand topdress	4.7d*	6.7b	7.0abc	5.3a
10%	Sand topdress	5.0cd	7.3a	7.7a	5.7a
None	Sand topdress	4.3d	6.0c	7.3ab	5.3a
15 lbs	Coring	6.0ab	5.8cd	6.3bc	5.7a
30 lbs	Coring	6.7a	5.8cd	6.0c	6.0a
None	Coring	5.7bc	5.2d	6.3bc	6.0a
None	None	4.0d	5.3d	6.1c	4.0b

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

Table 14. Effect of Sand Aid treatment on turfgrass quality and dew ratings of a Penncross creeping bentgrass green grown on sand. Hancock Turfgrass Research Center. Treatments were initiated in 1985. Quality rating scale of 1 - 9 with 9 = highest quality turf. For dew ratings 9 = no dew. Averages for three replications.

Treatment		Dew	Quality Rating		
Sand Aid	Auxillary	10/17	7/6	7/20	8/8
5%	Sand topdress	4.0c	6.3ab	7.3a	7.3ab
10%	Sand topdress	5.0b	6.7a	8.0a	8.0a
None	Sand topdress	4.3bc	4.0d	5.7c	6.3bc
15 lbs	Coring	7.0a	5.3bc	6.0bc	7.3ab
30lbs	Coring	7.0a	6.7a	7.0ab	8.0a
None	Coring	6.3a	6.3ab	6.0bc	7.3ab
None	None	4.3bc	5.0cd	5.0c	6.0c

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

Table 15. Effects of phosphorus and potassium treatments on soil tests of soil based Penncross creeping bentgrass green at 0-2 and 2-4 inch depths. Hancock Turfgrass Research Center. Nutrients expressed as lbs per acre. Treatments initiated 1982. Samples collected August, 1988.

Treatment lbs P and K per 1000 sq ft	0-2 inch depth				2-4 inch depth			
	P	K	Ca	Mg	P	K	Cu	Mg
0	141b*	140c	2109a	373b	157b	67b	1813a	345b
0.5	159b	157bc	2109a	416a	153b	95b	1761a	348ab
1	213b	197b	2063a	420a	163b	90b	1761a	356ab
2	375a	298a	2147a	435a	194a	160a	1762a	371a

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

Table 16. Effects of phosphorus and potassium treatments on soil tests of a sand/peat based Penncross creeping bentgrass green at 0-2 and 2-4 inch depths. Hancock Turfgrass Research Center. Nutrients expressed as lbs per acre. Initiated 1982. Samples collected August, 1988.

Treatment lbs P and K per 1000 sq ft	0-2 inch depth				2-4 inch depth			
	P	K	Ca	Mg	P	K	Cu	Mg
0	11d	107b	4925a	717a	5a	28d	3733a	370a
0.5	50c	162a	4894a	780a	16c	48c	3986a	438a
1	97b	176a	3668a	793a	31b	82b	4379a	521a
2	215a	170a	4491a	722a	82a	107a	3568a	430a

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

Table 17. Effects of phosphorus treatments on soil tests of a sand based Penncross creeping bentgrass green at 0-2 and 2-4 inch depths. Hancock Turfgrass Research Center. Nutrients expressed as lbs per acre. Treatments initiated 1983. Samples collected August, 1988.

Treatment P	0-2 inch depth P	K	Ca	Mg	2-4 inch depth P	K	Cu	Mg
0	7c	34a	335a	63a	8c	17a	234a	37a
1 spring 1 fall	29b	36a	337a	63a	28b	20a	234a	37a
1 spring	11c	48a	396a	68a	9c	17a	211a	27a
2 spring 2 fall	63a	56a	526a	81a	43a	20a	290a	40a

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

probably be used on sand greens. Although greens represent a small area of the golf course, use care to prevent loss of phosphorus by leaching when greens are adjacent to ponds, lakes or streams.

OTHER STUDIES

A cultivation study on Ram I Kentucky bluegrass at the Hancock Turfgrass Research Center was established in 1987 and will continue through 1989. Treatments include solid and hollow tine aerifying with large, medium and small equipment. No significant data have been taken on these plots as yet. Emphasis will be placed on effects of treatments on the thatch which exists on this turf. Off campus studies established in 1988 include a phosphorus and potassium response study on a very low nutrient testing soil at a condominium site near Detroit.

A series of different mixes of Kentucky bluegrass, perennial ryegrass and tall fescue were established on an unirrigated athletic field near Traverse City. The objective is to determine the establishment rate, adaptability to the environment and tolerance of moisture stress on this sandy soil. Of particular interest is how the tall fescue will survive in that environment.

WEATHER SUMMARY

One need not look at the weather statistics for 1988 to know it was a very unusual year for turf but a review of the numbers may be helpful in explaining why so much turf loss occurred. From mid-April through mid-July about one inch of rainfall occurred. Average rainfall during that period is over six inches. Temperatures were also well above normal with 37 days of high temperatures over $90^{o}F$ compared to an average of 11 per year. During the severe drought period we also experienced mostly sunny days (80% of possible in May through July), strong winds and low relative humidities. Evapotranspiration figures were much higher than normal with many days over .3 inch per day in May, June and early July, figures which would be considered more typical of desert areas. The longest days of the year occur during this time, contributing further to high evapotranspiration rates.

On irrigated sites turf managers had difficulty applying enough water to meet turf needs during the drought. When rainfall resumed and relative humidities rose to normal summer levels (just under .2 inch per day). Disease pressure became a significant problem on many turfs. Ironically, with higher than normal rainfall in August and September and the highest rainfall levels on record in October, we finished the year above normal in rainfall.

Unirrigated turfs turned dormant early in the summer. When rainfall came in July, crabgrass germinated and grew rapidly, responding to the high temperatures and without competition from desired grasses. Many turfs recovered reasonably well in August and September while others had suffered significant turf loss, necessitating overseeding or reestablishement practices. Unfortunately, many turfs were not improved in the fall, leaving a major need for overseeding or reestablishment in the spring of 1989.

ACKNOWLEDGEMENTS

The support of the Michigan Turfgrass Foundation and its members with financial support and donations of fertilizer and supplies is gratefully acknowledged. Without this support much less work could be addressed.