TURFGRASS SOIL MANAGEMENT RESEARCH REPORT - 1991

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Research conducted in 1991 emphasized several areas of soil management. This research was supported financially in part by the Michigan Turfgrass Foundation. Michigan State University Agricultural Experiment Station as well as several companies which provided support financially or with products and equipment and is gratefully acknowledged.

CULTIVATION STUDIES

Two long term cultivation studies previously established were continued. One was designed to determine the effect of timing of cultivation on annual bluegrass fairway turf. This study was initiated in 1989 in cooperation with J.M. Vargas Jr. at the Hancock Turfgrass Research Center. Cultivation treatments are applied with .5 inch diameter tines on 2 inch centers. Plot size is 6 ft by 10 ft with 3 replications. Turf quality ratings taken in 1991 are shown in Table 1. As observed in past years, there is little effect of cultivation timing on overall turf quality. It may be that since this plot area does not receive intensive traffic or moisture stress, differences are not appearing. In 1992 we will provide traffic and moisture stress treatments to determine if differences will develop. The weed count data is an estimate of the relative crabgrass presence in the plot. There is a tendency for spring (May and June) cultivation treatments to have higher crabgrass ratings, although there is considerable variability in the data. Certainly, if one opens the turf by cultivation during prime periods of crabgrass germination, it is very important to provide water and nitrogen for quick recovery of turf density so there is little time for crabgrass to germinate. Fertilizing 7-10 days before cultivation should be considered on sites with a history of crabgrass infestation.

Evaluation of rooting of the annual bluegrass as affected by time of cultivation was done on three dates in 1991. The resulting data are given in Table 2. Generally, there is little clear evidence that time of cultivation affected root measurements at the times plots were sampled. It is of interest to note that the October treatment date had somewhat higher roots on 2 of the dates of evaluation.

Table 1

Cultivation Timing Study 1991

Initiated June 6, 1989, Quality Ratings, 1=poor 9=excellent

Cored with .5 inch tines on 2 inch spacings, April 19, June 12, July 16, September 11 and October 22, 1991. Weed count taken July 27, 1991.

Treatment	4/17	5/15	6/19	7/24	8/14	9/18	10/7	11/6	7/25**
Mid May	6.2	6.1AB*	6.2	6.0	6.9	7.1	7.0	7.0 B	67.0AB
Mid June	6.1	6.4AB	6.2	5.9	7.0	7.0	7.0	7.0 B	76.5A
Mid July	6.1	6.4AB	6.1	5.5	7.0	7.0	7.0	7.4AB	45.2AB
Mid Aug	6.0	6.5A	6.4	6.0	7.1	7.1	7.2	7.1AB	47.0AB
Mid Sept	6.0	6.0 B	6.4	6.2	7.0	7.0	7.0	7.5A	34.0 B
Late Oct.	6.0	6.2AB	6.0	6.0	7.1	7.1	7.2	7.1AB	42.0AB

* Means followed by the same letter are not significantly different at the 5% level using the LSD range test.

** Means followed by the same letter are not significantly different at the 10% level using the LSD range test.

Table 2

Cultivation Timing Study 1991

Initiated June 6, 1989, Root and Thatch Weights, Root weight reported in KG M^{-3} and thatch weights reported in KG M^{-2}.

Cored with .5 inch tines on 2 inch spacings, April 19, June 12, July 16, September 11 and October 22, 1991.

	April 18			July 24			October 10		
Treatment	Thatch	0"-3"	3"-6"	Thatch	0"-3"	3"-6"	Thatch	0"-3"	3"-6"
Mid May	2.1	4.0	0.4	0.6 B*	1.5	0.4	0.6	1.9AB	0.20 B
Mid June	1.8	3.0	0.4	0.6 B	2.2	0.3	0.6	1.3 B	0.25AB
Mid July	1.1	3.4	0.3	0.7 B	4.0	0.4	0.9	1.9AB	0.26AB
Mid Aug	1.4	3.7	0.4	0.7 B	2.1	0.5	0.8	2.1A	0.28AB
Mid Sept	3.5	3.5	0.3	0.6 B	2.1	0.4	0.6	2.0AB	0.30AB
Late Oct.	1.5	3.3	0.5	1.1A	2.9	0.5	0.8	2.2A	0.42A

* Means followed by the same letter are not significantly different at the 5% level using the LSD range test.

At this point, we cannot say that there is enough evidence to recommend this timing of cultivation as a standard practice. However, based on other studies we believe that fall is a very appropriate time to consider cultivation. The maximum root production period for cool season grasses is in the spring. Loosening the soil by cultivation in the fall to late fall should provide maximum opportunity for good root growth the next spring.

The objective of another cultivation study is to determine the effect of several cultivation treatments on turf quality and thatch accumulation on Ram-I Kentucky bluegrass. This study was initiated in 1987 on a turf which had about 1 inch of thatch. Treatments include the Verti-Drain with hollow and solid tines, Toro greens aerifier used once and 3 times annually, a vertically operating tine aerifier which is set to penetrate to only 1 inch and an untreated check. The solid tine treatment brings no soil to the surface so there is no mixing of soil with the thatch. As a result, the solid tine treatment has had little effect on thatch accumulation. The shallow treatment is purposely set so there is very little soil brought to the surface to simulate what happens when an ineffective aerifier is used on a thatch site. There have been no differences in turf quality ratings taken, so no data are presented here. This study will continue in 1992.

EFFECT OF HIGH POTASSIUM RATES ON TURF AND SOIL TESTS

In recent years there has been a dramatic increase in the use of potash in fertilizing turfs, especially in high traffic and/or stress situations. This has occurred as a result of recent data indicating that greater wear tolerance has resulted from potash applications above those recommended based on soil tests and the generally accepted view that higher potassium will enhance stress and disease tolerance of turfgrasses. Some turf specialists are concerned that the rates being used by become excessive due to nutrient imbalances and/or high salt levels. The studies reported here were initiated in 1990 in cooperation with J.N. Rogers at the Hancock Turfgrass Research Center, one each on Bristol Kentucky bluegrass growing on loam soil, an annual bluegrass fairway height turf growing on loam soil and a creeping bentgrass green growing on a loamy sand soil. Treatments were applied at 0, 4, 8, and 12 lbs. K_20 (as potassium chloride) per 1000 sq. ft. annually in 2 lb. increments during the growing season. There was also a 12 lb. K_20 treatment applied as potassium sulfate. Each study also had a treatment based on soil tests as recommended by the Michigan State University Soil Testing Lab. Clippings were returned on the Kentucky bluegrass and annual bluegrass studies, but removed from the bentgrass green. Plot size was 4 ft. by 6 ft. with 3 replications.

There were no observable differences in turf quality in any of the 3 studies as reported last year. Soil samples were collected in November and tested for potassium, calcium and magnesium. The soil samples were separated into thatch, 0-3 inch and 3-6 inch depths for analysis. Data are shown in Tables 3, 4 and 5 for the Kentucky bluegrass, creeping bentgrass and annual bluegrass studies, respectively. The rates of K_20 applied for the soil test based treatments were: Bristol Kentucky bluegrass 3.0 lbs. in 1990 and 0.5 lb. in 1991; Penncross creeping bentgrass green - 5.5 lbs. in 1990 and 4.5 in 1991; annual bluegrass fairway - 3.5 lbs. in 1990 and 4.0 in 1991.

Soil test results indicate there are some differences in the responses observed to the potash applications. The higher K soil tests in the check plot on the Kentucky bluegrass study is reflected in the higher K tests at each rate of K_20 application compared to that observed in the annual bluegrass study, even though both are growing on loam soil. In both these studies, the downward movement of K at the higher rates of application is very apparent. As the K level in the surface layer becomes high, there is a natural leaching downward, even in these loam soils. At the excessive rates of 12 lbs. K_20, this would be expected to occur even when clippings are returned.

Table 3 High Potassium Study, 1991
Bristol Kentucky bluegrass, HTRC
Treatments applied 4/22, 5/1, 6/10, 7/15, 8/13, and 9/11, 1991
Sampled 11/4/91

Treatment	Rate Lbs K20/Year	Thatch			0-3 Inch			3-6 Inch		
		K	Ca	Mg	K	Ca	Mg	K	Ca	Mg
Check	---	493 E*	2880A	478A	134 D	2340A	503A	69 C	1769	298AB
KCL-K20	Soil Test-.5	890 D	2479AB	426 B	269 CD	1962AB	336AB	109 BC	2493	306AB
KCL-K20	4	1165 C	2300 B	434AB	361 C	1800 B	370AB	165 B	1616	324A
KCL-K20	8	1204 C	2267 B	418 B	526 B	1725 B	356AB	177 B	1548	308AB
KCL-K20	12	1432 B	2166 B	400 B	736A	1663 B	330 B	314A	1433	282 B
K2S04-K20	12	1617A	2131 B	394 B	882A	1764 B	338 B	340A	1410	288 B

* Means followed by the same letter are not significantly different at the 5% level using the LSD range test.

Table 4 High Potassium Study, 1991
Penncross creeping bentgrass, HTRC
Treatments applied 4/22, 5/1, 6/10, 7/15, 8/13, and 9/11
Sampled 11/4/91

Treatment	Rate Lbs K20/Year	Thatch			0-3 Inch			3-6 Inch		
		K	Ca	Mg	K	Ca	Mg	K	Ca	Mg
Check	---	192 D*	1969	308	53 D	1074	260A	34 D	899	196A
KCL-K20	Soil Test 4.5	318 BC	1983	348	149 C	1047	196AB	89 C	910	190A
KCL-K20	4	292 CD	2070	363	146 C	1088	216AB	76 C	821	178AB
KCL-K20	8	374ABC	1972	362	204 B	1047	206AB	127 B	781	176AB
KCL-K20	12	462A	2069	349	290A	1087	208AB	200A	870	166 B
K2S04-K20	12	405AB	1881	340	272A	1052	190 B	217A	935	158 B

* Means followed by the same letter are not significantly different at the 5% level using the LSD range test.

Table 5

High Potassium Study, 1991
Annual bluegrass, HTRC
Treatments applied 4/22, 5/1, 6/10, 7/15, 8/13, and 9/11
Sampled 11/4/91

Treatment	Rate Lbs K20/Year	Thatch			0-3 Inch			3-6 Inch		
		K	Ca	Mg	K	Ca	Mg	K	Ca	Mg
Check	---	156 D*	1659	408A	87 D	1407	391A	62 D	953 B	345A
KCL-K20	Soil Test 4.0	342 BC	1600	375 B	261 C	1660	375AB	130 BC	1406AB	328AB
KCL-K20	4	337 C	1563	357 B	242 C	1621	361 BC	114 CD	1238AB	330AB
KCL-K20	8	412 B	1565	363 B	386 B	1599	351 CD	169 B	1427AB	318 B
KCL-K20	12	498A	1621	358 B	494A	1621	336 D	269A	1387AB	289 C
K2S04-K20	12	508A	1623	379 B	562A	1621	352 CD	316A	1528A	314 B

* Means followed by the same letter are not significantly different at the 5% level using the LSD range test.

On the loamy sand green, the K soil tests are not as high as in the loam soil at each rate of application. This is to be expected because of the low cation exchange capacity in the sandy soil. Typically, available K soil test levels are not high on sandy soils in spite of high rates of application. Because of the low cation exchange capacities and susceptibility to leaching of potash found in sands, it is necessary to apply potash more frequently and at lighter rates than on finer textured soils.

Based on the data generated thus far, we are reasonably confident in the potash recommendations made by our M.S.U. Soil Testing Lab. The levels of K maintained by the soil test based treatments as found in the 0-3 inch depth is holding about where we expect them to be. Recommendations for fertilizer applications should be based on soil samples taken from the top 3 inches or so of soil. In order to effectively compare soil tests from one year to another, always sample to the same depth and at the same time of year. Note that the soil K tests in the thatch layers are much higher than in the 0-3 inch soil depth in all 3 studies as would be expected. Thatch has lower density than soil.

One area of concern with very high levels of K is the potential for causing an imbalance between potassium and magnesium. In these studies, there is evidence that the magnesium soil test levels in the 0-3 and 3-6 inch soil depths are lower with high rates of application of potash. It is not yet a problem on these soils for 2 reasons: the level of magnesium in the soil is naturally high and the irrigation water used at the Hancock Turfgrass Research Center is very high in both calcium and magnesium. With each irrigation the turf receives a small amount of both calcium and magnesium. Many water sources in Michigan are high in calcium and magnesium, but some are not. Turf managers are urged to monitor magnesium soil test levels carefully if using high rates of potash on sites were magnesium tests are low or when the irrigation water is low in magnesium. Secondly, apply reasonable rates of potash. Most soil test recommendations for potash are acceptable. For heavy use turf areas, one might consider using 1 or 2 pounds of potash annually over that recommended based on soil tests. For maximum protection against the salt effects of potash carriers, we suggest application of only 1 lb. K_20 per 1000 sq. ft. per application when applied in dry form and watered in. One might go as high as 1.5 lbs under "safe" conditions of lower temperature and low relative humidity. The salt effects from fertilizers can cause the visual symptoms of foliar (and crown) burn, but could also be harmful to roots and soil biological activity. We do not have any proof of the latter under normal use of soluble fertilizers, but we do suggest care in not applying excessive rates at one time. It is essential to limit soluble fertilizer applications when the turf is in significant moisture stress. Fertilizers should never be applied when the turf is wilting.

Some agronomists are also concerned about getting the nitrogen to potassium ratio too wide. As a general rule, the higher the rate of nitrogen applied on high use turfs, the higher the rate of potash should be used. This should be related to soil test, of course. For example, if a golf course superintendent is using 5 pounds N per 1000 sq. ft. annually on a putting green and soil tests recommend 3.5 pounds potash, one could use 4.5 to 5.0 pounds potash annually if applications are made throughout the year. Watch magnesium soil tests, of course. However, if one is using only 2.5 pounds N annually and soil tests call for 3.5 pounds potash, the range of 3.5 to 4 pounds potash annually would be more appropriate. We have observed in other studies that with higher rates of N, there is greater loss of potassium. Some of this would come through leaching and some would be lost through greater clipping removal when clippings are not returned to the turf.

EFFECT OF FERTILIZER APPLICATION WITH THE HYDROJECT

A prototype of the Hydroject aerifier developed by the Toro Co. was used to inject phosphorus and potassium into turf soils. These studies were initiated in 1990 and continued in 1991. The phosphorus treatments were established on a Penncross creeping bentgrass green at the Hancock Turfgrass Research Center. Phosphorus treatments were as shown in Table 6: untreated check; Hydroject aerification alone; a surface application of 2.5 lbs. P_20_5 per 1000 sq. ft.; phosphorus applied at 2.5 or 5.0 lbs. P_20_5 per 1000 sq. ft.

Table 6. Effect of phosphorus placement on soil P tests. Penncross creeping bentgrass putting green. Loamy sand soil. Hancock Turfgrass Research Center. Initiated in 1990, repeated in 1991. Sampled November, 1991.

P_2O_5	Available P, lbs/acre			
lbs/1000	thatch	0-3 inch	3-6 inch	6-9 inch
Check	15c	25c	36c	44c
Hydroject alone	18c	24c	38c	50bc
Surface, 2.5	208a	66b	42c	46bc
Hydroject, 2.5	38c	64b	93b	58ab
Hydroject, 5.0	92b	116a	129a	66a

Table 7. Effect of potash placement on soil K tests. Annual bluegrass fairway turf. Loam soil. Hancock Turfgrass Research Center. Initiated in 1990, repeated in 1991. Sampled November, 1991.

K_2O	Available K, lbs/acre		
lbs/1000	0-3 inch	3-6 inch	6-9 inch
Check	93d	61d	65c
Hydroject alone	114d	84d	80bc
Surface, 3.0	234b	111c	82bc
Surface, 6.0	304a	158b	86bc
Hydroject, 3.0	175c	145b	97ab
Hydroject, 6.0	267ab	238a	112a

The phosphorus treatments were split into 2 applications during the growing season. Soil tests on samples taken in November 1991 are given in Table 6. It is clear that the phosphorus from surface applications is found mostly in the thatch and the 0-3 inch depth. Injecting the phosphorus clearly places the phosphorus deeper in the soil. The higher rate of phosphorus injected is much higher than would be recommended based on soil tests and obviously raises P levels deeper in the soil as would be expected. When P is applied only on the surface, roots deeper in the soil tend to extract P from that zone thereby leaving much lower P levels deeper in the root zone. The benefit from the deeper placement of P with the Hydroject is not yet apparent based on observations of the turf to date.

A similar study with potash was established in 1990 on an annual bluegrass turf mowed at fairway height and growing on loam soil. Treatments are similar to those for the P study, but the rates of application of K_20 (Table 7) are 3 and 6 lbs. per 1000 sq. ft. In this loam soil, there is limited downward movement of K from surface applications. This occurred for both 3 and 6 lb. treatments. When injected with the Hydroject, it is clear the K is being placed deeper in the soil after 2 years of treatments. Based on these studies, the conclusion is that the Hydroject can be used effectively to inject P and K in to turf soils. These studies will be continued to evaluate the benefits of nutrient injection to turf.

NITROGEN CARRIER EVALUATIONS

Several nitrogen carriers were evaluated for responses at the Hancock Turfgrass Research Center in 1991. One study was conducted on perennial ryegrass. Nitrogen was applied at the rate of 1 lb. N per application on 3 dates: May 15, July 8 and August 14. Plot size was 4 ft. by 6 ft. with 3 replications. Carriers evaluated in this study are shown in Table 8: Rejuvenate and 21-0-0 are from the Anderson's Co.; Lawn Restore is from the Ringer Co.; Milorganite from the Milwaukee Sewerage Commission; Sustane from the Sustane Co.; and Sun-Shine from the Sun-Shine Co. There is a clear response to the applied N based on turf quality rating starting 2 weeks after application. Although a few products gave a somewhat slower response initially, later in the season most gave consistent quality ratings. Clippings were collected on 5 dates during the growing season (Table 9) as another means of measuring response to the applied nitrogen. On 3 of the 5 dates there were significant differences from the untreated check. Generally, the clipping weight responses were consistent with turf quality ratings.

A similar study with the same treatments was established on Britsol Kentucky bluegrass. Turfgrass quality ratings (Table 10) and clipping weight measurements (Table 11) showed responses which were consistent with observations from the study on perennial ryegrass.

A study designed to evaluate the efficacy of a coated fertilizer developed by the Vicksburg Chemical Co. was established in May. Carriers included Multicote, the coated fertilizer; miniprilled potassium nitrate and urea. The N was applied at the rate of 4 lbs. N per 1000 sq. ft. for the season: the Multicote was applied at 2 lbs. N each on May 8 and July 5; the miniprill and urea were applied on 6 dates, May 8, May 29, June 19, July 5, August 5 and August 27. The Multicote fertilizer provided the highest quality ratings consistently through the season (Table 12), better than the other N carriers in spite of more frequent applications. Clipping weight data (Table 13) indicated that the Multicote treatment gave uniformly high growth rates in spite having been applied only 2 times during the growing season. These data point out this carrier has the potential to be applied 2 times per year and give uniform release nitrogen for turf needs.

Table 8

Perennial Ryegrass Organic Fertilizer Study 1991
Quality Ratings, 1=poor, 9=excellent
Treatments applied May 15, July 8 and August 14.
Each treatment 1 pound of nitrogen per 1000 sq. ft.

Treatment	6/1	7/3	7/18	8/14	8/26	9/9	10/6
Rejuvenate	5.5 BC	5.5 B	7.6A	7.0ABC	8.0 B	6.8AB	6.8 BC
Anderson 21-0-0	5.2 C	5.5 B	6.5 B	6.8 BC	6.8 C	6.8AB	6.5 CD
Ringer Lawn Restore	6.5A	6.5A	7.4A	7.4AB	9.0A	7.8A	7.0 BC
Milorganite	6.0AB	6.2AB	6.5 B	7.5A	7.8 B	7.8A	7.2AB
Sustane	6.0AB	5.8AB	7.1AB	7.2AB	8.0 B	7.5A	6.8 BC
Sun-Shine	6.2A	6.2AB	6.6 B	7.6A	7.8 B	7.8A	7.6A
Check	4.0 D	4.5 C	5.4 C	6.4 C	5.5 D	5.8 B	6.1 D

* Means followed by the same letter are not significantly different at the 5% level using the LSD range test.

Table 9

Perennial Ryegrass Organic Fertilizer Study 1991
Clipping Weights in KG M^{-2}
Treatments applied May 15, July 8 and August 14.
Each treatment 1 pound of nitrogen per 1000 sq. ft.

Treatment	6/6	7/5	7/31	8/30	9/19
Rejuvenate	.405	.342A	.098ABC	.273A	.160
Anderson 21-0-0	.403	.363AB	.063 C	.218ABC	.134
Ringer Lawn Restore	.444	.378A	.122A	.184 BC	.139
Milorganite	.442	.342A	.086 BC	.207 BC	.174
Sustane	.443	.338A	.104AB	.204 BC	.165
Sun-Shine	.456	.388A	.084 BC	.236AB	.162
Check	.484	.199 B	.023 D	.164 C	.134

* Means followed by the same letter are not significantly different at the 5% level using the LSD range test.

Table 10.Kentucky bluegrass Organic Fertilizer Study 1991
Quality Ratings, 1=poor, 9=excellent
Treatments applied May 15, July 8 and August 14.
Each treatment 1 pound of nitrogen per 1000 sq. ft.

Treatment	6/7	7/3	7/18	7/31	8/14	8/26	8/31	9/3	10/6
Rejuvenate	6.9 B	7.1AB	7.2A	7.4ABC	6.8 B	8.1A	7.1AB	7.1 B	6.9 BC
Anderson 21-0-0	7.0 B	6.2 B	6.0 BC	5.9 D	5.8 C	6.5 B	6.2 B	6.2 C	6.5 C
Ringer Lawn Restore	7.8A	7.1AB	6.6ABC	8.0A	7.8A	8.2A	7.4A	7.8A	7.9A
Milorganite	6.8 B	6.9AB	5.8 CD	6.6 CD	6.9AB	7.5A	6.9AB	7.2AB	7.4AB
Sustane	7.3AB	7.2A	6.8AB	7.5AB	6.8 B	7.9A	7.2A	7.1 B	7.2AB
Sun-Shine	7.4AB	6.6AB	6.9AB	6.8 BC	7.2AB	8.2A	6.6AB	7.5AB	7.4AB
Check	6.1 C	5.2 C	4.9 D	5.0 E	5.0 C	5.1 C	5.2 C	5.2 D	6.2 C

* Means followed by the same letter are not significantly different at the 5% level using the LSD range test.

Table 11

Kentucky bluegrass Organic Fertilizer Study 1991
Clipping Weights in KG M^{-2}
Treatments applied May 15, July 8 and August 14.
Each treatment 1 pound of nitrogen per 1000 sq. ft.

Treatment	6/6	7/5	7/31	8/30	9/19
Rejuvenate	.408	.415A	.180A	.267A	.214A
Anderson 21-0-0	.433	.340AB	.088 CD	.199AB	.192A
Ringer Lawn Restore	.473	.412A	.165AB	.253A	.233A
Milorganite	.460	.395A	.122ABCD	.211AB	.205
Sustane	.445	.429A	.145ABC	.218AB	.221A
Sun-Shine	.472	.393A	.114 BCD	.235A	.208A
Check	.387	.250 B	.068 D	.145 B	.122 B

* Means followed by the same letter are not significantly different at the 5% level using the LSD range test.

Table 12

Vicksburg Chemical Coated Potassium Nitrate Study
Initiated May 8, 1991
Quality Ratings, 1 = poor 9 =excellent

Mulitcote treatment applied May 8 and July 5 at 2 pounds of nitrogen per 1000 sq. feet. for a total of 4 pounds of nitrogen per 1000 sq. ft. KNO_3 miniprills and Urea treatments applied May 8, May 29, June 19, July 5, August 5 and August 27 to total of 4 pounds of nitrogen per 1000 sq. ft.

Treatment	6/7	7/3	7/24	8/5	8/13	9/12	10/6	11/6
Multicote	5.75A*	7.00A	6.75A	7.50A	8.0A	8.00A	8.00A	7.50A
Mini-Prills	4.50 B	7.25A	6.00 B	6.50 B	7.0 C	6.75 B	6.62 B	6.25 B
Urea	4.75 B	6.50A	6.25AB	6.75AB	7.5 B	6.75 B	6.62 B	6.25 B
Check	4.00 B	4.00 B	5.00 C	5.00 C	6.0 D	5.75 C	5.38 C	5.25 C

* Means followed by the same letter are not significantly different at the 5% level using the LSD range test.

EFFECTS OF MANGANESE APPLICATIONS ON TURFGRASS QUALITY

The studies to evaluate the affect of foliar manganese applications on turf quality of a Penncross creeping bentgrass green at the Hancock Turfgrass Research center were continued in 1991. The first study utilized applications as shown in Table 14 on May 24, June 26, July 10 and July 30. Manganese sulfate did not provide a consistent improvement in turf quality although there was some increase in quality ratings from the first date of application. Thereafter, and in a second study (Table 15) established on September 3, there was no apparent benefit from manganese applications on this Penncross green on this loamy sand green. Ferrous sulfate did give generally improved quality ratings. However, some phytotoxicity can occur from foliar applications ferrous sulfate as was observed from the June 26 applications. Use care when making any soluble fertilizer application during high environmental stress conditions (high temperatures, wilting of turf, etc.).

EFFECTS OF USING ISOLITE IN TOPDRESSING PROGRAMS

A study was established July 2 on a Penncross putting green turf at the Hancock Turfgrass Research Center to evaluate the effect of mixing Isolite with sand in a sand topdressing program. Treatments were: sand alone; 90% sand, 10% Isolite; and 80% sand, 20% Isolite. Parameters evaluated included turfgrass quality ratings, volumetric moisture content (Table 16); soil temperature (Table 17); and root weights and surface hardness measurements (Table 18). Topdressing treatments were applied at the rate of 3 cubic ft. per 1000 sq. ft. at 3 week intervals. There were no differences observed in any of the parameters measured during this relatively short-term study. To properly evaluate a soil amendment like this, longer term studies are necessary.

WETTING AGENT EFFECTS ON TURF AND SOIL MOISTURE

The effects of wetting agents on turf and on soil moisture were evaluated in a series of studies on putting green turfs in 1991. The study was concentrated on the use of the Paragon wetting agent, which was compared to label rates of AquaGro and LescoWet, as well as an untreated check. One study involved treatments on July 30 and September 2 (Table 19). There were no meaningful differences in the moisture content of the soil.

Table 13

Vicksburg Chemical Coated Potassium Nitrate Study
Initiated May 8, 1991
Clipping Weights in kilograms per square meter.
Mulitcote treatment applied May 8 and July 5 at 2 pounds of nitrogen per 1000 sq. feet. for a total of 4 pounds of nitrogen per 1000 sq. ft. KNO_3 miniprills and Urea treatments applied May 8, May 29, June 19, July 5, August 5 and August 27 to total of 4 pounds of nitrogen per 1000 sq. ft.

Treatment	6/10	7/23	8/27	9/20	11/13**
Multicote	.33A*	.45A	.30A	.06A	38.71 B
Mini-Prills	.27AB	.33 B	.24A	.05A	40.79 B
Urea	.29AB	.35 B	.26A	.06A	41.42 B
Check	.21 B	.09 C	.10 B	.02 B	46.88A

* Means followed by the same letter are not significantly different at the 5% level using the LSD range test.
** Clegg readings in g-max values.

Table 14
Manganese Sulfate Study, 1991
Creeping bentgrass green, HTRC
Quality ratings 1 = poor 9 = excellent
Treatments applied 5/24, 6/26, 7/10, and 7/30

Treatment	Rate OZ/M	5/25	5/29	6/26	7/11	7/15	7/31
MNSO4	2	7.8A*	6.5A	1.0**	5.2 B	6.2	6.8 BC
MNSO4	4	6.5 B	5.5 B	1.0	5.8 B	6.5	6.2 C
FeSO4	2	6.8 B	5.6 B	4.0	6.8A	8.0	7.9A
Check	---	6.2 B	6.0AB	1.0	6.0A	6.2	7.0 B

* Means followed by the same letter are not signficantly different at the 5% level suing the LSD range test.
** Burn rating 1 = no burn, 9 = dead

Table 15 Manganese Sulfate Study, 1991
Creeping bentgrass green, HTRC
Quality ratings 1 = poor 9 = excellent
Treatment applied 9/3

Treatment	Rate OZ/M	9/4	9/5	9/6	9/11
MNSO4	6	6.5 B*	6.2 B	6.6 B	6.5 B
MNSO4	8	7.1AB	6.8 B	7.0 B	6.6 B
FeSO4	2	7.8A	8.0A	8.0A	7.9A
Check	---	6.5 B	6.6 B	7.2 B	6.8 B

* Means followed by the same letter are not signficantly different at the 5% level suing the LSD range test.

Table 16

Isolite Topdressing Study, Volumetric Moisture Measurements
Measurements from the top 7.5 cm
Initiated July 2, 1991

Initial treatments were 18 cubic feet per 1000 sq. ft. of each topdressing material applied after double coring with .5 inch tines. 3 cubic feet of material per 1000 sq. ft. applied on three week intervals after intitial treatment. Final season treatment was 18 cubic feet of each topdressing material per 1000 sq. ft. Treatment dates were initial July 2, 3 week treatments: 7/22, 8/13, 9/3, 9/24. Final treatment applied 10/15.

Treatment	VMC 7/23	VMC 7/30	VMC 8/6	VMC 8/13	VMC 8/28
80% Sand 20% Isolite	23.7	25.8	24.0	20.9	24.9
90% Sand 10% Isolite	24.5	27.0	24.6	21.2	25.2
100% Sand	24.6	26.0	24.1	19.6	17.4

Table 17 Isolite Topdressing Study, Soil Temperatures
Initiated July 2, 1991

Initial treatments were 18 cubic feet per 1000 sq. ft. of each topdressing material applied after double coring with .5 inch tines. 3 cubic feet of material per 1000 sq. ft. applied on three week intervals after intitial treatment. Final season treatment was 18 cubic feet of each topdressing material per 1000 sq. ft. Treatment dates were initial July 2, 3 week treatments: 7/22, 8/13, 9/3, 9/24. Final treatment applied 10/15.

Treatment	2.5cm 8/20	2.5cm 8/27	5.0cm 8/27	5.0cm 10/17 10 am	5.0cm 10/17 3 pm	10 cm 10/17 10 am	10 cm 10/17 3 pm
80% Sand 20% Isolite	24.0	29.5	28.2	45.6	54.4	45.1	46.7
90% Sand 10% Isolite	23.9	29.2	28.1	46.0	54.6	45.4	47.7
100% Sand	23.8	29.2	28.1	45.9	54.5	45.4	47.6

Table 18

Isolite Topdressing Study, Root Weights and g-max readings
Root samples taken 9/17/91
Initiated July 2, 1991

Initial treatments were 18 cubic feet per 1000 sq. ft. of each topdressing material applied after double coring with .5 inch tines. 3 cubic feet of material per 1000 sq. ft. applied on three week intervals after intitial treatment. Final season treatment was 18 cubic feet of each topdressing material per 1000 sq. ft. Treatment dates were initial July 2, 3 week treatments: 7/22, 8/13, 9/3, 9/24. Final treatment applied 10/15.

Treatment	Root Weight kg m^{-1} 0-3 inch	Root Weight kg m^{-1} 3-6 inch	g-max July 30	g-max Nov. 13
80% Sand 20% Isolite	20.7	9.5	66.9	50.8
90% Sand 10% Isolite	7.7	10.5	68.6	50.8
100% Sand	13.6	2.6	70.0	48.4

Table 19

Precision Laboratories Paragon Wetting Agent Study
Soil Moisture Measurements, HTRC
Treatments Applied July 30, September 2, 1991

Treatment	Rate OZ/M	8/1 VMC-7.5	8/23 VMC-7.5	8/23 VMC-15	9/20 VMC-7.5	9/20 GMC-7.5
Paragon	0.5	24.80	33.53	26.45	31.50AB*	12.60AB
Paragon	1.0	24.40	34.22	27.73	30.70 B	11.80 B
Paragon	2.0	23.40	33.72	26.70	31.40AB	12.48AB
Paragon	4.0	24.83	34.28	26.83	31.20AB	13.90A
Paragon	8.0	23.88	35.10	25.80	30.98AB	12.65AB
Paragon	16.0	25.80	34.85	28.30	32.90A	13.50AB
AquaGro	4.0	24.42	33.10	26.72	30.92AB	12.43AB
LescoWet	0.5	25.80	34.53	27.85	31.95AB	12.60AB
Check	--	23.85	33.33	27.42	31.60AB	12.65AB

* Means followed by the same letter are not significantly different at the 5% level using the LSD mean separation test.

True localized dry spot conditions did not develop during the year on these plots so there was no measurable effect on correcting this condition. Wetting agents can cause significant phytotoxicity (Table 20), so applications should be applied when the turf is not under significant stress and should be watered in immediately. In these studies, applications were watered in shortly after application.

One interesting aspect of these studies is the effect of the wetting agents on evapotranspiration. A study was initiated on August 31 on Penncross creeping bentgrass green turf. Wetting agents were Paragon, AquaGro and LescoWet. While there is some variability in the data and there were no differences on some dates, there were several dates when wetting agent treatments significantly reduced evapotranspiration rates (Tables 21-24). Because there was some phytotoxicity from some treatments, it may be the reduced evapotranspiration occurred because of the injury to the turf leaves. However, differences were observed as long as 20 days after treatment on September 20 (Table 23). The significance of the reduction in evapotranspiration is still to be determined, so these studies should be continued.

MULCHING OF TREE LEAVES INTO KENTUCKY BLUEGRASS TURF

Regulations will soon prevent the disposal of yard wastes in landfills. One of the significant sources of yard wastes is tree leaves in the fall. Effects of using a mower to grind the leaves and return them to the turf has not been reported to our knowledge. With this in mind, a cooperative study with Bruce Branham was initiated in October, 1990 to evaluate this practice. Treatments included 2 rates of tree leaves: High (470 grams dry leaf material per 1000 sq. ft.), Low (235 grams), and No leaves. Four nitrogen treatments were included: 2 lbs. N per 1000 sq. ft. with 2/3 applied in the spring or fall; and 4 lbs. N at similar times. Quality rating data in Table 25 suggest there was no negative effect of tree leave treatments on turf from the first year of treatments. There were small responses to the N treatments (Table 26). This study will be continued to determine the long term effects on turf quality, soil tests and thatch accumulation.

Table 20 Precision Laboratories Paragon Wetting Agent Study
Phytotoxicity Ratings, 9=Dead, 1=No Damage, HTRC
Treatments Applied July 30, September 2, 1991

Treatment	Rate OZ/M	July 31	August 9	September 3	September 5
Paragon	0.5	1.25 C*	1.5 BC	1.0 F	1.0 E
Paragon	1.0	1.75 C	1.0 C	1.75 DEF	2.0 CDE
Paragon	2.0	1.5 C	1.5 BC	2.25 DE	1.75 CDE
Paragon	4.0	1.75 C	1.5 BC	3.25 C	2.75 C
Paragon	8.0	3.0 B	2.25 B	5.0 B	6.5 B
Paragon	16.0	4.25 A	3.25 A	7.0 A	9.0 A
AquaGro	4.0	4.25 A	3.25 A	2.5 CD	2.5 CD
LescoWet	0.5	2.0 B	1.5 BC	1.5 EF	1.25 DE
Check	---	1.25 C	1.25 C	1.0 F	1.0 E

* Means followed by the same letter are not significantly different at the 5% level using the LSD mean separation test.

Table 21 Precision Laboratories Paragon Wetting Agent ET Study
Initated August 31, 1991, HTRC
Evapotranspiration expressed in mm day^{-1}

Treatment	Rate OZ/M	9/1	9/2	9/3	9/4	9/5	9/6	9/7
Paragon	4.0	3.68	4.12AB*	4.04AB	3.84	3.09	3.70	4.38
Paragon	8.0	3.95	3.93 C	3.75 C	3.71	2.59	3.55	3.97
AquaGro	4.0	3.70	4.12AB	4.02AB	3.84	2.79	3.76	4.18
LescoWet	0.5	3.83	3.91 BC	3.98 B	3.64	2.70	3.56	3.74
Check	---	3.34	4.25A	4.18A	3.88	2.76	3.86	4.38

* Means followed by the same letter are not significantly different at the 10% level using the LSD mean separation test.

Table 22 Precision Laboratories Paragon Wetting Agent ET Study
Initated August 31, 1991, HTRC
Evapotranspiration expressed in mm day^{-1}

Treatment	Rate OZ/M	9/8	9/9	9/10	9/11	9/12	9/13	9/15
Paragon	4.0	1.95	2.82A*	0.95 C	2.09A	2.13	1.48	0.46 B
Paragon	8.0	1.76	2.22 C	1.02 BC	1.93 B	1.99	1.45	0.46 B
AquaGro	4.0	1.86	2.58AB	0.97 BC	2.04AB	2.05	1.47	0.42 B
LescoWet	0.5	1.82	2.41 BC	1.05AB	1.93 B	2.05	1.53	0.46AB
Check	---	1.91	2.77A	1.14A	2.11A	2.21	1.52	0.51A

* Means followed by the same letter are not significantly different at the 10% level using the LSD mean separation test.

Table 23 Precision Laboratories Paragon Wetting Agent ET Study
Initated August 31, 1991, HTRC
Evapotranspiration expressed in mm day^{-1}

Treatment	Rate OZ/M	9/16	9/17	9/18	9/19	9/20	9/21	9/22
Paragon	4.0	1.27	1.53	1.97 B*	1.72 BC	1.84AB	1.86	2.33
Paragon	8.0	0.90	1.90	1.84 B	1.71 BC	1.71 B	1.73	1.23
AquaGro	4.0	1.26	1.51	1.84 B	1.61 C	1.65 B	1.74	2.65
LescoWet	0.5	1.26	1.54	1.93 B	1.85AB	1.85AB	1.82	2.09
Check	---	1.32	1.68	2.16A	2.02A	2.03A	1.97	2.28

* Means followed by the same letter are not significantly different at the 10% level using the LSD mean separation test.

Table 24 Precision Laboratories Paragon Wetting Agent ET Study
Initated August 31, 1991, HTRC
Evapotranspiration expressed in mm day^{-1}

Treatment	Rate OZ/M	9/23	9/24	9/25	10/8	10/9	10/10	10/11
Paragon	4.0	1.37	0.55	0.98	3.93	3.38	2.05	1.06
Paragon	8.0	1.19	0.43	0.92	4.95	2.80	1.74	0.94
AquaGro	4.0	1.65	0.50	0.99	4.13	3.35	2.01	1.00
LescoWet	0.5	1.27	0.44	0.93	4.36	2.91	1.78	1.00
Check	---	1.3	0.74	0.94	4.07	2.81	1.81	1.05

Table 25 **MULCHING OF TREE LEAVES INTO KENTUCKY BLUEGRASS[1]**

QUALITY RATING 1-9[2] - AVERAGES FOR ALL FERTILIZER TREATMENTS

									CLIPPING WEIGHTS
LEAVES	**4/19/91**	**5/19/91**	**5/22/91**	**6/13/91**	**7/25/91**	**8/21/91**	**9/17/91**	**10/29/91**	**5/29/91**
470 gm/M	5.21	5.21	6.88	6.88	7.58	7.29	7.67	8.46	17.224
235 gm/M	5.17	5.17	6.54	6.96	7.79	7.25	7.96	8.58	17.06
NO LEAVES	5.13	5.13	6.96	7.04	7.63	7.29	7.75	8.5	19.756
LSD P=0.05	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

[1] Mulching was conducted in November 1990

[2] Quality was rated on a scale from 1-9 with 9 indicating exceptional turf, 6.5 classified as acceptable and 1 indicating a completely dead stand

Table 26 **MULCHING OF TREE LEAVES INTO KENTUCKY BLUEGRASS[1]**

QUALITY RATINGS 1-9[2] - AVERAGES FOR ALL RATES OF LEAF MULCH

FERTILIZER RATE + TIMING[3]	4/19/91	5/19/91	5/22/91	6/13/91	7/25/91	8/21/91	9/17/91	10/29/91	CLIPPING WEIGHTS 5/29/91
2 lb/M (SPRING)	4.61	4.61	7.11	7.11	7.39	6.89	7.56	8.22	18.646
2 lb/M (FALL)	5.44	5.44	6.39	6.39	7.28	6.67	7.44	8.11	12.203
4 lb/M (SPRING)	4.61	4.61	7.17	7.28	8	7.56	7.94	8.83	23.108
4 lb/M (FALL)	6	6	6.5	7.06	8	8	8.22	8.89	18.097
LSD P=0.05	**0.4**	**0.6**	**0.4**	**0.4**	**0.3**	**0.4**	**0.3**	**0.3**	**3.8**

[1] Mulching was conducted in November 1990
[2] Quality was rated on a scale from 1-9 with 9 indicating exceptional turf, 6.5 classified as acceptable and 1 indicating a completely dead stand
[3] Spring program included applications begining in April while ending in September, and Fall prograss began in June and ended in November