THE EVALUATION OF SUMMER CULTIVATIONS WITH A TORO HY-DROJECT ON A CREEPING BENTGRASS PUTTING GREEN LOCATED IN THE COACHELLA VALLEY

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I. SUMMARY

Summer cultivations of creeping bentgrass/annual bluegrass putting greens in Southern California are needed to maintain soil water infiltration and percolation and soil aeration. During the summer, these needs are critical because the plants are weakened from prolonged heat stress. Though soil cultivations are effective, there is a balance between the maintenance of proper soil physical characteristics and plant injury via soil cultivation techniques, especially during the summer. Therefore, there is a need to define cultivation protocols via replicated studies, especially for recently developed soil cultivation techniques, such as the Toro HydroJect.

The objective of this study was to determine the optimum summer cultivation program using a Toro HydroJect for creeping bentgrass putting greens in the Coachella Valley. Optimum was defined in terms of visual turfgrass quality, plant growth, especially rooting, and soil physical characteristics.

This study was conducted on a creeping bentgrass putting green nursery located at The Springs Club, Rancho Mirage, California. The 15-week study was started on June 27 and ended October 5, 1995. Treatments were configured so that all possible combinations between HydroJect and rolling (simulated surface compaction) levels were imposed. HydroJect treatments were once every 3 weeks, once every 4 weeks, or no cultivation. Rolling treatments were once each week or no rolling. During the study, measurements of visual turfgrass quality and plant growth were taken, along with measurements of soil physical characteristics.

Results from this study showed that HydroJect cultivations during the summer did not significantly affect visual quality ratings, plant growth, nor soil physical characteristics. However, there may have been a trend toward decreased visual quality due to summer cultivations during extreme high air temperatures (110°F). Other results from this study showed that the average 35.5% soil air porosity and the average 18.5 inches/hour field infiltration rates of the soil of our study location were probably too good to improve via summer cultivations. Therefore, these data are inconclusive until further work is conducted on a more representative putting green soil.

II. BACKGROUND

Summer cultivations of creeping bentgrass/annual bluegrass putting greens are needed in Southern California to 1) reduce soil surface compaction and hardness due to traffic and/or sodium, 2) maintain soil water infiltration and percolation which are especially critical for roots subjected to high soil temperatures during the summer, and 3) maintain gas exchange which also is especially critical for roots subjected to high soil temperatures during the summer. In brief, prolonged high soil and air temperatures are the most limiting factors for bentgrass/annual bluegrass growth during the summer. Soils with limiting soil gas exchange and limiting soil water infiltration and percolation compound the detrimental effects of prolonged high temperatures. Maintaining these soil physical characteristics is a major key for successfully maintaining bentgrass/annual bluegrass putting greens during the summer in Southern California.

The maintenance of proper soil physical characteristics is a 12-month process and involves a proper soil cultivation and topdressing program during the spring and fall. However, the focus of this study is soil cultivations during the summer when bentgrass/annual bluegrass is not under optimal growing conditions. Due to the environmental stress of the summer, less plant-stressful techniques of soil cultivations are practiced, and have included spiking and coring with relatively small-diameter solid lines. A recently developed technique involves using high pressure water injection via a Toro HydroJect. This technique uses short bursts of high velocity streams of water to cultivate the soil while minimizing surface disruption. Though soil cultivation techniques during the summer are less plant stressful and disruptive to the surface, they do create plant injury. Therefore, there is a need to define proper summer cultivation protocols that balance the maintenance of proper soil physical conditions and plant injury.

The objective of this study was to determine the optimum summer cultivation program using a Toro HydroJect for creeping bentgrass putting greens maintained under the desert conditions of the Coachella Valley. Optimum was defined in terms of turfgrass visual quality, plant growth, especially rooting, and soil physical characteristics.

III. MATERIALS AND METHODS

This study was conducted on a creeping bentgrass putting green nursery located at the Springs Club, Rancho Mirage, California. The creeping bentgrass was 8 months old, and was managed to be a representative putting green, with the exception of no golf play. (Table 1).

The 15-week study was started on June 27 and ended October 5, 1995 (Table 2). Treatments were configured so that all possible combinations between HydroJect cultivation and rolling (simulated surface compaction) levels were imposed (Table 3). During the study, measurements of visual turfgrass quality and plant growth were taken (Table 4), along with measurements of soil physical characteristics (Table 5).

Table 1. Study outline of the 1995 Toro HydroJect study.

Objective:	To determine the optimum summer cultivation program using a Toro HydroJect for creeping bentgrass putting greens maintained under the desert conditions of the Coachella Valley. Optimum will be defined in terms of turgrass visual quality, plant growth, especially rooting, and soil physical characteristics.
Study Site:	A putting green nursery located at The Springs Club, Rancho Mirage, California. The root-zone was a well-drained sand, and the study area was seeded in October 1994 with a blend of Crenshaw, Providence, and Southshore creeping bentgrasses.
Experimental Design:	3 x 2 Factorial with four replications of each treatment arranged in a strip-block design. Factor I was HydroJect frequency: one cultivation once every 3 or 4 weeks or no cultivation. Factor II was rolled once each week or not rolled. Individual plot size was 5.5 ft x 6.0 ft.
Measurements:	Measurements of visual turfgrass quality, plant growth, and soil physical characteristics were taken (Tables 4 and 5).
Mowing:	Once every 2 days with either a triplex or walk-behind greens mower. Bench setting was 3/16 inches.
Irrigation:	Applied to promote optimal turfgrass quality and function without visual signs of drought stress. The area also was syringed when necessary, and an wetting agent was applied August 4 and 15. The wetting agent, Yucca TM, was applied at 2 ounces of product/1000 ft^2.
Fertilization:	Ammonium sulfate (21-0-0) was applied at 0.3 lb N/1000 ft^2 on July 8 and 28, and Milorganite (6-4-0) was applied at 0.3 lb N/1000 ft^2 on August 4 and 24. Iron sulfate was applied at 2 ounces product/1000 ft^2 on August 17 and September 5.
Pest Control:	Fore WSP and Aliette WDG were sprayed on June 29, July 11, July 25, August 8, and August 22 at 8 ounces and 4 ounces of product/1000 ft^2, respectively. Scotts Insecticide III granular was applied at 1.278 lb of product/1000 ft^2 on June 30

Table 2. Timeframe for the 15-week 1995 Toro HydroJect study.

Date	Activity
October 1994	Study area seeded[Z]
June 27, 1995	Initiate HydroJect treatments
June 29, 1995	Initiate roll treatments
August 16, 1995	Initiate visual ratings
September 27, 1995	Pull cores for plant morphological analysis
September 27 and October 5, 1995	Soil physical measurements[Y]

[Z]A blend of Crenshaw, Providence, and Southshore.
[Y]One week following appropriate HydroJect treatment.

Table 3. Total HydroJect cultivations and rolls during the 15-week study.

Treatments	Total Number of HydroJect Cultivations	Total Number of Rolls
A. 1 HydroJect/3 weeks 1 roll/week	5	14
B. 1 HydroJect/3 weeks No roll	5	0
C. 1 HydroJect/4 weeks 1 roll/week	4	14
D. 1 HydroJect/4 weeks No roll	4	0
E. No HydroJect 1 roll/week	0	14
F. No HydroJect No roll	0	0

Note: HydroJect was operated at full throttle, maximum hole density, with eleven #53 nozzles operating.
Note: A roll treatment was one pass with a 630-lb machine-driven roller.

Table 4. Plant measurement detail of the 1995 Toro HydroJect study.

Visual turfgrass quality
- 1 = poorest creeping bentgrass green
- 5 = minimally acceptable creeping bentgrass green
- 9 = best creeping bentgrass green

Plant mass

Three 5.9 cm diameter cores taken per plot, then sectioned, pooled, washed, and dried.

- Crown: plant material above 1.0 cm
- Upper roots: 1.0 cm to 7.6 cm
- Lower roots: 7.6 cm to 15.2 cm

Table 5. Soil physical measurement detail of the 1995 Toro HydroJect study.

- Field Infiltration Rates (one test per plot)-

- Double-ring infiltrometers
- 20-cm inner and 30-cm outer diameter rings
- Water levels of the two rings were controlled by two separate Meriot bottles with a ponding depth of 5.0 cm.
- Infiltration measured only for the inner ring.
- When infiltration rate was constant, the last three readings were averaged.

- Core Samples -

One undisturbed core, 5.0 cm diameter x 5.0 cm deep was taken 1.0 cm below the surface of each plot. Cores were transported to the research laboratory.

- Bulk Density (BD)
- Total Porosity = 1.0 - (BD/PD)[Z]
- Air Porosity =
  Total Porosity - Volumetric Water Content at 0.1 bar
- Field Capacity Volumetric Water Content =
  Volumetric water content at 0.1 bar
- Plant Available Volumetric Water Content =
  Volumetric Water Content at 0.1 bar - Volumetric Water Content at 1.0 bar

[Z]PD = particle density, assumed to be 2.65 g cm^{-3} for a sand.

IV. RESULTS AND DISCUSSION

Tables 6 through 9 show that the HydroJect, Roll, and HydroJect x Roll effects did not significantly affect visual turfgrass ratings, plant growth, nor soil physical characteristics. However, for illustration, Tables 10 through 14 show the nonsignificant effect of HydroJect treatments on visual turfgrass ratings, plant growth, and soil physical characteristics for rolled and not rolled treatments.

Though HydroJect treatments did not significantly affect visual turfgrass quality, the overall data may suggest a trend toward decreased visual quality due to summer cultivations with a HydroJect (see overall on Table 10). The decreased visual quality would probably be due to extremely high temperatures and possible dehydration of plants at the edge of the cultivation holes. Therefore, when day time air temperatures are high, 110°F, HydroJect cultivations should be accomplished early in the morning and followed by syringing, or not attempted. This may be especially true in late summer when the bentgrass quality is at its lowest which is a reflection of prolonged heat stress (see September visual ratings for the no HydroJect treatment on Tables 10 and 11).

HydroJect treatments did not significantly affect plant growth (Table 12). This observation may be understandable, since field infiltration rates and air porosity of the soil of our study location were relatively high (Table 13 and 14). Note that air porosity is a measure of the larger soil pores needed for air and moisture movement, while capillary porosity is a measure of the smaller soil pores needed for moisture retention. The USGA recommends that: total porosity = 35% to 55%; air porosity at 0.04 bar = 15% to 30%; capillary porosity at 0.04 bar = 15% to 25%; and saturated conductivity = 6 to 12 inches/hour. Thus, the average 35.5% air porosity and the average 18.5 inches/hour field infiltration rate of the soil of our study location would be considered high, and possibly difficult to improve via summer cultivations with a Toro HydroJect.

In summary, HydroJect cultivations during the summer did not significantly affect visual quality ratings, plant growth, nor soil physical characteristics. However, there may have been a trend toward decreased visual quality due to summer cultivations during extremely high air temperatures (110°F). This study was influenced by the fact that the soil physical characteristics of our study location were probably too good to improve via summer cultivations. Therefore, these data were inconclusive until a similar study is conducted on a location with soil physical characteristics that are more representative (air porosity $\simeq$ 25%; field infiltration rates = 2 to 4 inches/hour).

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Table 6. The effect of HydroJect frequency and rolling on visual turfgrass quality of creeping bentgrass.

Factorial effects	Visual turfgrass quality			
	August 16	August 30	September 18	Overall
HydroJect	NS	NS	NS	NS
Roll	NS	NS	NS	NS
HydroJect x Roll	NS	NS	NS	NS

*, **, ***, NS: Significant at P = 0.05, 0.01, 0.001 or not significant, respectively.

Table 7. The effect of HydroJect frequency and rolling on percent of turfgrass coverage that is brown.

Factorial effects	Percent brown turfgrass coverage		
	August 30	September 18	Overall
HydroJect	NS	NS	NS
Roll	NS	NS	NS
HydroJect x Roll	NS	NS	NS

*, **, ***, NS : Significant at P = 0.05, 0.01, 0.001 or not significant, respectively.

Table 8. The effect of HydroJect frequency and rolling on crown mass and root mass density.

Factorial effects	Crown mass	Root mass density	
		1.0 - 7.6 cm	7.6 - 15.2 cm
HydroJect	NS	NS	NS
Roll	NS	NS	NS
HydroJect x Roll	NS	NS	NS

*, **, ***, NS: Significant at P = 0.05, 0.01, 0.001 or not significant, respectively.

Table 9. The effect of HydroJect frequency and rolling on soil physical characteristics.

Factorial effects	Field infiltration rate	Bulk density	Total porosity	Air porosity	Plant available vol. water content
HydroJect	NS	NS	NS	NS	NS
Roll	NS	NS	NS	NS	NS
HydroJect x Roll	NS	NS	NS	NS	NS

*, **, ***, NS: Significant at P = 0.05, 0.01, 0.001 or not significant, respectively.

Table 10. The effect of HydroJect frequency and rolling on visual turfgrass quality of creeping bentgrass.

Treatment	August 16	August 30	September 18	Overall
Rolled (1/week)				
HydroJect once per 3 weeks	5.1	5.4	3.7	4.7
HydroJect once per 4 weeks	5.5	5.7	4.5	5.2
No HydroJect	5.5	5.7	5.0	5.4
LSD P = 0.05	NS	NS	NS	NS
Not rolled				
HydroJect once per 3 weeks	5.4	5.4	4.4	5.1
HydroJect once per 4 weeks	5.4	5.0	3.4	4.6
No HydroJect	5.6	5.7	4.9	5.4
LSD P = 0.05	NS	NS	NS	NS

Table 11. The effect of HydroJect frequency and rolling on percent of turfgrass coverage that is brown

Treatment	August 30	September 30	Overall
Rolled (1/week)			
HydroJect once per 3 weeks	6	19	13
HydroJect once per 4 weeks	3	10	7
No HydroJect	3	13	8
LSD P = 0.05	NS	NS	NS
Not rolled			
HydroJect once per 3 weeks	4	14	9
HydroJect once per 4 weeks	10	26	18
No HydroJect	5	13	9
LSD P = 0.05	NS	NS	NS

Table 12. The effect of HydroJect frequency and rolling on crown mass and root mass density.

Treatment	Crown mass (g/m^2)	Root mass density (mg/cm^3)	
		1.0 - 7.6 cm	7.6 - 15.2 cm
Rolled (1/week)			
HydroJect once per 3 weeks	118.1	0.022	0.002
HydroJect once per 4 weeks	165.5	0.026	0.007
No HydroJect	122.7	0.052	0.004
LSD P = 0.05	NS	NS	NS
Not rolled			
HydroJect once per 3 weeks	150.2	0.040	0.002
HydroJect once per 4 weeks	144.2	0.033	0.003
No HydroJect	125.2	0.027	0.002
LSD P = 0.05	NS	NS	NS

Table 13. The effect of HydroJect frequency and rolling on field infiltration rate and bulk density.

Treatment	Field infiltration rate(inches/hour)	Bulk density (g/cm^3)
Rolled (1/week)		
HydroJect once per 3 weeks	16.3	1.440
HydroJect once per 4 weeks	16.9	1.485
No HydroJect	20.7	1.417
LSD P = 0.05	NS	NS
Not rolled		
HydroJect once per 3 weeks	19.3	1.452
HydroJect once per 4 weeks	21.0	1.467
No HydroJect	17.0	1.465
LSD P = 0.05	NS	NS

Table 14. The effect of HydroJect frequency and rolling on soil porosity characteristics and plant available volumetric water content.

Treatment	Total porosity	Air porosity	Plant available vol. water content
Rolled (1/week)	----------	**m^3 m^{-3}**	----------
HydroJect once per 3 weeks	0.457	0.362	0.022
HydroJect once per 4 weeks	0.440	0.340	0.020
No HydroJect	0.465	0.355	0.030
LSD P = 0.05	NS	NS	NS
Not rolled			
HydroJect once per 3 weeks	0.452	0.369	0.022
HydroJect once per 4 weeks	0.446	0.346	0.022
No HydroJect	0.447	0.360	0.032
LSD P = 0.05	NS	NS	NS

Note: Multiply decimal fraction by 100 to obtain percent.