ASSESSING ROOT ZONE MIXES FOR PUTTING GREENS OVER TIME UNDER TWO ENVIRONMENTAL CONDITIONS

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Executive Summary

Project Title: Assessing Root Zone Mixes for Putting Greens over Time under Two Environmental Conditions

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.

Purpose: To investigate aspects of root zone construction affecting putting green performance in two microenvironments including:

1) pore size distribution (sand particle size distribution) and depth of root zone mix, and
2) organic (peats, composts), inorganic, soil and other additives for amending sand.

The potential of various root zone mixes to reduce management and resource inputs will be assessed through the monitoring of physical, chemical, and biological changes that occur as root zones (greens) mature.

Methods:

- Plots constructed in 2 locations (microenvironments) in 1997 (4 reps per location)
- Six sand sizes, conforming to and finer than USGA guidelines, were amended with sphagnum peat at 9:1 volume ratio, a seventh sand was used unamended. The three coarsest sands were used to constructed root zone plots with depths less than 12-inches.
- A silt loam, 2 organic and 2 inorganic materials were used to amend a USGA-sized sand, at varying volume ratios in the both microenvironments.
- All plots seeded on 31 May 1998. Mowing height of $^{1}/_{8}$-inch (0.125-inch) achieved on 25 May 1999. Irrigation was applied based on Class A pan evaporation and root zone water content. Curative applications of pesticides allowed evaluation of moderate pest activity.
- Data collected for visual quality, disease activity, root zone fertility, clipping nutrient content, root zone physical properties, and irrigation requirements.

Results and Discussion:

- Monitoring of wind velocity, humidity, soil temperature and evaporation from a Class A pan indicate substantial environmental differences between the lower and upper site.
- Plots in the lower (poor air circulation) site had better turf quality than the upper site in May and June. This response was reversed in August and September; upper site plots had better quality than lower. The initial decline in quality in the lower site, relative to the upper site, was observed in late-July when the effects of poor air circulation would be expected.
- Pest activity was affected by location and root zone treatment. Further evaluation is needed over time to understand the relative importance (consistency) of the interactions observed.
- Quality data indicated that the two finest sands in the sand size distribution study had the best performance during 1999. These finer sands do not conform to the 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.
- There was a significant interaction between location and root zone treatment throughout the season in the amendment study.
- Identification of the ability to maintain good performance in both microenvironments is important because putting greens are built in widely varying microenvironments. Variable turf performance over location is not desired because it creates consistency issues that challenge both turf managers and players of the game of golf.
- Root zones amended with 20%-soil and 10%-Profile in the lower site had the poorest turf performance by the end of the 1999 season.
- 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.

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 contiuned in 2000.
- Monitoring of humidity, wind velocity, air and soil temperatures will be continued in 2000.
- Turf performance data for quality, disease, stress and other characteristics will continue in 2000.
- Manuscripts will be submitted for publication regarding creeping bentgrass establishment as affected by root zone treatments in 2000.

I. Title: Assessing Differential Root Zone Mixes for Putting Greens Over Time Under Two Environmental Conditions

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III. Purpose: To investigate aspects of root zone construction affecting putting green performance in two microenvironments including:

3) pore size distribution (sand particle size distribution) and depth of root zone mix, and
4) organic (peats, composts), inorganic, soil and other additives for amending sand.

The potential of various root zone mixes to reduce management and resource inputs will be assessed through the monitoring of physical, chemical, and biological changes that occur as root zones (greens) mature.

IV. Location of Project: Hort Farm 2, New Jersey Agricultural Experiment Station, North Brunswick, NJ

V. Introduction: 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.

VI. Methods:

- Preliminary evaluations of root zone mixes conducted in the laboratory.
- Plots constructed in 2 locations (microenvironments) in 1997 (4 reps per location)
- Six sand sizes, conforming to and finer than USGA guidelines, were amended with sphagnum peat at 9:1 volume ratio (Table 1), a seventh sand was used unamended. The three coarsest sands were used to constructed root zone plots with depths less than 12-inches.
- A silt loam, 2 organic and 2 inorganic materials were used to amend a USGA-sized sand, at varying volume ratios in the both microenvironments (Table 2).
- All plots seeded on 31 May 1998 with 'L-93' creeping bentgrass at 1 pound per 1000 ft^2.
- Plots aerated with $^3/_8$-inch hollow tines in April 1999.
- Mowing height of $^1/_8$-inch (0.125-inch) achieved on 25 May 1999. Mowing was initiated on 4 July 1998 and maintained at ½-inch for 1998.
- Plot fertilization for 1999 presented in Table 3.

- Irrigation was applied based on Class A pan evaporation and root zone water content.
- Curative applications of pesticides allowed evaluation of moderate pest activity.
- Data 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 done in an experimental layout of randomized complete block design with 4 replications at two locations (two distinct microenvironments). Each microenvironment varied primarily with respect to evaporative demand (air circulation).

VII. Results and Discussion:

Location (Microenvironment) Effect

Turf Quality

- Monitoring of wind velocity, humidity, soil temperature and evaporation from a Class A pan indicate substantial environmental differences between the lower and upper site (data not shown).
- Location did affect the performance of creeping bentgrass in these two studies (Tables 4 and 7). Plots in the lower (poor air circulation) site had better turf quality than the upper site in May and June. This response was reversed in August and September; upper site plots had better quality than lower. The initial decline in quality in the lower site, relative to the upper site, was observed in late-July when the effects of poor air circulation would be expected.
- It is apparent from the quality data that the environmental conditions in the lower site result in better spring performance of the creeping bentgrass. Presumably, this is due to warmer soil temperatures in the lower site that create better growing conditions in winter and early-spring relative to the upper site.

Pests

- The upper (exposed) site had the greatest amount of dollar spot activity (Tables 6 & 9).
- Cutworm feeding damage was greatest in the lower site of the sand size distribution study (Table 6).
- Pink snow mold disease was affected by an interaction between location and root zone treatment in both studies. (Tables 5 & 8).
- Dead spot disease development on bentgrass also was related to an interaction between location and root zone treatment (Tables 5 and 9).
- Further evaluation is needed over time to understand the relative importance (consistency) of these interactions.

Sand Size Distribution Study

Turf Quality (Table 4)

- Quality data indicated that the two finest sands in the sand size distribution study had the best performance during 1999 (Table 4). These finer sands do not conform the 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

Turf Quality (Table 7)

- There was a significant interaction between location and root zone treatment throughout the season (Table 7). 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 site than the upper site. 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 site compared to the upper site. The interaction in August indicated that two treatments, the non-amended sand and 5%-sphagnum amended plots, were capable of maintaining good turf quality in the lower site as well as the upper site; turf quality for the other treatments declined in the lower site.
- Identifying this ability to maintain good performance in both microenvironments is important because putting greens are built in widely varying microenvironments. Variable turf performance over location is not desired because it creates consistency issues that challenge both turf managers and players of the game of golf.
- Turf performance among root zone treatments was more consistent in the upper site in August and September compared to the lower site, although treatment differences did exist in the upper site.
- More uniform treatment performance in the upper (exposed) site is likely due to the better growing environment of this site. The greater stress conditions of the lower site caused a more definitive separation of treatments.
- Amendment rate effects of turf performance were only significant in lower site during August and September, and indicated that higher rates of amending with soil and sphagnum peat decreased quality. A quadratic rate response was observed with reed sedge peat, indicating that amending with reed sedge peat produced lower turf quality than the non-amended sand.
- Root zones amended with 20%-soil and 10%-Profile in the lower site had the poorest turf performance by the end of the 1999 season (August and September ratings, Table 7).
- 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.

VII. Plan of Work:

- 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 contiuned in 2000.
- Monitoring of humidity, wind velocity, air and soil temperatures will be continued in 2000.
- Turf performance data for quality, disease, stress and other characteristics will continue in 2000.
- Manuscripts will be submitted for publication regarding creeping bentgrass establishment as affected by root zone treatments in 2000.

Table 1. Root zone porosity and fertility of treatments used in the sand size distribution study.

Sand Size	Porosity Air	Porosity Capillary	pH	P	K	Ca	Mg	O.M.†
	%			---------	lb acre^{-1}	----------		%
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

†, O.M. denotes organic matter content determined by combustion

Table 2. Root zone porosity and fertility of treatments used in the amendment study.

Sand Size	Porosity Air	Porosity Capillary	pH	P	K	Ca	Mg	O.M.†
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

†, O.M. denotes organic matter content determined by combustion

Table 3. Nitrogen fertilization and fertilizer nutrient ratio used for plots in both studies in 1999.

Date	Fertilizer Analysis			N Rate	
	N – P_2O_5 – K_2O			g m^{-2}	lb 1000ft^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-Jun	16	4	8	1.0	0.20
14-Jun	16	4	8	0.5	0.10
21-Jun	16	4	8	0.9	0.19
29-Jun	16	4	8	1.3	0.27
12-Aug	15.5	0	0	1.2	0.25
28-Aug	16	4	8	1.0	0.21
10-Sep	20	20	20	1.2	0.25
19-Sep	15.5	0	0	1.2	0.25
25-Sep	46	0	0	1.2	0.25
3-Oct	46	0	0	0.6	0.12
9-Oct	46	0	0	1.2	0.25
17-Oct	46	0	0	1.2	0.25
	Total N			22.0	4.53

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

	Apr 19	May 18	May 29	Jun 14	Jul 10	Jul 21	Aug 6	Sep 4
<u>ANOVA Source</u>								
Location	NS	**	NS	**	NS	NS	***	***
Treatment	***	***	*	***	***	***	***	***
Location x Treatment	NS	NS	NS	NS	NS	NS	NS	NS
<u>Location</u>	----------------------			Rating (9=best)		----------------------		
Lower Site	7.4	7.3	5.6	7.5	7.8	7.6	6.2	6.2
Upper Site	7.3	7.1	5.8	7.2	7.7	7.9	7.5	7.1
<u>Sand Size Treatment</u>†								
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
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
<u>Treatment Contrasts</u>:								
Fine vs Medium	NS	*	NS	NS	NS	NS	NS	NS
Fine vs Coarse	***	***	NS	***	***	*	***	***
Fine vs Extra Fine	**	***	NS	**	*	***	NS	***
Fine vs Mason	*	***	*	***	**	**	NS	**
Extra Fine vs Mason	NS	NS	NS	NS	NS	NS	NS	NS
Fine vs CM340	NS	NS	NS	NS	NS	NS	NS	NS
Fine vs CM 4-1	NS	*	NS	***	**	*	NS	**
Fine 12" vs Fine 10"	**	NS	NS	NS	NS	NS	ns	*
Medium 12" vs Medium 9"	NS	***	NS	NS	*	NS	NS	***
Coarse 12" vs Coarse 7" & 8"	***	*	NS	*	NS	NS	*	***
Coarse 7" vs Coarse 8"	NS	NS	NS	NS	NS	NS	NS	NS

†, Depth of root zone is 12-inches except for specified treatments.

Table 5. Pink snow mold disease and dead spot disease severity of 'L-93' creeping bentgrass grown on root zones varying by sand size distribution in two microenvironments in 1999.

	Pink Snow Mold 19-May		Pink Snow Mold 28-May		Dead Spot 22-July	
ANOVA						
Location	NS		NS		NS	
Treatment	***		***		NS	
Location*Treatment	**		***		*	
Location	Rating 9=best		% Area Damaged		Number of Patches	
Lower Site	6.8		24.3		1.4	
Upper Site	7.3		19.1		2.5	
Sand Size Treatments[†]	Lower Site	Upper Site	Lower Site	Upper Site	Lower Site	Upper Site
	Rating 9=best		% Area Damaged		Number of Patches	
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	***
Fine 12" vs Fine 10"	NS	NS	NS	NS	NS	*
Medium12" vs Medium9"	NS	NS	**	NS	NS	NS
Coarse 7" vs Coarse 8"	NS	*	NS	NS	NS	NS

†, Depth of root zone is 12-inches except for specified treatments.

Table 6. Cutworm damage and dollar spot disease severity of 'L-93' creeping bentgrass grown on root zones varying by sand size distribution in two microenvironments in 1999.

	Cutworm Damage 7-June	Dollar Spot Disease 18-June
ANOVA		
Location	*	**
Treatment	***	NS
Location*Treatment	NS	NS
Location	Damage Centers	Number of Spots
Lower Site	5.1	0.0
Upper Site	2.8	6.1
Sand Size Treatments†		
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" vs Fine 10"	*	NS
Medium12" vs Medium9"	NS	NS
Coarse 12" vs Coarse 7" & 8"	NS	NS
Coarse 7" vs Coarse 8"	NS	NS

†, Depth of root zone is 12-inches except for specified treatments.

Table 7. Turf quality ratings of 'L-93' creeping bentgrass grown on amended root zones in two microenvironments in 1999.

	19-Apr		18-May		29-May		14-Jun		10-Jul	21-Jul		6-Aug		4-Sep	
ANOVA															
Location	***		**		**		***		NS	**		***		**	
Treatment	***		***		***		***		***	***		***		***	
Location*Treatment	**		***		***		**		NS	*		***		***	
Location	Rating (9= best)														
Lower Site	7.4		7.3		6.0		7.4		7.4	7.2		5.8		5.8	
Upper Site	6.9		6.7		5.4		6.7		7.6	7.8		7.2		6.7	
Treatments	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Both	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% subgrd	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
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

Table 8. Cool season brown patch and pink snow mold disease severity of 'L-93' creeping bentgrass grown on amended root zones in two microenvironments in 1999.

	31-Mar Cool Season Brown Patch		19-May Pink Snow Mold		28-May Pink Snow Mold	
ANOVA						
Location	*		**		NS	
Treatment	**		***		***	
Location*Treatment	**		*		***	
	Number of rings		Rating 9=best		% Area Damaged	
Location						
Lower Site	0		7.4		24.3	
Upper Site	1		6.6		24.0	
Treatments	Lower Site	Upper Site	Lower Site	Upper Site	Lower Site	Upper Site
	Number of rings		Rating 9=best		% Area Damaged	
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% subgrd	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	***
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

Table 9. Cutworm feeding, and dollar spot and dead spot disease severity of 'L-93' creeping bentgrass grown on amended root zones in two microenvironments in 1999.

	7-Jun Cutworm	18-Jul Dollar Spot	22-Jul Dead Spot	
ANOVA				
Location	NS	**	NS	
Treatment	***	NS	***	
Location x Treatment	NS	NS	**	
Location	--------------	# of damage centers	--------------	
Lower Site	3.7	0.2	4.0	
Upper Site	2.2	3.6	5.8	
Treatments	Ave. of Two Sites	Ave. of Two Sites	Lower Site	Upper Site
	---------------------	# of damage centers	---------------------	
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% subgrd	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	**	***
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	*	**