CHAPTER 3

SURVEY OF SOIL TESTING PROGRAMS FOR TURFGRASS AREAS

Methods and Materials

To determine differences among turfgrass soil testing programs, a questionnaire and soil samples were distributed to the following soil testing laboratories:

(1) The Pennsylvania State University, University Park, Pennsylvania

(2) Michigan State University, East Lansing, Michigan

(3) The Sewerage Commission, Milwaukee, Wisconsin

(4) Virginia Polytechnic Institute and State University, Blacksburg, Virginia

(5) University of Maryland, College Park, Maryland

(6) University of Rhode Island, Kingston, Rhode Island

(7) Rutgers University, New Brunswick, New Jersey.

The questionnaire included the following questions concerning soil sampling on turfgrass areas, laboratory procedures, and recommendations:

(1) What is the recommended sampling depth for establishment fertilization?

(2) What is the recommended sampling depth for maintenance fertilization?

(3) Is thatch removed from the soil sample before it is tested?

(4) What methods are used to determine available or extractable nutrients?

(5) What are the desired ranges or low, medium, and high ranges for soil levels of phosphorus and potassium?

(6) Is cation exchange capacity taken into account for recommending potassium?

(7) Are recommendations ever made for the application of magnesium to turfgrass?

(8) For the same soil and pH value, do the amounts of limestone recommended differ for maintenance and establishment?

(9) For the same soil and phosphorus value, do the amounts of phosphorus recommended differ for maintenance and establishment?

(10) For the same soil and potassium value, do the amounts of potassium recommended differ for maintenance and establishment?

(11) Do recommendations differ for different Kentucky bluegrass (Poa pratensis L.) varieties?

(12) Do recommendations differ for red fescue (Festuca rubra L.) versus Kentucky bluegrass?

(13) Do recommendations differ for bentgrass (Agrostis sp.) versus Kentucky bluegrass?

(14) Do recommendations differ for Poa annua versus bentgrass greens?

(15) Do recommendations differ for greens versus fairways?

Soil samples were taken to a depth of 7.6 cm from seven turfgrass areas which represented different fertility levels. Thatch was removed,

and the samples were air-dried, crushed, and sieved through a 2-mm screen. Each sample was thoroughly mixed prior to dividing into subsamples for the laboratories. The laboratories were asked to analyze each soil, report their results, and make recommendations for maintenance liming and fertilization of a 'Merion' Kentucky bluegrass golf tee.

Results and Discussion

Questionnaire Results. Although certain phases of the turfgrass soil testing programs were rather uniform, responses to the questionnaire indicated that important differences existed among laboratories in soil testing procedures and interpretations of soil test results. Although some of these differences might be attributed to geographic location, most were probably due to the lack of information specifically relating soil testing to turfgrass situations, and to differences in interpretation of the existing information.

Sampling Depth. Recommended sampling depths for establishment and maintenance fertilizer recommendations were somewhat uniform among laboratories (Table 22). Sampling depth for establishment was usually in the range of 15.3 to 20.3 cm, or plow layer depth, for the primary reason that lime and fertilizer are incorporated into the soil to approximately these depths for turfgrass establishment. However, Michigan State generally suggested a sampling depth of only 5.1 cm. Recommended sampling depth for maintenance fertilization was most commonly in the range of 5.1 to 7.6 cm. Rhode Island suggested a sampling depth of 10.2 cm, while Rutgers recommended the most extreme

Table 22. Recommended sampling depths by different laboratories for establishment and maintenance fertilizer recommendations.

Laboratory	Sampling Depth	
	Maintenance	Establishment
	cm	
Pennsylvania State Univ.	7.6	15.3
Michigan State Univ.	5.1	5.1
Milwaukee Sewerage Commission	5.1 + thatch	15.3 - 20.3
V.P.I. & S.U.	5.1 - 7.6	10.2 - 15.3
Univ. of Maryland	7.6	15.3
Univ. of Rhode Island	10.2	15.3
Rutgers Univ.	15.3 - 17.8	15.3 - 17.8

value, 15.3 to 17.8 cm; however, Rutgers was giving consideration to changing to a 7.6 or 10.2 cm sampling depth.

Thatch Inclusion. Only one laboratory, the Milwaukee Sewerage Commission, recommended that thatch be included with the sample for soil testing. Although at the time of the questionnaire there was no data which showed what effect the inclusion of thatch might have on measured soil fertility values, The Milwaukee Sewerage Commission believed that thatch traps nutrients, and thus should be tested. If thatch was included with the soil sample, some of the laboratories reported that it would be removed in the normal screening procedure rather than by physically separating it from the soil sample prior to processing.

Nutrient Extraction. The extracting solutions used by the various laboratories were for the most part consistent according to geographic location of the laboratories (Table 23). Laboratories located in coastal states (Rutgers University, University of Maryland, University of Rhode Island, and V.P.I. & S.U.) used the North Carolina Double Acid procedure for both P and K determinations. Penn State and Michigan State used Bray P1 for P determinations and 1N NH_4OAc for K determinations, the most commonly used extractants for these nutrients in the north central region (Jones, 1973). The Milwaukee Sewerage Commission was the only laboratory not utilizing extractants predominantly used in their region. They used the Hellige-Truog test for P and K determinations, although they were looking for other methods to determine P on alkaline soils.

Table 23. Extractants used by different laboratories for determining available phosphorus and potassium.

Laboratory	Extractant	
	Phosphorus	Potassium
Pennsylvania State Univ.	Bray P1	1N NH_4OAc
Michigan State Univ.	Bray P1	1N NH_4OAc
Milwaukee Sewerage Commission	Hellige-Truog	Hellige-Truog
V.P.I. & S.U.	Double Acid	Double Acid
Univ. of Maryland	"	"
Univ. of Rhode Island	"	"
Rutgers Univ.	"	"

Nutrient Ranges. All laboratories based fertilizer recommendations on individually established ranges of measured P and K levels; however, wide differences existed among laboratories for relative ranges of P and K (Tables 24 and 25 respectively). Ranges for P and K were categorized as low, medium, and high, or as very low, low, medium, high, and very high. Maximum values used by the different laboratories for ranges of P varied from 3 to 15 lb P/acre in the very low range, from 11 to 131 lb P/acre in the low range, from 38 to 300 lb P/acre in the medium range, and from any value greater than 38 lb P/acre to any value greater than 300 lb P/acre in the high range.

Differences also existed for the ranges of K; however, the magnitude of differences was not as great as with P. Maximum values for the ranges of K varied from 18 to 50 lb K/acre in the very low range, from 66 to 101 lb K/acre in the low range, from 116 to 176 lb K/acre in the medium range, from 234 to 310 lb K/acre in the high range, and from any value greater than 234 lb K/acre to any value greater than 310 lb K/acre in the very high range. The Pennsylvania State University based K recommendations on ranges of percent saturation of K rather than on actual levels. It was the only laboratory to directly take into account CEC in fertilizer recommendations. Percent saturation values of less than 2 percent were considered low and values greater than 5 percent were considered high. Although not considered in making recommendations, nutrient saturation ratios of 2:1 for Mg to K and 6:1 for Ca to Mg were reported as desirable (Harper and Hinish, 1973). Some laboratories indirectly took cation exchange capacity into account by increasing fertilizer recommendations for sandy soils.

Table 24. Ranges for soil phosphorus levels by different laboratories.

Laboratory	Ranges for phosphorus				
	Very low	Low	Medium	High	Very high
	lb P/acre				
Pennsylvania State Univ.	--	<131	<300	<500	--
Michigan State Univ.	<15	< 25	< 40	< 70	> 70
Milwaukee Sewerage Comm. *	--	--	200	--	--
V.P.I. & S.U.	< 3	< 11	< 38	<108	>108
Univ. of Maryland	< 7	< 22	< 59	<110	>110
Univ. of Rhode Island	--	< 80	<100	>100	--
Rutgers Univ.	--	< 22	< 59	> 59	--

* Reported only minimum level desirable.

Table 25. Ranges for available soil potassium by different laboratories.

Laboratory	Ranges for available potassium				
	Very low	Low	Medium	High	Very high
	lb K/acre				
Pennsylvania State Univ.*	--	<2% saturation	<5% saturation	>5% saturation	--
Michigan State Univ.	<50	<101	<175	<250	>250
Milwaukee Sewerage Comm. +	--	--	150-200	--	--
V.P.I. & S.U.	<18	< 74	<176	<310	>313
Univ. of Maryland	<42	< 66	<158	<234	>234
Univ. of Rhode Island	--	< 79	<116	--	--
Rutgers Univ.	--	< 66	<158	>158	--

* Bassd potassium recommendations on ranges of % saturation.

\+ Reported only minimum level desirable.

Magnesium Recommendations. Less attention was given to Mg recommendations than to those for either P or K recommendations. Only the Milwaukee Sewerage Commission recommended specific amounts of Mg to be applied. They also recommended applications of calcitic limestone or gypsum, depending on the soil pH, if they considered Mg too high in relation to Ca levels. Other laboratories, while not recommending specific amounts of Mg, would recommend use of soluble Mg or of dolomitic rather than calcitic limestone when Mg was low. Wide differences existed in minimum desired levels of soil Mg. Rutgers University recommended applications of Mg when soil levels fell below 30 lb Mg/acre, while the Milwaukee Sewerage Commission recommended Mg applications when soil levels fell below 800 lb Mg/acre. As in the case of P and K, differences in desired soil levels of Mg were probably strongly influenced by the strength of the extracting solutions used by the laboratories. However, these differences in desired soil nutrient levels may also reflect differences in interpretation of existing turfgrass fertility data.

Maintenance Versus Establishment Recommendations. All laboratories recommended different amounts of P and K for maintenance versus establishment fertilization. Only Penn State and V.P.I. did not recommend different amounts of lime for maintenance versus establishment, although V.P.I. did feel that such a distinction should be made. Two basic reasons were given for differences in lime and fertilizer recommendations for maintenance and establishment: (1) differences in the fertility requirements of seedling versus mature turfgrass plants, and (2) fertilizer is surface applied for maintenance

while being incorporated into the soil for turfgrass establishment. Laboratories usually recommended higher amounts of lime, P, and K for establishment than for maintenance.

Recommendations for Different Grasses. With the exception of the Milwaukee Sewerage Commission, all laboratories recommended different amounts of fertilizer, particularly N, for bentgrass versus bluegrass areas. Although the Milwaukee Sewerage Commission did not make such a distinction, they were not as concerned with the pH on hihgly buffered soils for bentgrass. Some discrepency did exist between laboratories in recommendations for bentgrass versus bluegrass areas. Although Penn State recommended more N and P for bentgrass in fairway and rough areas (no difference for tees), Rhode Island recommended less fertilizer as well as lower pH for bentgrass.

Less uniformity occurred for Kentucky bluegrass varieties. Three laboratories, V.P.I., Rhode Island, and Maryland, did not distinguish among Kentucky bluegrass varieties in making fertilizer recommendations. Michigan State recommended more N for Merion bluegrass and less for Delta, Park, and Kenblue bluegrasses than for other varieties. Both Rutgers and Penn State recommended more fertilizer for Merion bluegrass than for other bluegrass varieties.

Lower amounts of N were recommended for red fescue than for Kentucky bluegrass by all laboratories except Rhode Island; however, the Rhode Island would make such a distinction if the particular situation was known. Generally, none of the laboratories differentiated between red fescue and Kentucky bluegrass for P and K recommendations.

Only one laboratory, Rutgers, recommended different amounts of fertilizer for bentgrass versus Poa annua L. greens; however, they did not indicate which grass would receive more fertilizer.

Greens Versus Fairway Recommendations. Distinctions were made by all laboratories in fertilizer recommendations between greens and fairways. Fertilizer recommendations were higher for greens since clippings are constantly removed from greens and are not removed from fairways, and since greens usually receive more intensive irrigation than fairways.

Soil Test Results. The seven laboratories were asked to report soil test results as well as lime and fertilizer recommendations for the maintenance of a 'Merion' bluegrass tee area for each of the samples. Some confusion may arise in comparing soil test results from different laboratories due to differences in units in which results are reported. Several differences occurred among the laboratories surveyed. Measured soil P and K values were reported in lb P/acre and lb K/acre respectively by Michigan State, Rutgers, and the Milwaukee Sewerage Commission, and as lb P_2O_5/acre and lb K_2O/acre by V.P.I. and Maryland. Penn State reported P values in lb P/acre and K in both meq/100 g soil and percent saturation. Rather than reporting actual P and K values, Rhode Island reported the range, from very low to very high, into which the measured value fell.

Similar variation occurred in the method of reporting fertilizer and lime recommendations. Michigan State and V.P.I. gave P and K recommendations in lb P_2O_5/1000 ft^2 and lb K_2O/1000 ft^2 respectively.

Rhode Island, Maryland, and Rutgers gave recommendations for P and K in lb/1000 ft^2 of fertilizer of a specific N-P_2O_5-K_2O ratio. Differences in recommendations were accomplished by changing the amount and/or ratio of recommended fertilizer. Penn State gave recommendations in lb P_2O_5/1000 ft^2 and lb K_2O/1000 ft^2 or in lb/1000 ft^2 of fertilizer with a specific fertilizer analysis, depending on the type of turfgrass area. The Milwaukee Sewerage Commission used several methods for reporting fertilizer recommendations. P recommendations were made in lb/1000 ft^2 of fertilizer with a specific fertilizer analysis, or in lb/1000 ft^2 of superphosphate or triple superphosphate. K recommendations were made in lb/1000 ft^2 of fertilizer with a specific analysis or in lb/1000 ft^2 of sulfate or muriate of potash. With the exception of Penn State, which made lime recommendations in lb/acre, all laboratories made lime recommendations in lb/1000 ft^2.

To simplify comparisons among laboratories, all reported P values have been converted to lb P/acre, K values to lb K/acre, and fertilizer and lime recommendations to lb P/1000 ft^2, lb K/1000 ft^2, and lb limestone/1000 ft^2.

Particle size analysis and cation exchange capacity of each of the samples were determined before distributing the samples to the laboratories. Results are shown in Table 26.

Although variation occurred among laboratories in reported values for pH and available soil P and K (Tables 27, 28, and 29 respectively), results were very similar for laboratories using common extractants. Penn State and Michigan State, using the same extractants

Table 26. Textural class and cation exchange capacity of soils distributed to different laboratories.

Soil Number	Particle Size Analysis* Sand	Silt	Clay	Textural Class	Cation Exchange Capacity +
	%				meq/100 g
1	19.6	50.2	30.2	silty clay loam	10.8
2	19.0	44.8	36.2	silty clay loam	10.8
3	25.2	41.6	33.2	clay loam	10.5
4	22.4	30.4	47.2	clay	8.6
5	24.8	42.0	33.2	clay loam	9.7
6	28.8	38.0	33.2	clay loam	10.4
7	27.8	35.6	36.6	clay loam	9.3

* Determined by method of Bouyoucus (1962).

\+ Determined by The Pennsylvania State University Soil Testing Laboratory.

Table 27. The pH of different soils as measured by various laboratories.

Laboratory	pH							
	Soil 1	Soil 2	Soil 3	Soil 4	Soil 5	Soil 6	Soil 7	Avg.
Pennsylvania State Univ.	6.5	5.7	5.6	6.7	5.8	6.5	6.5	6.2
Michigan State Univ.	6.7	5.8	5.8	6.6	5.8	6.4	6.2	6.2
Milwaukee Sewerage Comm.	6.6	5.5	5.5	6.3	5.7	6.4	6.2	6.0
V.P.I. & S.U.	6.5	5.5	5.4	6.4	5.5	6.2	6.1	5.9
Univ. of Maryland	6.4	5.5	5.4	6.3	5.5	6.2	6.0	5.9
Univ. of Rhode Island	6.4	5.7	5.6	6.2	5.7	6.2	6.1	6.0
Rutgers Univ.	6.3	5.6	5.4	6.3	5.5	6.2	6.0	5.9

Table 28. Available phosphorus in different soils as measured by various laboratories.

Laboratory	Available phosphorus						
	Soil 1	Soil 2	Soil 3	Soil 4	Soil 5	Soil 6	Soil 7
	lb P/acre						
Pennsylvania State Univ.	378	42	410	14	36	318	112
Michigan State Univ.	306	30	384	20	50	384	119
Milwaukee Sewerage Comm.	235	10	315	Trace	Trace	305	80
V.P.I. & S.U.	>121*	28	>121	15	12	>121	95
Univ. of Maryland	259	20	317	11	20	308	81
Univ. of Rhode Island*	Medium	Very Low	Medium	Very Low	Very Low	Medium	Low
Rutgers Univ.	216	25	315	10	26	318	94

* Did not report actual value, only range.

Table 29. Available potassium in different soils as measured by various laboratories.

Laboratory	Available potassium						
	Soil 1	Soil 2	Soil 3	Soil 4	Soil 5	Soil 6	Soil 7
	lb K/acre						
Pennsylvania State Univ.	538	218	117	164	218	195	515
Michigan State Univ.	531	229	137	183	217	171	480
Milwaukee Sewerage Comm.	265	90	75	105	90	80	240
V.P.I. & S.U.	313	142	86	116	142	96	288
Univ. of Maryland	374	157	154	129	124	124	341
Univ. of Rhode Island*	Very high	Medium	Low	Medium	Medium	Low	Very High
Rutgers Univ.	327	167	126	157	154	151	400

* Did not report actual value, only range.

for P and K, usually reported higher levels of both P and K as well as higher pH values than the other laboratories. The Milwaukee Sewerage Commission usually reported pH and P values similar to the coastal laboratories, while reporting consistently lower values for K. It would appear, due to the similarity in results among laboratories using common extractants, that the laboratory determination of available nutrients is one of the soundest phases of the turfgrass soil testing programs.

Despite the uniformity in reported soil test values, wide differences in lime and fertilizer recommendations existed among laboratories, even among those using the same extractants. Lime recommendations (Table 30) varied by as much as 100 lb/1000 ft^2 for the same soil when the pH was above 6.0, and by as much as 180 lb/1000 ft^2 when the pH was below 6.0. Rhode Island, V.P.I., and Michigan State tended to recommend lower amounts of lime than the other laboratories. Although Penn State recommended lime at any pH value of 6.7 or less, Michigan State did not recommend any lime at pH values as low as 5.8. Maryland and V.P.I. did not recommend lime until pH dropped to values of 6.3 and 6.1 respectively.

P recommendations (Table 31) varied as much as 2.2 lb P/1000 ft^2 for the same soil. As might be expected, recommendations varied to a greater degree on soils low in P. Penn State and the Milwaukee Sewerage Commission usually recommended the highest amounts of P. In contrast to recommendations ranging from 0 to 2.4 lb P/1000 ft^2 by Penn State, Rhode Island recommended 0.4 lb P/1000 ft^2 for all seven soils.

Table 30. Lime recommendations by different laboratories for the maintenance of a Merion bluegrass tee area.

Laboratory	Lime recommendations						
	Soil 1	Soil 2	Soil 3	Soil 4	Soil 5	Soil 6	Soil 7
	lb/1000 ft^2						
Pennsylvania State Univ.	50	125	125	50	100	50	50
Michigan State Univ.	0	0	0	0	0	0	0
Milwaukee Sewerage Comm.	30	100	100	100	100	50	100
V.P.I. & S.U.	0	80	90	0	80	0	30
Univ. of Maryland	0	165	180	30	165	50	85
Univ. of Rhode Island	25	70	70	35	70	35	25
Rutgers Univ.	40	80	120	40	120	40	50

Table 31. Phosphorus recommendations by different laboratories for the maintenance of a Merion bluegrass tee area.

Laboratory	Phosphorus recommendations						
	Soil 1	Soil 2	Soil 3	Soil 4	Soil 5	Soil 6	Soil 7
	lb P/1000 ft^2						
Pennsylvania State Univ.	0.0	2.4	0.0	2.4	2.4	0.7	1.5
Michigan State Univ.	0.0	0.9	0.0	1.3	0.4	0.0	0.0
Milwaukee Sewerage Comm.	0.0	1.8	0.0	2.2	2.2	0.0	2.2
V.P.I. & S.U.	0.0	0.9	0.0	0.9	0.9	0.0	0.4
Univ. of Maryland	0.0	1.0	0.0	1.1	1.1	0.0	0.0
Univ. of Rhode Island	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Rutgers Univ.	0.4	1.1	0.4	2.6	0.9	0.4	0.4

Similar but larger variation occurred for K recommendations (Table 32). Recommendations varied by as much as 5.0 lb K/1000 ft^2, with a minimum of 2.5 lb K/1000 ft^2 occurring. Penn State and the Milwaukee Sewerage Commission usually recommended the highest amounts of K. On soils low in K, Rutgers and Rhode Island usually recommended the lowest amounts of K; however, both laboratories made recommendations for soils high in K for which several of the other laboratories did not recommend any K.

These differences among laboratories in lime and fertilizer recommendations for the same soil could have been the result of several factors. Differences in the buffering capacity and the ability to fix P and K by the predominant soils in each area, as well as climatic differences, could have had a definite effect. Differing approaches to fertilization, such as applying enough to meet only the minimal needs of the turfgrass plant, applying more than is required to insure against the possibility of a deficiency, or using a greater amount on the assumption that clippings will be removed, could also account for some of the differences in recommendations. However, the basic reason for the differences may be the dependence of turfgrass soil testing programs on research done in areas such as pasture or forage crops, and on turfgrass fertility research which was not specifically designed to relate turfgrass response to different levels of fertilization on soils with different inherent fertility levels.

Table 32. Potassium recommendations by different laboratories for the maintenance of a Merion bluegrass tee area.

Laboratory	Potassium recommendations						
	Soil 1	Soil 2	Soil 3	Soil 4	Soil 5	Soil 6	Soil 7
	lb K/1000 ft^2						
Pennsylvania State Univ.	0.0	2.5	4.6	3.3	2.5	3.3	0.0
Michigan State Univ.	0.8	1.7	2.5	1.7	1.7	2.5	0.0
Milwaukee Sewerage Comm.	2.5	5.8	3.7	3.7	3.7	3.7	2.5
V.P.I. & S.U.	0.0	2.5	2.5	2.5	2.5	2.5	1.7
Univ. of Maryland	0.0	2.0	2.7	2.0	2.0	2.7	0.0
Univ. of Rhode Island	1.7	0.8	1.7	0.8	0.8	1.7	0.8
Rutgers Univ.	0.7	1.2	1.2	1.2	1.7	1.2	0.7

Summary and Conclusions

A questionnaire and soil samples were distributed to seven soil testing laboratories to determine differences among turfgrass soil testing programs. Responses to the questionnaire indicated that although certain phases of turfgrass soil testing programs were uniform among laboratories, significant differences did exist.

Recommended sampling depth was usually in the range of 15.3 to 20.3 cm or plow layer depth for turfgrass establishment and 5.1 to 7.6 cm for turfgrass maintenance. Only one of the seven laboratories, the Milwaukee Sewerage Commission, recommended that thatch be included with the soil sample.

Extracting solutions for P and K determinations were generally uniform on a regional basis.

Fertilizer recommendations by the laboratories were based on ranges of P and K. Ranges were classified as low, medium, and high, or as very low, low, medium, high, and very high. Maximum values used by the various laboratories for each category, especially for P, showed a wide variation. Penn State based K recommendations on ranges of percent potassium saturation rather than on actual levels, and was the only laboratory to directly take CEC into account in making potassium recommendations. Less attention was given by the laboratories to Mg recommendations than to either P or K recommendations.

The laboratories usually recommended higher amounts of lime, P, and K for establishment than for maintenance.

Most of the laboratories recommended different amounts of fertilizer, particularly nitrogen, for bentgrass versus bluegrass and

red fescue versus bluegrass. However, only three of the laboratories made distinctions among Kentucky bluegrass varieties in making fertilizer recommendations and only one laboratory made a distinction between bentgrass versus Poa annua L. greens. All of the laboratories made higher fertilizer recommendations for greens than for fairways.

Analysis of the soil samples by the laboratories showed that although laboratories using the same extractants reported similar P and K values, wide differences existed in fertilizer recommendations. Fertilizer recommendations for the same soil varied by as much as 2.2 lb P/1000 ft^2 and 5.0 lb K/1000 ft^2, with a minimum of 2.5 lb K/1000 ft^2 occurring. Lime recommendations for the same soil varied by as much as 180 lb/1000 ft^2.

Differences among laboratories in fertilizer recommendations could have been due to several factors such as differences in soils and climate and differing approaches to fertilization. However, the basic reason is probably the lack of data specifically relating soil testing to turfgrass areas. One of the primary goals of future turfgrass fertility research should be, therefore, to conduct field calibration studies relating turfgrass response to soil test values and to application of different rates of nutrients to soils with different inherent fertility.