

1999 RUTGERS Turfgrass Proceedings



THE NEW JERSEY TURFGRASS ASSOCIATION

In Cooperation With

RUTGERS COOPERATIVE EXTENSION
NEW JERSEY AGRICULTURAL EXPERIMENT STATION
RUTGERS, THE STATE UNIVERSITY OF NEW JERSEY
NEW BRUNSWICK

Distributed in cooperation with U.S. Department of Agriculture in furtherance of the Acts of Congress of May 8 and June 30, 1914. Cooperative Extension work in agriculture, home economics, and 4-H. Zane R. Helsel, Director of Extension. Rutgers Cooperative Extension provides information and educational services to all people without regard to sex, race, color, national origin, disability or handicap, or age. Rutgers Cooperative Extension is an Equal Opportunity Employer.

1999 RUTGERS TURFGRASS PROCEEDINGS

of the

**New Jersey Turfgrass Expo
December 7-9, 1999
Trump Taj Mahal
Atlantic City, New Jersey**

**Volume 31
Published July, 2000**

The Rutgers Turfgrass Proceedings is published yearly by the Rutgers Center for Turfgrass Science, Rutgers Cooperative Extension, and the New Jersey Agricultural Experiment Station, Cook College, Rutgers University in cooperation with the New Jersey Turfgrass Association. The purpose of this document is to provide a forum for the dissemination of information and the exchange of ideas and knowledge. The proceedings provide turfgrass managers, research scientists, extension specialists, and industry personnel with opportunities to communicate with co-workers. Through this forum, these professionals also reach a more general audience, which includes the public. Articles appearing in these proceedings are divided into two sections.

The first section includes lecture notes of papers presented at the 1999 New Jersey Turfgrass Expo. Publication of the New Jersey Turfgrass Expo Notes provides a readily available

source of information covering a wide range of topics. The Expo Notes include technical and popular presentations of importance to the turfgrass industry.

The second section includes research papers containing original research findings and reviews covering selected subjects in turfgrass science. The primary objective of this section is to facilitate the timely dissemination of original turfgrass research for use by the turfgrass industry.

Special thanks are given to those who have submitted papers for this proceedings, to the New Jersey Turfgrass Association for financial assistance, and to those individuals who have provided support to the Rutgers Turf Research Program at Cook College - Rutgers, The State University of New Jersey.

Dr. Ann B. Gould, Editor
Dr. Bruce B. Clarke, Coordinator

UPDATE ON ROOT ZONE MIXTURE RESEARCH FOR PUTTING GREENS

James A. Murphy, Josh Honig, T. J. Lawson, Hiranthi Samaranayake,
Stephanie L. Murphy, Bruce B. Clarke, and Miguel Sosa¹

The USGA guidelines for construction of golf putting greens are often difficult and expensive to achieve due mainly to limited availability and relatively high cost of suitable materials. As a result, there is a need to understand the consequences of implementing various construction specifications that may or may not conform to USGA guidelines. Moreover, the microenvironment in which a putting green is constructed is likely to affect turf performance. This research project was designed to increase our understanding of these issues by assessing the changes that occur in root zone performance over time. A better understanding of root zone performance also will provide the information needed to develop future studies of management practices directed towards minimizing resource and maintenance inputs.

The overall goal of this research project is to assess the potential of various root zone mixes to reduce management and resource inputs through the monitoring of the physical, chemical, and biological changes that occur as root zones (greens) mature. Our objectives are to investigate aspects of root zone construction that affect putting green performance in two microenvironments. These aspects include 1) pore size distribution (sand particle size distribution) and depth of root zone mix, and 2) organic (peat, compost) materials, inorganic materials, soil, and other additives commonly used for amending sand root zones.

MATERIALS AND METHODS

- Preliminary evaluations of root zone mixes were conducted in the laboratory.
- Field plots were constructed in two locations (microenvironments) in 1997 (four replications per location).
- Six sand sizes, conforming to and finer than USGA guidelines, were amended with sphagnum peat at a 9:1 volume ratio (Table 1) and a seventh sand was used unamended. The three coarsest sands were used to construct root zone plots with depths less than 12 inches.
- A silt loam and two organic and two inorganic materials were used to amend a USGA-sized sand at varying volume ratios in both microenvironments (Table 2).
- In the poor air circulation microenvironment (lower location), an additional four organic and four inorganic amendments were studied (Table 6).
- All plots were seeded on 31 May 1998 with L-93 creeping bentgrass at 1 lb/1000 ft².
- Mowing was initiated on 4 July 1998 and maintained at 1/2 inch for 1998. A mowing height of 1/8 inch was achieved on 25 May 1999.
- Plots were aerated with 3/8 inch hollow tines in April 1999.
- Plots were fertilized for 1999 as presented in Table 3.
- Irrigation was applied based on Class A pan evaporation and root zone water content.
- Curative applications of pesticides permitted the evaluation of low to moderate pest activity.

¹ Associate Extension Specialist in Turfgrass Management, Graduate Assistant, Soils and Plants Technician, Research Scientist, Director, Rutgers Cooperative Extension Soil Testing Laboratory, Extension Specialist in Turfgrass Plant Pathology, and Research Assistant, respectively, New Jersey Agricultural Experiment Station, Cook College, Rutgers, The State University of New Jersey, New Brunswick, NJ 08901-8520.

- Data were collected for visual quality, disease activity, root zone fertility, clipping nutrient content, root zone physical properties, and irrigation requirements.
- Evaluation of root zone mixes in the field was accomplished using an experimental layout of randomized complete block design with four replications in two locations (microenvironments). The microenvironments varied primarily with respect to evaporative demand (air circulation).

RESULTS AND DISCUSSION

Turf Quality

Location (Microenvironment) Effect

- Monitoring of wind velocity, soil temperature, and evaporation from a Class A pan indicated that the lower location had lower wind velocities and evaporation of water and higher soil temperatures than the upper location (data not shown).
- Plots in the lower (poor air circulation) location had better turf quality than the upper location in May and June (Tables 4 and 5). This response reversed in August and September; plots in the upper location had better quality than plots in the lower location. The initial decline in quality in the lower location relative to the upper location was observed in late July when the detrimental effects of poor air circulation would be expected.
- It is apparent from the quality data that the environmental conditions in the lower location enhanced spring performance of the creeping bentgrass. Presumably, this is due to warmer soil temperatures in the lower location that create better growing conditions in winter and early spring relative to the upper location.
- This relatively sudden (over one month) reversal in performance between open and enclosed microenvironments may be a contributing factor to the difficulties experienced by many superintendents in managing enclosed putting greens. During the initial part of the growing season, enclosed putting greens may appear healthier and more vigorous than

openly exposed putting greens. Good performance during this time may encourage greens committees and turf managers to delay the implementation of important management practices that could minimize stress on these greens later in the season.

Sand Size Distribution Study

- The two finest sands in the sand size distribution study had the best performance during 1999 (Table 4). These finer sands do not conform to the sand size guidelines of the USGA Green Section.
- The more coarse sand size distribution treatments usually resulted in poorer turf performance.
- Reduced root zone depth generally improved turf performance; this response was most evident as the sand size distribution became coarser.

Amendment Study Over Two Locations

- There was a significant interaction between location and root zone treatment throughout the season (Table 5). The interaction in April indicated that all sphagnum-amended plots, the non-amended sand, and the 10% reed sedge amended plots had better quality in the lower location than in the upper location. All other treatments were similar between the two locations. Other interactions in the spring reflected better performance of some root zone treatments in the lower location compared to the upper location. The interaction in August indicated that two treatments, the non-amended sand and the 5% sphagnum amended plots, were capable of maintaining good turf quality in the lower location as well as the upper location; turf quality for the other treatments declined in the lower location.
- Identifying this variation in turf performance due to microenvironment and root zone construction is important because putting greens are built in widely varying microenvironments. A better understanding of the variation in turf performance over location will help both turf managers and golf competitors struggling with

inconsistencies in turf quality on putting greens.

- Turf performance among root zone treatments was more consistent in the upper location in August and September compared to the lower location, although treatment differences did exist in the upper location. More uniform treatment performance in the upper (exposed) location is likely due to the better growing environment of this location. The greater stress conditions of the lower location caused a more definitive separation of treatments.
- Amendment rate effects on turf performance were only significant in the lower location during August and September and indicated that higher rates of soil and sphagnum peat decreased quality. The quadratic rate response observed with reed sedge peat indicated that amending with reed sedge peat at both the 5 and 10% rate produced lower turf quality than the non-amended sand.
- Root zones amended with 20% soil and 10% Profile in the lower location had the poorest turf performance by August and September of 1999 (Table 5).
- The inorganic amendments ZeoPro and Profile did not produce a performance advantage over organic amendments in 1999. In fact, when differences were evident these amendments had lower turf quality than other amendments.

Amendment Study In Lower Location

- As mentioned above, the amendment study in the lower location included another four organic and four inorganic amendments. The performance ranking of all amendment treatments in the lower location is listed in Table 6.
- Two of the top five ranking amendment treatments, 20% AllGro with AT Sales sand and 10% Kaofin, do not conform to USGA guidelines.
- The 100% soil treatment did not produce satisfactory turf. Turf grown on the loamy soil suffered from severe scalping caused by non-uniform settling. In addition, regular hand-

weeding of *Poa annua* was required for this treatment.

- The 10% Greenschoice and 10% ZeoPro + micros treatments suffered from severe localized dry spot development that strongly detracted from turf performance.

Pest Activity

- The upper location had the greatest amount of dollar spot activity (Tables 8 and 10).
- Cutworm feeding damage on the sand size distribution study was greatest in the lower location (Table 8).
- Dollar spot, pink snow mold, and yellow patch were more active in the upper (exposed) location than in the lower location in 1999 (Tables 7 to 10).
- Plots amended with Profile and Greenschoice were the most severely affected by pink snow mold (Table 9). Plots amended with 20% AT Sales AllGro, 5% Kaofin, 20% sphagnum, and 100% soil had the least pink snow mold activity.
- A higher amending rate of soil, sphagnum, and reed sedge appeared to suppress disease severity of bentgrass dead spot (caused by *Ophiosphaerella agrostis*), especially in the upper location (Table 10).
- Bentgrass dead spot was most severe on 100% sand and 10% Profile plots in the upper location. The activity of this disease was higher for plots amended with ZeoPro in the upper location than in the lower location. 5% reed sedge was the only treatment to have greater dead spot activity in the lower location.
- Further evaluation is needed over time to understand the relative importance (consistency) of these interactions.

Plan of Work for 2000

- Samples of clippings, roots, and soil have been collected for assessment of rooting and soil physical and chemical properties in 1999. Samples are currently being processed and analyzed.

- Sampling of clippings, roots and soil will be continued in 2000.
- Monitoring of humidity, wind velocity, and air and soil temperatures will be continued in 2000.
- Turf performance data for quality, disease, stress, and other characteristics will be collected.

ACKNOWLEDGMENTS

This work was supported by the Rutgers Center for Turfgrass Science, the New Jersey

Agricultural Experiment Station, State and Hatch Act funds, other grants, and gifts. Additional support was received from the Tri-state Turf Research Foundation, the United States Golf Association, the Golf Course Superintendents Association of America, the New Jersey Turfgrass Association, the New Jersey Turfgrass Foundation, the Golf Course Superintendents Association of New Jersey, U.S. Silica (formerly Unimin, formerly Morie Sand), Dawson Corporation, Koonz Sprinkler Supply, AT Sales, and the New Jersey State Golf Association.

Table 1. Porosity and fertility of root zone treatments used in the sand size distribution study.

Sand Size	Porosity		pH	P	K	Ca	Mg	O.M. ¹
	Air	Capillary						
	------(%)-----		-----lb/acre-----					
Coarse USGA	29.5	7.3	6.7	27	6	310	68	0.4
Medium USGA	22.2	14.0	7.0	36	13	323	81	0.4
Fine USGA	17.5	17.6	7.1	33	14	278	77	0.4
Extra Fine	11.8	25.1	7.2	33	14	311	83	0.5
Mason	12.8	26.9	7.0	34	12	305	78	0.4
CM 340	24.2	13.9	7.1	38	14	339	87	0.4

¹Organic matter content as determined by combustion

Table 2. Porosity and fertility of root zone treatments used in the amendment study.

Sand Size	Porosity		pH	P	K	Ca	Mg	O.M. ¹
	Air	Capillary						
	------(%)-----		-----lb/acre-----					
Sand	15.5	23.6	7.2	39	16	169	56	<0.1
Soil 2.5%	18.2	21.4	6.8	55	19	198	60	0.1
Soil 5%	15.0	21.1	6.7	55	20	240	60	0.2
Soil 20%	13.0	23.1	6.9	86	54	462	111	0.4
Reed Sedge 5%	15.7	22.2	6.8	34	14	372	72	0.4
Reed Sedge 10%	7.4	32.9	6.7	31	13	601	93	0.7
Sphagnum 5%	15.0	21.3	7.0	44	16	245	72	0.2
Sphagnum 10%	16.7	24.1	7.0	42	15	336	92	0.4
Sphagnum 20%	11.8	33.1	6.8	33	14	474	132	0.8
Profile 10%	22.1	21.2	7.2	52	94	600	78	0.1
ZeoPro 10%	22.8	19.8	6.4	83	153	538	96	0.3

¹Organic matter content as determined by combustion

Table 3. Fertilization schedule and nitrogen (N) rate used for sand size distribution and amendment root zone studies in 1999.

Date	-----Fertilizer Analysis-----			-----N Rate-----	
	N	P ₂ O ₅	K ₂ O	g/m ²	lb/1000 ft ²
7 May	18	4	10	4.8	0.99
17 May	16	4	8	1.5	0.30
21 May	16	4	8	1.6	0.33
28 May	16	4	8	1.6	0.32
1 June	16	4	8	1.0	0.20
14 June	16	4	8	0.5	0.10
21 June	16	4	8	0.9	0.19
29 June	16	4	8	1.3	0.27
12 August	15.5	0	0	1.2	0.25
28 August	16	4	8	1.0	0.21
10 September	20	20	20	1.2	0.25
19 September	15.5	0	0	1.2	0.25
25 September	46	0	0	1.2	0.25
3 October	46	0	0	0.6	0.12
9 October	46	0	0	1.2	0.25
17 October	46	0	0	1.2	0.25
22 November	46	0	0	1.9	0.38
	Total N =			23.9	4.91

Table 4. Turf quality ratings of L-93 creeping bentgrass grown on root zones varying by sand size distribution in two locations in 1999.

Source of variation	-----Rating Date-----							
	April 19	May 18	May 29	June 14	July 10	July 21	Aug. 6	Sept. 4
ANOVA								
Location	NS ¹	**	NS	**	NS	NS	***	***
Treatment	***	***	*	***	***	***	***	***
Location x Treatment	NS	NS	NS	NS	NS	NS	NS	NS
Location								
	-----Rating (9 = best)-----							
Lower Location	7.4	7.3	5.6	7.5	7.8	7.6	6.2	6.2
Upper Location	7.3	7.1	5.8	7.2	7.7	7.9	7.5	7.1
Sand Size Treatment²								
Fine USGA	7.3	7.3	5.5	7.4	8.0	7.6	7.0	6.3
Fine USGA 10 inch	8.0	7.3	5.9	7.5	8.1	7.5	7.3	7.0
Medium USGA	7.6	6.5	5.6	7.0	7.5	7.6	6.6	5.8
Medium USGA 9 inch	7.6	7.8	6.1	7.5	8.1	8.0	7.0	6.9
Coarse USGA	6.3	6.0	4.8	6.3	6.8	6.8	5.3	4.5
Coarse USGA 8 inch	7.3	6.6	5.6	7.0	6.9	7.4	6.5	6.4
Coarse USGA 7 inch	7.4	6.9	5.8	7.0	7.0	7.4	6.6	6.3
Extra Fine	7.9	8.5	5.9	8.3	8.8	8.9	7.1	7.6
Mason	7.8	8.6	6.5	8.6	8.9	8.6	7.1	7.3
CM 340	7.0	6.8	5.1	7.3	7.6	7.8	6.9	6.6
CM 4-1	5.9	6.5	5.4	6.3	7.1	7.0	6.8	7.3

(Continued)

Table 4 (continued).

Source of variation	-----Rating Date-----							
	April 19	May 18	May 29	June 14	July 10	July 21	Aug. 6	Sept. 4
LSD	0.5	0.6	0.9	0.6	0.6	0.6	0.5	0.6
CV%	6.0	8.2	14.5	8.3	7.6	8.0	6.9	8.8
Treatment Contrasts								
Fine vs. Medium	NS	*	NS	NS	NS	NS	NS	NS
Fine vs. Coarse	***	***	NS	***	***	*	***	***
Fine vs. Extra Fine	**	***	NS	**	*	***	NS	***
Fine v.s Mason	*	***	*	***	**	**	NS	**
Extra Fine vs. Mason	NS	NS	NS	NS	NS	NS	NS	NS
Fine vs. CM 340	NS	NS	NS	NS	NS	NS	NS	NS
Fine vs. CM 4-1	NS	*	NS	***	**	*	NS	**
Fine 12 inch vs. Fine 10 inch	**	NS	NS	NS	NS	NS	NS	*
Medium 12 inch vs. Medium 9 inch	NS	***	NS	NS	*	NS	NS	***
Coarse 12 inch vs. Coarse 7 inch and 8 inch	***	*	NS	*	NS	NS	*	***
Coarse 7 inch vs. Coarse 8 inch	NS	NS	NS	NS	NS	NS	NS	NS

¹NS = not significant; * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$

²Depth of root zone is 12 inches except for specified treatments

Table 5. Turf quality of L-93 creeping bentgrass grown on amended root zones in two microenvironments in 1999.

Source of variation	Rating Date															
	April 19	May 18	May 29	June 14	July 10	July 21	Aug. 6	Sept. 4								
ANOVA																
Location	***1	**	**	***	NS	**	***	**								
Treatment	***	***	***	***	***	***	***	***								
Location x Treatment	**	***	***	**	NS	*	***	***								
Location																
	Rating (9 = best)															
Lower Location	7.4	7.3	6.0	7.4	7.4	7.2	5.8	5.8								
Upper Location	6.9	6.7	5.4	6.7	7.6	7.8	7.2	6.7								
Treatments																
	Location															
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Both (Avg.)	Lower	Upper	Lower	Upper	Lower	Upper	
Sand	6.8	6.0	7.0	5.3	5.8	4.0	7.3	5.8	7.1	7.0	7.5	6.8	7.5	6.5	7.0	
Soil 2.5%	6.8	6.5	7.5	6.8	5.5	5.3	6.8	6.5	7.0	7.3	8.0	6.0	7.0	6.3	7.0	
Soil 5%	7.3	6.8	7.5	6.5	6.8	5.5	7.8	7.0	7.5	6.8	8.3	5.5	7.8	5.8	7.5	
Soil 5% on Subgrade	7.0	6.8	7.5	6.8	6.3	5.3	7.5	6.3	7.4	7.5	8.0	6.3	7.8	6.3	7.3	
Soil 20%	5.5	6.0	6.3	7.3	5.3	6.3	6.8	7.0	7.0	6.5	8.0	4.3	7.0	4.5	6.8	
Sphagnum 5%	8.0	6.5	7.8	6.3	6.5	5.3	7.8	6.3	7.6	8.0	7.8	7.0	7.3	7.0	6.8	
Sphagnum 10%	8.5	7.0	8.0	6.8	6.5	5.5	8.0	6.5	8.3	7.5	7.5	6.5	7.3	6.3	6.3	
Sphagnum 20%	9.0	8.0	8.0	8.0	7.0	6.8	8.8	8.8	8.4	8.0	8.5	6.0	7.0	6.0	6.5	
Dakota 5%	8.0	7.8	7.5	7.0	6.0	5.5	7.5	7.5	7.8	7.0	8.0	5.8	7.5	5.3	7.0	
Dakota 10%	8.8	7.8	7.5	7.8	5.8	6.5	8.0	8.5	8.9	8.3	8.5	6.3	7.3	6.0	6.5	
Profile 10%	6.8	6.8	6.0	5.8	4.3	3.8	5.8	5.0	6.8	6.3	6.5	4.5	6.0	4.0	5.3	
ZeoPro 10%	7.0	7.0	6.8	6.0	6.0	5.0	6.8	5.8	6.8	6.5	7.5	5.3	7.0	5.3	6.8	
LSD		0.5		0.8		0.8		0.8	1.2		0.7		0.7		0.7	
CV%		7.0		8.2		9.4		8.4	7.7		6.5		7.5		7.9	

(Continued)

Table 5 (continued).

Source of variation	Rating Date								Location							
	April 19		May 18		May 29		June 14		July 10		July 21		Aug. 6		Sept. 4	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Both (Avg.)	Lower	Upper	Lower	Upper	Lower	Upper	
Linear Contrasts																
Soil Rate (0 to 20%)	***	NS	**	***	NS	***	NS	*	NS	NS	NS	***	NS	***	NS	
Sphagnum (0 to 20%)	***	***	*	***	**	***	***	***	***	*	*	*	NS	*	NS	
Reed Sedge (0 to 10%)	***	***	NS	***	NS	***	NS	***	***	***	**	NS	NS	NS	NS	
Quadratic Contrasts																
Soil Rate (0 to 20%)	*	*	*	*	**	**	NS	*	NS	NS	*	*	NS	NS	NS	
Sphagnum (0 to 20%)	NS	NS	NS	NS	NS	NS	NS	**	NS	NS	NS	NS	NS	NS	NS	
Reed Sedge (0 to 10%)	NS	**	NS	NS	NS	NS	NS	NS	NS	*	NS	*	NS	**	NS	

¹ NS = not significant; * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$

Table 6. Performance ranking of all amendment treatments based on 1999 turf quality average of L-93 creeping bentgrass in the lower (poor air circulation) location. Except where designated, amended root zones are 12 inches deep and built over a 4 inch gravel layer.

Amendment Material	Amendment Rate (by volume)	Turf Quality ¹ 1999 Avg.
	(%)	
1 AllGro ²	20	8.6
2 Kaofin	5	8.3
3 Sphagnum Peat	20	7.6
4 Sphagnum Peat	5	7.5
5 Sphagnum Peat	10	7.4
6 Reed Sedge Peat	10	7.3
7 AllGro	10	7.3
8 Irish Peat	20	7.2
9 Irish Peat	10	7.1
10 Isolite	10	7.0
11 Fertl-soil Compost	5	6.9
12 Axis	10	6.8
13 Soil on subgrade	5	6.8
14 Reed Sedge Peat	5	6.8
15 None (Sand)	0	6.8
16 Soil	5	6.7
17 Soil	2.5	6.6
18 ZeoPro in surface 4 inches	10	6.3
19 ZeoPro	10	6.2
20 Profile	10	5.6
21 Soil	20	5.5
22 Profile	20	5.5
23 ZeoPro + Micros in surface 4 inches	10	4.8
24 Greenschoice	10	3.9
25 Soil	100	2.8
LSD at 5% =		0.4

¹9 = best turf quality; > 5 = acceptable turf quality

²AllGro compost mixed at 20% volume ratio with a sand that contains too much fine-sand based on USGA guidelines for root zone composition; all other amendments mixed with a medium sand conforming to USGA size guidelines

Table 7. Severity of pink snow mold and bentgrass dead spot of L-93 creeping bentgrass grown on root zones varying by sand size distribution in two microenvironments in 1999.

Source of Variation	-----Pink Snow Mold-----		Bentgrass Dead Spot			
	19 May	28 May	22 July			
ANOVA						
Location	NS ¹	NS	NS			
Treatment	***	***	NS			
Location x Treatment	**	***	*			
Location	Rating²	Area Damaged (%)	Number of Patches			
Lower Location	6.8	24.3	1.4			
Upper Location	7.3	19.1	2.5			
Sand Size Treatments³	-----Location-----					
	Lower	Upper	Lower	Upper	Lower	Upper
Fine USGA	7.5	7.0	23.3	22.8	1.3	6.3
Fine USGA 10 inch	7.0	7.5	29.3	20.0	1.3	3.0
Medium USGA	6.3	6.8	35.5	21.0	2.5	2.3
Medium USGA 9 inch	7.0	7.5	18.3	18.0	0.8	1.5
Coarse USGA	6.5		27.8		1.0	
Coarse USGA 8 inch	6.5	7.3	19.3	20.8	0.5	2.8
Coarse USGA 7 inch	7.3	7.3	15.0	16.0	0.5	0.3
Extra Fine	6.5	8.3	28.8	14.0	0.8	1.0
Mason	7.5	7.8	11.3	14.5	2.0	1.0
CM 340	5.5	6.8	47.3	20.5	2.8	3.0
CM 4-1	7.5	6.8	12.3	23.8	1.8	0.8
LSD	0.8		11.1		2.5	
CV%	8.5		35.9		95.2	
Treatment Contrasts						
Fine vs. Medium	**	NS	*	NS	NS	**
Fine vs. Extra Fine	*	**	*	NS	NS	***
Fine vs. Mason	NS	NS	*	NS	NS	***
Extra Fine vs. Mason	*	NS	**	NS	NS	NS
Fine vs. CM 340	***	NS	***	NS	NS	*
Fine vs. CM 4-1	NS	NS	NS	NS	NS	***

(Continued)

Table 7 (continued).

Source of Variation	-----Pink Snow Mold-----		Bentgrass Dead Spot			
	19 May	28 May	22 July			
	-----Location-----					
	Lower	Upper	Lower	Upper	Lower	Upper
Fine 12 inch vs. Fine 10 inch	NS	NS	NS	NS	NS	*
Medium 12 inch vs. Medium 9 inch	NS	NS	**	NS	NS	NS
Coarse 7 inch vs. Coarse 8 inch	NS	*	NS	NS	NS	NS

¹NS = not significant; * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$

²9 = least disease

³Depth of root zone is 12 inches except for specified treatments

Table 8. Severity of cutworm damage and dollar spot of L-93 creeping bentgrass grown on root zones varying by sand size distribution in two microenvironments in 1999.

Source of Variation	Cutworm Damage 7 June	Dollar Spot 18 June
ANOVA		
Location	*1	**
Treatment	***	NS
Location x Treatment	NS	NS
Location		
	Number of Damage Centers	Number of Spots
Lower Location	5.1	0.0
Upper Location	2.8	6.1
Sand Size Treatments²		
Fine USGA 12 inch	2.5	1.5
Fine USGA 10 inch	5.1	4.9
Medium USGA 12 inch	3.0	4.1
Medium USGA 9 inch	4.6	5.9
Coarse USGA 12 inch	2.0	0.0
Coarse USGA 8 inch	1.5	2.1
Coarse USGA 7 inch	1.6	1.9
Extra Fine	8.6	2.8
Mason	10.6	3.6
CM 340	1.8	2.8
CM 4-1	1.6	1.0
LSD	2.5	6.1
CV%	59.7	202.3
Treatment Contrasts		
Fine vs. Medium	NS	NS
Fine vs. Coarse	NS	NS
Fine vs. Extra Fine	***	NS
Fine vs. Mason	***	NS
Extra Fine vs. Mason	NS	NS
Fine vs. CM 340	NS	NS
Fine vs. CM 4-1	NS	NS
Fine 12 inch vs. Fine 10 inch	*	NS

(Continued)

Table 8 (continued).

Source of Variation	Cutworm Damage 7 June	Dollar Spot 18 June
	Number of Damage Centers	Number of Spots
Medium 12 inch vs. Medium 9 inch	NS	NS
Coarse 12 inch vs. Coarse 7 inch and 8 inch	NS	NS
Coarse 7 inch vs. Coarse 8 inch	NS	NS

¹NS = not significant; * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$

²Depth of root zone is 12 inches except for specified treatments

Table 9. Severity of yellow patch and pink snow mold of L-93 creeping bentgrass grown on amended root zones in two microenvironments in 1999.

Source of Variation	Yellow Patch		-----Pink Snow Mold-----			
	31 March		19 May	28 May		
ANOVA						
Location	*1		**	NS		
Treatment	**		***	***		
Location x Treatment	**		*	***		
Location	Number of Rings		Rating²		Area Damaged (%)	
Lower Location	0		7.4		24.3	
Upper Location	1		6.6		24.0	
Sand Size Treatments	-----Location-----					
	Lower	Upper	Lower ²	Upper ²	Lower	Upper
Sand	0	0.5	7.8	5.5	23	33
Soil 2.5%	0	1.8	8.0	7.0	20	20
Soil 5%	0.5	0	7.5	6.5	27	23
Soil 5% Subgrade	0	0	7.8	6.5	15	22
Soil 20%	0	0	6.8	7.8	21	11
Sphagnum 5%	0	0.8	7.3	6.3	28	26
Sphagnum 10%	0	0	7.5	6.5	24	24
Sphagnum 20%	0	0	8.5	7.5	9	13
Dakota 5%	0	0.5	7.3	6.8	39	22
Dakota 10%	0	0	7.8	7.5	26	11
Profile 10%	0	4.3	5.5	5.5	49	44
ZeoPro 10%	0	4.5	7.3	6.0	10	40
LSD	2.0		1.0		13	
CV%	265		10.3		37	
Linear Contrasts						
Soil Rate (0 to 20%)	NS	NS	*	***	NS	**
Sphagnum (0 to 20%)	NS	NS	NS	***	*	**
Reed Sedge (0 to 10%)	NS	NS	NS	***	NS	***

(Continued)

Table 9 (continued).

Source of Variation	Yellow Patch 31 March		-----Pink Snow Mold----- 19 May 28 May			
	-----Location-----					
	Lower	Upper	Lower	Upper	Lower	Upper
Quadratic Contrasts						
Soil Rate (0 to 20%)	NS	NS	NS	NS	NS	NS
Sphagnum (0 to 20%)	NS	NS	*	NS	NS	NS
Reed Sedge (0 to 10%)	NS	NS	NS	NS	*	NS

¹NS = not significant; * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$

²9 = least disease

Table 10. Severity of cutworm feeding, dollar spot, and bentgrass dead spot of L-93 creeping bentgrass grown on amended root zones in two microenvironments in 1999.

Source of Variation	Cutworm 7 June	Dollar Spot 18 July	Bentgrass Dead Spot 22 July	
ANOVA				
Location	NS ¹	**	NS	
Treatment	***	NS	***	
Location x Treatment	NS	NS	**	
Location -----Number of Damage Centers-----				
Lower Location	3.7	0.2	4.0	
Upper Location	2.2	3.6	5.8	
Sand Size Treatments -----Location-----				
	Both (Avg.)	Both (Avg.)	Lower	Upper
Sand	0.8	0.6	7.8	14.0
Soil 2.5%	1.3	1.1	7.0	8.3
Soil 5%	2.3	1.9	4.3	3.5
Soil 5% Subgrade	2.4	2.5	2.3	4.5
Soil 20%	2.9	2.4	0.5	1.0
Sphagnum 5%	4.0	3.6	3.3	4.3
Sphagnum 10%	5.3	1.4	2.0	4.8
Sphagnum 20%	6.6	1.9	2.0	0.8
Dakota 5%	3.1	2.0	9.3	3.5
Dakota 10%	5.3	2.6	1.8	3.8
Profile 10%	1.0	0.5	5.0	13.3
ZeoPro 10%	0.6	2.1	3.0	8.3
LSD	1.9	NS	4.2	
CV%	64.2	125	60.9	
Linear Rate Contrasts				
Soil (0 to 20%)	*	NS	***	***
Sphagnum (0 to 20%)	***	NS	**	***
Reed Sedge (0 to 10%)	***	NS	**	***

(Continued)

Table 10 (continued).

Source of Variation	Cutworm 7 June	Dollar Spot 18 July	Bentgrass Dead Spot 22 July	
	-----Location-----			
	Both (Avg.)	Both (Avg.)	Lower	Upper
Quadratic Rate Contrasts				
Soil (0 to 20%)	NS	NS	NS	***
Sphagnum (0 to 20%)	NS	NS	NS	NS
Reed Sedge (0 to 10%)	NS	NS	*	**

¹NS = not significant; * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$