

## Abstract

A field study was carried out to assess the effect of sequential treatments of several surfactants and PlantFoodCo product combinations on Volumetric Water Content (VWC), Drought Stress responses and Turfgrass Quality. The field trial was located at the Dempsey Research site in County Kildare, Ireland, established on a *Poa annua* sward on a USGA specification sand rootzone. Treatments comprised: Hydration A-Plus<sup>®</sup>, Surfactant A, Surfactant B, Hydration A-Plus<sup>®</sup>/PolyPhosphite 30<sup>®</sup>/Green-T impulse<sup>®</sup>, Hydration A-Plus<sup>®</sup>/Green-T<sup>®</sup> 12-Iron/KelPlant<sup>®</sup> 1-0-1 and untreated Control. Treatments were randomised with 3 replications and applied sequentially at 28-day intervals from June to September 2021. Treatment assessments were carried out at 2-week intervals in areas of VWC, drought stress responses (wilt), turfgrass quality, Normalised Difference Vegetative Index (NDVI and EC (ds/m). The trial produced interesting statistically significant data, as listed below.

### Volumetric Water Content

Data analyses determined no significant differences between treatments of the mean VWC percentages, although the Controls did have the lowest mean VWC. However, the results comparing VWC between each treatment at 10-day intervals over the full trial period, produced interesting and significant differences between treatments.

In the Control plots, VWC percentages fluctuated widely between periods of high and low precipitation, Surfactant A gave rise to higher VWC percentages in comparison to Control, maintaining increased levels of VWC percentages throughout the full period.

With the Surfactant B treatment, VWC was lower and/or equal to the Control plots during periods of higher precipitation, with VWC levels increasing compared to Controls during dry periods.

The three treatments containing Hydration A-Plus<sup>®</sup>, when compared to Surfactant A, Surfactant B and Controls, maintained consistent levels of VWC percentages throughout the trial period with significantly less peaks and troughs than all other treatments. Importantly, these were the only treatments which maintained significantly higher levels of VWC, compared to Controls, during the hot, dry period in July 2021.

### Drought stress responses

The hot and dry climatic conditions in mid-July 2021 gave rise to significant wilting, all the surfactant treatments reduced wilting significantly compared to Controls. Despite being no statistically significant differences between surfactant treatments those containing Hydration A-Plus<sup>®</sup> producing the best drought responses by having the lowest level of observable wilt.

### Turf Quality

All treatments enhanced turf quality compared to untreated Controls during varied climatic conditions. However, the mean turf quality data over the full trial period shows that only the Hydration A-Plus<sup>®</sup> containing treatments significantly improved quality compared to Controls. This was further substantiated by the turf quality data for August which shows the Hydration A-Plus<sup>®</sup> containing treatments were significantly better than all other treatments.

## Methodology

**Field trial:** Trial plots, situated at the Dempsey research site, Co Kildare, Ireland, were based on a *Poa annua* golf green established on a USGA rootzone. Plot size were 1 x 1 m and set out as a randomised design. The turf was maintained at 5 mm height of cut and standard management practices (nutritional inputs and topdressing) were carried out to maintain the green, however, no surfactants other than those in the treatment list were applied at any time prior to or during the trial period.

### Treatments

Treatments were randomised with 3 replications, comprising of sequential applications, commencing 6<sup>th</sup> June 2021, and continuing at 28-day intervals until September 2021. Treatment rates and timings as shown in Table 1, these were applied using 16l knapsack sprayers calibrated to deliver 800/ha.

Table 1 Treatment rates and timings

<b>Rates and timings, 4 treatments x 3 replications, every 28 days from June to September 2021</b>		
<b>Number</b>	<b>Treatment</b>	<b>Rate 28-day</b>
<b>1</b>	<b>Hydration A-Plus®</b>	<b>4.8l/ha</b>
<b>2</b>	<b>Turfgrass Surfactant A (Revolution)</b>	<b>19l/ha</b>
<b>3</b>	<b>Turfgrass Surfactant B (ProWet Evolve)</b>	<b>12.5l/ha</b>
<b>4</b>	<b>Hydration A-Plus®</b> <b>PolyPhosphite 30®</b> <b>Green-T impulse®</b>	<b>4.8l/ha</b> <b>10l/ha</b> <b>10l/ha</b>
<b>5</b>	<b>Hydration A-Plus®</b> <b>Green-T® 12-Iron</b> <b>KelPlant® 1-0-1</b>	<b>4.8l/ha</b> <b>10l/ha</b> <b>10l/ha</b>
<b>6</b>	<b>Untreated control</b>	

## Assessments

Treatment assessments were carried out at 2-week intervals commencing 20<sup>th</sup> June until 21<sup>st</sup> September and comprised of:

**Percent Volumetric Water Content (VWC)** measured using a Pogo (Stevens Water Monitoring Systems Inc.). The Pogo also recorded canopy temperatures in degrees C, and **electrical conductivity (EC/ds)**.

**Turfgrass quality (TQ)** was assessed visually and rated on a 1 to 10 scale, based on 10 being best and 1 being poorest



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**Normalised difference vegetation index (NDVI)** was determined using a Sunseeker handheld NDVI meter, 0 to 1 scale with 0 poorest and 1 best.

**Wilt** Drought stress resistance was assessed on a 0 to 10 visual rating scale, with 0 being no wilting and 10 complete wilting.

## Data analysis

Seven series of assessments were carried between June and September 2021, all raw data were collated and are presented on MS Excel. VWC, EC (ds/m), Turf quality, NDVI, and Wilt, were statistically analysed using one-way Anova and statistical differences separated using Tukey HSD at P=0.05. (SPSS 24 analytical software).

## Results and Discussion

As this was primarily a trial to assess the effects a range of surfactants had on turfgrass drought stress responses the environmental conditions at the trial site over the assessment period was a significant factor. Figures 1 and 2 show the monthly and weekly precipitation and weekly daytime maximum temperatures. The period between the 18<sup>th</sup> to 25<sup>th</sup> July was extremely hot and dry and this was the only period during the trial when significant wilting was observed on the trial plots. There were other periods when precipitation was low, as in mid-June and early September, but the irrigation was sufficient to prevent any serious drying out. Because of this, wilt data are presented only for the assessment periods of 12<sup>th</sup> and 25<sup>th</sup> of July, as to include data from all the bi-weekly assessments would skew the results.

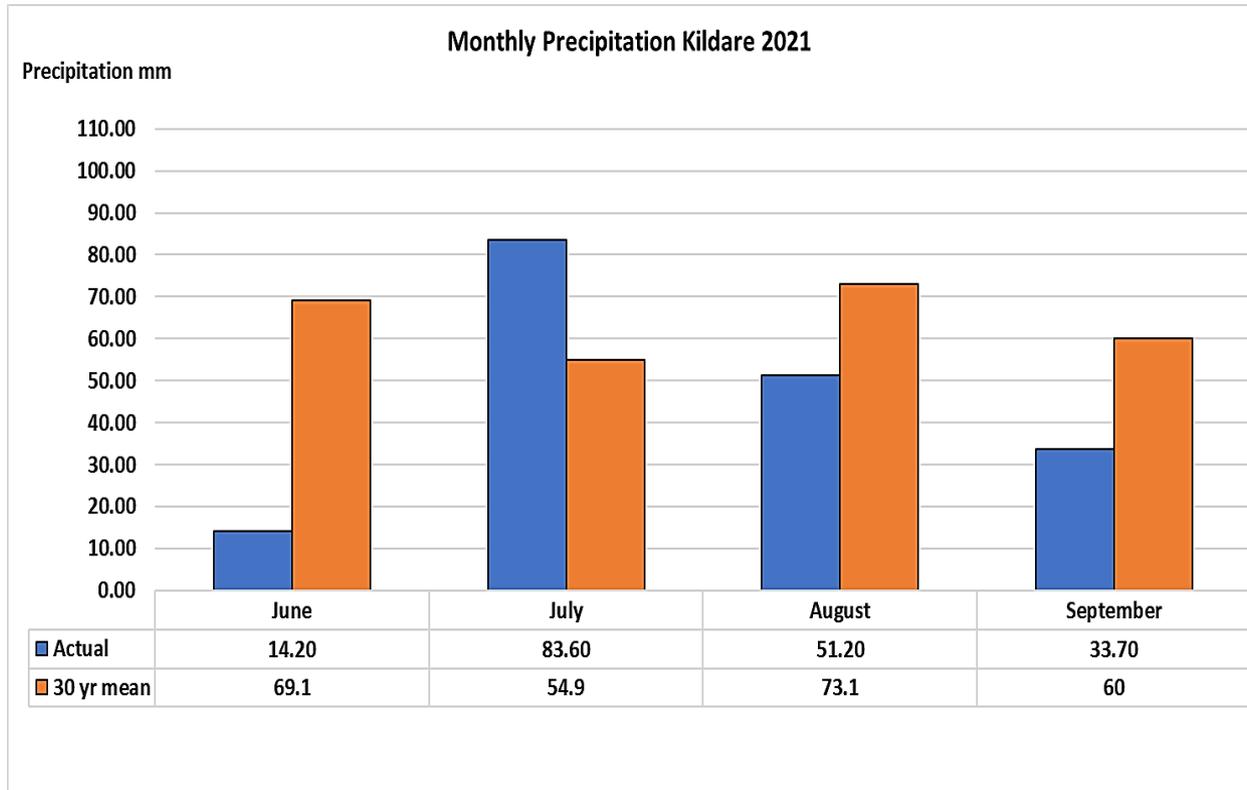
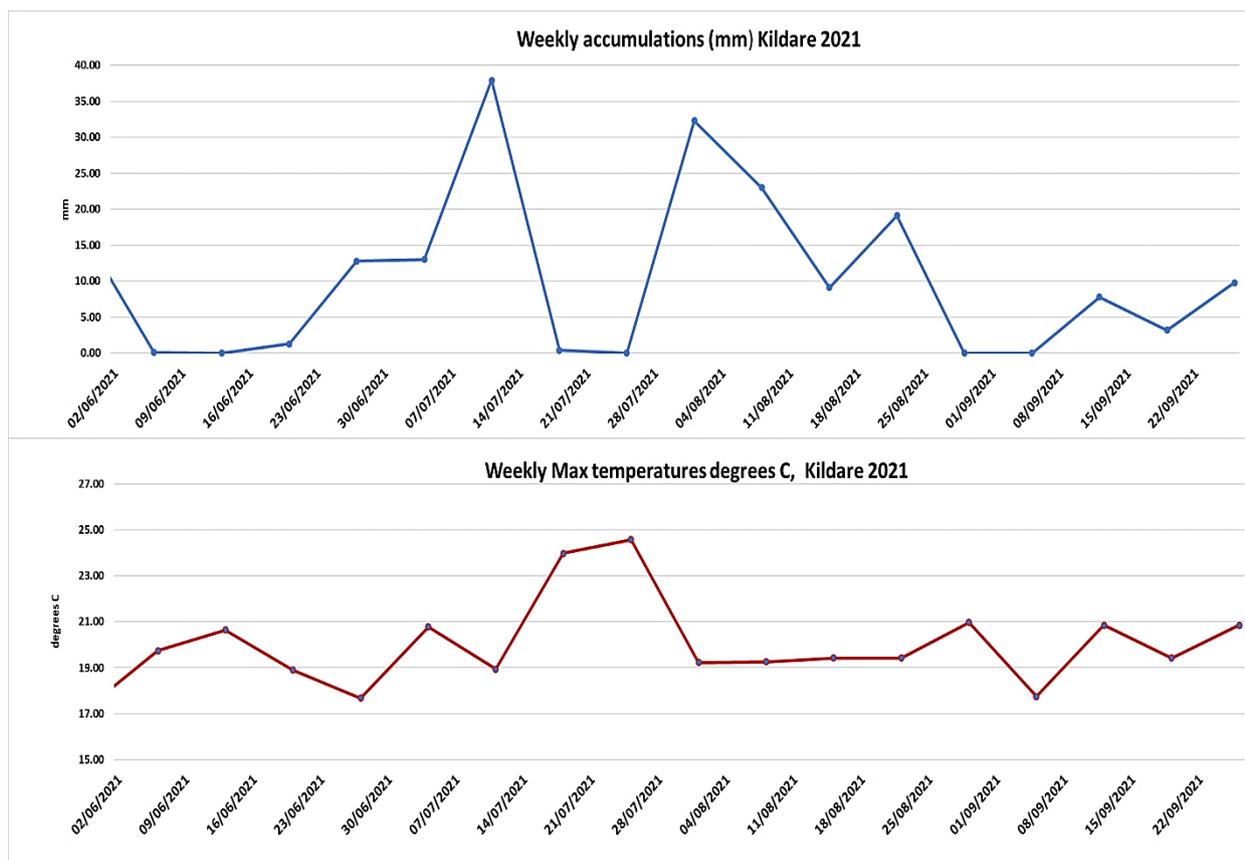


Figure 1. Thirty year mean precipitation and monthly precipitation in mm, for Kildare in May, June, July, August, and September 2021.

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Over the full trial period, seven separate assessments were carried out and the mean values of the VWC, EC, Canopy temperatures, Turf Quality, NDVI and Wilt data are shown in Table 2.

Table 2 Mean values of 7 assessments of VWC, EC, Canopy Temperature, Turf Quality, NDVI and Wilt, between June and September 2021

PFC Surfactant Trial, mean data from June to September 2021						
Treatment	Moisture (VWC)	EC(ds/m)	Temp(C)	Turf Quality	NDVI	Wilt (Mean of July 12 & 25)
Hydration A-Plus®	24.665	0.396	20.323	7.952	0.809	1.833
Surfactant A	24.671	0.384	20.404	7.714	0.802	2.667
Surfactant B	22.498	0.325	20.555	7.631	0.781	2.333
Hydration A-Plus®, PolyPhosphite 30®, Green-T impulse®	24.560	0.405	20.736	8.071	0.815	2.167
Hydration A-Plus®, Green-T® 12-Iron, KelPlant® 1-0-1	23.725	0.399	20.974	8.024	0.811	2.000
Control	21.621	0.298	21.255	7.476	0.779	6.333

## Volumetric Water Content:

Seven assessments of VWC were carried out over the trial period and the mean values are shown in Figure 3. The mean percent VWC ranged from 21.621% for the Control treatment to 24.671% for the Surfactant A treatment. Viewing the data in Figure 3, it is clear the differences between treatments in mean VWC over the full trial period were negligible, the treatments in order of highest mean VWC were, Surfactant A (24.671%), Hydration A-Plus® (24.665%), Hydration A-Plus®/PolyPhosphite 30®/Green-T impulse® (24.560%), Hydration A-Plus®/Green-T® 12-Iron/KelPlant® 1-0-1 (23.725%), Surfactant B (22.498%) and Control (21.621%). This uniformity of results was confirmed by statistical analyses, there were no significant differences ( $p = 0.358$ ) in mean VWC between treatments.

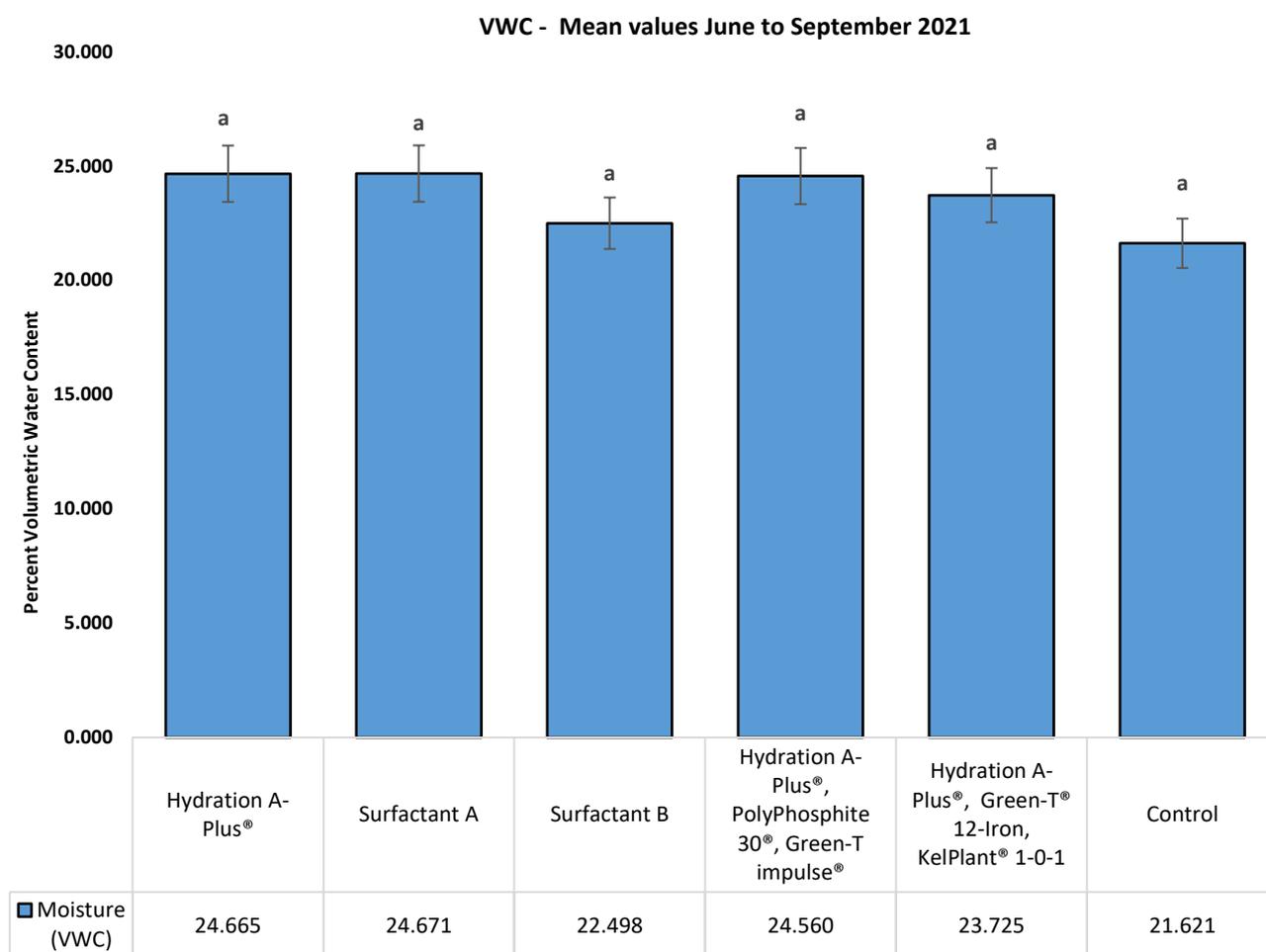


Figure 3. Volumetric Water Content. Mean of 7 assessments of VWC between June and September 2021, n=3. Bars are 95% confidence intervals; letters indicate significant differences between treatments at  $P = 0.05$ .



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Of greater interest and value, however, are the data comparing VWC of each treatment to the control and between each treatment at 10-day intervals over the full trial period. These data are shown in Figures 4 to 7 and what's of interest is how each surfactant affected VWC compared to controls during fluctuating periods of wet and dry weather. One result which stands out is the fluctuating levels of VWC in the Control plots, high VWC levels of 25% to 26% during periods of high precipitation but dropping significantly to 17% during the two dry periods in July and September.

The Surfactant A treatment in comparison to Control, gave rise to higher levels of VWC throughout the full period, the trend lines mirroring the Control line, basically maintaining increased levels of moisture in the upper rootzone throughout the full period.

The Surfactant B treatment produced a different response to Surfactant A, as can be seen in Figure 3, during the periods of higher precipitation, VWC was lower than the Control plots, but VWC levels increased during the two dry periods of July and September.

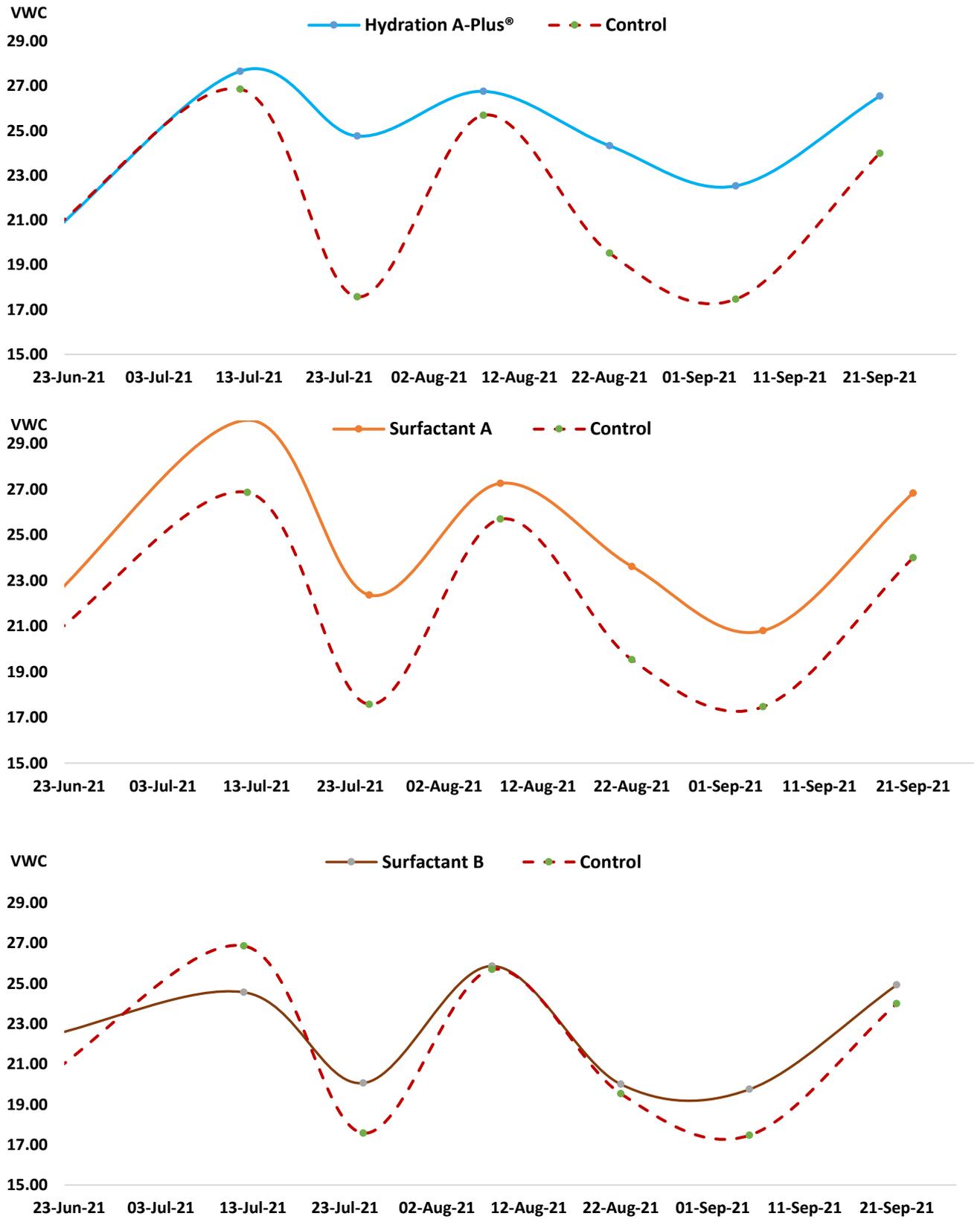
The Hydration A-Plus<sup>®</sup> treatment produced a different result from either of the other two surfactants used. Compared to the other two surfactants, the VWC throughout the trial period on the Hydration A-Plus<sup>®</sup> plots was much more uniform, with significantly less peaks and troughs, as can be seen in Figure 3. Most notable is the comparison of VWC on the 23<sup>rd</sup> of July point, (which was the peak of the drought with high temperatures approaching 30° C) this was when the turfgrasses experienced greatest heat and drought stress. At this time period, the VWC in the Control plots was 17.57%, the Hydration A-Plus<sup>®</sup> plots were +7.2% at 24.77%, Surfactant A +4.8% at 22.37% and Surfactant B +2.49% at 20.06%. A similar improvement was observed during the second dry period in September.

This uniformity of soil moisture levels was also observed on the other two treatments which contained Hydration A-Plus<sup>®</sup>, as can be seen in Figures 5 and 6. The VWC in the plots treated with the Hydration A-Plus<sup>®</sup>/PolyPhosphite 30<sup>®</sup>/Green-T impulse<sup>®</sup> combination and the Hydration A-Plus<sup>®</sup>/Green-T<sup>®</sup> 12-Iron/KelPlant<sup>®</sup> 1-0-1 combination also maintained a uniformity of soil moisture levels through the full trial period.

The uniformity of percent VWC throughout the trial period is clearly visualised in Figure 7, the solid blue lines of the Hydration A-Plus<sup>®</sup> containing treatments contrast well with the peaks and troughs of the dotted red lines of the other two surfactant treatments and Control.

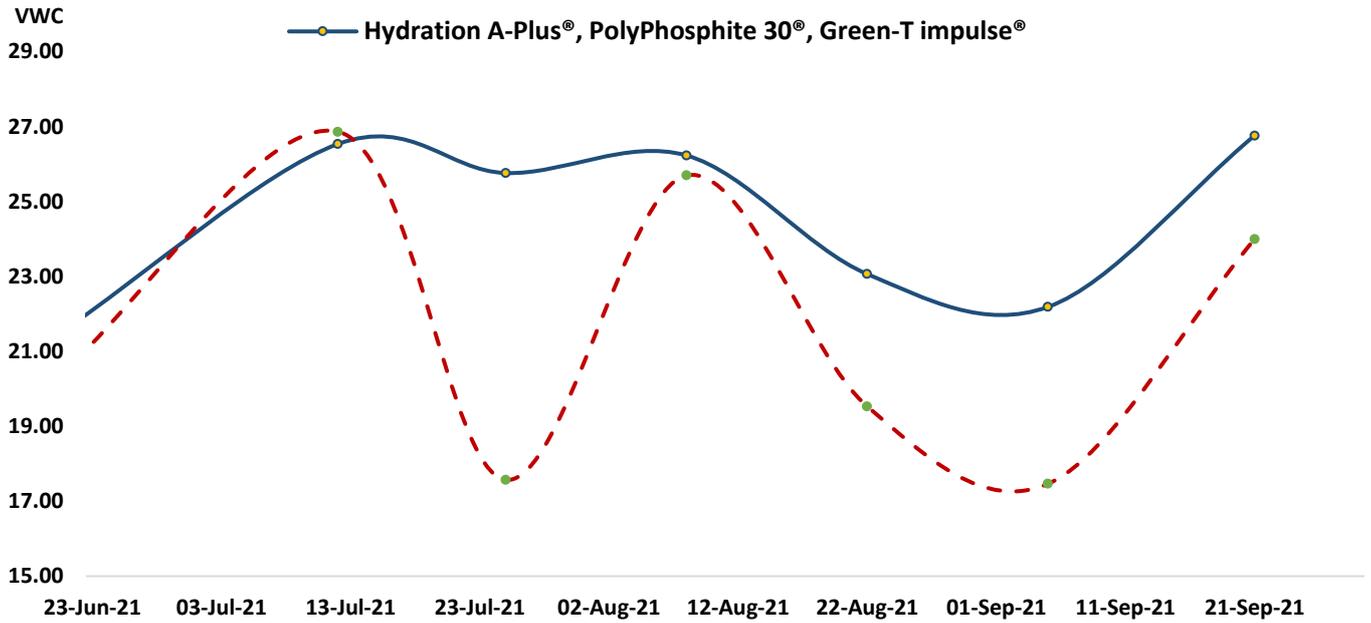
This observed uniformity of moisture infiltration, percent VWC and the elevated levels of soil moisture availability during drought stress periods is a crucial factor in maintaining turfgrass quality and a very significant factor in reducing drought stress related wilt and the trial results in these area confirm this.

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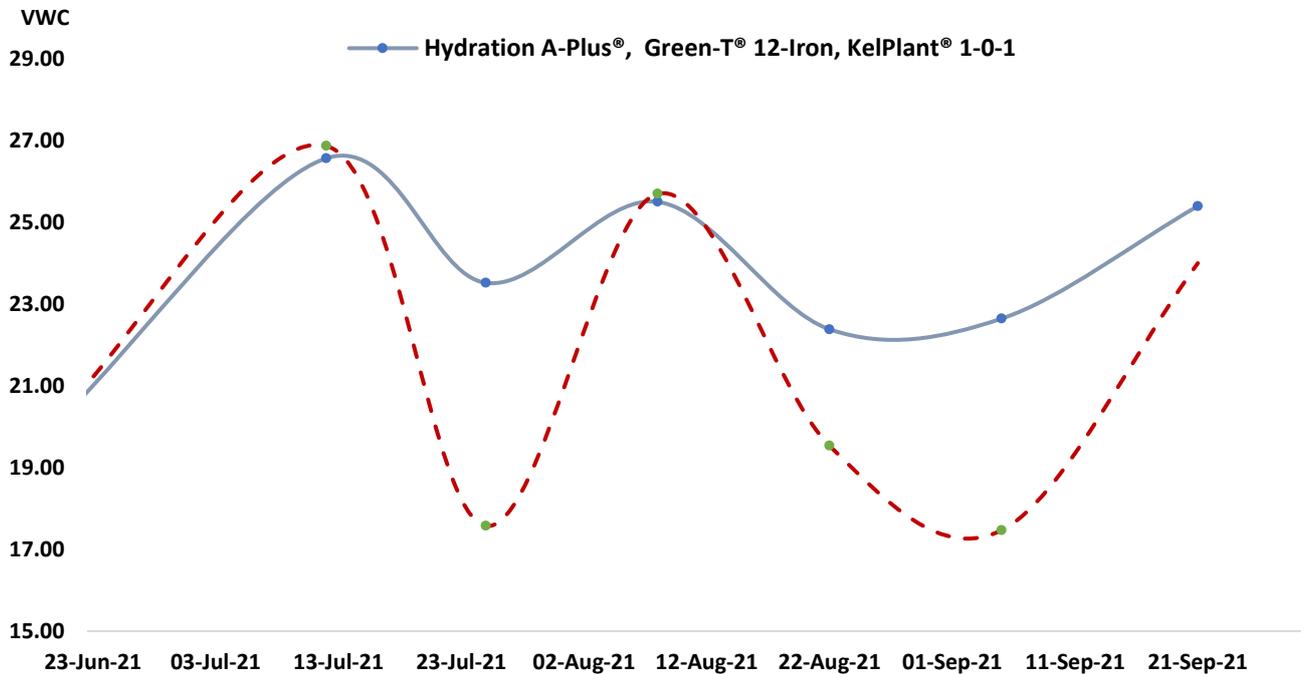
**VWC at 10-day intervals from June to September 2021**

Figure 4. The effect of Hydration A-Plus®, Surfactant A and Surfactant B on Volumetric Water Content compared to Controls at 10-day intervals over the full trial period.



**VWC at 10-day intervals from June to September 2021**

Figure 5. The effect of the combination treatment of Hydration A-Plus®, PolyPhosphite 30® and Green-T impulse® on Volumetric Water Content compared to Controls at 10-day intervals over the full trial period.



**VWC at 10-day intervals from June to September 2021**

Figure 6. The effect of the combination treatment of Hydration A-Plus®, Green-T® 12-Iron and Kelp 1-0-1 on Volumetric Water Content compared to Controls at 10-day intervals over the full trial period

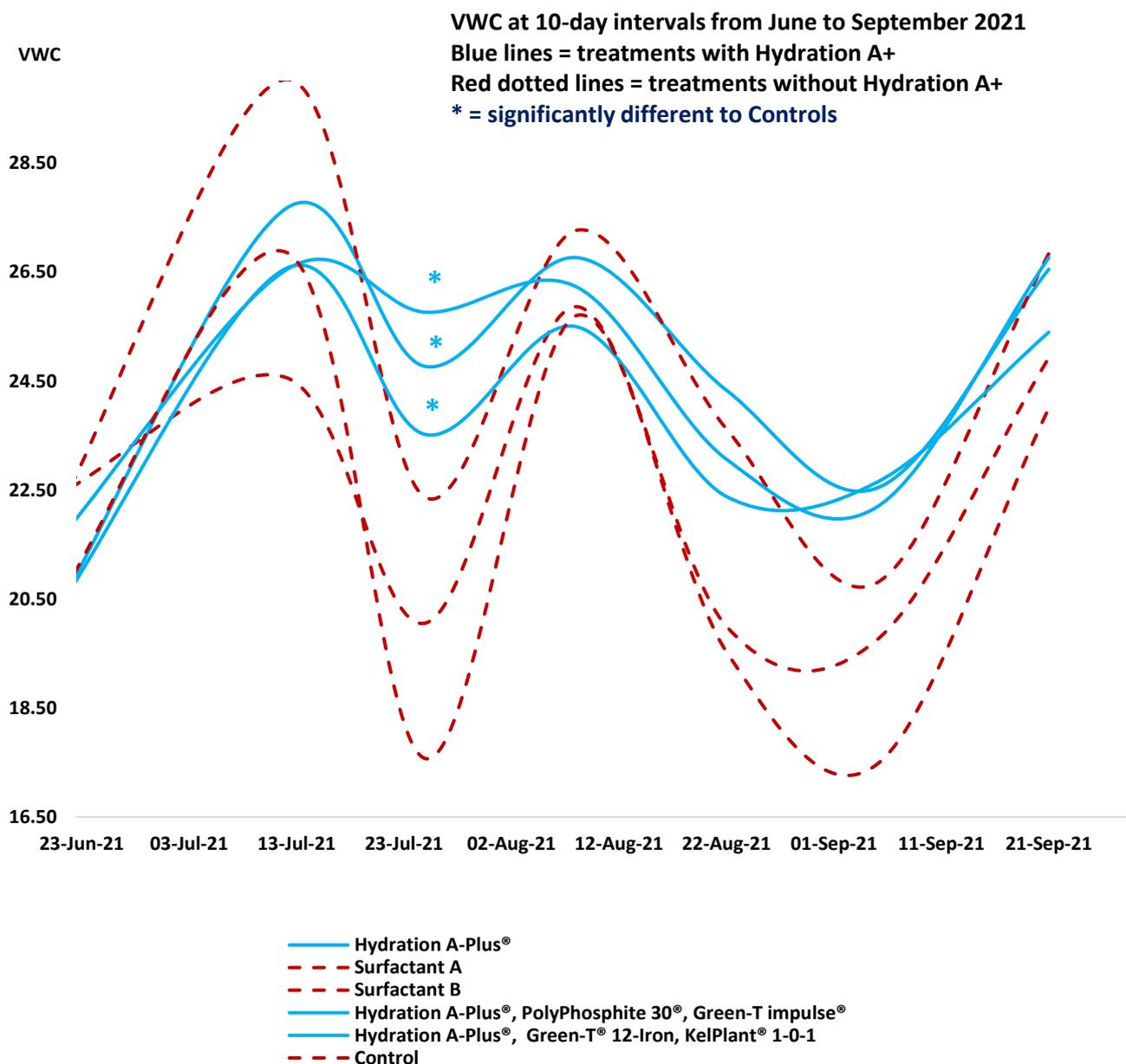


Figure 7. Treatment effect on VWC at 10-day intervals over the trial period. Blue lines show treatments containing Hydration A-Plus®, Red dotted lines show treatments that do not contain Hydration A-Plus®.

### Treatment effect on drought stress related wilt

Drought stress resistance was assessed by determining the amount of wilt in each trial plot and rating it on a 1 to 10 visual scale, with 1 being no wilting and 10 complete wilting. As can be seen in the precipitation and maximum daytime temperature data (Figures 1 and 2) there was really only one period which allowed for significant wilt to develop. There were a number of other dry periods i.e., early to mid-June and early September but, adequate moisture via irrigation was applied in the trial area and prevented excessive drying down. The period from 14<sup>th</sup> to 28<sup>th</sup> July had no precipitation and was accompanied by extremely high temperatures (for Ireland). Average daily temperature during this period was 25.28°C with a peak daytime

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temperature of 28.00°C. This gave rise to significant wilting on the trial plots. Figure 8 shows the mean wilt assessments for the assessments carried out on 12<sup>th</sup> and 25<sup>th</sup> of July 2021.

All surfactant treatments reduced wilt significantly ( $p < 0.001$ ) compared the Controls. The best performing treatments in order from best to worst were Hydration A-Plus<sup>®</sup> (1.883), Hydration A-Plus<sup>®</sup>/Green-T<sup>®</sup> 12-Iron/KelPlant<sup>®</sup> 1-0-1 combination (2.000), Hydration A-Plus<sup>®</sup>/PolyPhosphite 30<sup>®</sup>/Green-T impulse<sup>®</sup> combination (2.167), Surfactant B (2.333) and Surfactant A (2.667). While the rate of wilt varied amongst treatments statistically there were no differences between them.

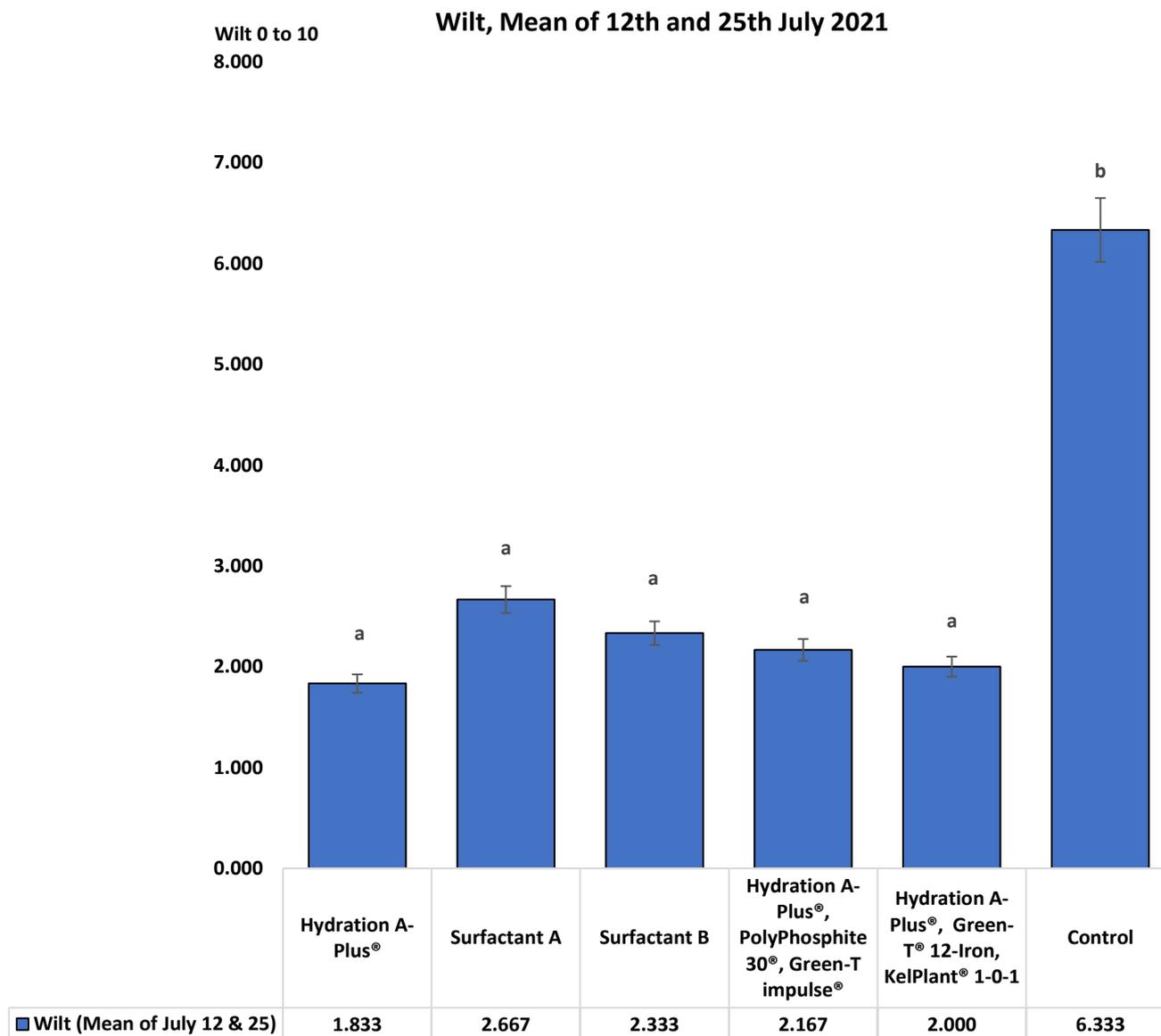


Figure 8. Wilt. Mean of 2 assessments of wilt in July 2021, n=3. Bars are 95% confidence intervals; letters indicate significant differences between treatments at P = 0.05.



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## Turf Quality

Turfgrass quality is defined as the degree to which a turf conforms to an agreed standard that is a composite of uniformity, shoot density, leaf texture, growth habit, smoothness, and colour and is obviously a major factor in assessment of any treatments applied to turfgrass surfaces. During this trial TQ varied through the period of the trial, due to climatic and maintenance operations.

When the mean of all seven TQ assessments were collated there appears at first observation to be numerically minimal differences between the quality ratings. All treatments containing Hydration A-Plus<sup>®</sup> produced numerically better turf quality results than all other treatments. When statistically analysed, there were significant differences determined. The results are shown in Figure 9, the treatments which produced the best turf quality over the full trial period were, in order of best to worst: Hydration A-Plus<sup>®</sup>/PolyPhosphite 30<sup>®</sup>/Green-T impulse<sup>®</sup> combination (8.071), Hydration A-Plus<sup>®</sup>/Green-T<sup>®</sup> 12-Iron/KelPlant<sup>®</sup> 1-0-1 combination (8.024), Hydration A-Plus<sup>®</sup> (7.952), Surfactant A (7.714), Surfactant B (7.631 and Control (7.476).

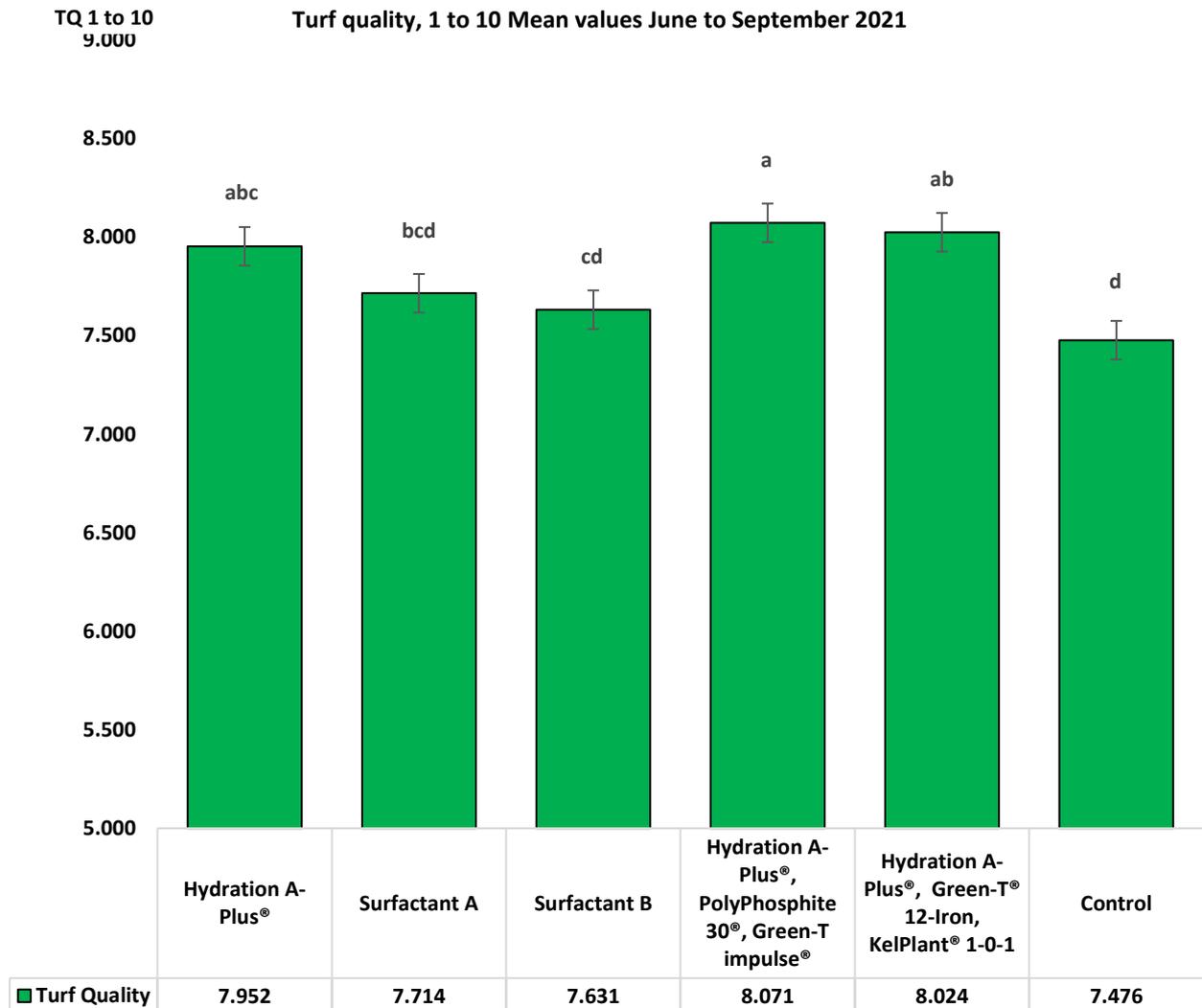


Figure 9. Turf Quality. Mean of 7 assessments of Turfgrass Quality between June and September 2021, n=3. Bars are 95% confidence intervals; letters indicate significant differences between treatments at P = 0.05.



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Statistical analyses determined the Hydration A-Plus®/PolyPhosphite 30®/Green-T impulse® combination produced significantly better results than the Control, Surfactant A and Surfactant B treatments, and was statistically the same as the Hydration A-Plus® and the Hydration A-Plus®/Green-T® 12-Iron/KelPlant® 1-0-1 combination treatments. The Hydration A-Plus® was statistically the same as Surfactant A and Surfactant B, with no significant difference determined between Surfactant A, Surfactant B, and Controls.

TQ 1 to 10

Turf quality 1 to 10, at 10 day intervals from June to September 2021

\* = significantly different to Controls

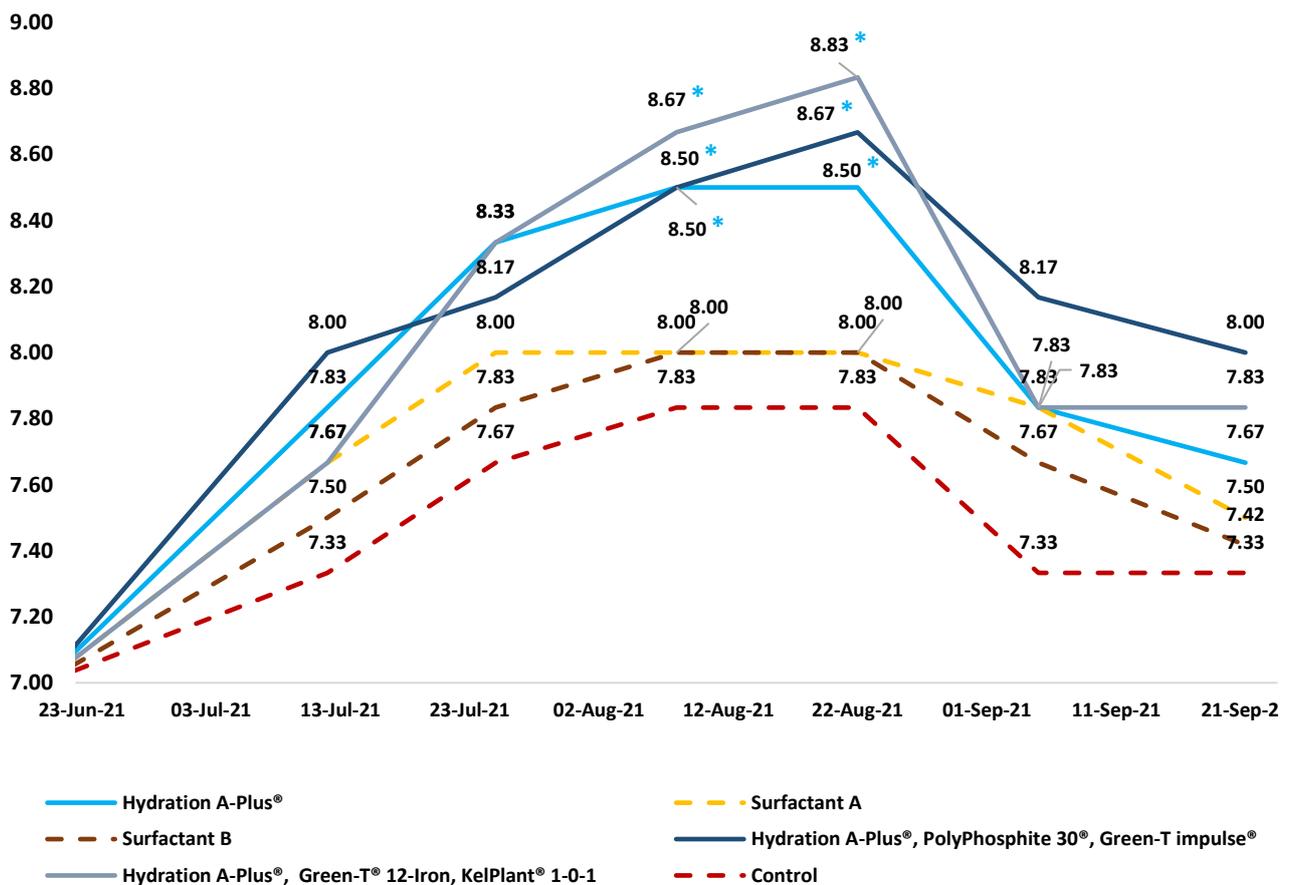


Figure 10. Treatment effect of Turfgrass Quality at 10-day intervals from June to September 2021. Solid lines show treatments containing Hydration A-Plus®, dotted lines show all other treatments.

As with the mean VWC data a more comprehensive evaluation of how the treatments affected turf quality is to look at the fluctuations of quality at 10-day periods over the full trial period, this is shown in Figure 10. The treatments containing Hydration A-Plus® produced enhanced turf quality consistently throughout the full period. It's worth noting however, that although the quality was enhanced, the difference between the lowest Control rating and the highest rating was quite small, e.g., on the 22<sup>nd</sup> of August the Hydration A-Plus®/Green-T® 12-Iron/KelPlant® 1-0-1 treatment was rated at 8.83 while the Control was 7.83. Even so the Hydration A-Plus® treatments led to consistently higher quality throughout the season.



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## NDVI

Normalised Difference Vegetation Index (NDVI) is an indicator of photosynthetically active biomass which can be used to assess plant health. NDVI is rated on a 0 to 1 scale with the higher readings indicating a healthier more photosynthetically active plant.

The seven assessments of NDVI during this trial varied in scope, due to varying climatic conditions There were, however, some significant differences amongst treatments as shown in Figure 1. The mean NDVI data supported the Turf Quality assessments in that Hydration A-Plus®/PolyPhosphite 30®/Green-T impulse® combination (0.815), Hydration A-Plus®/Green-T® 12-Iron/KelPlant® 1-0-1 combination (0.811), Hydration A-Plus® (0.809) produced the highest NDVI readings, statistically better than the Surfactant B (0.781) and Controls (0.779) but statistically the same as Surfactant A (0.802).

These data mirror and therefore support the Turf Quality mean data as shown in Figure 9.

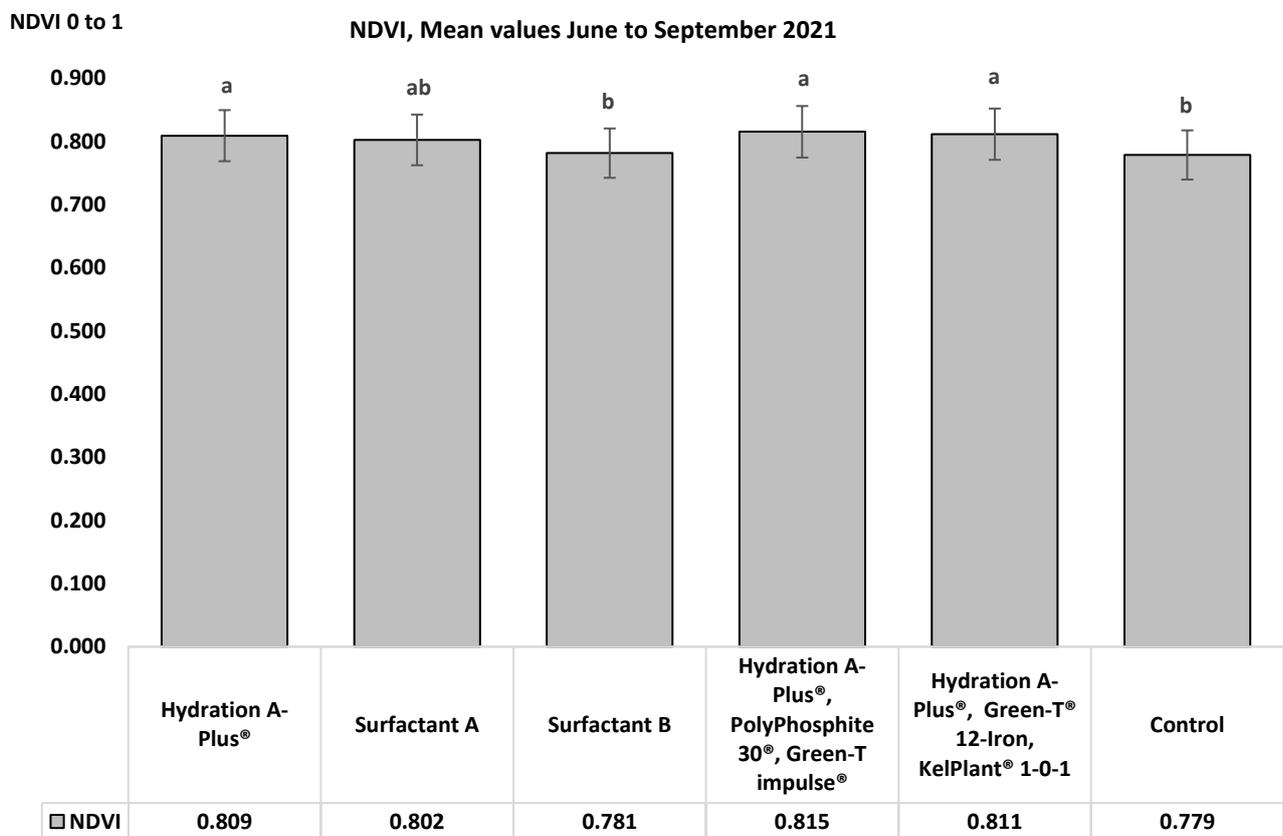


Figure 11. Mean of 7 assessments of NDVI between June and September 2021, n=3. Bars are 95% confidence intervals; letters indicate significant differences between treatments at P = 0.05.

The enhancement of turfgrass quality following sequential treatments with surfactants during both dry and wet weather conditions, has been observed previously, and in this trial all surfactants produced enhanced turf quality compared to the Controls. This can be attributed to a number of factors, e.g., better infiltration and uniformity of water distribution, reduced soil repellency, improved nutrient availability/uptake and enhanced microbial activity.



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It would be also anticipated that the Hydration A-Plus<sup>®</sup>/Green-T<sup>®</sup> 12-Iron/KelPlant<sup>®</sup> 1-0-1 combination and the Hydration A-Plus<sup>®</sup>/PolyPhosphite 30<sup>®</sup>/Green-T impulse<sup>®</sup> combination would give rise to improved turf quality compared to surfactant treatments alone, as these treatments contained a range of elements and compounds which would stimulate growth and have also shown in other studies to improve turf quality. However, the Hydration A-Plus<sup>®</sup> treatment when compared to the two other surfactants also produced higher quality turfgrass ratings throughout. To get an understanding of why this occurred we can look at the EC data as shown below.

### EC

Electrical Conductivity (EC) is the measure of a soil's salinity measured in d/Sm. This measurement can be used to determine the soluble salt (nutrient) content in the soil. EC gives a reading of all soluble salts present but gives no indication of the types or amounts of each salt. In this current study it allows for an assessment and comparison of nutrient availability in the treated plots. What can be seen in Figure 11 is interesting, as it clearly shows the impact on nutrient levels the treatments had.

The mean EC data in order from highest to lowest were: Hydration A-Plus<sup>®</sup>/PolyPhosphite 30<sup>®</sup>/Green-T impulse<sup>®</sup> combination (0.405), Hydration A-Plus<sup>®</sup>/Green-T<sup>®</sup> 12-Iron/KelPlant<sup>®</sup> 1-0-1 combination (0.399), Hydration A-Plus<sup>®</sup> (0.396), Surfactant A (0.384), Surfactant B (0.325) and Control (0.298).

Statistically the Hydration A-Plus<sup>®</sup>/PolyPhosphite 30<sup>®</sup>/Green-T impulse<sup>®</sup> combination, Hydration A-Plus<sup>®</sup>/Green-T<sup>®</sup> 12-Iron/KelPlant<sup>®</sup> 1-0-1 combination, Hydration A-Plus<sup>®</sup> and Surfactant A were the same and better than the Surfactant B and Controls. There was also no significant difference between the Surfactant A, Surfactant B and Controls.

While there were significant differences between treatments, the standout data show that all the surfactant treatments gave rise to higher levels of nutrient availability compared to untreated Controls. But what also can be concluded is that the acid component of Hydration A-Plus<sup>®</sup> would seem to be allowing for an increase in nutrient availability by solubilising locked up nutrients in the rhizosphere, thus allowing for this enhancement of turf quality.

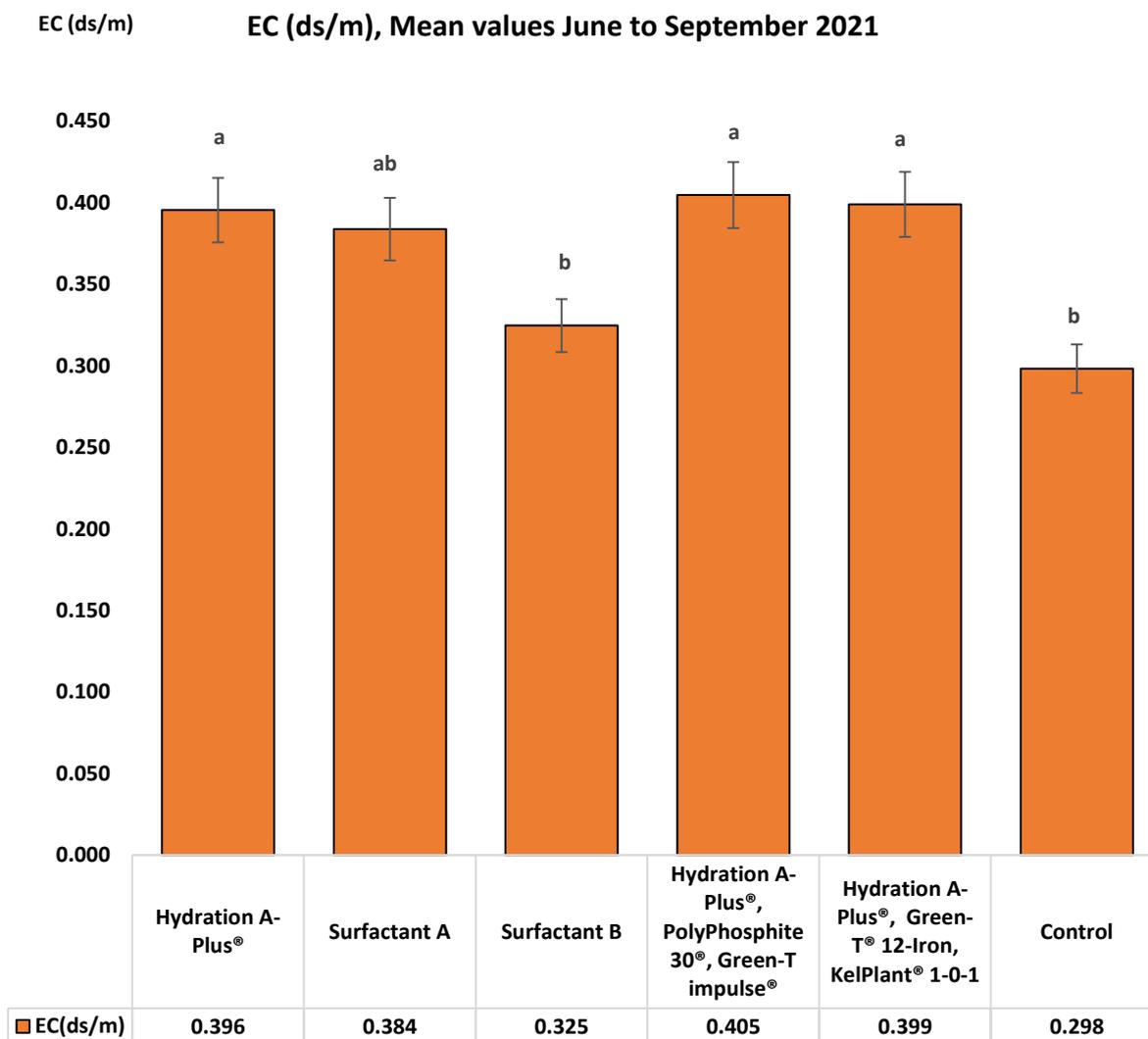


Figure 12. EC. Mean of 7 assessments of EC (ds/m) between June and September 2021, n=3. Bars are 95% confidence intervals; letters indicate significant differences between treatments at P = 0.05



### Main points

The trial began on the 6<sup>th</sup> of June 2021 and treatments were applied at 28-day intervals until September 2021. Seven assessments were carried out, gathering data on treatment effects on Volumetric Water Content, drought stress related Wilt, Turf Quality, NDVI readings and EC levels. The trial produced interesting and significant results in areas of VWC, Wilt and Turf Quality.

#### Volumetric Water Content

The results of the mean percent VWC show no significant differences between treatments, although the Controls did have the lowest mean VWC. However, the results comparing VWC of each treatment to the Control and between each treatment at 10-day intervals over the full trial period produced interesting and valuable information.

- In the Control plots, VWC percentages fluctuated widely between periods of high and low precipitation.
- The Surfactant A treatment gave rise to higher VWC percentages in comparison to Control, maintaining increased levels of VWC percentages throughout the full period.
- With the Surfactant B treatment, VWC was lower and/or equal to the Control plots during periods of higher precipitation, with VWC levels increasing compared to Controls during the two dry periods of July and September.
- The VWC in the treatments containing Hydration A-Plus<sup>®</sup>, when compared to the other two surfactants and Controls maintained consistent levels of VWC percentages throughout the trial period with significantly less peaks and troughs, these were the only treatments which maintained significantly higher levels of VWC, compared to Controls, during the hot, dry period in July 2021.

The three surfactants trialled, managed soil moisture in different ways, all increased VWC compared to Controls during the dry periods, but for most of the trial period there were distinct peaks and troughs, only the Hydration A-Plus<sup>®</sup> maintained consistent levels of VWC.

#### Wilt/drought responses

The hot and dry climatic conditions in mid-July 2021 gave rise to significant wilting. All the surfactant treatments reduced wilting significantly compared to Controls. Despite being no statistically significant differences between surfactants, the treatments containing Hydration A-Plus<sup>®</sup> produced the best drought responses by having the lowest level of observable wilt.



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### **Turf quality**

The results of this trial relating directly to plant health, the EC, NDVI and Turf Quality provided statistically significant data and supports the conclusions of the 2020 PlantFoodCo Irish surfactant trial in that sequential treatments with surfactants will enhance turfgrass health and quality, even during non-stressful environmental growth conditions.

This current 2021 trial has shown that sequential surfactant treatments will enhance turf quality compared to untreated Controls during varied climatic conditions, but also that some surfactants will produce better quality results than others!

The treatments containing the Hydration A-Plus<sup>®</sup>/PolyPhosphite 30<sup>®</sup>/Green-T impulse<sup>®</sup> combination, Hydration A-Plus<sup>®</sup>/Green-T<sup>®</sup> 12-Iron/KelPlant<sup>®</sup> 1-0-1 combination and Hydration A-Plus<sup>®</sup> produced consistently better-quality turf throughout the full trial period and produced significantly higher quality turf than all other treatments throughout the month of August.

Overall, this trial produced interesting and satisfactory results, the sequential use of surfactants has been shown to be beneficial in areas of managing soil moisture, drought stress responses and enhancing turfgrass quality.

The Hydration A-Plus<sup>®</sup> product performed very well and in combination with the other PlantFoodCo nutritional inputs produced the best quality turfgrass surfaces, with treated surfaces better able to respond to drought stress challenges.