Phosphorus Effect on Turfgrass Growth and Soil Moisture During Drought and Post-Drought Recovery

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Introduction

Water availability for turfgrass irrigation is increasingly limited by climate change and water use regulations for the landscape and golf industries (Green, 2005). Phosphorous (P) fertilization is also being regulated for the turfgrass industry in North America with the concern of surface water contamination (Miller, 2012).

Drought stress adversely affects nutrient metabolism (Kreuzwieser and Gessler, 2010), while nutrient uptake ability in drying soils affects plant drought tolerance (Gordon et al., 1999). The addition of P (15 and 30 mg P kg^{-1} soil) to a P deficient soil alleviated drought stress for soybean at the reproductive stage and help offset the impact of drought on crop quality and yield (Jin et al., 2006). Phosphorous deficiency is associated with delayed allocation of biomass and P to leaves and stems of wheat, which in turn affects the plants ability to tolerate drought stress as measured by maintaining yield under drought (Rodriguez and Goudriaan, 1995). Higher levels of P nutrition increased the ability of plants to tolerate drought in forage crops through the increase of total leaf area, and development and penetration of roots in deeper soil layers (Saneoka et al., 1990). Turfgrass with P fertilization had more root growth than turfgrass without P although the root:shoot ratio of turfgrasses with low P was greater than those with high P (Lyons et al., 2008).

In this study we compared 4 turfgrasses with a high and low P fertilization during dry down and post-drought recovery periods to determine how P fertilization impacts the drought tolerance of mowed grasses. We hypothesize that low P fertilization would improve drought tolerance by increasing the root:shoot allocation of available carbon to roots under mowed conditions.

Objective

To determine how phosphorus affects drought tolerance under water deficit conditions for different turfgrasses.

Methods

Establishment

- 7.62 cm diameter PVC tubes
- 40 cm USGA 80:20 soil mix with 10 cm pea gravel at bottom
- Deionized water for irrigation
- Liquid 20-8-20 at 112.5 g N $100m^{-2}wk^{-1}$ for establishment period of 2 wks

Turfgrass

- Pencross creeping bentgrass – seeded
- L93 creeping bentgrass – seeded
- SR7200 velvet bentgrass – seeded
- Annual bluegrass (AB) – tillered from Guelph Turfgrass Institute green

Fertilization

- Hoagland solution
- Modified hoagland solution without P
- Application rate: 45.4g N $100m^{-2}wk^{-1}$ for 11 wks before dry down, and resumed during post-drought recovery period

Irrigation

- Well-watered with D.I. water
- Water withheld for 21 days then resumed for 30 days

Experimental design

- Randomized Complete Block Design with 4 replications

Mowing

- All pots were clipped three times a week and the clipping weights for the week were pooled

Figure 1. Turfgrass at 14 days after drought treatment.

Measurements

- Turfgrass color – twice a week visual rating on a scale of 0 to 9 (9-dark green, 0-straw yellow)
- Clipping dry weight – weekly
- Soil moisture at 5, 10, 15, 20, 25 cm depth below turf – twice a wk
- Root dry weight at 0-3, 3-12, >12 depths – at harvest
- Total root length – at harvest

Results

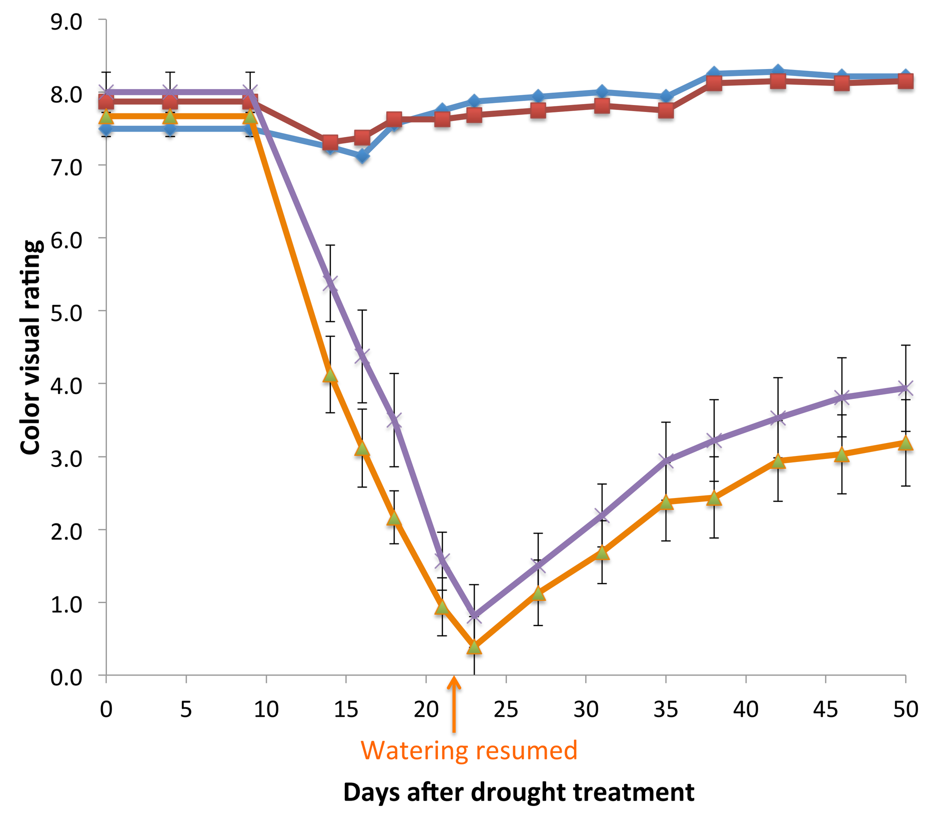

Figure 2. Color (0-9 scale) of four turfgrasses under well watered and drought treatments at different phosphorus fertility. Arrow represents the timepoint watering resumed in the drought treatments. Error bars represent 95% confidence interval of a mean of four replicates of four different species pooled.

The No P treatment had higher color ratings than P treatment during the dry-down period. P did not affect turfgrass color for well watered treatment or during the recovery period (Fig 2).

Table 1. Color (0-9 scale), clipping dry weight, and soil moisture (average of 5 depths) of four turfgrasses at 2, 9, 14, 21 days after drought treatment (DADT) and 5, 13, 24 days after drought recover (DADR). Letters indicate significant differences within a column.

Turfgrass	2 DADT	9 DADT	14 DADT	21 DADT	5 DADR	13 DADR	24 DADR
	Color						
L93	8.0a	7.9a	5.5b	1.4a	0.5d	1.2c	1.3c
Pencross	8.0a	7.9a	5.9a	1.6a	1.4b	3.8b	4.8b
AB	7.8ab	5.6c	2.6d	0.3b	0.9c	1.1c	1.5c
SR7200	7.6b	7.1b	5.0c	1.8a	2.5a	4.6a	6.1a
	Clipping dry weight (g)						
L93	0.05a	0.08ab	0.00	0.00	0.01b	0.01b	0.02c
Pencross	0.05a	0.10a	0.00	0.00	0.04a	0.05a	0.07a
AB	0.03b	0.04c	0.00	0.00	0.00b	0.00b	0.01c
SR7200	0.04ab	0.07b	0.00	0.00	0.05a	0.04a	0.05b
	Soil moisture (%vol)						
L93	7.06c	3.85c	0.69d	0.00c	8.61c	11.12c	
Pencross	8.27b	4.80b	1.56c	0.00c	9.72b	12.01b	
AB	8.32b	4.93b	2.58a	0.86a	10.23a	13.15a	
SR7200	8.67a	5.27a	2.28b	0.33b	9.63b	12.08b	

SR7200 had the best color during the recovery period and was able to recover to an acceptable level after 24 days. Pencross had the highest clipping dry weight. SR7200 had the highest soil moisture at 2 and 9 DADT. AB had the highest soil moisture for 14 and 21 DADT and 5, 13 DADR (Table 1).

Table 2. Color (0-9 scale) of four turfgrasses with different phosphorus fertility during a dry down and post-drought recovery period. Letters indicate significant differences within a column and * indicates difference between P fertility.

Turfgrass	No P	P	
	Dry down		
L93	5.5a	4.4b	*
Pencross	5.7a	5.2a	*
AB	3.3b	3.1d	
SR7200	5.6a	3.9c	*
	Post-drought recovery		
L93	1.1b	0.9c	
Pencross	4.0a	2.5b	*
AB	1.0b	1.3c	
SR7200	4.9a	4.0a	*

The No P treatment had higher color ratings than P treatment for L93, Pencross, and SR7200 for both periods. AB had the lowest or equal to the lowest color ratings compared with other turfgrasses regardless of P fertilization (Table 2).

Table 3. Rooting parameters of four turfgrasses with different phosphorus fertility during a dry down and post-drought recovery period. Letters indicate significant differences within a column and * indicates difference between P fertility.

Turfgrass	No P	P	
	Root dry weight (g)		
L93	139.3a	137.8a	
Pencross	121.9a	105.9b	
AB	64.7b	79.1c	
SR7200	135.2a	80.9c	*
	Total root length (cm)		
L93	1244.2ab	1104.7	
Pencross	1342.9a	1005.8	
AB	958.5b	901.5	*
SR7200	1048.6b	881.7	*

The P treatment resulted in smaller root dry weight for SR7200, and shorter root total length for SR7200 and AB compared with the No P treatment. AB had the smallest root dry weight and total root length compared with other grasses (Table 3).

Table 4. Soil moisture at three depths of four turfgrasses with different phosphorus fertility during a dry down and post-drought recovery period. Letters indicate significant differences within a column and * indicates difference between P fertility.

Turfgrass	No P	P	
	5cm		
All	2.28	2.15	*
	20cm		
L93	4.77c	4.46d	
Pencross	5.97b	5.69c	
AB	6.46a	7.19a	*
SR7200	6.22ab	6.59b	*
	25cm		
L93	7.42c	6.63d	*
Pencross	8.94b	8.83c	
AB	9.58a	10.92a	*
SR7200	9.34ab	9.97b	*

AB and SR7200 had higher soil moisture levels for the P than the No P treatments at 20 and 25 cm. All turfgrasses had higher soil moisture levels for the No P than P at 5 cm (Table 4).

Summary

- AB had the lowest color rating, the lowest root dry weight and root length compared to the other species regardless of P rate.
- Plant with low P fertility had longer root length than the high P treatment for SR7200 and AB in addition to greater root mass in SR7200. SR7200 had the best color recovery from drought stress.
- Lower soil moisture at deeper depths in AB and SR7200 in the No P treatment than the P treatment is indicative of the increased allocation to roots in the No P treatment observed in these grasses.
- AB and SR7200 preserve soil moisture longer than CB during dry down period due to lower ET rates associated with reduced shoot growth from allocating carbon to the roots.

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