Further Evaluations of High Pressure Water Injection as a Turf Management Tool

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The Toro Company has recently introduced high pressure water injection as a new method to deeply cultivate soil while minimizing surface disruption. Research here at M.S.U. has shown water injection cultivation to have considerable promise as a year-round tool for management of soil compaction. Water injection cultivation (WIC) has similar effects on soil properties as hollow tine cultivation, but imparts less damage to crown and root tissue of the turf. The reduced level of injury should allow; 1) cultivation during and prior to environmental conditions considered to stressful for hollow tine cultivation, and 2) more frequent cultivation on sites subjected to routine compaction stress.

Continued research at M.S.U. is evaluating the potential of water injection as a management tool with objectives concerning the effectiveness of injecting wetting agents and nutrients as compared to surface (foliar) applications.

Wetting Agent Injection

Localized dry spot (LDS) is a common problem on turfs growing on soils of a high sand content. Management of LDS generally involves the application of a wetting agent to enhance water infiltration in the afflicted areas. A study was initiated to investigate the effect of wetting agent injection on LDS formation on a creeping bentgrass green. The treatments were 1) no wetting agent (check), 2) water injection (no wetting), 3) 2 oz/1000 ft^2 wetting agent sprayed, 4) 2 oz/1000 ft^2 wetting agent injected, 5) 8 oz/1000 ft^2 wetting agent injected, and 6) 32 oz/1000 ft^2 wetting agent injected. Treatments were applied 10 Aug., 1990. Two additional applications of treatments 2, 3, and 4 were performed on 27 Aug., and 11 Sept., 1990. Soil moisture content and visual quality were monitored through a 41 day period following the initial treatment application. Supplemental irrigation was applied after treatment application and then only minimal irrigation was used to encourage development of LDS. Rainfall of 1.75 inches occurred on 7 Sept., 1990.

Figure 1 displays soil moisture contents during this study. The check plots consistently maintained the lowest soil moisture levels compared to all treatments. The sprayed plots had significantly lower soil moisture contents compared to water injected plots on two dates, 3 and 27 days after initial treatment (Figure 1). The 2 oz/1000 ft^2 injected wetting agent treatment had a significantly higher soil moisture content compared to the sprayed treatment on only one date, 27 days after initial treatment (DAIT). The 8 and 32 oz/1000 ft^2 injected wetting agent treatments had significantly higher soil moisture contents compared to the sprayed treatment on four dates; 3, 10, 17, and 27 DAIT. No

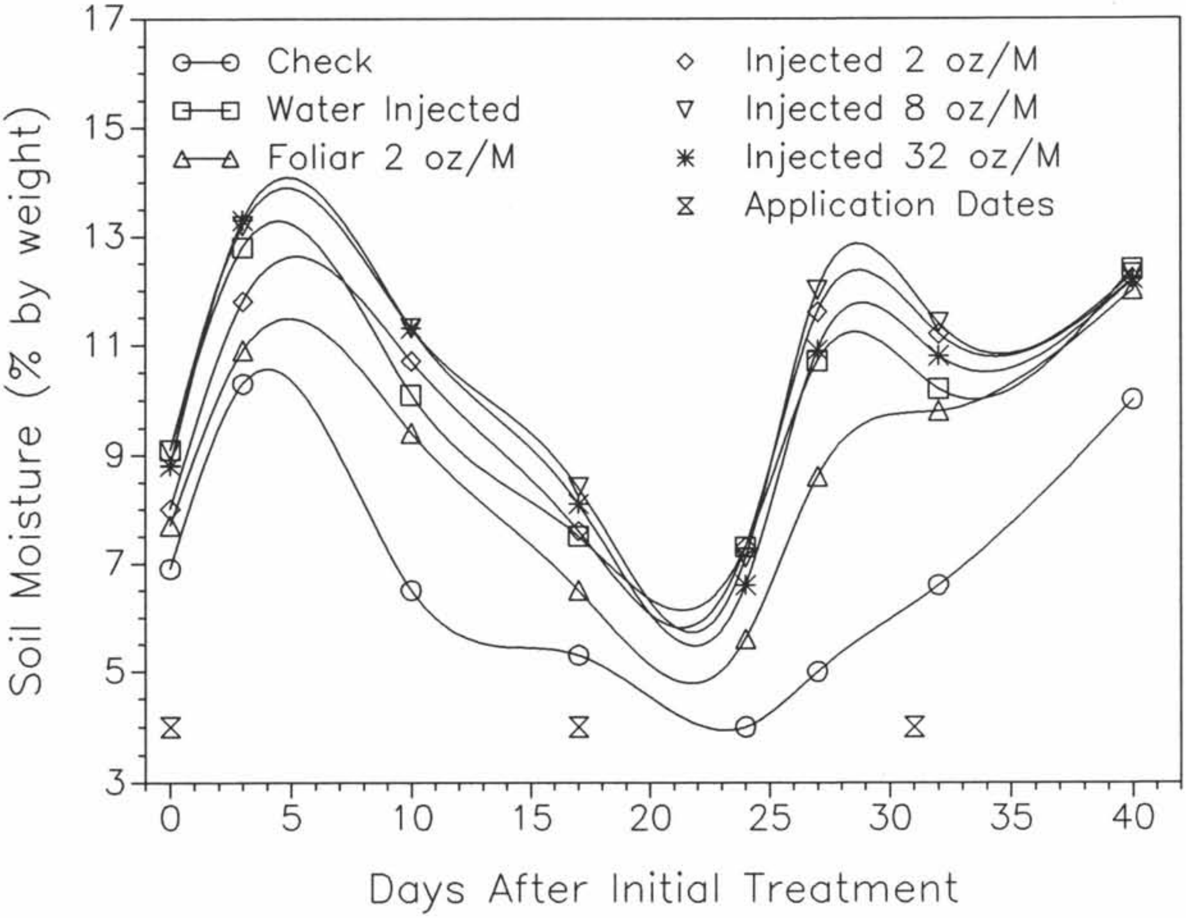

Figure 1. Soil (1 to 3 inch depth) moisture content following wetting agent application in August and September, 1990.

differences in soil moisture content were observed between the 8 and 32 oz/1000 ft^2 wetting agent injection treatments. Due to the frequent rains during the season of 1990, monitoring of long term residual effects of wetting agent application techniques, particularly the 8 and 32 oz/1000 ft^2 injected treatments, was not possible.

Figure 2 presents visual quality during this study. Visual quality of the check plots dropped below acceptable levels within 10 days after the initial treatment applications. The water injection and sprayed wetting agent plots dropped below acceptable levels on one date (28 DAIT). Injected wetting agent treatment at all rates maintained acceptable quality levels throughout the study (Figure 2). This preliminary data suggested that water injection alone may be an effective treatment for localized dry spot. Addition of wetting agent to the water injection treatment did increase the control of LDS formation compared to the sprayed wetting agent treatment on a few dates. Further evaluations are needed to completely determine the effectiveness of wetting agent injection.

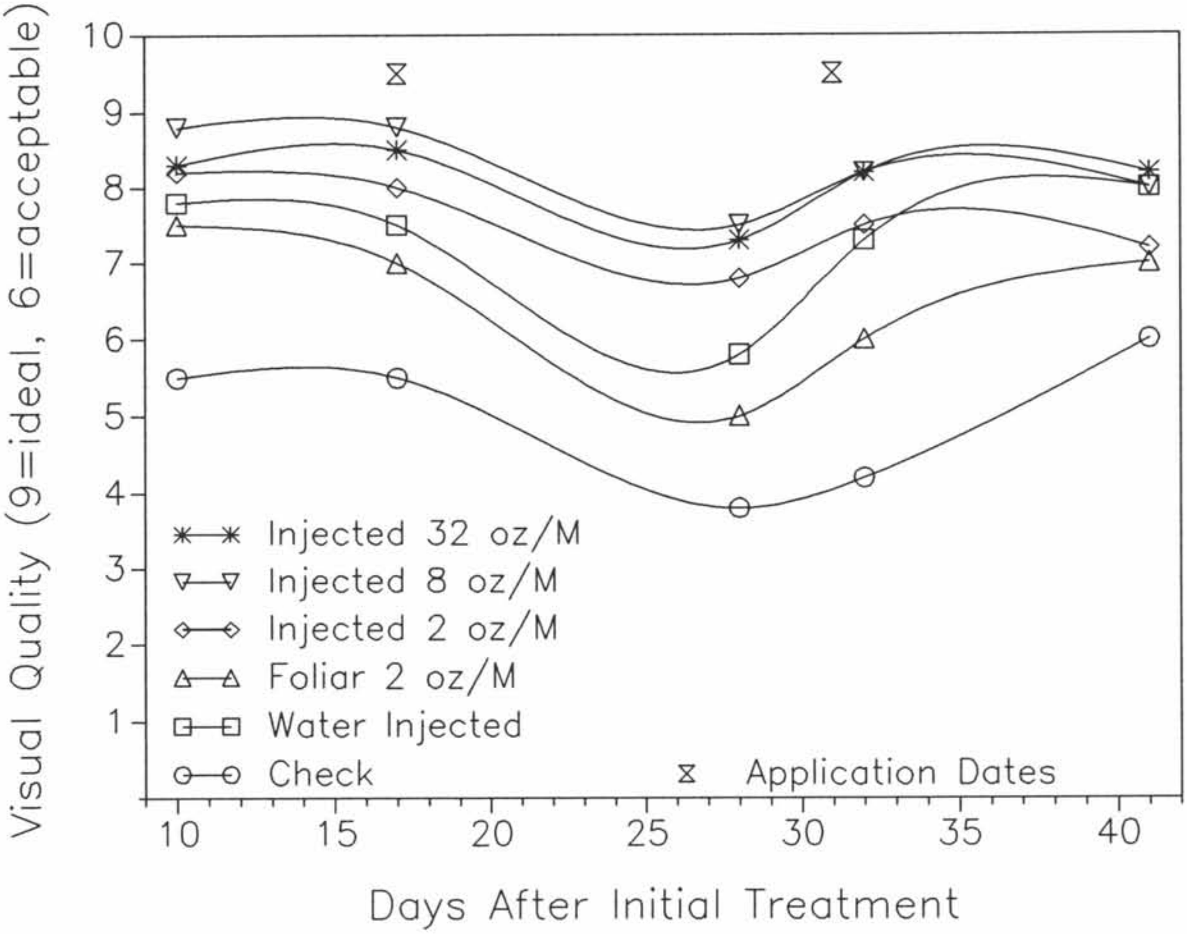

Figure 2. Visual quality following wetting agent application in August and September, 1990.

Phosphorus Injection

Phosphorus levels have been shown to decline in the rootzone of turf soils were clippings are removed. This effect is often referred to as a mining of soil phosphorus. Surface fertilization with phosphorus creates a highly concentrated zone of phosphorus within the thatch layer and upper 3 inches of the rootzone. Research with agricultural crops has demonstrated that root systems will proliferate in zones or pockets of soil containing high levels of nutrients. Surface fertilization of turf may be promoting extensive root development in the soil surface at the expense of root development beyond the 2 to 3 inch depth.

A study was initiated to evaluate injection of phosphorus with the high pressure water injection technique on a creeping bentgrass green grown on a loamy sand soil. The treatments were 1) no phosphorus fertilization (check), 2) water injection (no phosphorus), 3) 3 lb/1000 ft^2 P_2O_5 sprayed, 4) 3 lb/1000 ft^2 P_2O_5 injected, and 5) 6 lb/1000 ft^2 P_2O_5 injected. Treatments were applied twice at half rate on 17 August and 10 October, 1990. Calcium phosphate dissolved in water served as the phosphorus carrier. Evaluations in this study include soil phosphorus testing, tissue analysis, clipping yield, and rooting. Soil testing for phosphorus at four depth zones was performed on 2 Nov., 1990. The soil zones examined were the thatch layer, 0 to 3, 3 to 6, 6 to 9 inches. Only results for soil phosphorus have been completed and will be reported here.

Table 1 presents the soil phosphorus levels measured on 2 Nov., 1990. Sprayed application of phosphorus increased phosphorus levels within the thatch dramatically compared to the injected application treatments. Only the 6 lb/1000 ft^2 P_2O_5 injection increased P levels in the thatch layer. Phosphorus levels were increased at the 0 to 3 inch depth by the 3 lb/1000 ft^2 P_2O_5 sprayed and 6 lb/1000 ft^2 P_2O_5 injected applications. Only the injected applications of phosphorus increased P levels within in 3 to 6 inch zone. No significant increases in P levels were found in the 6 to 9 inch zone. Water injection channels reached an average depth of 6 inches, thus an increase in P levels below the 6 inch depth would not be expected during the short time of this study.

Table 1. Soil phosphorus levels at selected depths following phosphorus fertilization with foliar and injected application techniques, 2 Nov., 1990.

	Thatch Layer	0 to 3" Zone	3 to 6" Zone	6 to 9" Zone
		lb / acre		
Check	24 c	26 c	40 c	50 a
Water Inject	23 c	24 c	46 c	52 a
Spray 3 lb/M	138 a	40 ab	42 c	48 a
Inject 3 lb/M	37 bc	34 bc	61 b	56 a
Inject 6 lb/M	61 b	44 a	87 a	62 a

Numbers followed by the same letter are not significantly different at the 0.05 level of probability.

Spray application of phosphorus concentrated P at the surface (thatch to 3 inch depth) while injected applications placed phosphorus down to the 6 inch depth. Further evaluations of tissue analysis, clipping yield, and root development will help determine whether subsurface placement of phosphorus has a greater effectiveness than surface application.

Nitrogen Injection

Nitrogen injection studies have been initiated to determine the response of creeping bentgrass to subsurface application of nitrogen. The first experiment examined the response of creeping bentgrass to urea injection. Injection holes were spaced in either a 3 x 6 or 3 x 3 inch pattern. The objective of this study was to evaluate the uniformity of response to the two different spacings of urea injection. A uniform response to urea injection on 3 x 3 inch spacing was observed. The green-up response of the 3 x 3" pattern remained uniform throughout the duration of the study (3 months). Urea injection on the 3 x 6 inch spacing resulted in a striped response pattern. The striped green-up on the 3 x 6" pattern plots remained non-uniform throughout the study.

A second nitrogen study was performed to compare foliar and injection application of urea. A 3 x 3 inch spacing was used for the urea injection treatment. Treatments used urea as a nitrogen carrier and were;

1) sprayed at 0.5 lb N / 1000 ft^2,
2) sprayed at 1.0 lb N / 1000 ft^2,
3) water injected then sprayed at 0.5 lb N / 1000 ft^2,
4) water injected then sprayed at 1.0 lb N / 1000 ft^2,
5) injected at 0.5 lb N / 1000 ft^2,
6) injected at 1.0 lb N / 1000 ft^2, and
7) injected at 2.0 lb N / 1000 ft^2.

Treatments 3 and 4 were water injected (no urea) prior to nitrogen application (spray) to distinguish between the cultivation channel influence and the nitrogen injection influence on rooting. Rooting responses to treatments 5, 6, and 7 have a combination of cultivation channel and nitrogen injection factors that may influence rooting responses. Visual quality (Table 2) was monitored to measure the green-up residual characteristics of each application method. At a given rate of nitrogen, no differences in quality were observed between sprayed and injected applications up to 40 days after treatment.

The residual response to these treatments will be monitored to determine the longevity of injected nitrogen fertilization. Injection of nitrogen offers the potential for reduced volatilization of nitrogen following fertilization. Reduced nitrogen losses via volatilization may increase the length of response to nitrogen or decrease the total amount of nitrogen needed annually. Conversely, injection of nitrogen increases the chance for leaching of nitrate past the rootzone. Potential nitrogen losses through leaching may be minimized by injecting during periods of low rainfall. Evaluations of clipping yield and rooting need to be made in future studies.

Table 2. Long-term visual quality response to sprayed and injected applications of urea on a creeping bentgrass green; treatments applied 20 Sept, 1990.

Nitrogen Rate	Application Method	11 October 21 DAT[y]	20 October 30 DAT	30 October 40 DAT
lb/1000 ft^2				
0.5	Sprayed	5.7 c	5.7 c	5.0 c
1.0	Sprayed	7.7 b	7.7 b	7.0 b
0.5	Sprayed[z]	5.7 c	6.0 c	5.0 c
1.0	Sprayed[z]	8.0 ab	7.3 b	7.0 b
0.5	Injected	5.3 c	6.0 c	4.7 c
1.0	Injected	7.3 b	7.3 b	7.0 b
2.0	Injected	9.0 a	9.0 a	8.3 a

y, DAT = Days After Treatment
z, Sprayed treatment preceded by Water Injection without urea.
Numbers followed by the same letter are not significantly different at the 0.05 level of probability.

Conclusions

High pressure water injection of wetting agent, phosphorus, and nitrogen has shown promise as an alternative method to foliar application of these materials. These studies are in the preliminary stages and further evaluations need to be made to fully understand the potential of high pressure water injection technology. Research in this area will be continuing.