USGA PROGRESS REPORT - 1988

Turfgrass Culture and Water Conservation

prepared by:

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EXECUTIVE SUMMARY

During 1988, studies were conducted on creeping bentgrass water use rates, root growth, root distribution, topgrowth, verdure, clipping to verdure ratio, and wear tolerance. Studies were initiated to evaluate the effects of mowing height and vertical mowing frequency on creeping bentgrass putting green quality and rooting characteristics. A study was initiated to observe the effects of syringing on creeping bentgrass putting green quality, root growth and stress tolerance. A study was initiated to determine the interactive effects of mowing, nitrogen, clipping removal or return, and irrigation frequency on creeping bentgrass competition with annual bluegrass under fairway conditions. In addition, two fairway studies were initiated to determine the interactive effects of potassium nutrition and irrigation level on both Kentucky bluegrass and perennial ryegrass fairways.

Creeping Bentgrass Water Use Rates. Ten creeping bentgrass cultivars were evaluated for water use under field conditions. Water use rates varied from a low of 3.2 mm for Pennlinks on 22 May 1987 to a high of 10.7 mm on 25 June 1987 for Seaside. In 1988, Pennlinks had a low water use of 3.5 mm on 3 Oct. and a high of 8.5 mm on 11 June, while Seaside ranged from a low of 4.3 mm on 3 Oct. to a high of 9.9 mm on 10 and 11 June. Seaside was the cultivar with the highest water use rate, while Pennlinks consistently had the lowest, during the two year study. Water use among the 10 cultivars varied from 16 % to 28 % with a mean of 20 %. Cultivar selection could be used to account for a 20 % reduction in water use. These results also indicate a strong potential to breed and select cultivars with lower water use rates.

Creeping Bentgrass Growth and Development. Ten creeping bentgrass cultivars were studied for topgrowth, clipping yield, verdure, and clipping yield to verdure ratio. Cultivars differed in topgrowth by as much as 24 %. Clipping yields varied by 31 %. Verdure varied by 18 %. Clipping yield was positively correlated (r= 0.83) and verdure was negatively correlated (r= -0.79) to cultivar water use rates. Clipping yield to verdure ratios varied from 0.7 for Pennlinks to 1.3 for Seaside. Cultivars with ratios of less than 1.0 had intermediate to low water use rates while those with ratios of 1.0 or greater had intermediate to high water use rates. Topgrowth characteristics of clipping yield and verdure could be used as selection criteria for cultivars with reduced water use rates.

Creeping Bentgrass Root Growth and Distribution. Creeping bentgrass cultivars varied in total root production by 31 %. Pennlinks produced the greatest root growth and Penneagle produced the least. Cultivars varied in their root distribution. Five cultivars produced root growth to depths of 750 mm, while two cultivars produced roots only to 450 mm. Emerald, Prominent and Penneagle had 90 %, 85 %, and 87 % of their root growth in the upper 300 mm, respectively. These results demonstrate that creeping bentgrass cultivars could be selected or developed with improved root production and distribution. Cultivars with low water use rates and with the ability to redistribute their root systems in the soil profile as surface soil moisture

is depleted are feasible to develop within creeping bentgrass.

Creeping Bentgrass Wear Tolerance. Creeping bentgrass wear tolerance as influenced by cultivar and nitrogen nutrition were evaluated. Cultivars differed in wear tolerance; however, there was a cultivar x nitrogen interaction for wear tolerance. In most cultivars, wear tolerance increased as nitrogen nutrition increased from 2.0 to 4.0 lbs/ 1000 sq ft/growing season and declined from 4.0 to 6.0 lbs/ 1000 sq ft/growing season but wear tolerance for Penneagle increased linearly with rates of nitrogen from 2.0 to 6.0 lbs/ 1000 sq ft/ growing season. Turfgrass wear tolerance was positively correlated to cultivar verdure density (r= 0.80). Wear injury recovery varied among cultivars, but all cultivars recovered better as nitrogen rate was increased from 2.0 to 6.0 lbs/ 1000 sq ft/ growing season.

New investigations. New investigations have been initiated in late 1988. These investigations involve cultural practice interactions on putting green and fairway turfgrass quality, playability and stress tolerance. Three graduate students have been hired to serve as project leaders in these investigations. These students include: K. S. Erusha, T.A. Salaiz, and K. N. Kim. Results of their work will be forth coming in 1989.

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CREEPING BENTGRASS WATER USE RATES

Ten creeping bentgrass cultivars (Table 1) were evaluated over a two year study of creeping bentgrass water use rates. Cultivars were established from seed in minilysimeters and water use rates (e.g. Evapotranspiration rates) were evaluated in the field. Lysimeters were located in the field with a turfgrass fetch of 150 m. Lysimeters were filled with fritted-clay.

The cultivars were mowed five times weekly at 12.5 mm and clippings were removed. Turfs were fertilized at a rate of 30 g N / m^2 / season. Irrigation was supplied as needed when turfs were not being evaluated for water use. Fungicides were applied on a preventive basis. Herbicides and insecticides were applied as needed.

Evapotranspiration rates were assessed 14 times in each year, beginning with measurements taken in May and ending with those made in October. A randomized complete block design was used with 6 replications for a total of 60 observations. Data were subjected to analysis of variance and means were separated, using Least Significant Difference at the 5 % probability level.

Cultivars differed consistently in their water use rates over the two year study (Tables 1 and 2). Pennlinks had the lowest water use rate and Seaside had the highest. Water use rates varied by seasonal evapotranspirational demand. Cultivar rates were lowest in spring and fall, and highest in summer. In 1987, cultivar rates ranged from a low of 3.2 mm to a high of 10.7 mm. Pennlinks had a low of 3.2 mm on 22 May and a high of 8.3 on 25 June. Seaside ranged from a low of 4.0 mm on 4 Oct. to a high of 10.7 on 25 June. In 1988, Pennlinks had a low ET of 3.5 mm on 3 Oct. and a high ET of 8.5 mm on 11 June, while Seaside ranged from a low of 4.3 mm on 3 Oct. to a high of 9.9 mm on 11 June. In 1987, potential ET for 22 May and 25 June were 4.5 mm and 9.0 mm, respectively. In 1988, potential ET for 11 June and 3 Oct. were 12.5 mm and 3.8 mm, respectively. Seaside consistently had a water use rate that exceeded potential ET. Pennlinks had an actual ET that averaged 86 % of potential ET.

Water use rates among cultivars varied by 16 % to 28 % with and average difference among cultivars of 20 %. Seaside was used as the standard cultivar for comparison purposes using LSD at the 5 % probability level. An experimental cultivar, SR-1020, also had a high water use rate that differed from Seaside's on only four of 14 measurement dates in 1987, and only two out of 14 times in 1988. Cobra had a high water use rate that differed significantly from Seaside's on eight measurement dates in 1987 and 1988. Penncross consistently had a lower ET than Seaside, and ranked intermediate to high in water use compared to other cultivars tested. Penneagle, SR- 1019, Prominent, and Emerald ranked intermediate to low in water use. Pennlinks and DK-515 ranked low in water use.

These results indicate a strong potential to select, breed and develop reduced water use rates in creeping bentgrass cultivars.

Table 1. Evapotranspiration (ET) rates of 10 creeping bentgrass cultivars grown under field conditions and maintained at 12.5 mm cutting height, during the 1987 growing season.

Cultivar	Evapotranspiration Rate (mm day^{-1})[z]						
	22 May	29 May	9 June	11 June	13 June	25 June	16 July
Seaside	5.9	7.1	6.2	9.8	9.8	10.7	9.0
SR-1020	5.6	6.8	5.6	9.5	9.2	10.3	8.5
Cobra	5.4	6.8	5.4	9.4	9.0	10.5	7.9
Penncross	5.3	6.5	5.0	9.3	8.8	9.5	8.2
SR-1019	5.2	6.4	5.3	9.1	8.7	9.3	8.0
Penneagle	4.6	6.4	4.9	8.7	8.3	9.3	7.9
Emerald	4.6	6.4	4.3	8.5	8.5	8.9	7.9
Prominent	4.1	6.0	4.5	8.1	8.2	8.8	7.7
DK-515	3.3	5.8	4.1	8.1	8.0	8.4	7.6
Pennlinks	3.2	5.3	4.0	7.9	7.8	8.3	7.5
LSD (0.05)=	0.4	0.5	0.4	0.6	0.5	0.7	0.7
ET_p =	4.5	5.8	5.0	8.3	8.0	9.0	8.5

[z]Water use rates were determined by minilysimetry and were measured under field conditions with a turfgrass fetch of 150 m^2.

Table 1. (cont') Evapotranspiration (ET) rates of 10 creeping bentgrass cultivars grown under field conditions and maintained at 12.5 mm cutting height, during the 1987 growing season.

Cultivar	Evapotranspiration Rate (mm day^{-1})[z]						
	17 July	23 July	13 Aug	15 Aug	2 Sept	8 Sept	12 Oct
Seaside	8.9	9.5	5.6	8.1	5.6	6.4	4.0
SR-1020	8.5	9.4	5.6	7.9	3.7	5.9	3.9
Cobra	8.3	9.5	4.6	7.9	3.8	5.9	3.8
Penncross	8.1	9.3	5.4	7.7	4.0	5.8	3.9
SR-1019	7.9	9.1	5.3	7.9	3.9	5.5	3.8
Penneagle	7.9	9.3	5.2	7.7	4.3	5.3	4.0
Emerald	7.8	8.8	5.0	7.5	4.1	5.4	4.2
Prominent	7.7	8.5	4.8	6.8	4.1	5.3	4.2
DK-515	7.4	8.5	4.6	6.7	3.3	5.1	3.5
Pennlinks	7.2	8.3	4.0	6.8	3.3	5.0	3.3
LSD (0.05)=	0.5	0.7	0.3	0.5	0.3	0.3	0.4
ET_p =	8.0	9.0	4.8	7.0	5.5	5.8	3.8

[z]Water use rates were determined by minilysimetry and were measured under field conditions with a turfgrass fetch of 150 m^2.

Table 2. Evapotranspiration (ET) rate of 10 creeping bentgrass cultivars grown under field conditions and maintained at 12.5 mm cutting height, during the 1988 growing season.

Cultivar	Evapotranspiration Rate (mm day^{-1})[z]						
	24 May	29 May	10 June	11 June	28 June	6 July	13 July
Seaside	8.8	9.0	9.9	9.9	9.3	9.1	9.3
SR-1020	8.0	9.0	9.0	9.0	8.8	8.7	9.1
Cobra	7.9	8.7	9.3	9.0	8.7	8.7	9.0
Penncross	7.8	8.5	9.0	9.5	8.5	8.5	8.6
SR-1019	7.5	8.3	8.7	9.0	8.1	8.2	8.5
Penneagle	7.4	8.0	8.7	9.1	8.0	8.0	8.5
Emerald	7.2	8.0	8.5	9.0	7.9	7.9	7.8
Prominent	7.0	7.9	8.4	8.9	7.8	7.8	7.3
DK-515	6.7	7.5	8.0	8.8	7.7	7.7	7.2
Pennlinks	6.5	7.1	8.0	8.5	7.6	7.6	7.0
LSD (0.05) =	0.5	0.6	0.6	0.7	0.6	0.5	0.5
ET_p =	7.8	8.3	9.3	12.5	9.3	9.3	8.5

[z]Water use rates were determined by minilysimetry and were measured under field conditions with a turfgrass fetch of $150m^2$.

Table 2. (cont') Evapotranspiration (ET) rate of 10 creeping bentgrass cultivars grown under field conditions and maintained at 12.5 mm cutting height, during the 1988 growing season.

Cultivar	Evapotranspiration Rate (mm day $^{-1}$)[z]						
	20 July	3 Aug	10 Aug	17 Aug	2 Sept	9 Sept	3 Oct
Seaside	6.6	9.2	8.2	9.5	9.5	7.0	4.3
SR-1020	6.5	9.1	8.0	9.3	9.5	6.7	3.8
Cobra	6.3	9.0	7.9	8.6	9.3	6.7	3.8
Penncross	6.3	8.7	7.7	8.8	8.8	6.8	3.7
SR-1019	6.1	8.3	7.7	8.6	8.7	6.5	3.6
Penneagle	5.9	8.0	7.5	9.3	8.6	6.3	3.5
Emerald	5.6	7.9	6.8	8.5	8.5	6.1	3.8
Prominent	5.8	7.5	6.3	8.6	8.4	6.0	3.5
DK-515	5.5	7.5	6.0	7.8	8.5	6.0	3.3
Pennlinks	5.2	7.5	5.9	7.8	8.0	5.9	3.5
LSD (0.05) =	0.3	0.6	0.4	0.7	0.7	0.3	0.3
ET_p =	6.3	8.3	6.5	8.0	9.0	6.0	3.8

[z]Water use rates were determined by minilysimetry and were measured under field conditions with a turfgrass fetch of 150m^2.

Table 3. Topgrowth, clipping yield, verdure, and clipping yield/verdure ratio for 10 creeping bentgrass cultivars.

Cultivar	Topgrowth[z] (g)	Clipping[y] Yield (g)	Verdure[x] (g)	Clipping Yield/ Verdure Ratio[w]
SR-1020	7.0	3.6	3.4	1.1
Penncross	6.8	3.3	3.5	0.9
Seaside	6.6	3.7	2.9	1.3
Cobra	6.5	3.3	3.2	1.0
Pennlinks	6.4	2.6	3.8	0.7
Prominent	6.3	3.0	3.3	0.9
Penneagle	6.1	3.2	2.9	1.1
Emerald	5.9	3.1	2.8	1.1
SR-1019	5.8	3.0	2.8	1.1
DK-515	5.3	2.5	2.8	0.9
LSD (0.05) =	0.7	0.6	0.5	0.3

[z]Topgrowth was measured as clipping yield accumulated over 8 weeks of growth plus verdure at termination of study.

[y]Clipping yield values were accumulated over 8 weekly mowings and were expressed on a dry weight basis.

[x]Verdure was the green vegetation beneath the mowing height at the termination of the study and was expressed on a dry weight basis.

[w]Clipping yield/verdure ratio was based on clipping weight ÷ verdure.

CREEPING BENTGRASS GROWTH AND DEVELOPMENT

The 10 creeping bentgrass cultivars evaluated in the water use rate studies were evaluated for topgrowth, clipping yield, verdure, and clipping yield to verdure ratio. Cultivars were grown under field conditions and were maintained as described in the water use rate study.

Cultivars were arranged in a randomized block design with six replications per treatment for a total of 60 observations. Data were subjected to analysis of variance and mean were separated using Least Significant difference at the 5 % probability level. Seaside was selected as the standard cultivar for comparison purposes. Growth factors were correlated with turfgrass ET.

Clippings were collected with each mowing (i.e. 5 times weekly), dried at 70 C , and the accumulated clipping for the eight week period were weighed. Clipping yields were reported on a dry weight basis. Verdure was measured at the termination of the study. Verdure was reported on a dry weight basis. Topgrowth was determined as clipping yield for the eight weeks plus verdure at the end of the study. Clipping yield to verdure ratio was determined by dividing clipping yield by verdure.

Turfgrass ET was determined weekly using minilysimeters and procedures previously described. Cultivars responded similarly over two years of study for both ET and growth parameters.

Cultivars differed in topgrowth (Table 3). Topgrowth varied by 24 % between the highest and lowest producing cultivars. Clipping yields varied by 31 % (Table 3). Verdure varied by 18 % (Table 3). Clipping yield to verdure ratio differed from 0.7 to 1.3.

Cultivars differed in ET. ET data were not shown because cultivars had the same ET rates as those previously reported (Tables 1 and 2). Clipping yield was positively correlated (r= 0.83) to cultivar ET. Verdure was negatively correlated (r= -0.79) to cultivar ET rate. These results indicated that clipping yield and verdure could be used as selection criteria for selecting and breeding creeping bentgrass cultivars with reduced water use rates.

Clipping yield to verdure ratio values indicated that cultivars with values of less than one had intermediate to low water use rates, while those cultivars with values greater than one had water use rates that were intermediate to high. Development of cultivars with less vertical elongation or slower vertical elongation rates would be desirable where water conservation is a primary concern.

CREEPING BENTGRASS ROOTING

Creeping bentgrass cultivars were studied for root growth and root growth distribution in a specially designed hydroponic system under greenhouse growing conditions. A randomized complete block experimental design with six replications per cultivar was used.

The hydroponic system and procedures were described previously in the 1986 USGA Progress Report. The study was conducted over a 8 week period in 1987 and was repeated in 1988. Cultivars were mowed five times weekly at 12.5 mm and clippings were collected, dried and weighed. No pesticides were applied during the course of this study.

Nutrient solution was changed weekly. It was replaced to the level of draw-down based on evapotranspiration rate. Cultivars were exposed to declining solution levels over the course of the 8 week study based on the cultivars ET rate. At the end of 8 weeks the study was terminated. Plants were removed from the hydroponic system and roots were separated from the topgrowth by severing plants and roots at the crown. Roots were further separated into 150 mm increments from 0 to 750 mm.

Creeping bentgrass cultivars differed in total root production (Table 4). There was a total variation of 31 % among the cultivars tested. Pennlinks had the greatest root production and Penneagle had the least. Penncross, Cobra, and SR-1020 had high root production values, but each produced less than Pennlinks. Seaside, Emerald, DK-515, and SR-1019 had intermediate root production values. Penneagle and Prominent ranked lowest in total root production.

Root distribution is of greater value than total root production, since cultivars may produce high root numbers, but have these roots restricted to the surface soil areas, thus limiting the cultivars ability to use soil moisture further down in the profile. Creeping bentgrass cultivars differed in their root distribution (Table 5). Five cultivars produced roots to a depth of 750 mm, while two cultivars had their root growth restricted to the upper 450 mm. Emerald produced 90 % of it root growth in the upper 300 mm. Prominent and Penneagle produced 85 % and 87 % of their root growth in this same zone. These cultivars were shallow rooted types that apparently lack the ability to redistribute their root system under declining moisture levels.

These results demonstrate that creeping bentgrass cultivars could be selected and developed to enhance root growth production and distribution characteristics. Cultivars with reduced ET and enhanced rooting would be desirable for developing water conservation programs.

Table 4. Total root weight and root distribution percentage for 10 creeping bentgrass cultivars.

Cultivar	Total[z] Root Wt. (mg)	Root Distribution (%)[y] 0-150mm	150-300mm	300-450mm	450-600mm	600-750mm
Pennlinks	1069	44	24	21	9	2
Penncross	998	49	23	21	6	1
Cobra	970	47	27	17	8	1
SR-1020	952	43	24	21	10	2
Seaside	898	56	27	13	4	0
Emerald	878	62	28	10	0	0
DK-515	853	44	29	23	4	0
SR-1019	826	46	27	15	10	2
Prominent	786	60	25	15	0	0
Penneagle	742	64	23	13	0	0
LSD (0.05) = 67		--	--	--	--	--

[z]Total root weight was expressed as mg dry weight produced after eight weeks growth in a hydroponic system.

[y]Root distribution percentage was based on root production per 150mm increment ranging from 0 to 750 mm.

Table 5. Root distribution for 10 creeping bentgrass cultivars grown in a hydroponic system.

Cultivar	Root Distribution (mg)[z]				
	0-150mm	150-300mm	300-450mm	450-600mm	600-750mm
Pennlinks	470	257	224	96	22
Penncross	489	230	210	60	9
Cobra	456	262	165	77	10
SR-1020	409	228	200	96	19
Seaside	503	242	117	36	0
Emerald	544	246	88	0	0
DK-515	375	247	196	35	0
SR-1019	380	223	124	83	16
Prominent	472	196	118	0	0
Penneagle	475	171	96	0	0
LSD (0.05) =	35	28	17	--	N.S.

[z]Root distribution based on mg dry weight per 150mm increments, ranging from 0 to 750 mm.

CREEPING BENTGRASS WEAR TOLERANCE

Creeping bentgrass cultivars and nitrogen nutrition levels were evaluated for their influence on turfgrass wear tolerance. Cultivars were grown in a field evaluation and were fertilized with different nitrogen rates (Table 6). Treatments were arranged in a split plot design with cultivars as main plots and nitrogen rates as subplots. Wear treatments were applied with a specially designed wear simulator.

Cultivars were mowed 6 to 7 times per week at 3.9 mm. Nitrogen levels were applied every 14 days during the growing season at rates equivalent to meet the total amount applied per treatment rate per season. Fungicides were applied in a preventive program. Herbicides and insecticides were applied as needed. Turfs were irrigated to prevent visual drought stress symptoms.

Cultivars differed in wear tolerance and in recovery from wear injury (Table 6). There was a cultivar by nitrogen interaction for wear tolerance. Most cultivars showed an increase in wear tolerance as nitrogen increased from 2.0 lbs/ 1000 sq ft/ season to 4.0 lbs, but declined when rates increased from 4.0 to 6.0 lbs/ 1000 sq ft / season. Penneagle was an exception. Wear tolerance of Penneagle increased with increasing nitrogen nutrition. Wear injury recovery varied among cultivars, but all cultivars recovered better as nitrogen nutrition levels increased. Wear tolerance ratings were positively correlated to cultivar verdure density ($r = 0.80$).

This study supports the selection and development of wear tolerant creeping bentgrass cultivars for use on putting greens, golf tees and fairways. It also supports careful manipulation of fertilizer programs for enhanced wear tolerance and wear injury recovery.

Table 6. Creeping bentgrass wear tolerance and recovery from wear injury as influenced by cultivar and nitrogen rate.

Cultivar	Nitrogen (lbs. N/1000 ft^2/Season)	Wear Tolerance[z] 4 Oct	Wear Recovery[y] 4 Nov
Penncross	2	7.8	7.8
	4	8.5	9.0
	6	5.8	8.7
Penneagle	2	6.7	6.7
	4	7.8	9.0
	6	8.5	9.0
Seaside	2	6.7	7.3
	4	7.5	9.0
	6	5.7	8.3
Prominent	2	6.3	6.7
	4	7.0	8.0
	6	6.0	8.7
Emerald	2	6.0	6.0
	4	7.0	8.0
	6	5.7	8.3
Blend	2	6.7	6.5
	4	8.0	9.0
	6	5.3	8.3
LSD (0.05) =		0.5	0.7

[z]Wear tolerance based on 1 to 9 scale with 1 = 100% injury and 9 = no injury.

[y]Wear recovery based on 1 to 9 scale with 1 = no recovery and 9 = complete recovery.