USGA Progress Report - 1985

Turfgrass Cultural Practices and Their Interactive Effects on Rooting

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A USGA/University of Nebraska Research Project
Initiated 19 April 1985

Executive Summary

This research project was initiated under an agreement between the United States Golf Association (USGA) and the University of Nebraska-Lincoln (UN-L) which was entered into on 19 April 1985.

UN-L Contributions.

During the 1985 project period, the University of Nebraska made the following contributions to the joint research project by developing the following facilities:

1. An additional 18,000 sq. ft. of golf green research area, bringing the total research green area to approximately 46,000 sq. ft.

2. Completion of the Turfgrass Rhizotron Research facility with 40 root cells for rooting observations.

3. Irrigation scheduling research site with 20,000 sq. ft. of area divided into 24 individually controlled irrigation plots with tensiometers.

4. Addition of 3,500 sq. ft. to the Turfgrass Research Field Lab and Maintenance Facility.

USGA Research Accomplishments.

The following are accomplishments relating to the United States Golf Association support of this joint research project:

1. Developed a technique using neutron scattering to assess turfgrass depth and distribution of rooting, and to determine rootzone soil moisture extraction.

2. Developed a hydroponic method to screen differences in turfgrass rooting based on species, cultivar, and cultural practices. Verified responses of hydroponic system to those observed under field conditions.

3. Evaluated a nondestructive method for determining leaf area index (LAI) in turfs. Confirmed this technique on 7 cool season turfgrass species.

4. Evaluated nitrogen and potassium effects on creeping bentgrass and Kentucky bluegrass turfs. The golf green evaluation with creeping bentgrass was further interacted with irrigation frequency. Potassium enhanced turfgrass rooting and drought avoidance in both species. Turfgrass wear tolerance was enhanced by potassium treatments and recuperative rate was enhanced by nitrogen in the creeping bentgrass evaluation which was conducted on a high sand content growing media.

Turfgrass Rooting Investigations

The following studies are reported as part of the on going project with the USGA which involves the interactive effects of turfgrass culture on rooting. Some of the turfgrass species used in the preliminary stages of the investigation are not ones that are typically recommended for golf course turfs. These grasses are included because this research was in part in progress upon receipt of the USGA grant and in part because they were conducive to rapid methodology testing.

Turfgrass Rooting and Soil Moisture Depletion.

Thirty-six tall fescue clones were vegetatively propagated and planted in a replicated field experiment under mowed conditions to study depth and extent of rooting and soil moisture depletion. The experiment was designed to measure rooting using destructive and nondestructive methods. Neutron scattering technique was used to determine soil moisture depletion during an extended, controlled-drought stress. The controlled-drought stress was induced by covering the experimental area whenever rainfall was eminent and excluding irrigation input. Clones differed in rooting depth and soil moisture extraction (Table 1). Total field root production and soil water present in the 120 cm soil profile at the end of a 75 day induced drought stress were related ($r = -0.78$) and were significant at the 0.01 probability level. Approximately two-thirds of the clonal wilt response could be related to soil moisture content, indicating superior soil moisture extraction was one of the mechanisms involved in wilt values obtained for the clones tested (Table 2). Seedlings with large root mass production based on controlled environment studies tended to produce large root mass values in the field experiment.

Clonal Rooting Evaluation and Hydroponics.

Fifteen tall fescue clones from the field investigation for rooting and soil moisture depletion were brought into the greenhouse to study their root production and distribution under decreasing moisture levels in a hydroponic system. Nutrient solution in the hydroponic system was allowed to decline according to evapotranspirational demand of the individual clones. Solutions were changed weekly to prevent nutrient imbalance and salt build-up. Clones were clipped and the clippings were collected every five days. Eight weeks after initiating the declining water level of this study, the study was terminated and plants were harvested and separated from their root systems. Plant top growth was dried in a forced-air oven at 70 C of 48 hrs and weighed (mg dry weight/plant). Top growth dry weights and clipping yield driy weights were combined and expressed as total top growth for the study. The root systems were measured for length based on the deepest root. The root systems were separated into 15 cm segments ranging from 0-15 cm to 60-75 cm (i.e. 5 segments representing the depth of the profile). Clones differed for total top growth and total root growth and distribution (Tables 3 and 4). Top growth and root growth varied by 34% and 44%, respectively. Clone 25 had the greatest percentage of total root growth supporting its top growth when compared to the other clones tested (Table 5). Clones 25, 20, 29, and 31 had higher top growth and root growth production and greater percentage of root mass supporting the top growth than the other clones. Clones 26 and 15 have low top growth but high root growth production and high percentage of root mass supporting the top growth. This hydroponic system proved to be valuable for separating genetic differences and rooting characteristics and was applicable to results obtained with the same clones grown under drought stress in the field.

The hydroponic system is presently being used to investigate similar rooting responses in Kentucky bluegrass (**Poa pratensis** **L.**) and is projected for studies involving genetic differences in rooting with perennial ryegrass (**Lolium perenne L.**) and creeping bentgrass (**Agrostis palustris Huds.**). Upon concurrence with field collected data for these species, it is projected that this procedure will be helpful in assessing root responses relating to interactions with cultural practices.

Hydroponic System Refinement.

A preliminary study was conducted to determine if polyvinyl chloride (PVC) pipe could be used as a container for a hydroponic system for growing turfs for rooting studies. The previously mentioned hydroponic study with tall fescue clones was conducted using heavy cardboard cylinders which were lined with polyethylene to hold the nutrient solution. There was some concern expressed by researchers that the PVC pipe might emit volatile materials that could be detrimental to turfgrasses growing in the hydroponic solution. Treatments in this study consisted of: (a) nontreated; (b) painted with a latex paint; and (c) lined with 6 mil polyethylene. The effect of decreasing water level was also evaluated. Two nutrient solution levels were studied: (1) solution replenished every third day, and (2) a nonfill that allowed the solution to decline according to evapotranspirational demand. Solutions in both cases were changed weekly to avoid nutrient imbalance and potential salt build-up. Kentucky bluegrass was used as the indicator plant.

The nontreated PVC containers had the greatest top growth and root weight for the two solution levels (Table 6). There was a reduction in root and top growth with the painted containers, indicating the paint was likely toxic to the Kentucky bluegrass turfs. The turfs differed in root distribution according to water levels maintained (Figures 1a and 1b). The fill treatment had greater root distribution in the upper 0-15 cm than the nonfill treatment. The nonfill treatment had more rooting in the 15-30 and 30-45 cm depths than the fill treatment.

Results of this study indicate that nontreated PVC pipe containers can be used effectively on hydroponic turfgrass rooting evaluations without harmful effects. This study further indicates that declining water levels in the hydroponic system can be effectively used to differentiate root distribution with similar results as that expected from soils.

Figure 1a.

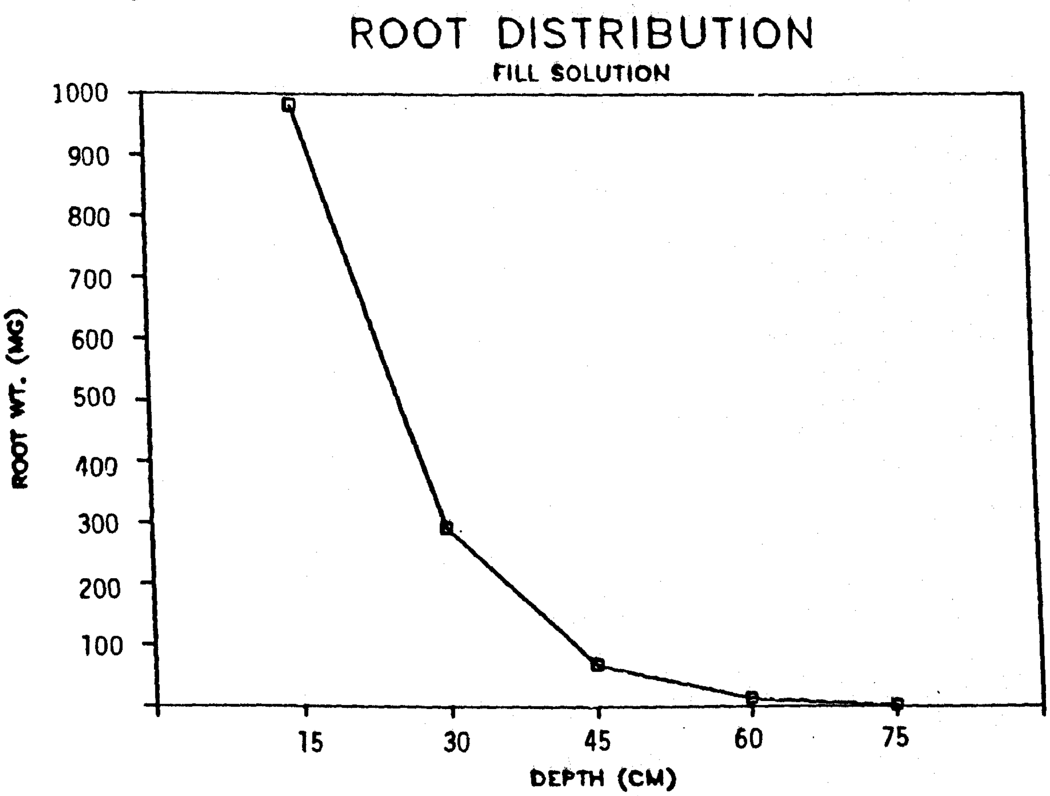

Figure 1b.

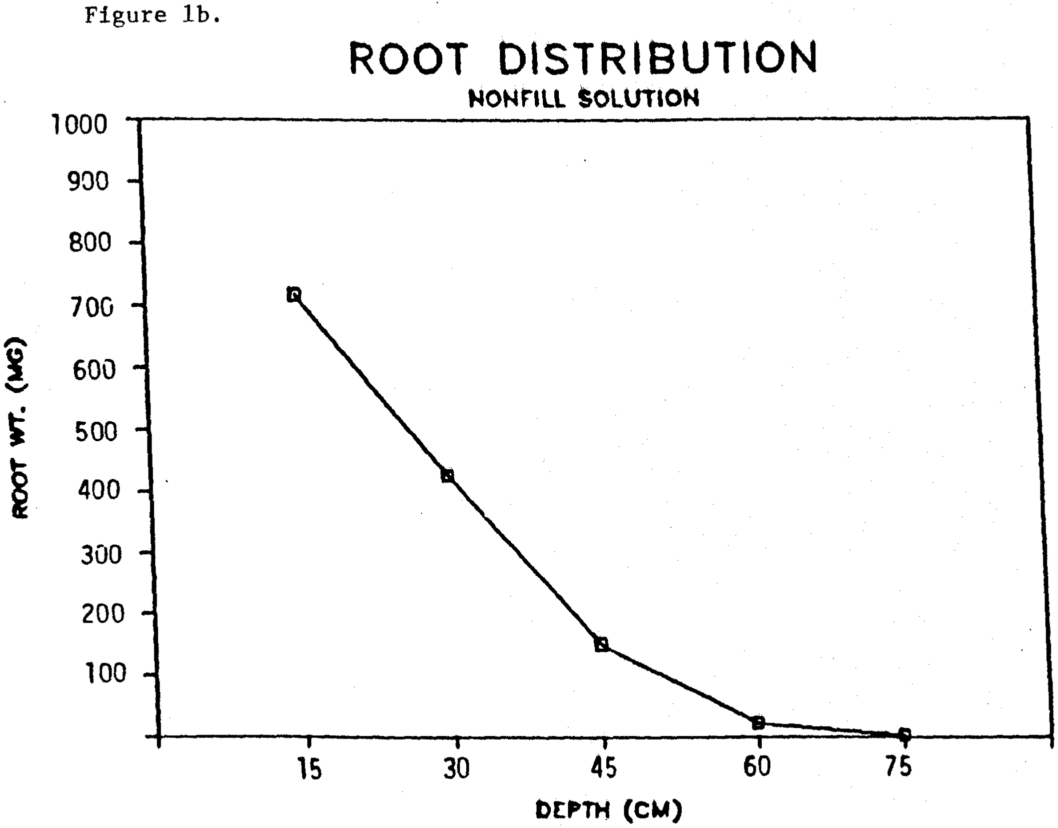

Table I. Contrast significance and mean soil moisture depletion (SMD) rates for tall fescue clones having high or low root or shoot production. Rates are in (mm day-1).

Period	Depth (cm)	P>F value	High roots[†]	Low roots	Depth (cm)	P>F value[‡]	High shoot	Low shoot
June 30 to July 14.								
	0-15	0.02	0.27	0.14	0-15	0.53	0.23	0.19
	15-30	0.16	0.73	0.65	15-30	0.87	0.68	0.69
	30-45	0.01	0.91	0.64	30-45	0.21	0.74	0.66
	45-60	0.01	0.78	0.54	45-60	0.13	0.66	0.58
	60-75	0.01	0.59	0.24	60-75	0.04	0.46	0.31
	75-90	0.01	0.42	0.19	75-90	0.57	0.29	0.26
	90-105	0.63	0.17	0.14	90-105	0.16	0.19	0.11
	105-120	0.94	0.23	0.23	105-120	0.14	0.31	0.27
	Total	0.01	4.10	2.79	Total	0.06	3.59	3.05
July 15 to August 4.	Depth (cm)	P>F value	High roots	Low roots	Depth (cm)	P>F value	High shoot	Low shoot
	0-15	0.02	0.60	0.72	0-15	0.43	0.65	0.67
	15-30	0.01	0.68	0.83	15-30	0.70	0.76	0.75
	30-45	0.01	0.73	0.90	30-45	0.41	0.83	0.84
	45-60	0.01	0.81	0.91	45-60	0.61	0.88	0.89
	60-75	0.03	0.85	0.92	60-75	0.31	0.86	0.89
	75-90	0.92	0.94	0.95	75-90	0.62	0.97	0.92
	90-105	0.01	1.06	0.95	90-105	0.60	1.02	0.99
	105-120	0.04	1.04	0.96	105-120	0.57	0.97	0.95
	Total	0.01	6.71	7.15	Total	0.87	6.94	6.96
August 5 to August 29	Depth (cm)	P>F value	High roots	Low roots	Depth (cm)	P>F value	High shoot	Low shoot
	0-15	0.09	0.20	0.23	0-15	0.35	0.21	0.22
	15-30	0.24	0.14	0.16	15-30	0.70	0.15	0.16
	30-45	0.64	0.15	0.16	30-45	0.33	0.16	0.15
	45-60	0.49	0.15	0.16	45-60	0.25	0.18	0.16
	60-75	0.03	0.12	0.15	60-75	0.23	0.14	0.17
	75-90	0.07	0.11	0.15	75-90	0.55	0.14	0.12
	90-105	0.09	0.13	0.17	90-105	0.13	0.16	0.15
	105-120	0.24	0.18	0.14	105-120	0.81	0.17	0.16
	Total	0.19	1.17	1.22	Total	0.89	1.31	1.29

[†] Contrast formulated by grouping 6 upper and lower clones for each effect.
[‡] Experimental error rate 0.05. Contrast significance level = 0.01 (Bonferroni).

Table 2. Contrast significance and mean soil moisture depletion (SMD) rates (mm day -1) for tall fescue clones having high or low wilt values during the summer of 1984, Mead Nebraska.

	June 30 to July 14.				July 15 to August 4.				August 5 to 29		
Depth	P>F value	High wilt	Low wilt	Depth	P>F	High wilt	Low wilt	Depth	P>F	High wilt	Low wilt
0-15	0.22	0.24	0.18	0-15	0.01	0.62	0.71	0-15	0.05	0.24	0.27
15-30	0.43	0.71	0.65	15-30	0.01	0.72	0.81	15-30	0.31	0.16	0.18
30-45	0.96	0.74	0.74	30-45	0.01	0.79	0.86	30-45	0.28	0.16	0.17
45-60	0.32	0.64	0.69	45-60	0.55	0.85	0.85	45-60	0.11	0.14	0.17
60-75	0.74	0.35	0.37	60-75	0.49	0.86	0.87	60-75	0.28	0.12	0.15
75-90	0.21	0.22	0.29	75-90	0.94	0.97	0.97	75-90	0.32	0.11	0.13
90-105	0.42	0.05	0.09	90-105	0.71	1.04	1.01	90-105	0.32	0.15	0.13
105-120	0.59	0.19	0.21	105-120	0.41	0.99	0.95	105-120	0.08	0.21	0.16
Total	0.68	3.14	3.23	Total	0.05	6.83	7.04	Total	0.06	1.29	1.37

Values are means of 3 replicates of 6 clones in extreme rank for plant wilt response.
Experimental error rate = 0.05. Contrast significance level = 0.05.

Table 3. Verdure, total clipping yield, total top growth, total root growth, and percent rooting response of 15 tall fescue clones grown in a hydroponic solution.

Clone	Verdure(g)	Clipping Yield(g)	Top growth(g)z	Root growth(g)y
29	13.2 ax	2.5 abcde	15.7 a	2.3 abc
2	12.5 a	3.1 abc	15.6 a	2.3 ab
27	12.0 ab	3.1 abc	15.0 ab	2.5 a
20	11.9 ab	2.4 bcde	14.3 abc	2.1 abcd
31	11.6 ab	2.8 abcd	14.4 abc	2.1 abcd
4	10.8 bc	1.9 de	12.8 cde	1.7 de
25	10.7 bcd	2.9 abcd	13.6 abcd	2.3 abc
5	10.0 cde	2.9 abcd	12.9 bcde	1.9 bcde
22	10.0 cde	3.4 a	13.4 bcd	2.5 a
15	9.1 def	1.7 e	10.8 ef	1.4 e
19	8.8 ef	2.3 bcde	11.0 ef	2.1 abcd
21	8.7 ef	3.2 abc	11.8 def	2.5 a
33	8.3 f	2.2 cde	10.5 f	2.0 abcd
26	7.9 f	3.2 ab	11.2 ef	2.1 abcd
14	7.8 f	2.5 abcde	10.3 f	1.7 cde

z Verdure + clipping yield
y Mean total root growth of four replications.
x Mean separation within columns by Duncan's multiple range test, 5% level.

Table 4. Total root production and distribution of 15 tall fescue clones grown in a hydroponic solution.

	Root Production (mg)[z]				
Clone	0-15 cm[y]	15-30 cm	30-45 cm	45-60 cm	60-75 cm
21	1920 a[x]	492 ab	69 abcde	4 a	---
22	1895 a	502 ab	108 abcde	9 a	8 a
2	1833 ab	444 abcd	60 bcde	5 a	1 a
27	1828 ab	538 a	109 abcde	9 a	---
19	1750 ab	328 cde	35 bcde	2 a	---
25	1655 ab	406 abcde	166 a	52 a	38 a
29	1636 ab	478 abc	134 ab	26 a	6 a
33	1585 ab	352 bcde	50 bcde	4 a	---
31	1544 ab	438 abcd	121 abc	13 a	2 a
20	1515 abc	362 bcde	114 abcd	23 a	5 a
5	1515 abc	317 de	20 de	---	---
26	1507 abc	437 abcd	128 ab	36 a	26 a
14	1379 bc	301 de	26 cde	9 a	---
4	1374 bc	264 e	13 e	---	---
15	1064 c	268 e	47 bcde	13 a	3 a

z Values are mean of four replications.
y Root distribution is broken down in five 15 cm segments.
x Mean separation within columns by Duncan's multiple range test, 5% level.

Table 5. Total top growth; percent rooting response, and water used by 15 tall fescue clones.

Clone	Top growth (g)[z]	Percent (g)[y]	Water level (mm)[x]
29	15.7 a[w]	2.7 abcd	324 ab
2	15.6 a	1.3 cd	311 abcd
27	15.0 ab	1.3 cd	349 a
31	14.4 abc	3.8 abc	315 abcd
20	14.3 abc	4.6 ab	300 bcde
25	13.6 abcd	5.5 a	327 ab
22	13.4 bcd	1.8 bcd	322 abc
5	12.9 bcde	0.7 d	290 bcde
4	12.8 cde	2.1 abcd	268 de
21	11.8 def	1.9 bcd	300 abcde
26	11.2 ef	3.8 abc	323 ab
19	11.0 ef	2.0 abcd	269 de
15	10.8 ef	5.2 ab	257 e
33	10.5 f	2.2 abcd	274 cde
14	10.3 f	1.8 bcd	257 e

z Verdure + clipping yield
y Percentage of total root growth supporting top growth based on hydroponic solution level.
x Water loss from evapotranspiration
w Mean separation within columns by Duncan's multiple range test, 5% level.

Table 6. Top growth (clippings and verdure) and root weights of 'Birka' Kentucky bluegrass grown in lined, painted, or nontreated polyvinyl chloride tubes with hydroponic solution.

PVC Treatment	Top growth (g)[z] fill	nonfill	Root growth (g) fill	nonfill
lined	9.0 a[y]	6.7 b	1.4 a	1.2 ab
nontreated	8.6 a	8.2 a	1.5 a	1.4 ab
painted	6.2 b	5.7 b	1.2 b	1.3 ab

[z] Verdure + clippings

[y] Values are means of six replications. Means with the same letter are not significantly different.

Table 7. Soil potassium levels in a 'Seaside' creeping bentgrass turf growing on sand and receiving two watering regimes.

Potassium[z] (lbs. K/1000 sq. ft.)	Soil Potassium Levels (kg/ha)[y] Watered Daily	Watered 2X/Week
0 (0)	34	36
2 (10)	43	43
4 (20)	40	51
6 (30)	61	68
8 (40)	168	200
LSD (0.05) =	18	18
Rate (L) =	*	**

[z]Potassium treatments received 6 lbs. N/1000 sq. ft. ($30 g/m^2$)/ growing season. Values in parenthesis are g k/m^2.

[y]Turfs were watered daily or twice weekly with 1.5 inches each regime totalling (38 mm) of water per week. Values are means of 3 replications per treatment.

*,** indicate significance at 0.05 and 0.01 probability levels, respectively.

Table 8. Turfgrass quality of 'Seaside' creeping bentgrass, growing on a fine-sand medium and receiving two watering regimes with varying potassium nutrition.

Potassium[z] (lbs. K/1000 sq. ft.)	Turfgrass Quality[y] Watered Daily	Watered 2X/Week
0 (0)	5.3	5.9
2 (10)	6.1	6.2
4 (20)	6.7	6.3
6 (30)	6.9	7.3
8 (40)	7.3	7.5
LSD (0.05) =	0.2	0.2
Rate (L) =	*	**

[z]Potassium treatments received 6.0 lbs. N/1000 sq. ft. (30g K/m^2)/growing season. Values in parenthesis are g K/m^2.

[y]Turfgrass quality was based on a 1 to 9 scale with 1 = poorest, 6 = acceptable, and 9 = best. Water regimes were daily or twice weekly with each regime totalling 1.5 inches (38 mm) of water per week. Turfgrass quality values are means of 5 monthly assessments (May-September 1985) and 3 replications per treatment.

*, ** indicates significance at the 0.05 and 0.01 probability levels, respectively.

Table 9. 'Seaside' creeping bentgrass; root density for turf growing on sand and receiving two watering regimes with varying potassium nutrition levels.

Potassium[z] (lbs. K/1000 sq. ft.)	Root Density (mg/150 in.³)[y] Watered Daily	Watered 2X/Week
0 (0)	453	473
2 (10)	583	646
4 (20)	673	713
6 (30)	743	756
8 (40)	937	1237
LSD (0.05) =	12.7	12.7
Rate (L) =	**	**

[z]Potassium treatments received 6.0 lbs. N/1000 sq. ft. (30g/m²)/growing season. Values in parenthesis are g K/m².

[y]Root density were expressed as mg dry wt/150 in³ (2.36 X 10⁻³). Water regimes were daily or twice weekly with each regime totalling 1.5 inches (38 mm) of water/week. Values in a column are means of 4 subsamples and 3 replications per treatment.

** indicates significance at the 0.01 probability levels.

Table 10. Wilting tendency of 'Seaside' creeping bentgrass as influenced by potassium treatment.

Potassium[z] (lbs. K/1000 sq. ft.)	Wilting Tendency[y] Watered Daily	Watered 2X/Week
0 (0)	5.7	4.0
2 (10)	3.8	3.2
4 (20)	2.7	3.2
6 (30)	2.0	1.8
8 (40)	1.5	1.5
LSD (0.05) =	0.4	2.7
Rate (L) =	**	**

[z]Potassium treatments received 6.0 lbs. N/1000 sq. ft. (30g N/m^2)/growing season. Values in parenthesis are g K/m^2.

[y]Wilting tendency was based on 1 to 9 scale with 1 = no wilt, and 9 = 90-100% of turf wilted. Water regimes were daily or twice weekly with each regime totalling 1.5 inches (38 mm) of water/week. Wilting tendency was assessed 2:00 p.m. on 19 July 1985, after 48 hrs. with no irrigation or precipitation.

** indicates significance at the 0.01 probability level.

Table 11. Wear tolerance responses for 'Seaside' creeping bentgrass growing on a fine-sand and receiving two watering regimes with varying potassium levels.

Potassium[z] (lbs. K/1000 sq. ft.)	Wear Tolerance[y] Watered Daily	Watered 2X/Week
0 (0)	328	303
2 (10)	404	385
4 (20)	431	449
6 (30)	604	606
8 (40)	625	623
LSD (0.05) =	25	25
Rate (L) =	*	*

[z]Potassium treatments received 6.0 lbs. N/1000 sq. ft. (30g K/m²)/growing season. Values in parenthesis are g K/m².

[y]Wear tolerance was based on number of revolutions by wear machine necessary to wear-away verdure leaving exposed soil and shoots and no green vegetation.

*indicates significance at the 0.05 probability level.

Table 12. Verdure of 'Fylking' Kentucky bluegrass treated with nitrogen and potassium.

Nitrogen (lbs. N/1000 sq. ft.)	Nitrogen (gN/m^2)	Verdure (kg/m^2)[z] Fresh Wt.	Verdure (kg/m^2)[z] Dry Wt.
0	0	1.87	0.75
2	10	1.88	0.78
4	20	2.37	0.89
6	30	2.05	0.90
8	40	2.20	0.92
	LSD (0.05) =	0.39	0.19
Potassium (lbs. K/1000 sq. ft.)	**Potassium (gK/m^2)**		
0	0	2.11	0.88
2	10	2.02	0.82
4	20	2.18	0.86
6	30	2.01	0.84
8	40	2.01	0.87
	LSD (0.05) =	ns	ns
	N-Rate (L) =	ns	*
	N-Rate (Q) =	*	ns
	K-Rate (L) =	ns	ns
	N-Rate (Q) =	ns	ns

[z]Verdure values are means of four subsamples and three replications per treatment.

*, ns indicate significance and nonsignificance at 0.05 probability level.

Table 13. Rooting response of 'Fylking' Kentucky bluegrass treated with potassium (K).

Potassium		Root Mass (mg)[z]		
(lbs. K/1000 sq. ft.)	(gK/m²)	0-100 mm	100-200 mm	200-300 mm
0	0	261	13	0
2	10	321	60	0
4	20	373	63	13
6	30	383	67	13
8	40	420	113	40
	LSD (0.05) =	32	27	3
	Rate (L) =	*	*	*

[z]Root mass expressed on a dry weight basis. Values are means of four subsamples and three replications/treatment.

* indicates significance at the 0.05 probability level.

Table 14. Soil pH, phosphorus and potassium levels as influenced by potassium treatments.

Potassium		Soil		
(lbs. K/1000 sq. ft.)	(gK/m²)	pH	Phosphorus (kg/ha)	Potassium (kg/ha)
0	0	7.0	18.3	431
2	10	7.0	18.5	854
4	20	7.1	18.3	1134
6	30	7.1	18.8	1516
8	40	7.2	18.3	1933
	LSD (0.05) =	0.1	ns	79
	Rate (L) =	ns	ns	*

Table 15. Soil pH, phosphorus and potassium as influenced by nitrogen treatments.

Nitrogen		Soil		
(lbs. N/1000 sq. ft.)	(gN/m²)	pH	Phosphorus (kg/ha)	Potassium (kg/ha)
0	0	7.3	26.8	1209
2	10	7.2	20.8	1197
4	20	7.1	16.2	1174
6	30	7.1	15.8	1167
8	40	7.0	12.4	1119
	LSD (0.05) =	0.1	5.6	53
	Rate (L) =	ns	*	*