Examining Soil Surfactant Performance at the Active Ingredient Level

UofA DIVISION OF AGRICULTURE RESEARCH & EXTENSION University of Arkansas System

D.P. O'Brien, M.D. Richardson, S.J. Kostka

Department of Horticulture, University of Arkansas, Fayetteville, AR 72701

UNIVERSITY OF ARKANSAS DALE BUMPERS COLLEGE OF AGRICULTURAL, FOOD & LIFE SCIENCES

INTRODUCTION

Turfgrass Soil Surfactants

- Are a leading water conservation strategy on golf courses, playing important roles for water movement, retention, and uptake in sand-based putting greens (Gelertner et al., 2015; Jacobs & Barden, 2018)
- Registration and labeling requirements differ from pesticides, resulting in less clarity about the contents and performance of commercial surfactants
- Active ingredients for 32 (of 192) U.S. products are classified as *unknown* or *not disclosed*; what is known, is that most turfgrass soil surfactants are *non-ionic* (142) *block copolymers* (112) (Fidanza et al., 2020)

➢ There is a need for research connecting surfactant *function* with *structure*

Block Copolymers

- Are amphiphilic molecules with a central hydrophobe polyoxypropylene oxide (PPO), flanked by hydrophilic polyoxyethylene oxide (PEO) (**Fig. 1**)
- *Poloxamer* is the generic name; the trade name is *Pluronic*® (BASF)
- Both the hydrophobe and hydrophile can be altered incrementally, resulting in a wide-range of functionality (Alexandridis, 1997)

Hydrophilic-Lipophilic Balance (HLB)

- Ratio of hydrophilic to hydrophobic portions of a surfactant molecule
- Increasing value = increased hydrophilicity and water solubility (**Fig. 2**)
- Dominant property for surfactant efficacy in wetting water repellant soils; *HLB ≤ 10* preferred (Kostka & Bially, 2003; Kostka & Schuermann, 2008)

➢ This research seeks to work with *block copolymers of known HLB*, rather than commercial products with uncertainties about their composition

The objective of this research was to keep the central hydrophobe constant while altering hydrophilic chain length to examine the role of HLB on surfactant performance in sand-based greens

Fig. 1

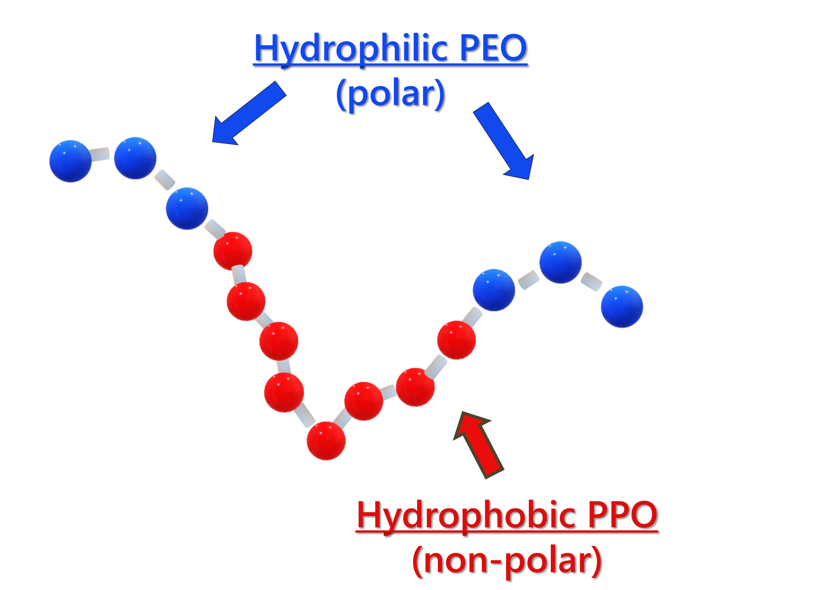


Fig. 1. Block copolymer molecules have a central hydrophobe (red) of polyoxypropylene oxide (PPO) and hydrophilic chains (blue) of polyoxyethylene oxide (PEO).

Fig. 2

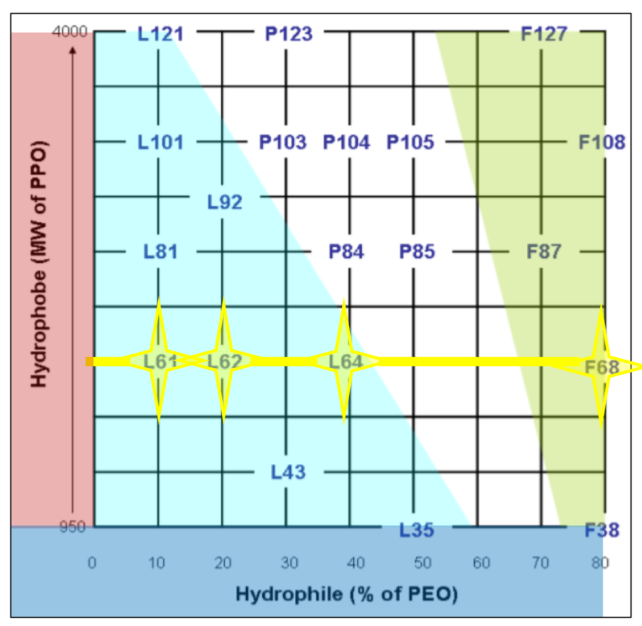


Fig. 2. Hydrophilic-hydrophobic relationship of Pluronic (poloxamer) block copolymers (BASF); highlighted compounds were used in this research.

MATRIALS & METHODS

Experimental Area & Design

- Mature USGA sand-based, creeping bentgrass green (*Agrostis stolonifera* L.) in Fayetteville, AR (36°06'03" N lat, 94°10'22.W long), managed under representative maintenance practices (3.2 mm height of cut) (**Fig. 3**)
- Split-plot design, arranged in a randomized complete block, with four replications; whole-plot factor was irrigation (2 levels), and split-plot factor was soil surfactant (6 levels) (**Fig. 4**)

Fig. 3

Fig. 3. Sand-based, creeping bentgrass putting green (*Agrostis stolonifera* L. cv '007' (2021) & 'Pure Distinction' (2022)) used in this research.

Fig. 4

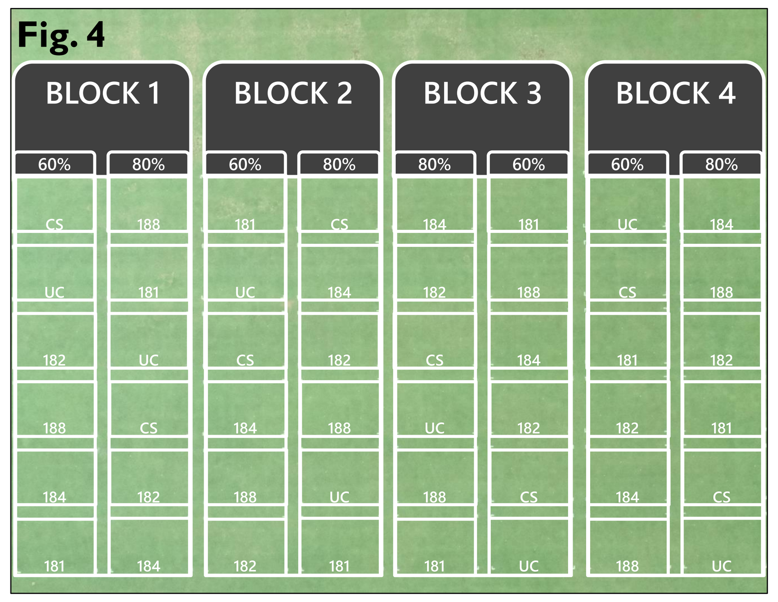


Fig. 4. Split-plot design with irrigation whole-plots (two levels) and six soil surfactant split-plots (CS=commercial standard; UC=untreated control).

Treatments & Applications

(Materials & Methods continued)

- **Whole-plots:** irrigation replacing 60 or 80% net evapotranspiration (ET)
- **Split-plots:** soil surfactants consisting of four Poloxamer compounds (181, 182, 184, 188), a commercial standard (Revolution, Aquatrols Corp.), and an untreated control (**Table 1**)
- Surfactants were applied every four weeks using a single-nozzle boom and spray shield (207 kPa), in a spray volume of 815 L ha^{-1}, and were uniformly watered-in with 5 mm of irrigation
- Initial treatments were applied on 11-May 2021 & 3-May 2022

Data Collection

- Important to capture both *above ground & below ground effects*
- **Above ground:** visual ratings for turfgrass quality (1-9 scale), and percent localized dry spot (LDS)
- **Below ground:** volumetric water content (VWC), at 3.8 and 7.6 cm (24 subsamples per plot), using TDR350 (Spectrum Technologies Inc.)
- Data were collected weekly in 2021 and bi-weekly in 2022; because of space limitations, this poster will focus on the 2022 trial

Table 1. Soil surfactant treatments applied to split-plots

Treatment ID	Pluronic ID	HLB[1]	Rate (g / m²)	Trt / plot (ml or g*)
Poloxamer 181	(L61)	(3)	2	4.4
Poloxamer 182	(L62)	(7)	2	4.3
Poloxamer 184	(L64)	(15)	2	4.3
Poloxamer 188	(F68)	(29)	2	4.5 *
Revolution			2	4.4
Untreated control			0	0

[1]HLB – hydrophilic-lipophilic balance

RESULTS & DISCUSSION

- Above ground, Poloxamer 188 (HLB=29) resulted in greater LDS than other surfactant treatments (**Fig. 5**), and was not significantly different from the untreated control in turfgrass quality (**Fig. 6**)
- Both above and below ground, Poloxamers 181 & 182 (HLB=3 & 7) were not significantly different from the commercial standard (**Figs. 6 & 7**)
- Below ground, at 60% irrigation, VWC of Poloxamer 188 at both 3.8 and 7.6 cm was significantly lower than other surfactant treatments during the final two months of the trial **(Fig. 8)**
- However, VWC differences were observed at 80% irrigation (**Fig. 8**)

Fig. 5

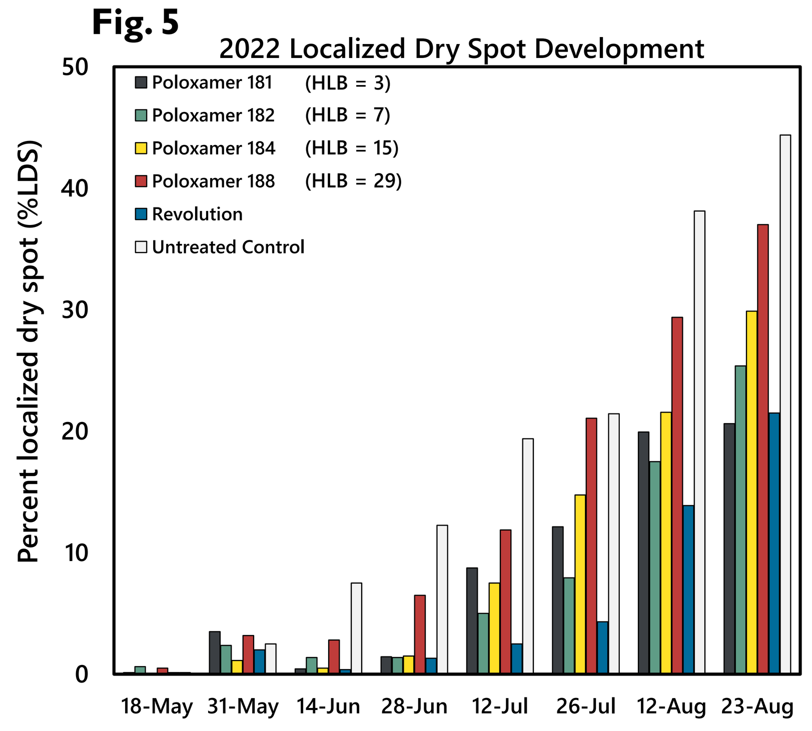


Fig. 5. Poloxamer 188 ranked last among surfactants for reducing localized dry spot in 2022.

Fig. 6

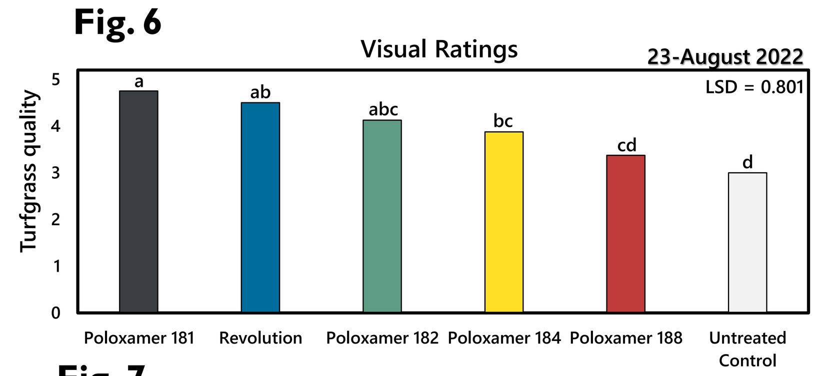
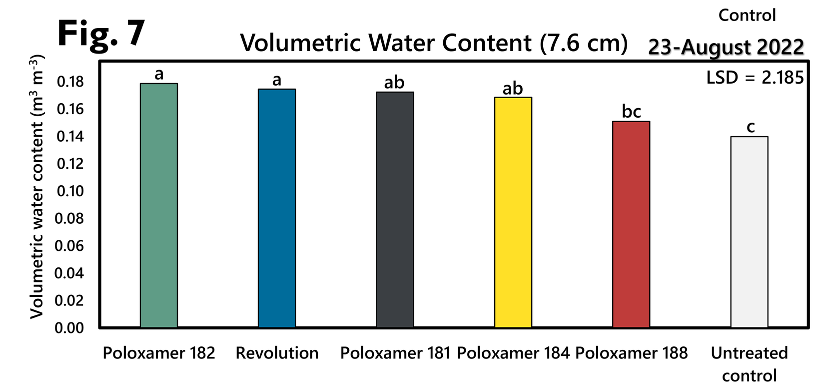


Fig. 7



Figs. 6 & 7. The relationship between above and below ground data at the end of the 2022 trial.

Fig. 8

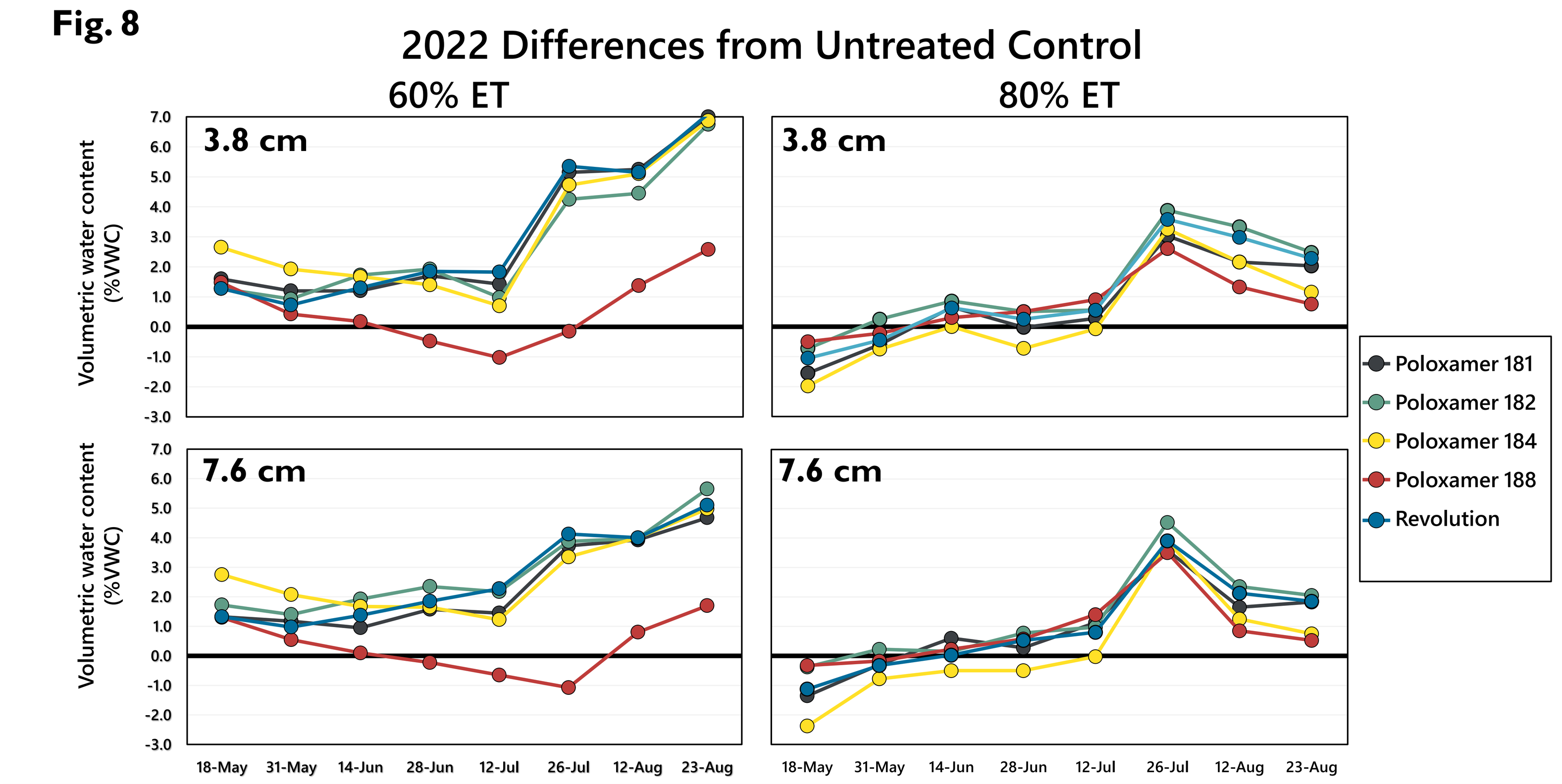


Fig. 8. The importance of considering irrigation when conducting wetting agent research illustrated by Poloxamer 188 (red) resulting in significantly lower volumetric water content at both 3.8 and 7.6 cm depths under 60% irrigation treatment, yet no significant differences were observed with the 80% irrigation treatment.

Future Research

(Results & Discussion continued)

- Investigate vertical lines from Pluronics gird (**Fig. 2**), controlling hydrophile percentage to examine effects of different hydrophobe molecular weights
- Investigate blends of high and low HLB poloxamers; the addition of high HLB poloxamers to those with low HLB has reportedly enhanced performance through improved solubility (Kostka & Bially, 2003)

CONCLUSIONS

- Poloxamer 188 with the highest HLB (29) was significantly different from other soil surfactants with HLB values ≤15, as evidenced by:
  - Greater incidence of LDS and lower turfgrass quality above ground
  - Reduced VWC below ground at 3.8 and 7.6 cm (60% ET)
- Poloxamers 181, 182, 184 (HLB=3, 7, 15 respectively) as stand-alone surfactants performed similar to a commercial turfgrass wetting agent
- Further exploring the relationship between irrigation and surfactant performance may elucidate greater understanding of functional differences between poloxamers with different HLB values

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