Foliar Urea-Nitrogen Use Efficiency of Warm-Season Putting Green Turfgrasses Under Salinity Stresses

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Objectives:

1. *Quantify absorption, translocation, and assimilation of foliar-applied urea-N of in three warm-season putting green turfgrasses.*
2. *Optimize absorption, translocation, and assimilation of foliar-applied urea-15N by the turfgrasses under various salinity stressful conditions.*
3. *Investigate leaf N metabolism at a molecular level - urease activity among the turfgrasses associated with nickel applications.*
4. *Investigate the impact of long-term foliar-applied N on root growth among different turfgrasses.*

Foliar applications are a popular practice in turfgrass management. Past research has mainly focused on various products and rates, without the concern of the influence of leaf surface characteristics between species. This ongoing research is tasked with identifying the major leaf characteristics and mechanisms that affect foliar uptake and identify possible management practices to increase uptake levels.

Results

Leaf Morphology: Leaf surface results indicate a large difference between leaf surface morphology between warm-season grass species. Surface roughness (SA) as measured by a LEXT Optical Profiler, reveals warm-season species investigated range from 1.23 SA to 6.14 SA for Zoysia japonica and Paspalum vaginatum, respectively (Figure 1). Other warm-season turfgrasses have SA that fall between these grasses with the mean being 2.48 SA.

Cuticle Composition and Morphology: The chemical composition of turfgrass cuticles is currently being investigated. Preliminary data reveal cuticles of warm-season grasses are composed of mainly primary alcohols, alkanes, and fatty acids. Although similar compounds have been found in the cuticles, differences in amount and percentages could play a major role influencing hydrophobicity of the leaf surface. Cuticle morphology images reveal similar architecture with membranous platelets being the most common cuticle structure found on grasses (Figure 2).

Hydrophobicity: The contact angle of a water droplet on a surface is a measure of its hydrophobicity (>90o = hydrophobic, <90o = hydrophilic). The more hydrophobic a leaf surface is the less opportunity for solution uptake. Hydrophobicity of warm-season grasses was measured with a 1µl and a micrograph taken with a horizontal

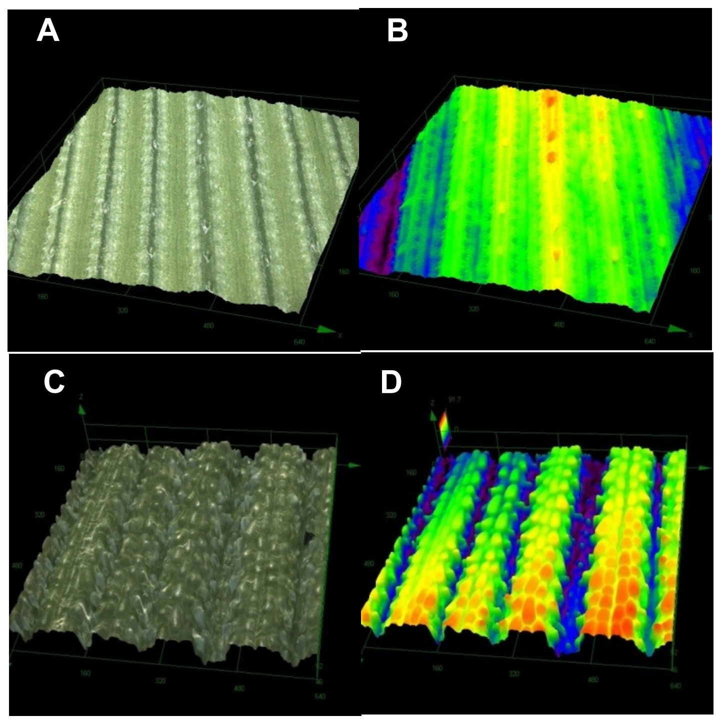

Figure 1: Examples of Images acquired for surface roughness calculation. Images obtained with a LEXT optical profiler, at 20x magnification. A,C) Three-dimensional color renderings of leaf morphology for Z. japonica and Paspalum vaginatum, respectively. B,D) Height intensity maps to demonstrate the roughness of leaf surface for Z. japonica and Paspalum vaginatum, respectively.

stereomicroscope (Figure 3). Hydrophobicity data ranged from 131.3o for bermudagrass to only 43.7o for centipedegrass. Data suggests hydrophobicity is related to leaf surface roughness (Figure 4), but that other factors such as surface chemistry and cuticle morphology could have an influence as well.

Conclusions:

Leaf characteristics including leaf morphology, cuticle composition and cuticle morphology differ significantly among grass species. The influence of these factors is demonstrated by the hydrophobicity test and significant relationship seen with leaf surface roughness. Continuing research aims to identify the leaf cuticle's relationship with hydrophobicity as well as, investigate stomata size and density. Also future work will investigate the uptake kinetics of various products and try to identify the uptake routes of solutions through the leaf surface.

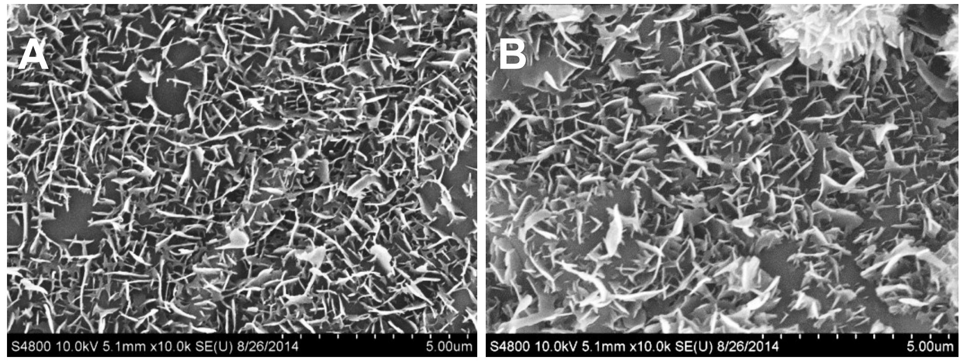

Figure 2: Scanning electron micrographs of cuticle morphology for hybrid bermudagrass (A) and Z. matrella (B) demonstrating similar cuticle morphology between grasses.

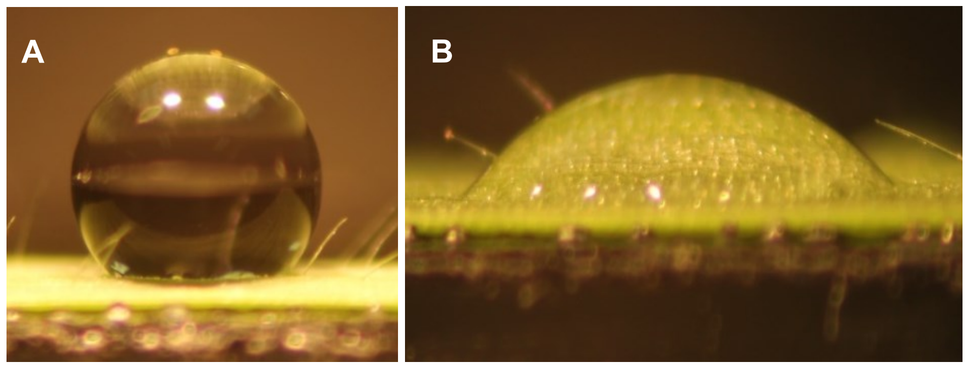

Figure 3: Micrograph images of 1µl water droplets on adaxial side of leaf for (A) bermudagrass and (B) centipedegrass, demonstrating the differences seen in hydrophobicity between species.

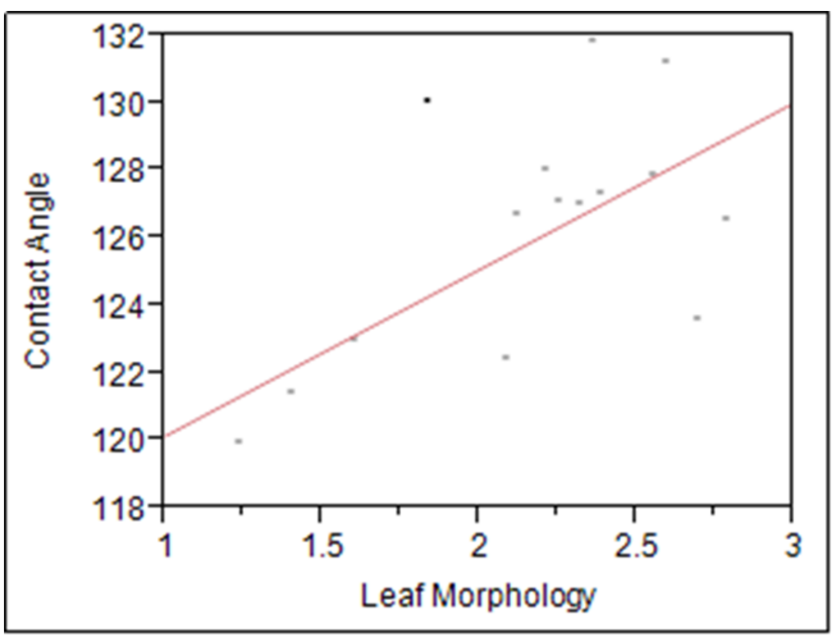

Figure 4: Correlation analysis of leaf morphology and contact angle. As leaf morphology increases the contact angle of the water droplet increases, also. (r = 0.6313, p = 0.0372*)

Field plots on July 9, 2014

Table 1. Turf quality for TifEagle bermudagrass treated with Urea and Nickel from June to September, 2014.

Urea (kg N/ha)	Nickel (kg/ha)	Turf Quality [z]		
		July	August	September
85	0	5.58 e [y]	5.17 f	5.42 g
	3	6.17 bcd	6.33 de	6.67 ef
	6	6.17 bcd	6.33 de	6.83 def
	12	5.58 e	6.16 e	6.33 f
170	0	6.58 abc	6.83 cd	6.92 cdef
	3	6.08 cde	6.75 cd	6.92 cdef
	6	6.50 abc	7.42 ab	7.58 ab
	12	5.92 de	7.17 bc	6.75 ef
255	0	6.92 a	7.58 ab	7.50 abc
	3	7.00 a	7.92 a	7.75 a
	6	6.67 ab	7.25 bc	7.08 bcde
	12	6.08 cde	7.92 a	7.42 abcd
LSD [x]		0.58	0.57	0.62
Source of variation				
Urea		***	***	***
Nickel		**	**	**
Urea*Nickel		NS	**	***

, * Significant at 0.01, 0.001 probability levels.

[z] Turf quality was rated weekly on a 1-9 scale with 9 being dark green turf and 1 being dead turf with >6 being acceptable.

[y] Values within a column followed by the same letter are not significantly different at P≤0.05 by protected LSD.

[x] Fisher's protected least significant difference at P≤0.05.

Notes: Urea and Nickel combined solutions were applied bi-weekly from June 19th, 2014 in total of 7 times.

Table 2. Chlorophyll index for TifEagle bermudagrass treated with Urea and Nickel from June to September, 2014.

Urea (kg N/ha)	Nickel (mg/kg)	Chlorophyll Index[z] July	August	September
85	0	201.25 d[y]	253.75 f	246.75 f
	3	250.75 bc	302.75 e	309.00 de
	6	254.25 bc	309.25 e	322.75 cde
	12	253.00 bc	298.50 e	321.25 cde
170	0	240.25 c	317.75 de	301.25 e
	3	247.50 bc	323.50 cde	323.50 cde
	6	271.25 ab	361.25 ab	352.00 ab
	12	261.50 bc	342.00 bcd	342.50 abc
255	0	257.75 bc	349.25 bc	323.75 cde
	3	270.50 ab	366.50 ab	330.50 bcd
	6	256.75 bc	354.50 b	330.50 bcd
	12	290.50 a	390 a	363.00 a
LSD[x]		28.00	28.86	25.21
Source of variation				
Urea		***	***	***
Nickel		***	***	***
Urea*Nickel		NS	*	**

*, **, *** Significant at 0.05, 0. 01, 0.001 probability levels.

[z] Chlorophyll index was measured monthly using a Field Scout CM 1000 Chlorophyll Meter with a 0-999 scale of total amount of chlorophyll in the plant tissue.

[y] Values within a column followed by the same letter are not significantly different at P≤0.05 by protected LSD.

[x] Fisher's protected least significant difference at P≤0.05.

Notes: Urea and Nickel combined solutions were applied bi-weekly from June 19th, 2014 in total of 7 times.

Table 3. Urease activity for TifEagle bermudagrass treated with Urea and Nickel from June to September, 2014

Urea (kg N/ha)	Nickel (kg/ha)	Urease Activity (µmol NH4+/min/g FW) July	August
85	0	29.21 h[z]	46.04 d
	3	59.21 f	69.08 bc
	6	95.83 bc	84.78 ab
	12	98.94 ab	90.22 a
170	0	26.03 h	38.87 d
	3	65.90 e	67.45 c
	6	103.33 a	97.52 a
	12	91.74 c	90.77 a
255	0	36.78 g	40.83 d
	3	66.78 e	69.89 bc
	6	97.72 b	93.77 a
	12	84.85 d	68.67 c
LSD[y]		5.24	15.89
Source of variation			
Urea		NS	NS
Nickel		***	***
Urea*Nickel		***	NS

*, **, *** Significant at 0.05, 0. 01, 0.001 probability levels.

[z] Values within a column followed by the same letter are not significantly different at P≤0.05 by protected LSD.

[y] Fisher's protected least significant difference at P≤0.05.