Type of the Paper (Article, Review, etc.)

Study into commercially available soil wetting agent's vs an Australian manufactured salicylic acid-based product

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Abstract:

The use of soil wetting agents or soil surfactants is becoming increasingly popular as they improve water efficiencies and turf quality. This soil wetting agent research was on nine soil wetting agents, and their effects on Turf Quality, Soil Moisture content, and water penetration times. This is in comparison to a proprietary salicylic acid product and an untreated control.

This is the second year we have run this trial, and the previous year's results show that there are some definite plant health benefits from using some soil surfactants. On high sand-content root zones, you apply wetting agents to turfgrasses for two main reasons.

- Firstly, to help manage the symptoms of hydrophobic soils, and
- Secondly to improve the uniformity of soil moisture through the profile.

The trial comprised a completely randomized block design (CRBD) with six replicates and ran for 163 days on a creeping bent grass (Agrostis stolonifera var MacKenzie) green at Bonnie Doon Golf Club in Sydney, Australia. All products were applied at label rates and then washed in as per their labels.

Turf Quality, soil moisture contents, organic matter content and water penetration times were significantly impacted by soil wetting agents.

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1.0 Results:

1. The TriCure Treatment gave a significantly lower Turf Colour than HydraHawk, Tour Turf ELL, HydroForce Ultra, Tour Turf REO, Penterra, Proprietary incorporating salicylic acid and Tour Turf FTE (Tour Turf).

2. At the 37mm depth Penterra was the only treatment that gave a significantly lower soil moisture content than the control.

3. At 37mm, H2Pro Trismart had significantly higher soil moisture levels than Hydrahawk, Tour Turf ELL, Penterra, and Tour Turf FTE.

4. At 75 mm, Penterra has a significantly lower moisture content than the Control. Penterra is also significantly lower than the Tricure and H2Pro Trismart.

5. With the Water Drop Penetration Test (WDPT) at a 1cm depth there are significant differences exist. H2Pro Trismart has significantly faster WDPT than HydraHawk.

6. At a 2cm depth, H2Pro Trismart, and Tour Turf FTE treatments have significantly faster WDPT compared to HydraHawk. There were no significant differences between any of the other treatments.

7. At the 3cm depth, the WDPT of the Gilba Proprietary, the HydroForce Ultra and the Tour Turf ELL treatments were all faster compared to the HydraHawk treatment.

8. The HydroForce Ultra was the only treatment that had a significantly higher organic matter content than the Control.

Keywords: bio-stimulant; turfgrass; organic matter; root growth; wetting agent; soil water; salicylic acid

2.0 Introduction

Using water effectively is crucial to maintain a healthy, disease-free playing surface. Too much water and it tends to produce a soft, disease prone surface, and an increase in management costs. These are seen as more frequent fungicide applications and a shallower root system. The latter results in turfgrass wilting as soon as it comes under any degree of moisture stress. In contrast, too little water, and turf tends to struggle or die.

Soil water is vital to maintain optimal turfgrass growth, and as Turf Managers come under increasing pressure efforts are increasing to better manage this valuable resource.

A huge amount of work has been carried out into the use of soil surfactants in turfgrass. The result is that these are now widely used in the Australian turfgrass industry.

Manufacturers make numerous claims often without independent supporting data, so this trial was designed to see if differences did exist in the performance between these.

In recent years several plant health benefits have been shown with some of these soil wetting agents. These plant health benefit claims are made as a direct result of the surfactant molecules being used.

For example, in our 2022 trials, we showed that some soil wetting agents reduce dollar spot incidence when used at label rates. In contrast others had little to no effect.

Very little work has been done looking at the utilization of these in conjunction with salicylic acid, and as far as we are aware this trial will be the first time the plant health benefits of a high loading of salicylic acid into a soil wetting agent will be trialled.

3.0 Products Tested

3.1 H2Pro TriSmart

A considerable amount of research has been carried out into the performance of H2Pro TriSmart. Four independent field trials, executed by the STRI in Bingley, UK, each with an 8 times treatment replication, demonstrated that a H2Pro TriSmart program significantly improves turfgrass quality traits.

A 2017 independent trial at the STRI Australia, Brisbane illustrated the value of utilising a wetting agent programme on ultra dwarf couch, to significantly improve surface quality and colour and to reduce localised Dry spot. H2Pro TriSmart also maintained an improved surface quality with a 40% water saving over control plots, demonstrating water use efficiency from a wetting agent programme.

H2Pro TriSmart is registered as a non-microbial bio-stimulant under the latest EU Fertilizing Product Regulation (FPR)(1009/2019).

Improvements of turf quality, turf colour, turf uniformity, turf density and NDVI were measured for TriSmart treated plots in comparison with an untreated control, as well as significantly greater volumetric moisture content percentage (VMC %).

2020 work carried out by Aqua aid in Europe looked at monthly applications of OARS vs several other soil wetting agents including Trismart. Soil moisture was only measured at the 75mm depth. Their results were that all the tested wetting agents resulted in a significantly higher soil moisture balance compared to the untreated control plots.

3.2 HydraHawk (Product 2)

HydraHawk is claimed to be a highly efficient soil surfactant that is works quickly and is made from 100% natural materials.

HydraHawk claims to help water penetrate compact or arid soils, and helps plants utilize water and survive in extreme heat, drought and saline soils.

3.3 Tour Turf ELL (Product 3)

TourTurf® ELL Respond® Extreme Long Lasting is a unique wetting agent formulation designed to work consistently with increased longevity within any turf grass rootzone.

It is resistant to microbial degradation in adverse climatic conditions, where temperatures are typically over 20°C.

TourTurf® ELL contains a specific blend of wetting agent technologies. The new innovative residual long chain wetting agent is 20-35% longer than in other industry standard wetting agents.

The updated product formulation includes spreading and penetrating agents to ensure ELL penetrates the turf grass surface quickly which means it is not readily subjected to the degrading effects of UV light.

This penetration ability ensures the product enters the rootzone efficiently and does not bind itself strongly to the organic matter in the top of the thatch layer. This in turn creates a firmer playing surface with less moisture in the thatch layer.

3.4 Tricure (Product 4)

TriCure AD® is marketed as an advanced soil surfactant designed to prevent and control hydrophobic soil conditions while maintaining optimum soil-water management. It works by attaching to both soil and organic particles, reduces the surface tension of water, and attracts a thin film of water close to the particle surfaces. This allows the optimum moisture to be held for plant use while aiding water release and effective drainage.

Leinauer et al (2005) looked at several wetting agents, and their effects on sand-based rootzone hydrophobicity and putting green turf appearance. The efficacy of wetting agents varied over depth and was most pronounced at depths of 2.5 cm or less.

The products that most consistently reduced hydrophobicity (soil water repellency) were Aqueduct, Brilliance, Cascade Plus, HydroWet, Primer Select and TriCure.

Products that consistently did the best job of reducing hydrophobicity also unfortunately had potential (though limited potential) to cause some reduction in turf quality. However, this decrease in quality was seen in a maximum of two out of nine locations.

Johnson and Leeper (2011) found that block polymer and modified block polymer wetting agents (TriCure®, Revolution®) increased soil moisture and uniformity distribution by an average of 4.7 and 4.8%, respectively. A follow up study was conducted in 2011 on the same golf courses with a modified treatment list. TriCure® increased soil moisture by an average of 4.4%. Dispatch® decreased soil moisture by 4.7%, and increased uniformity by 6.5%.

Baird et al in 2013 found that under extreme water stress conditions, Revolution® (Aquatrols) performed the best of all products tested in alleviating turf drought symptoms and LDS incidence. TriCure AD® was next best.

Recently Xiong and Anderson in 2020, evaluated 15 soil wetting agents for their effects on surface tension, infiltration, and plant available water/retention.

1. Within 30 minutes after application and by 10 minutes into ponding, all the selected wetting agents reached a steady infiltration rate.
2. Tricure fell into the second group that produced moderate amounts of plant-available water, ranging from 7% to 9%.

Our own work on Tricure in 2022 has shown a reduction in dollar spot infection centres.

3.5 HydroForce Ultra (Product 5)

HydroForce Ultra is a newly discovered, innovative modified Block Co-Polymer surfactant technology, altered to enhance adsorption to hydrophobic materials and to radically increase wettability and responsiveness. The product has been extensively trialled by the US University system (Purdue & Penn State) showing significant benefits.

By managing soil water more efficiently, HydroForce Ultra maximises turfgrass quality, health and plant performance.

Our own work on HydroForce Ultra has shown a reduction in dollar spot infection centres (2022) when this is used as a soil wetting agent. There is also a strong suggestion that it does improve turf quality significantly under drought stress conditions as shown after 14 days of air drying at room temperature.

Image 1. Turf Condition after 14 days of being air dried. HydroForce Ultra is the 5th from the Left

3.6 Tour Turf REO (Product 6)

TourTurf® REO Respond® Extreme Organic Wetting Agent is the first 100% organic wetting agent from TourTurf® to be approved for use in organic farming and is especially designed for the turfgrass market.

3.7 Penterra (Product 7)

Penterra™ is formulated to decrease surface tension between water, soil and plants, which in turn, provides oxygen for soil microbes necessary for healthy subterranean environments.

3.8 Control (8)

The control was untreated and water was just applied.

3.9 Gilba SA (Product 9).

Gilba SA is composed of an alkyl glucoside to block copolymer ratio of 4:1 whilst also containing a percentage of salicylic acid (the exact amount is a trade secret).

3.9.1 Salicylic acid

Salicylic acid (SA) is a phenolic phytohormone and is found in plants with roles in plant growth and development, photosynthesis, transpiration, ion uptake and transport. It is involved in endogenous signaling against both biotic and abiotic stress, being an important plant hormone that regulates many aspects of plant growth and development.

SA application has also reportedly increased heat tolerance (Larkindale, 2002). Induction of defence-related genes and stress resistance in biotic stressed plants have also been reported (Kumar, 2014).

SA is an effective SAR inducer, but its phytotoxicity precludes widespread use (Conrath et al, 2015). While treating plants or suspension cells with high concentrations of SA or its functional analogs directly induces defences, low concentrations elicit little to no response. Following subsequent infection, however, defences are activated more rapidly and/or strongly (Conrath et al, 2006). This priming phenomenon, also occurs in systemic leaves of plants exhibiting SAR.

Comparative work looking at the efficacy of salicylic acid and Acibenzolar-S-methyl (ASM) was carried out into Alternaria solani, which is a destructive pathogen to tomato crops (Aslam et al, 2019). Foliar and seedling root dipping application of Bion and salicylic acid not only reduced the disease severity but also enhanced the plant growth.

3.9.2. Turf specific research.

The level of SA was shown to increase slightly after the first hour of heat stress in creeping bentgrass (Larkindale and Huang 2005).

Work was carried out on perennial ryegrass by Shahgholi et al, 2013 examining the interaction between Trinexapac ethyl and salicylic acid. Treatment of 0.27 g of salicylic acid had the maximum height compared with other treatments which showed significant difference from control treatment at 5% level. Trinexapac-ethyl with concentrations of 0.8 and 1.2 ml/m2 and salicylic acid with concentrations of 0.27 and 0.54 g/ m2 increased colour quality and chlorophyll content.

He et al 2005 examined the effects of SA at different concentrations (0, 0.1, 0.25, 0.5, 1, and 1.5 mmol) on heat tolerance of Kentucky bluegrass exposed to 46°C for 72 h in a growth chamber.

Among SA concentrations, 0.25 mmol was most effective in enhancing heat tolerance in Kentucky bluegrass, which was manifested by improved regrowth potential following heat stress of 72 h and maintenance of leaf water content at 77% during the 12-h stress period like that under normal temperature conditions.

Hosseini, Kafi and Arghavani (2016) looked at the effect of salicylic acid on physiological characteristics of Lolium grass (Lolium perenne cv. ‘Numan’) under drought stress. Salicylic acid foliar application at 0.75- and 1.5-mm levels increased the content of chlorophyll a, b and reduced electrolyte leakage, proline accumulation and antioxidant enzyme activity, which suggested that salicylic acid can be used to reduce the negative impacts of drought stress.

3.9.3 Previous Research.

Our 2020 work showed that salicylic acid applied to creeping bent grass lead to increased root growth and lateral root branching, better turf quality and faster and more consistent seed germination.

By incorporating this the idea is to increase the ability of turf to better abiotic stress and drought whilst also maintaining a strong and vigorous root architecture.

3.10 Tour Turf FTE (10)

TourTurf® FTE Respond® Extreme Fine Turf Enhancer is an advanced wetting agent which provides both superior traditional wetting agent benefits such as water conservation, firm playing surfaces and dry patch management, and at the same time helps to increase bent and fescue dominance in turfgrass swards.

4.0 Materials and Methods.

The practice putting green at Bonnie Doon G.C in Sydney, NSW was chosen to carry out this trial, with the surface comprising approximately 85-90% creeping bent grass (Agrostis stolonifera var MacKenzie). This was the second year of the trial after we started this in 2022/23 using the same trial site.

A completely randomized block design (CRBD) was marked out after using Edgar II for its design and layout. The trial area comprised 10 treatments with 6 replicates, with one treatment being an untreated control (60 plots in total). Each plot had a surface area of m2 with a 50 mm buffer around each.

Applications were made on 31st October 2023 with further applications being made on 23rd November 2023, 11th December 2023, 7th February 2024 and the 4th of March 2024.

All treatments were applied in the label rate amount of water and then immediately washed in using the in-ground irrigation system present at the site. This applied approximately 6mm of water.

The treatments are:
(1) H2Pro (ICL).
(2) Hydrahawk (Geoponics).
(3) Tour Turf ELL (Tour Turf).
(4) Tricure (Mitchell Products).
(5) HydroForce Ultra (Indigo).
(6) Tour Turf REO (Tour Turf).
(7) Penterra (Geoponics).
(8) Control.
(9) Proprietary incorporating salicylic acid and
(10) Tour Turf FTE (Tour Turf).

Following application, the green was maintained as usual with fertilizer and irrigation applied when required.

Table 1. Rates and water volumes for products trialled.

Treatment	Active Ingredient	Rate g(ml)/m2	Rate Product Kg (L)/Ha	water volume L/Ha	Comments
H2Pro Trismart (1)	Dipropylene Glycol Methyl Ether 5-10%; 3-5% 3-butoxypropan-2-ol	2.5	25	800	Rate then lowered to 10L/Ha
Hydrahawk (2)	Trade Secret	0.48	4.8	800	
Tour Turf ELL (3)	Blend of polypropylene and polyethylene glycols	2	20	800	
Tricure (4)	Reverse Block Co-polymer	1.25	12.5	800	
HydroForce Ultra (5)	Modified Block Co-polymer	12.5	12.5	800	
Tour Turf REO (6)	25-50% Sophorolipids	2	20	800	
Penterra (7)	70% anionic blend; 30% propylene glycol	0.48	4.8	800	
Control (8)	-	-	-	800	
Gilba (9)	Block co-polymer and APG	1.25	12.5	800	
Tour Turf FTE (10)	Co-block polyethoxylated surfactants and soil penetrants.	2	20	800	

Assessments are as follows:
1. Turf Dark Green Colour Index (DGCI).
2. Turf Colour Quality.
3. Moisture Content at 37mm and 75mm.
4. Water Droplet Penetration Test.
5. Organic Matter by Loss on Ignition.

4.1 Digital Image Analysis.

Turf Quality Analysis was carried out using a light box. The 0.75 x 0.75 m light box was positioned in the centre of the plots and images taken using a Panasonic DMC-TZ80. On each sampling date one image was taken per plot giving a total of 60 images. The images were then analysed using Turf analyzer software to determine the DGCI, and Colour Quality.

Image 2. Light Box LHS and TDR 350 RHS

4.2 Moisture Content 37 mm and 75 mm.

Soil volumetric moisture content (VMC %) was recorded using two TDR 350 (Spectrum Technologies) units fitted with 37 mm (1.5 inch) and 75 mm (3 inch) tines. Samples were taken randomly in each plot with both units and the results logged.

This gave a total of 60 results at both depths on each sampling date (120 in total).

4.3 Water Droplet Penetration Test (WDPT).

19mm cores were taken three weeks after the 23rd of November application and dried at room temperature for 14 days. A water droplet penetration time was then carried out on each individual core at 0-2, 2-4 and 4-6 cm depth. This involves timing how long a drop of water took to penetrate the soil profile at each respective depth. The test was repeated three times on each core at each depth and the mean then recorded for the three readings.

4.4 Loss on Ignition (LOI).

Organic Matter Content variations over depth was assessed over a 6cm depth. 25cm cores were taken from each plot and then shipped to Westgate Laboratories in Orange for independent testing.

The methodology involved removing the surface vegetation to a depth of 1cm and these samples were then dried for 48 hours in a muffle furnace at 60°C.

The oven-dried samples were then ashed in a muffle furnace at 440°C for 4 hours. The substance remaining after ignition is the ash. The ash content is expressed as a percentage of the mass of the oven-dried sample.

% Ash Content = (C X 100)/B
where: C = ash weight in g, and B = oven-dried test specimen, weight in g.

The calculation to determine the amount of organic matter by difference, is as follows:

% Organic matter = 100.0 - D
where: D = ash content, %.

If these products were increasing root growth, organic matter contents would increase over the control. The assumption was that as this was initially a clean USGA spec sand, any increases in organic matter would be due to increases in root growth.

The Plots were monitored regularly using digital image analysis in combination with Image J.

4.5 Statistical Analysis

Statistical analysis was carried out using Studio R, agricolae package. All data were subjected to two-way ANOVA (analysis of variance) to determine the Treatment effects. Treatment means were separated using the Duncan's multiple range test at the P = 0.05 level of probability.

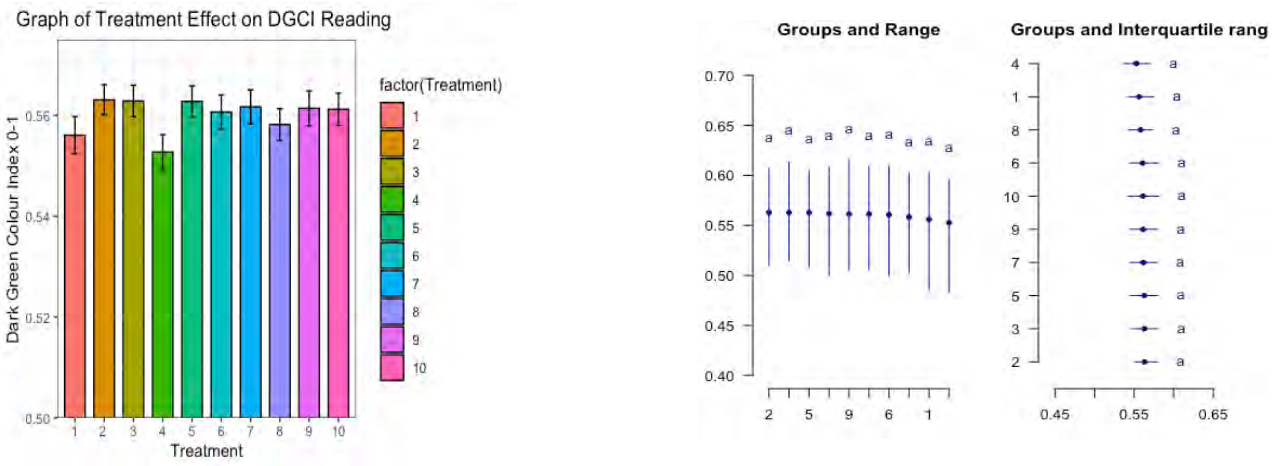
5.0 Results.

5.1 Dark Green Colour Index (DGCI).

In all the graphs the solid red lines are applications times.

Over the duration of the trial, Digital Image Analysis showed no significant differences (P<0.05) between the treatments.

Figure 1. Dark Green Colour Index. Values with different letters are significantly different (P < 0.05).



5.2 Colour Quality.

With Colour Quality, significant differences did exist between treatments (P<0.05).

Figure 2. Colour Quality. Values with different letters are significantly different (P < 0.05).

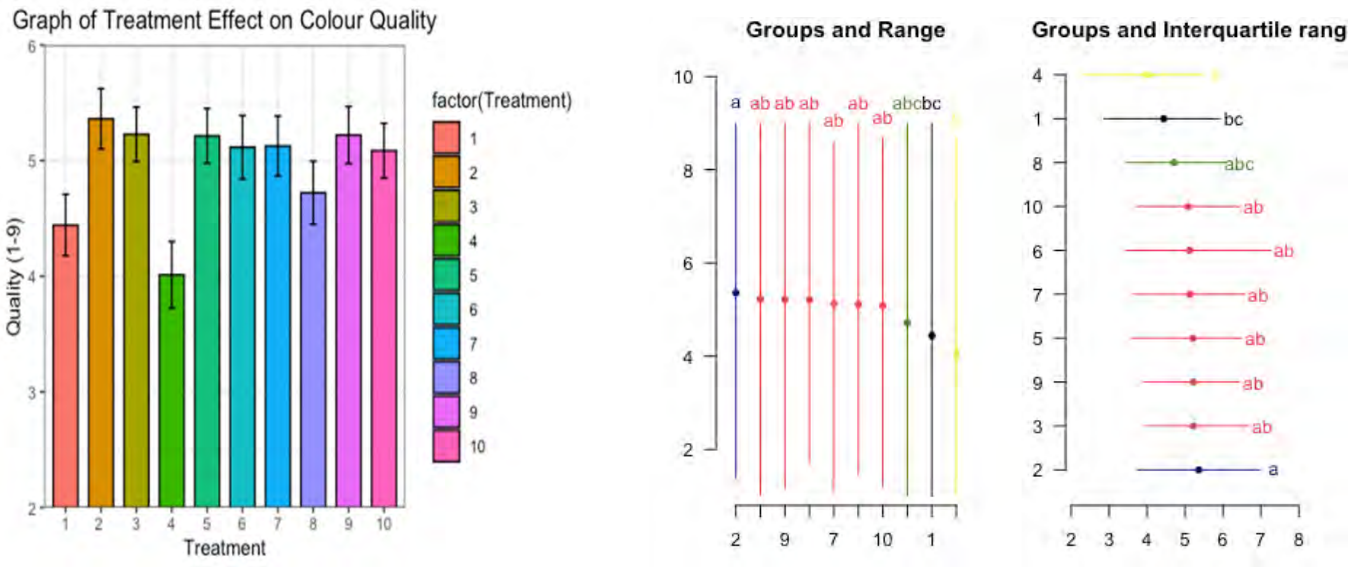
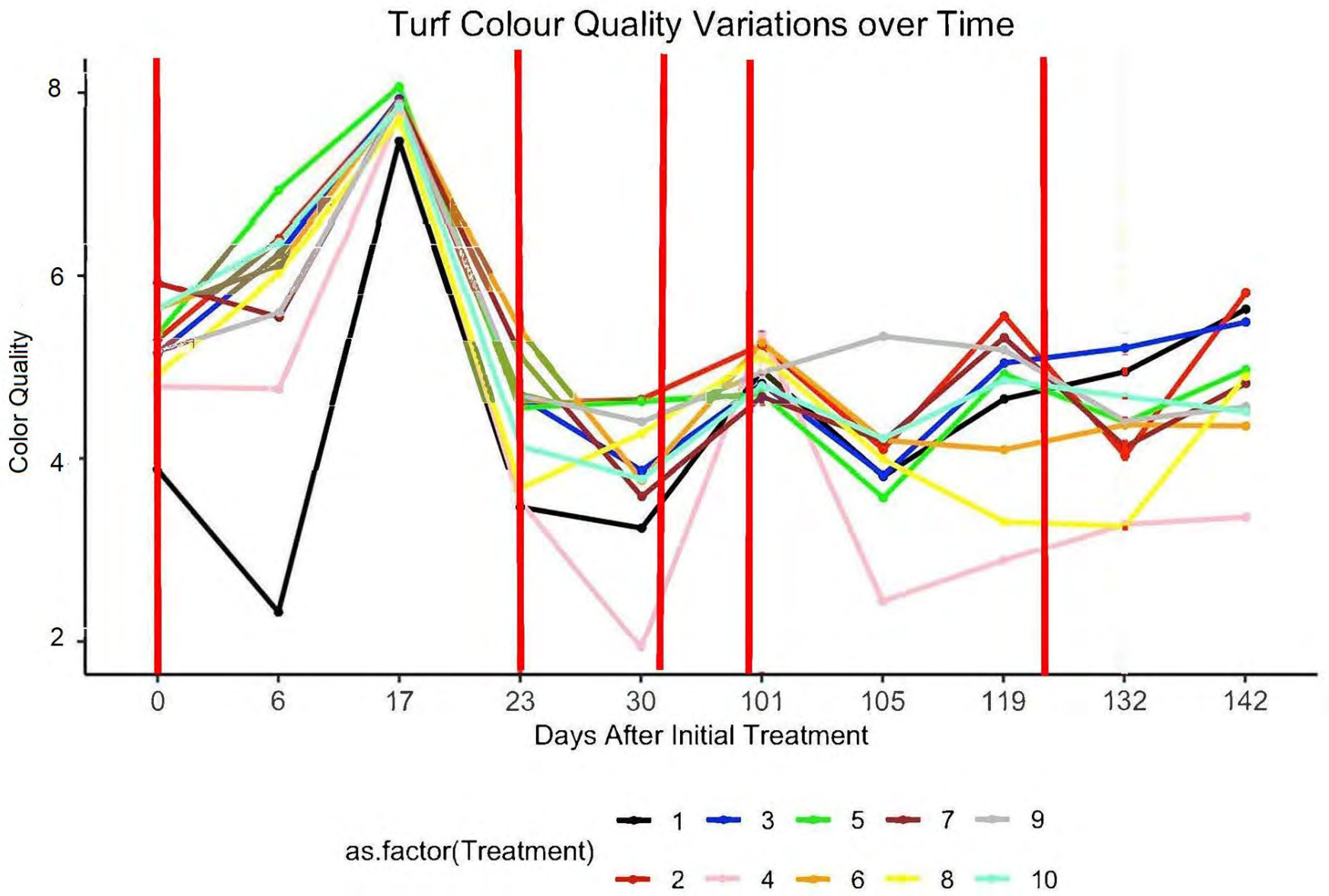


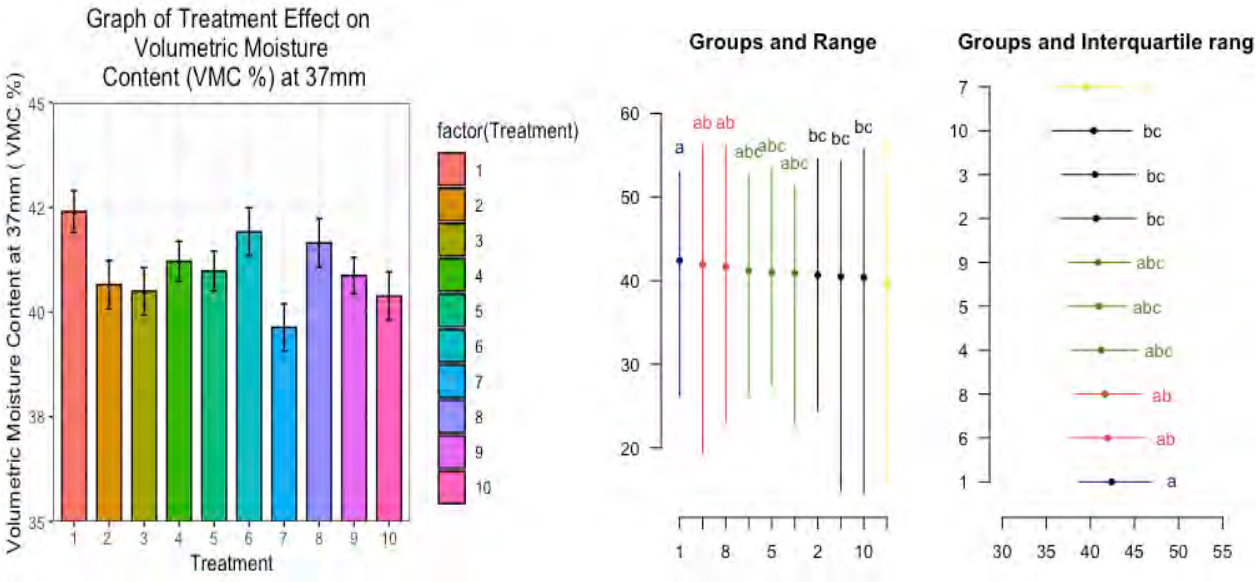
Figure 3. Colour Quality Values Over Time



5.3 Volumetric Water Capacity (VWC) %.

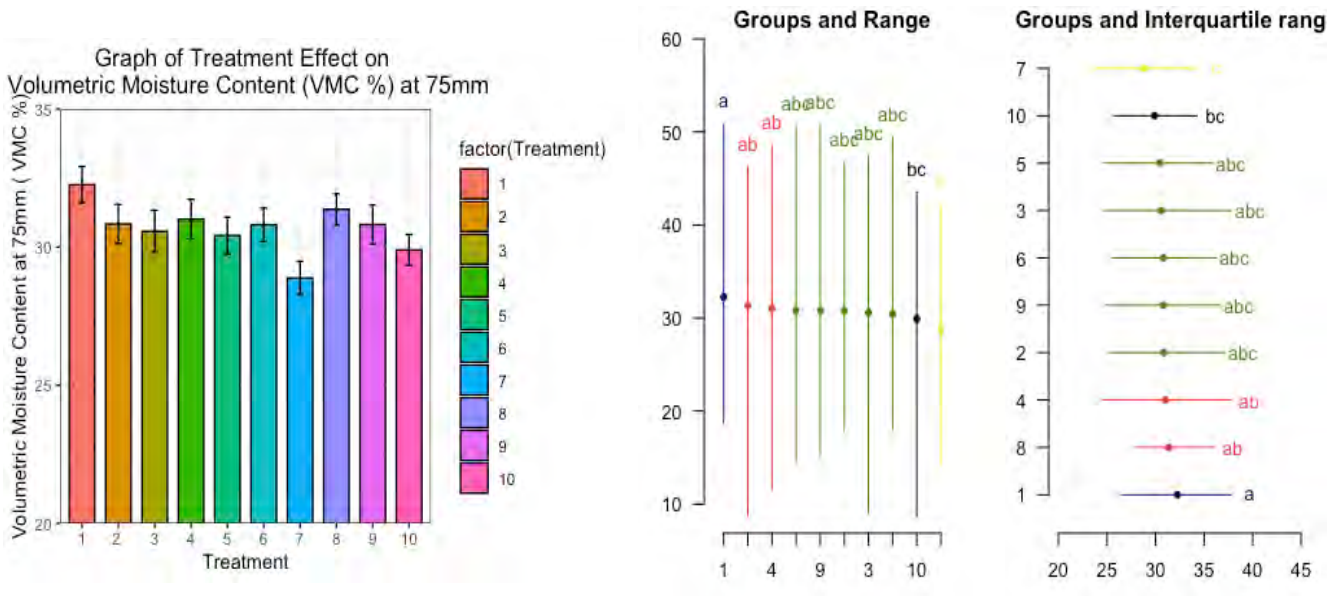
At 37 mm significant differences did exist between treatments (P<0.05). H2Pro Trismart had significantly higher soil moisture levels than Hydrahawk, Tour Turf ELL, Penterra, and Tour Turf FTE. Penterra was the only treatment to be significantly lower than the control.

Figure 4. VWC % at 37 mm. Values with different letters are significantly different ($P < 0.05$).



At 75 mm, Penterra continued to have a significantly lower moisture content than the Control. Penterra was also significantly lower than the Tricure and H2Pro Trismart.

Figure 5. VWC % at 75mm. Values with different letters are significantly different ($P < 0.05$).



The Moisture results can be divided into two clear timeframes. From the trial start to 58 days and then again from 99 days to 163 days. When we plot the results for 0-58 days at 37 mm vs the base mean we get a clearer idea of how these perform. In this instance Tour Turf FTE gives a highly significant result ($P \leq 0.001$), while H2Pro Trismart and Penterra are significant at $P < 0.05$.

Figure 6. VWC % at 37 mm day 0-58. * ($P < 0.05$). ** ($P < 0.01$) and *** ($P < 0.001$)

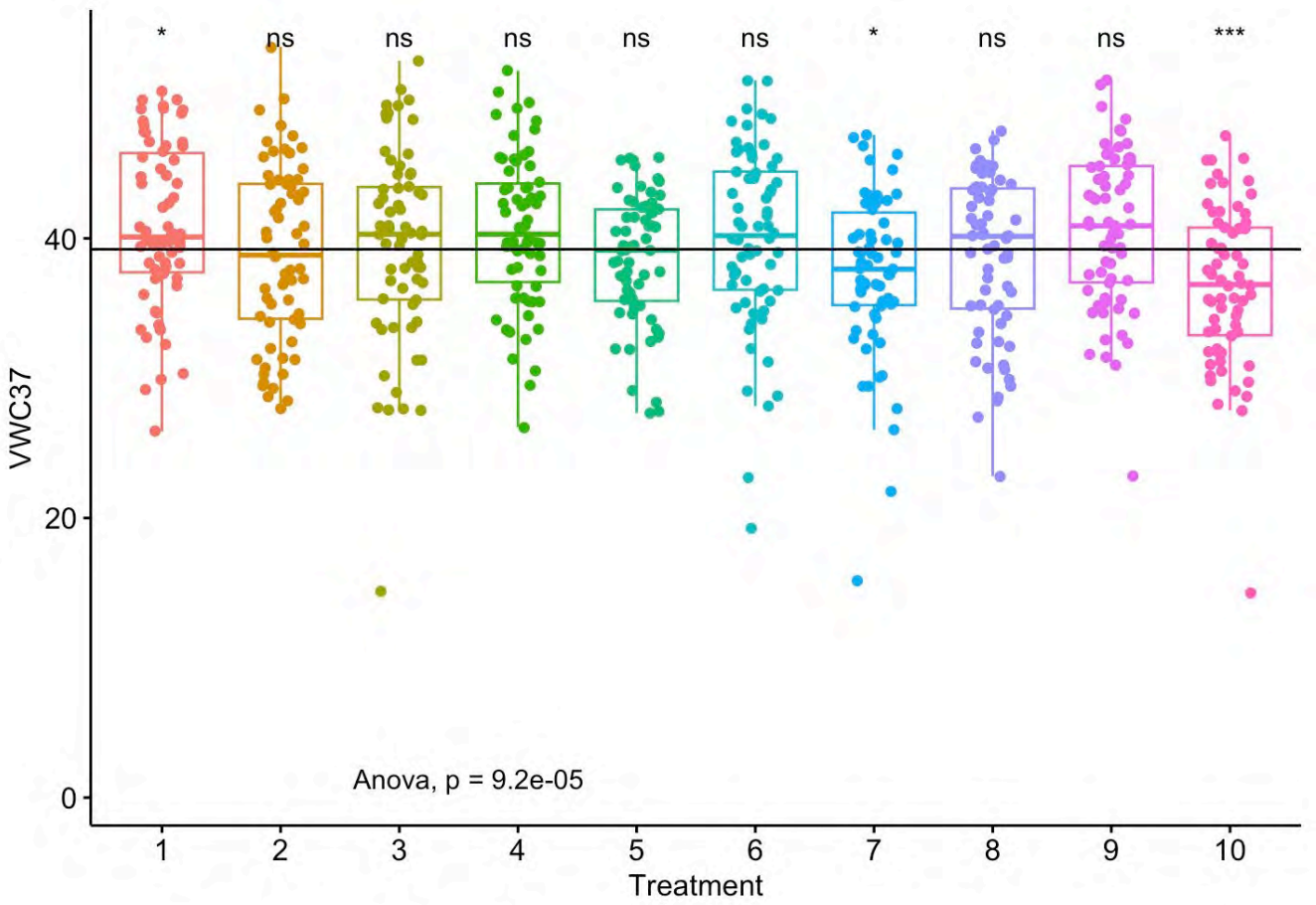


Figure 7. Fluctuations in VMC % at 37 mm days 0-58

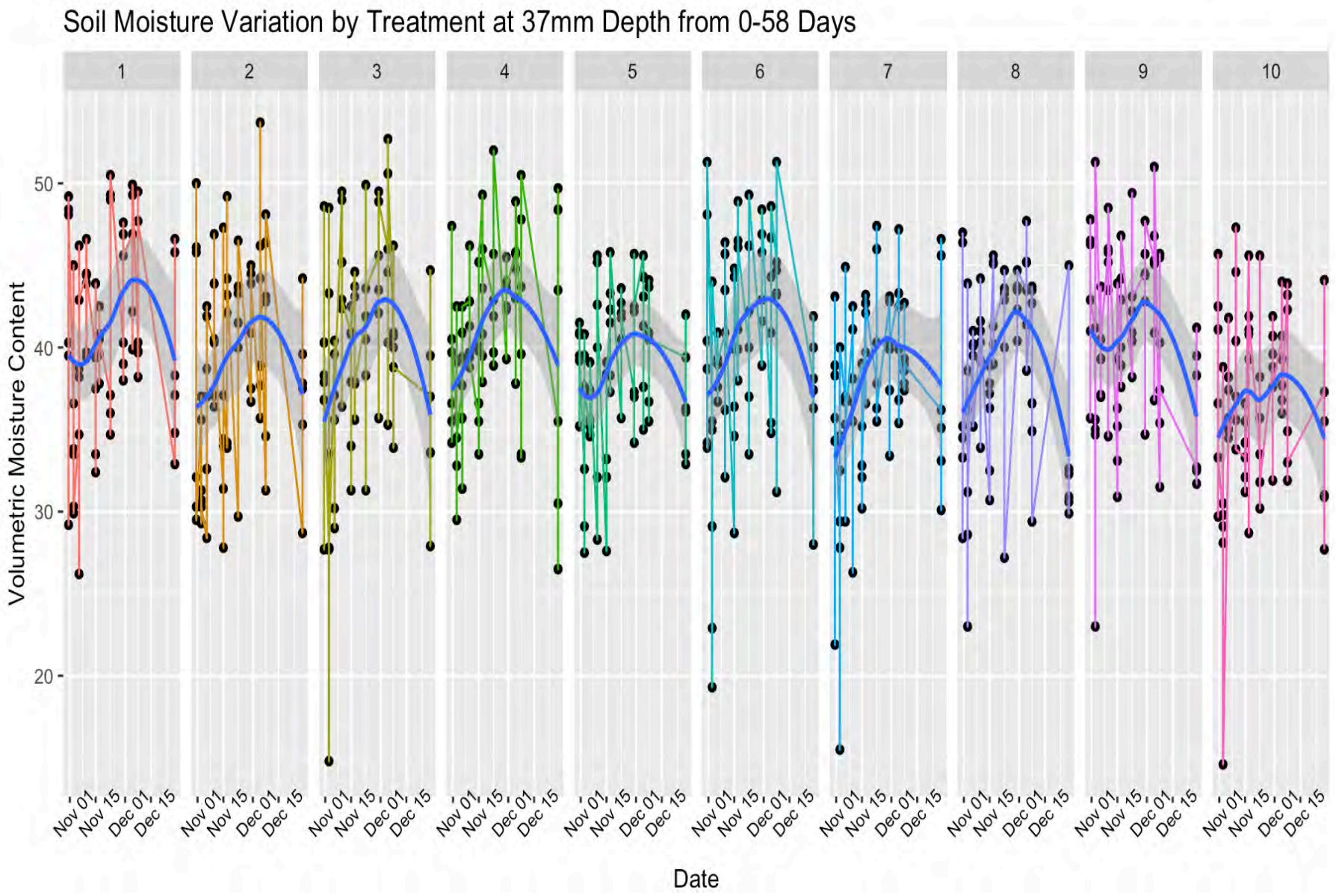
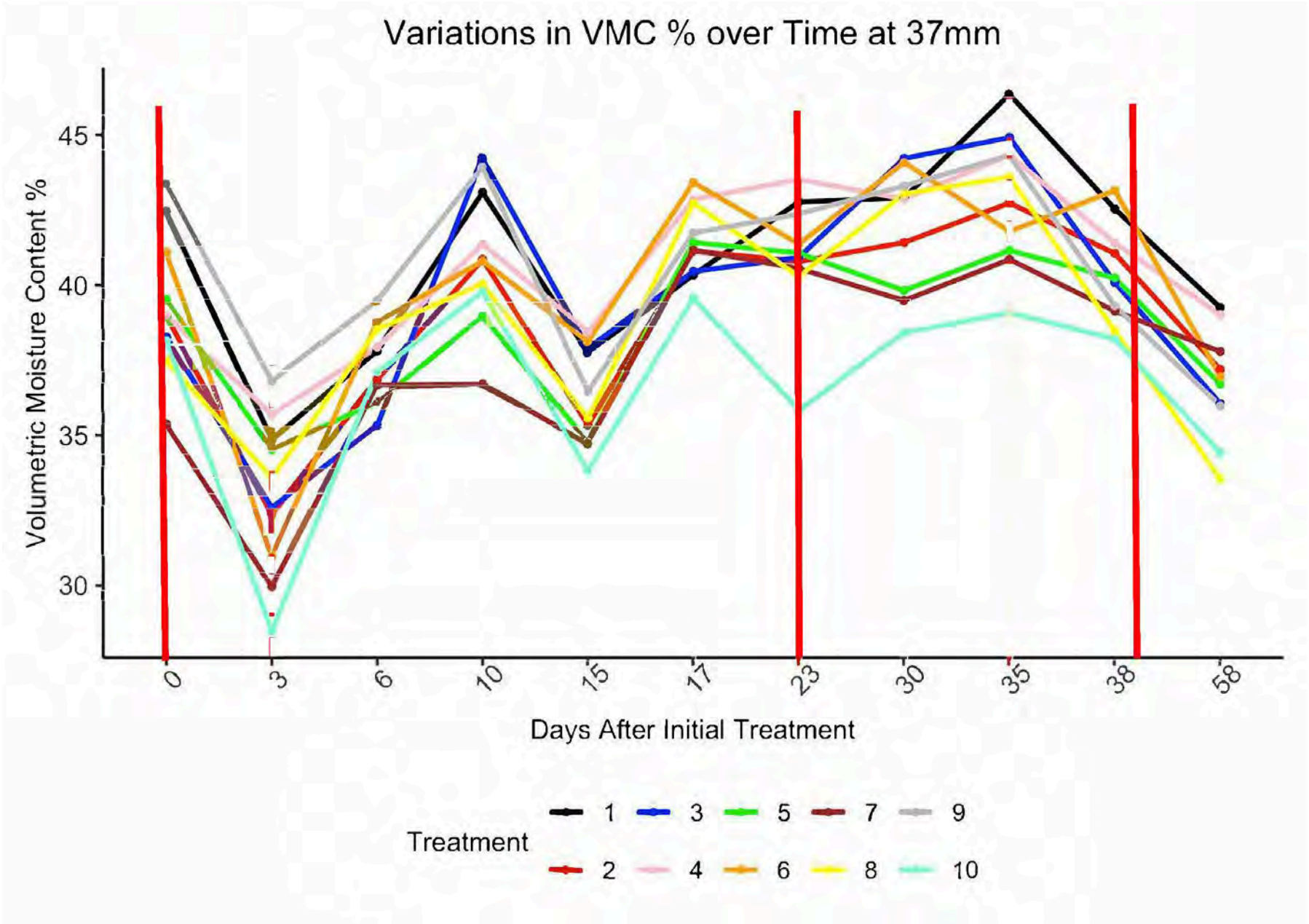


Figure 8. VMC % at 37mm at 0-58 days



When we plot the results for 99-163 days at 37mm vs the base mean we see that the proprietary surfactant plus salicylic acid ($P < 0.01$), the Control and Tour Turf FTE ($P < 0.05$) are the only treatments giving significant results.

Figure 9. VWC % at 37 mm day 99 - 163. * ($P < 0.05$). ** ($P < 0.05$) and *** ($P < 0.001$)

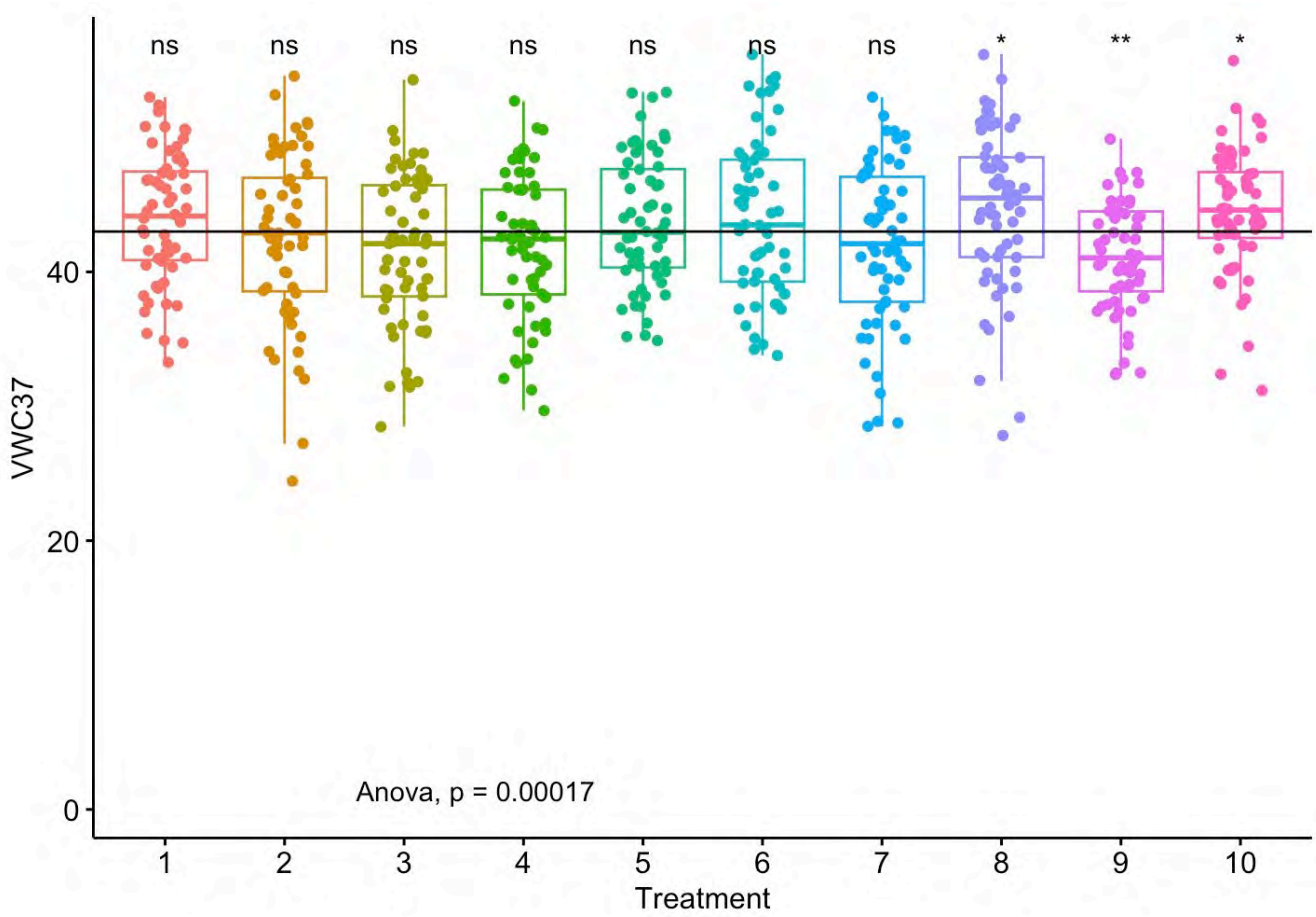


Figure 10. Fluctuations in VMC% at 37mm days 99-163

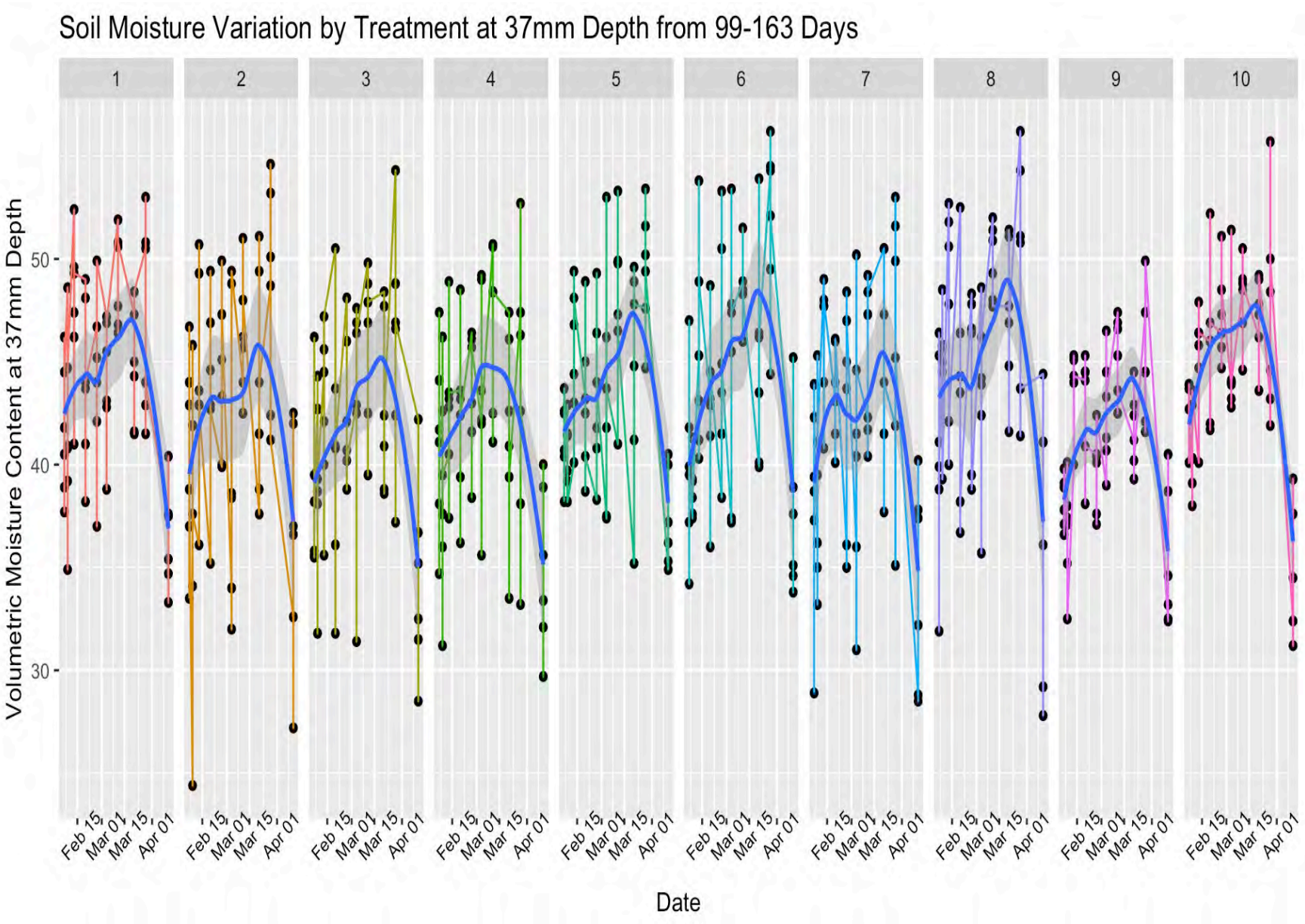
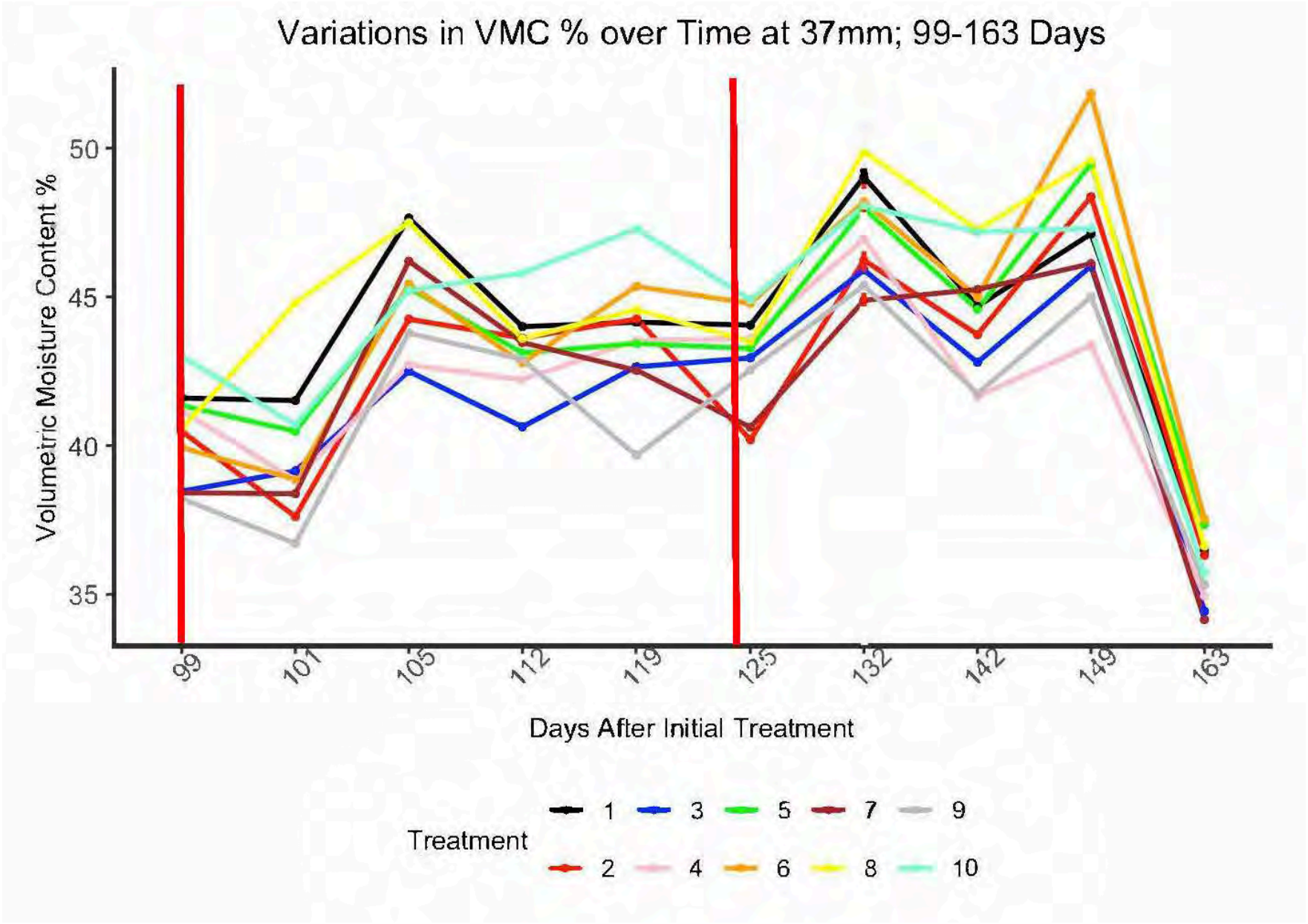


Figure 11. VMC% at 37mm days 99-163



When we plot the results for 0-58 days at 75 mm vs the base mean we see the 0–58-day results repeated with Tour Turf FTE, H2Pro Trismart and Penterra being significant at $P < 0.01$. The proprietary surfactant plus salicylic acid (9) is significantly higher at $P < 0.05$.

Figure 12. VWC % at 75 mm day 0-58. * ($P < 0.05$). ** ($P < 0.01$) and *** ($P < 0.001$)

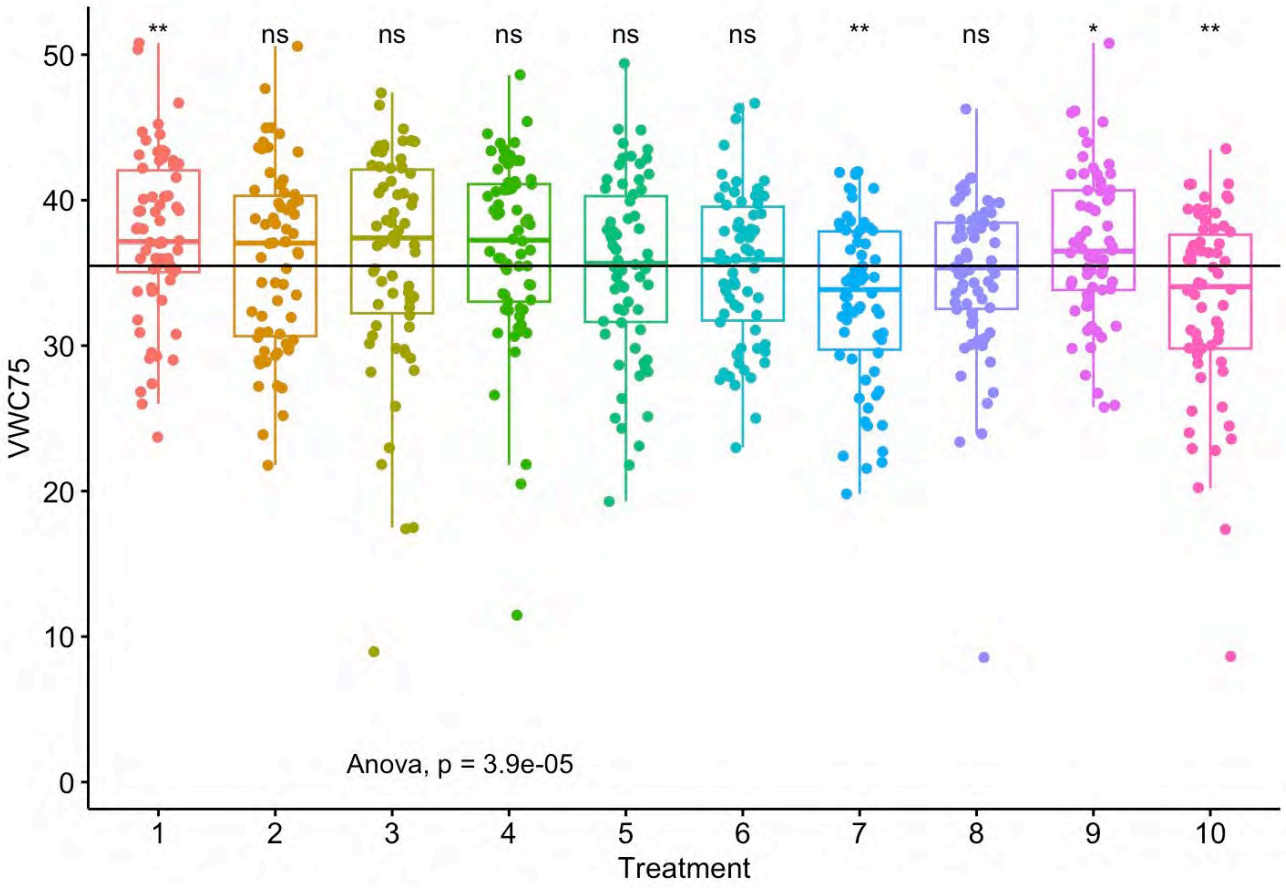


Figure 13. Fluctuations in VMC% at 75mm days 0-58

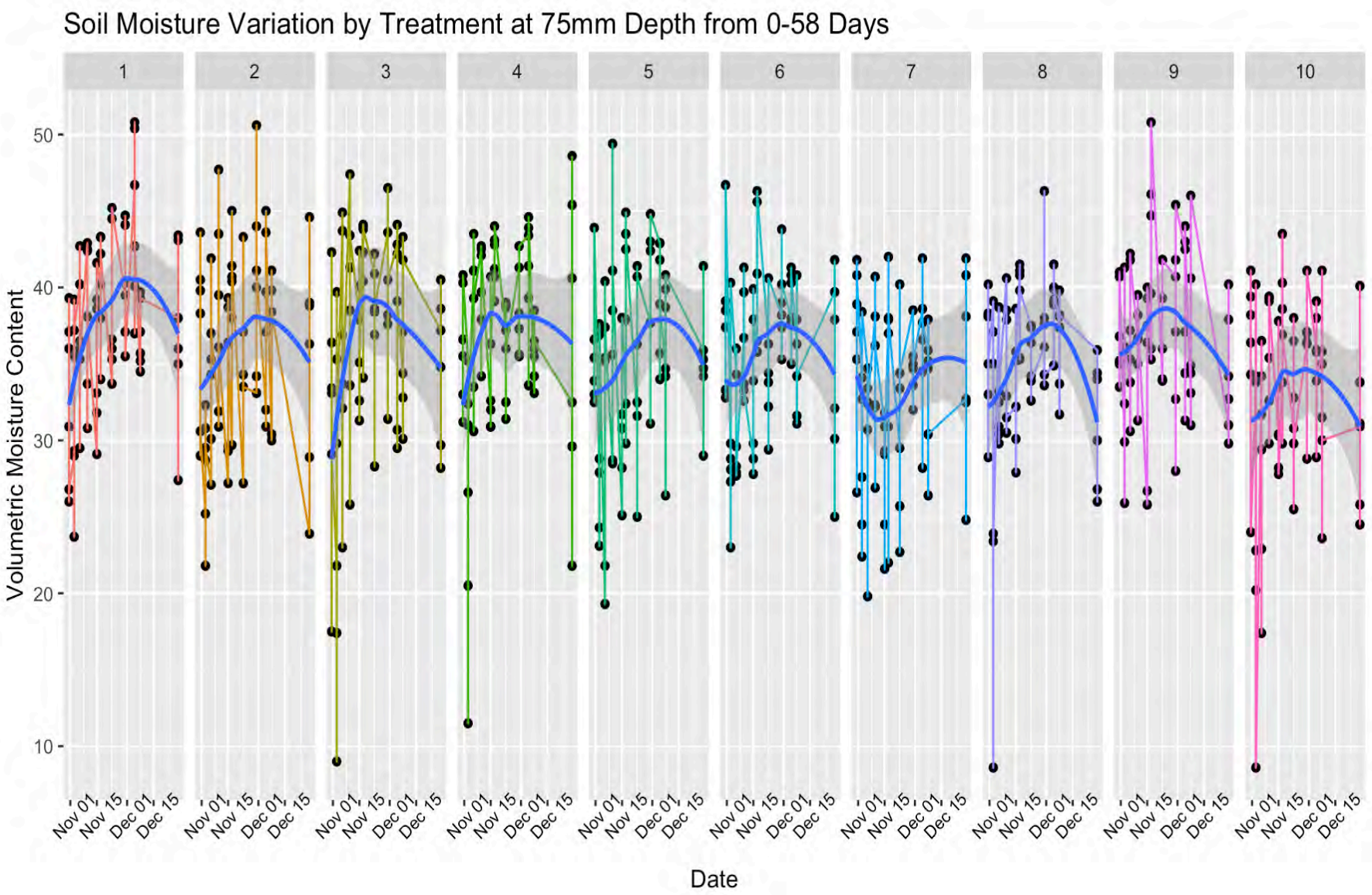
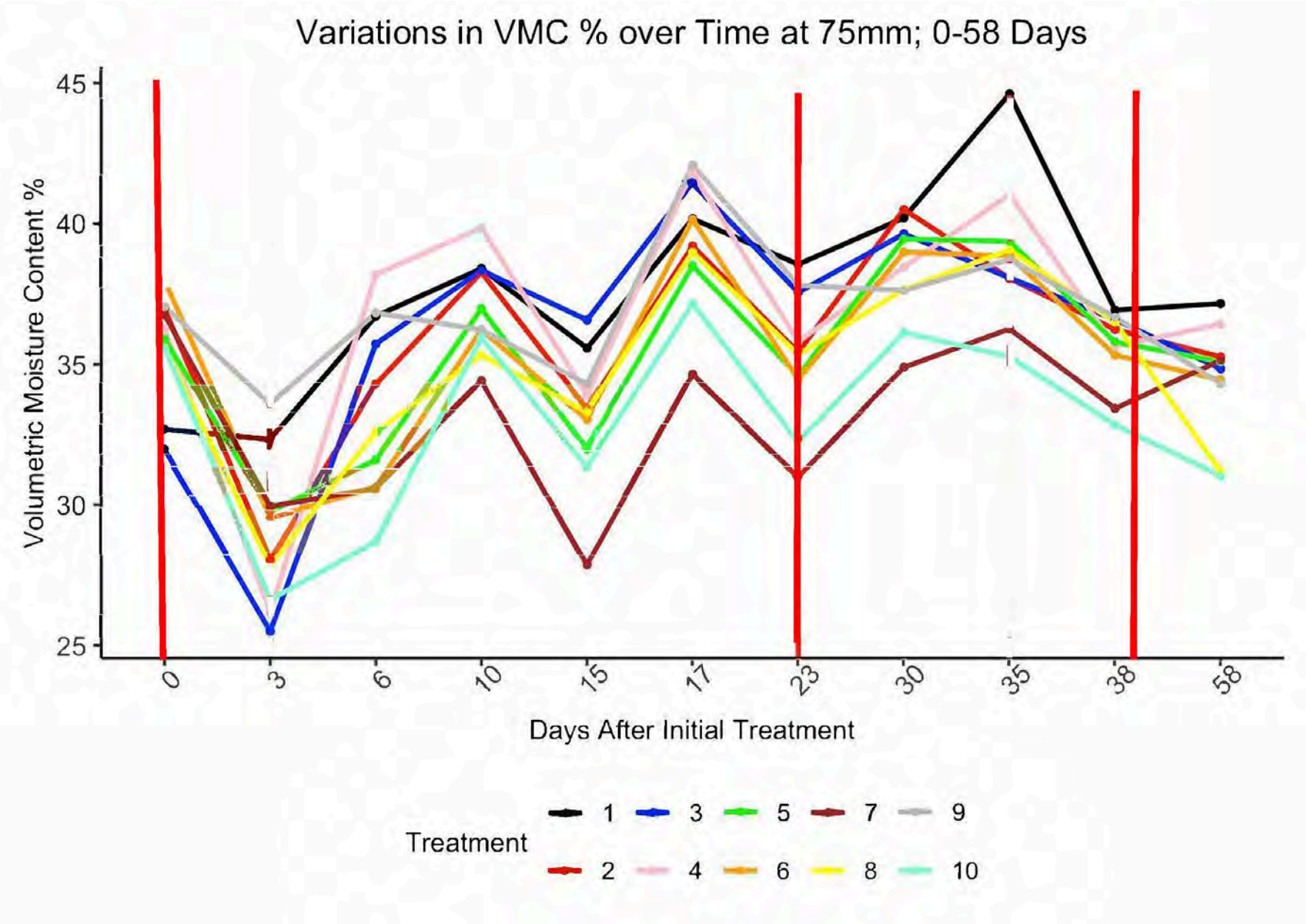


Figure 14. VMC% at 75mm from 0-58 days



When we plot the results for 99-163 days at 75 mm vs the base mean we see the Control having significantly higher soil moisture ($P < 0.01$). Tour Turf FTE is also significantly higher ($P < 0.05$) and the proprietary mix and Penterra lower at ($P < 0.05$).

Figure 15.VWC % at 75 mm day 99 - 163. * ($P < 0.05$). ** ($P < 0.01$) and *** ($P < 0.001$)

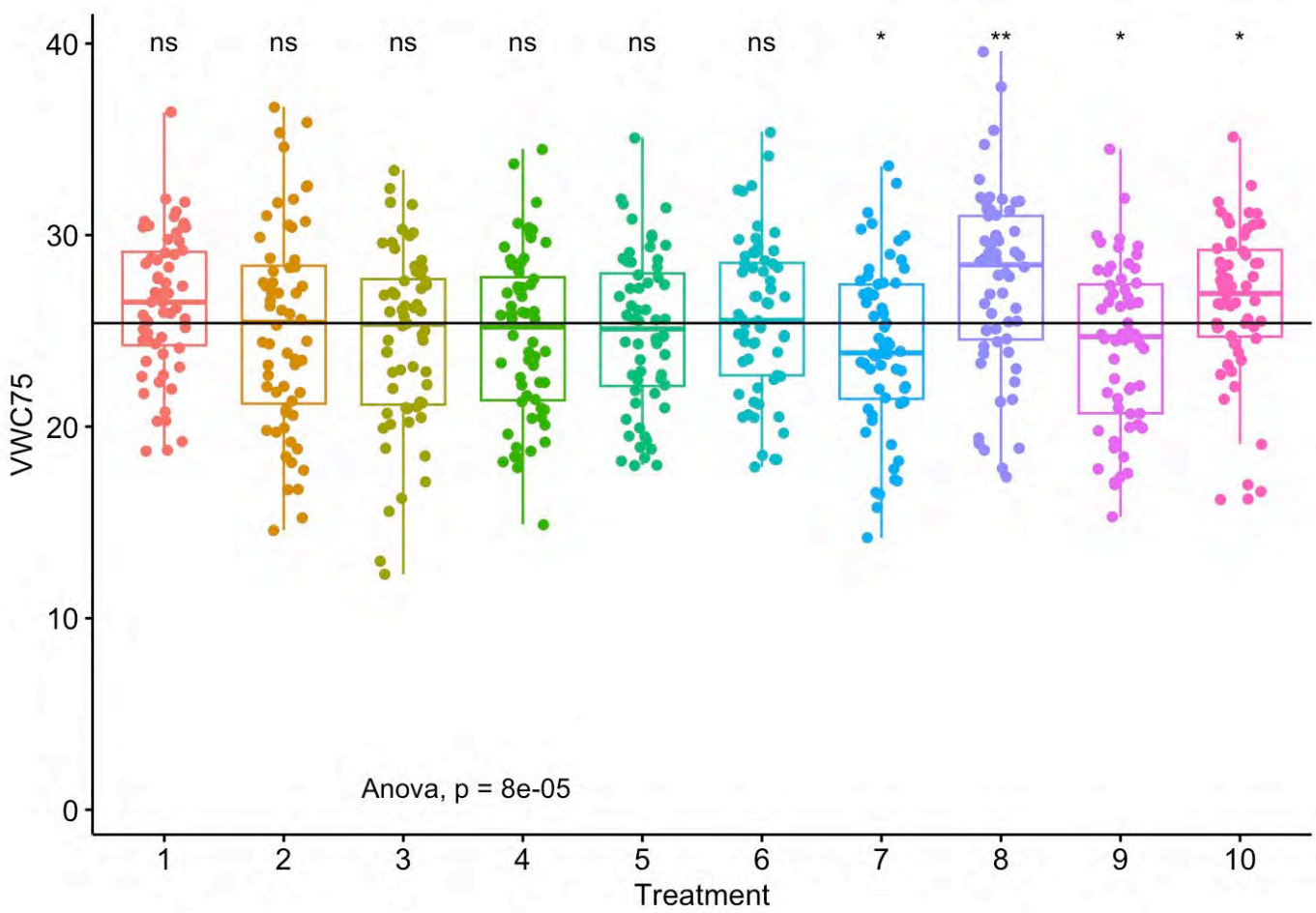


Figure 16. Fluctuations in VMC% at 75mm days 99-163

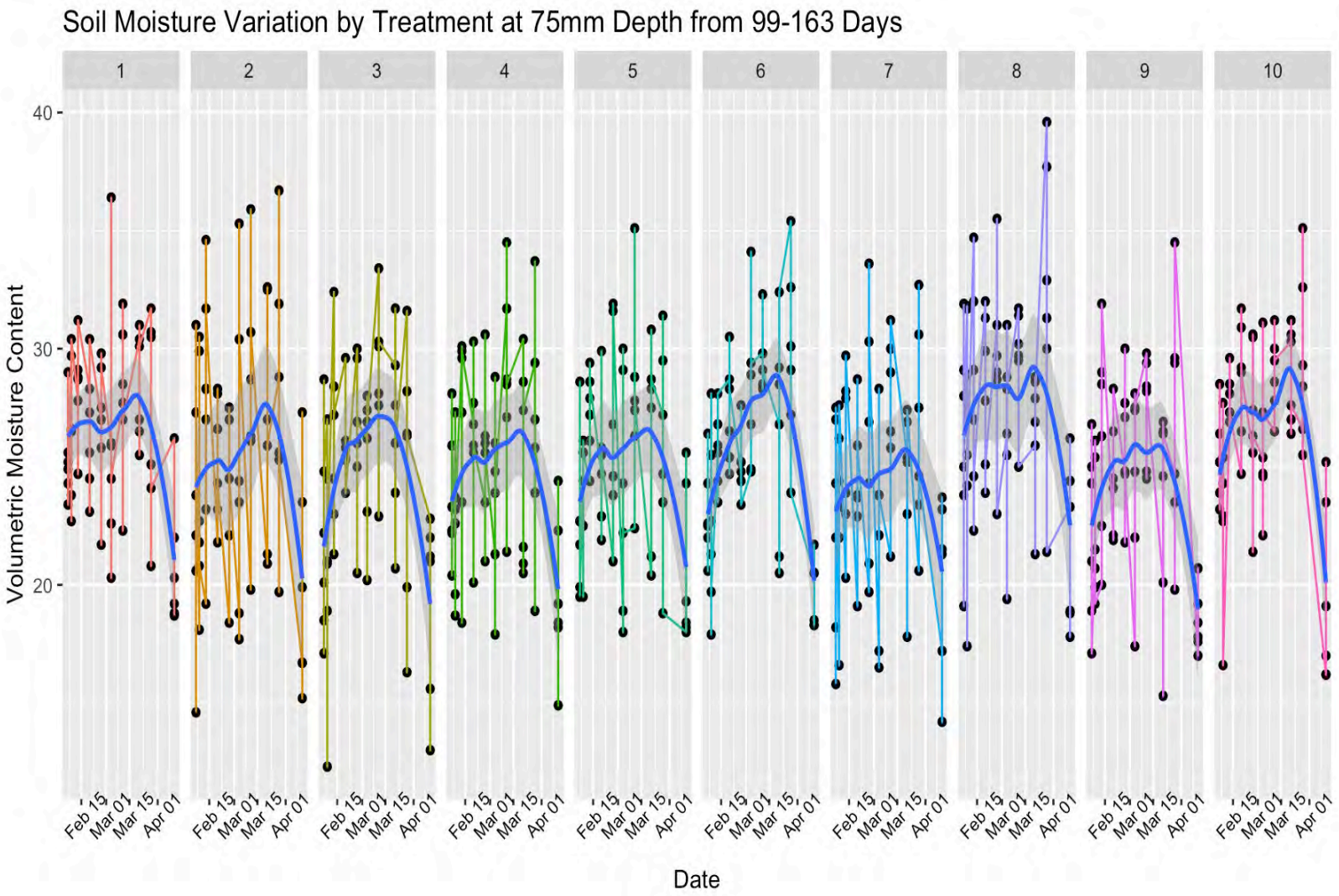
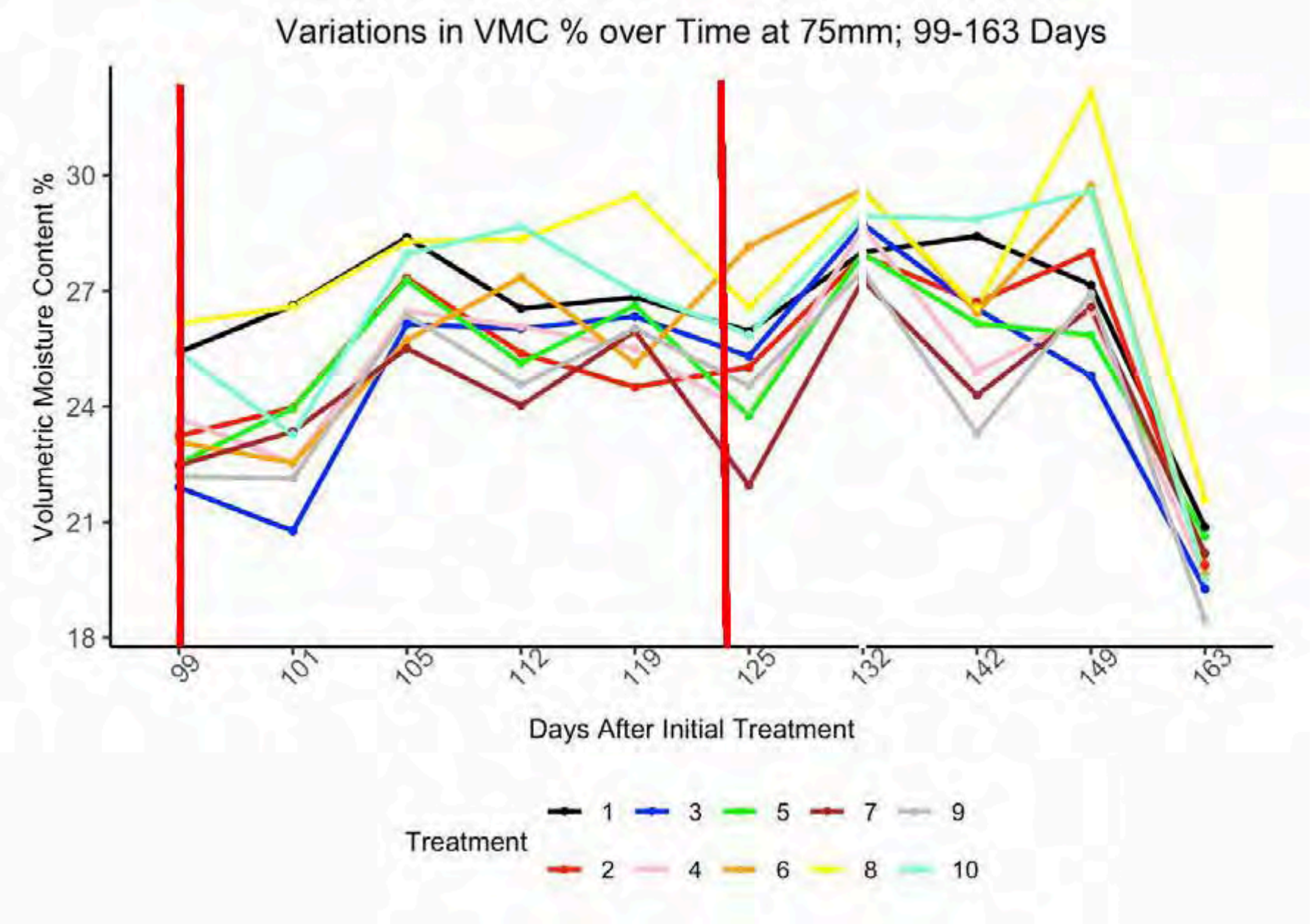


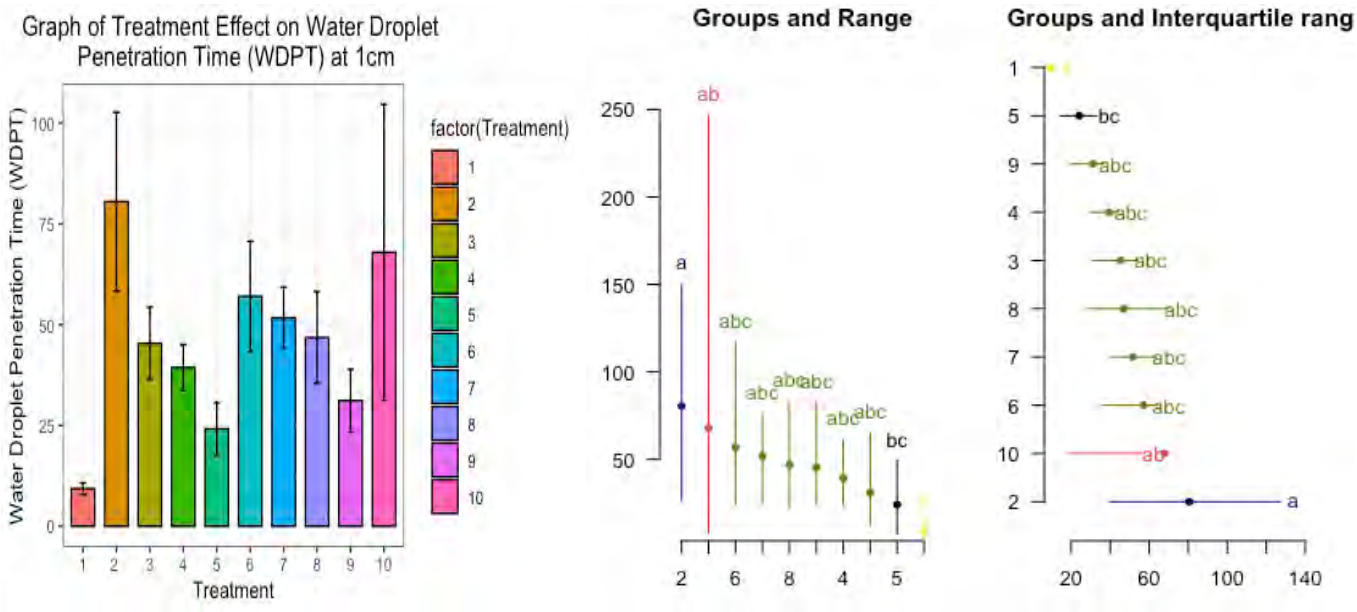
Figure 17. VMC% at 75mm days 99-163



5.4 Water Droplet Penetration Test (WDPT).

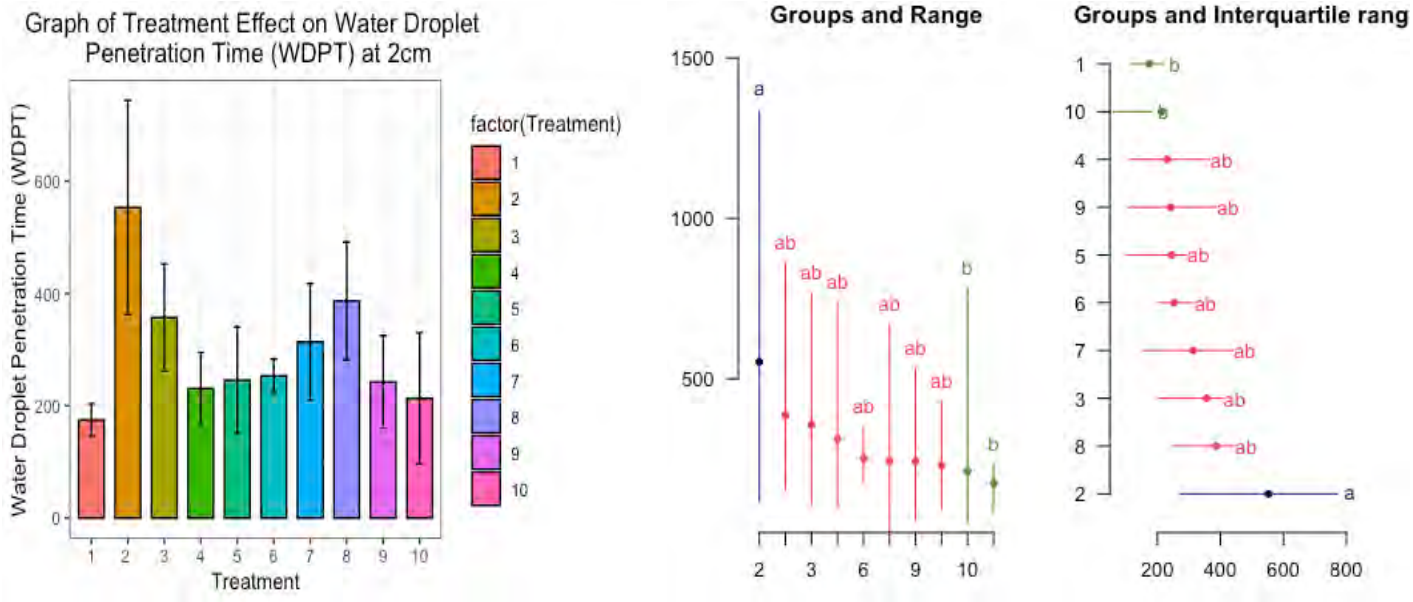
The H2Pro Trismart treatment performed extremely well in the upper 1 cm of the rootzone and gave consistent rapid movement away from the soil surface. This was significantly faster than the Tour Turf FTE and Hydrahawk.

Figure 18. WDPT at 1 cm. Values with different letters are significantly different ($P < 0.05$).



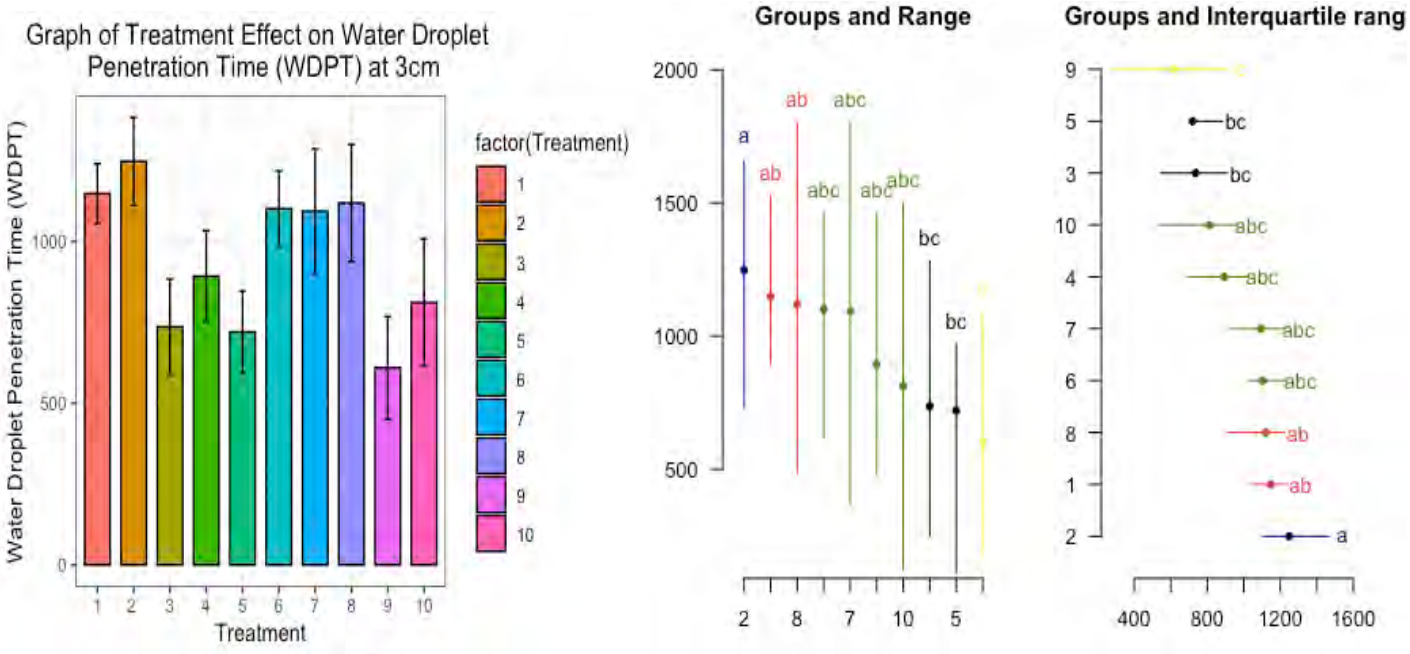
At a 2 cm depth H2Pro Trismart had the lowest soil moisture. However, none of the treatments gave significant differences in comparison to the Control at 2cm. The Tour Turf REO and H2Pro Trismart treatments both moved water significantly faster than the Hydrahawk treatment.

Figure 19. WDPT at 2 cm. Values with different letters are significantly different ($P < 0.05$).



At 3 cm the proprietary treatment was the only one to show a significantly lower soil moisture content than the Control. The proprietary, HydroForce Ultra and Tour Turf ELL products all had significantly lower water droplet penetration times compared to Hydrahawk.

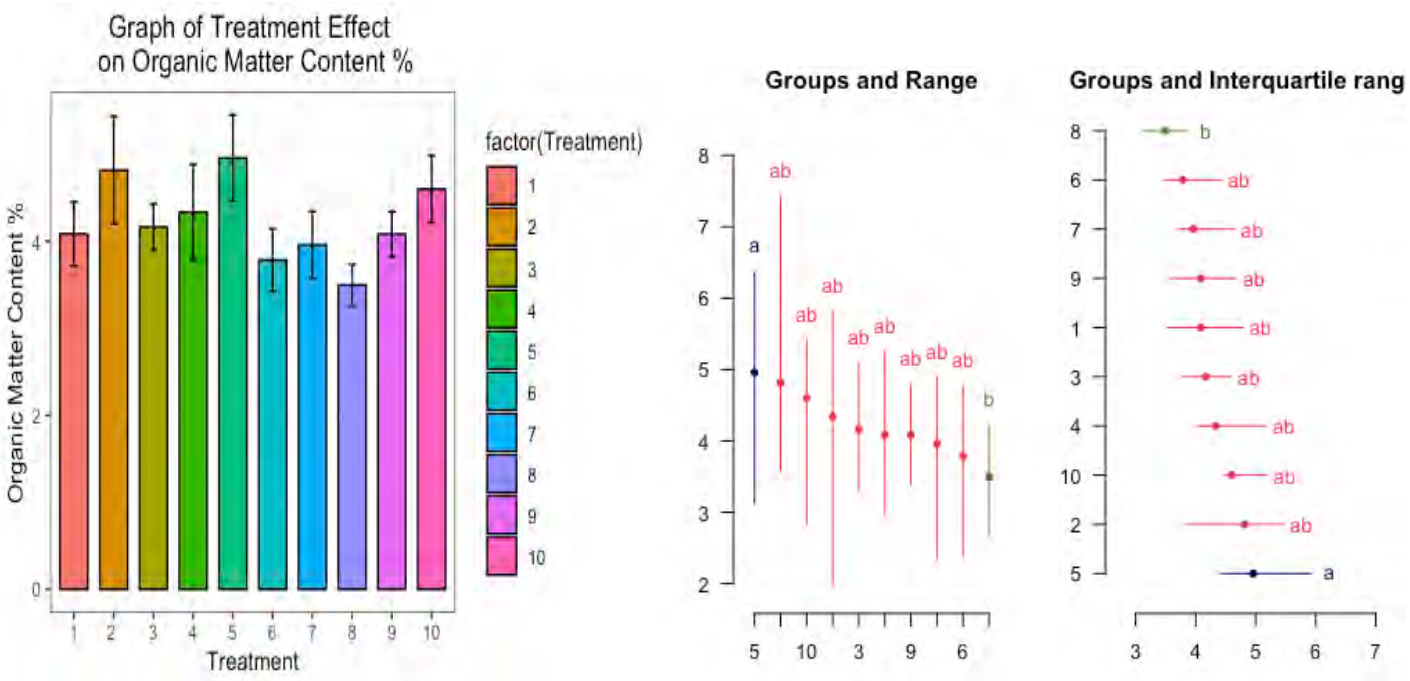
Figure 20. WDPT at 3 cm. Values with different letters are significantly different ($P < 0.05$).



5.5 Organic Matter by Loss on Ignition.

HydroForce Ultra is the only treatment that gave a significantly higher organic matter content than the untreated Control. There were no significant differences between any of the other treatments.

Figure 21. Organic Matter %. Values with different letters are significantly different ($P < 0.05$).



6.0 Discussion.

The first point is that these trials were not on stressed turf. Irrigation was never limiting so improvements in drought tolerance or turf quality under stress are not valid. The closest we came to that was the turf response to 14 days being air dried for the Water Droplet Penetration Test (WDPT).

6.1 Colour Quality.

In the work of Leinauer (2007), in 2 of 9 locations they saw a decline in turf quality with Tricure. We also see this over the duration of the trial. The TriCure Treatment and H2Pro Trismart, both cause an initial decline in Colour Quality after application.

The initial drop off in turf Colour Quality after using the H2Pro stops with follow up applications, as the rate reduces from 25L/Ha to 10L/Ha.

With the TriCure we initially proposed that this is due to a delay in the wash in after the first Treatment. This was due to irrigation issues resulting in a three-to-four-hour delay before irrigation. However, this pattern of a drop off in Turf Quality continues after each application of TriCure, even when we immediately water it in.

On this basis we would be wary of the label that states immediate watering-in is not necessary. On the 31st of October the temperature was 29°C which might explain this initial phytotoxicity.

However, the temperatures on the other application days were 23.1 °C, 27.3°C, 23.5°C and 22.9°C, and on all these days watering in was immediate. Even then there was still some phytotoxicity. On this basis we strongly suggest immediately washing in.

Over the trial duration the only treatments to not give significantly higher Colour Quality than TriCure are the control and H2Pro Trismart.

6.2 Dark Green Colour Index (DGCI).

There were no significant differences between any of the treatments and the untreated control.

6.3 Volumetric Moisture Capacity (VMC %).

There are two questions that these results raise as to what is a good soil wetting agent?

- Does a good soil wetting agent increase the soil moisture content of a soil profile or move it away from the surface?

- Even if a soil wetting agent holds water is this available to the turfgrass? From the condition of the turfgrass when air dried for 14 days this would suggest that this isn't necessarily the case with all soil surfactants.

Jiang et al (2022) in a study of 21 soil wetting agents found that some could hold up to 1.4-times additional plant available water than others.

Interestingly Tricure was classed as only being able to hold moderate amounts of plant available water, ranging between 7.5 % and 6.3%.

Over the duration of this trial Penterra consistently gives lower VMC% at both the 37- and 75-mm depth. In contrast the Hydrahawk and H2Pro Trismart both give the highest VMC% over the trial duration, and also when the two sample periods are looked at independently.

However, H2Pro has the advantage that it quickly moves water away from the surface even in a hydrophobic soil. HydroForce Ultra and Tour Turf REO also seem to be able to move water quickly away from the surface and retain it in the top 1cm of the profile.

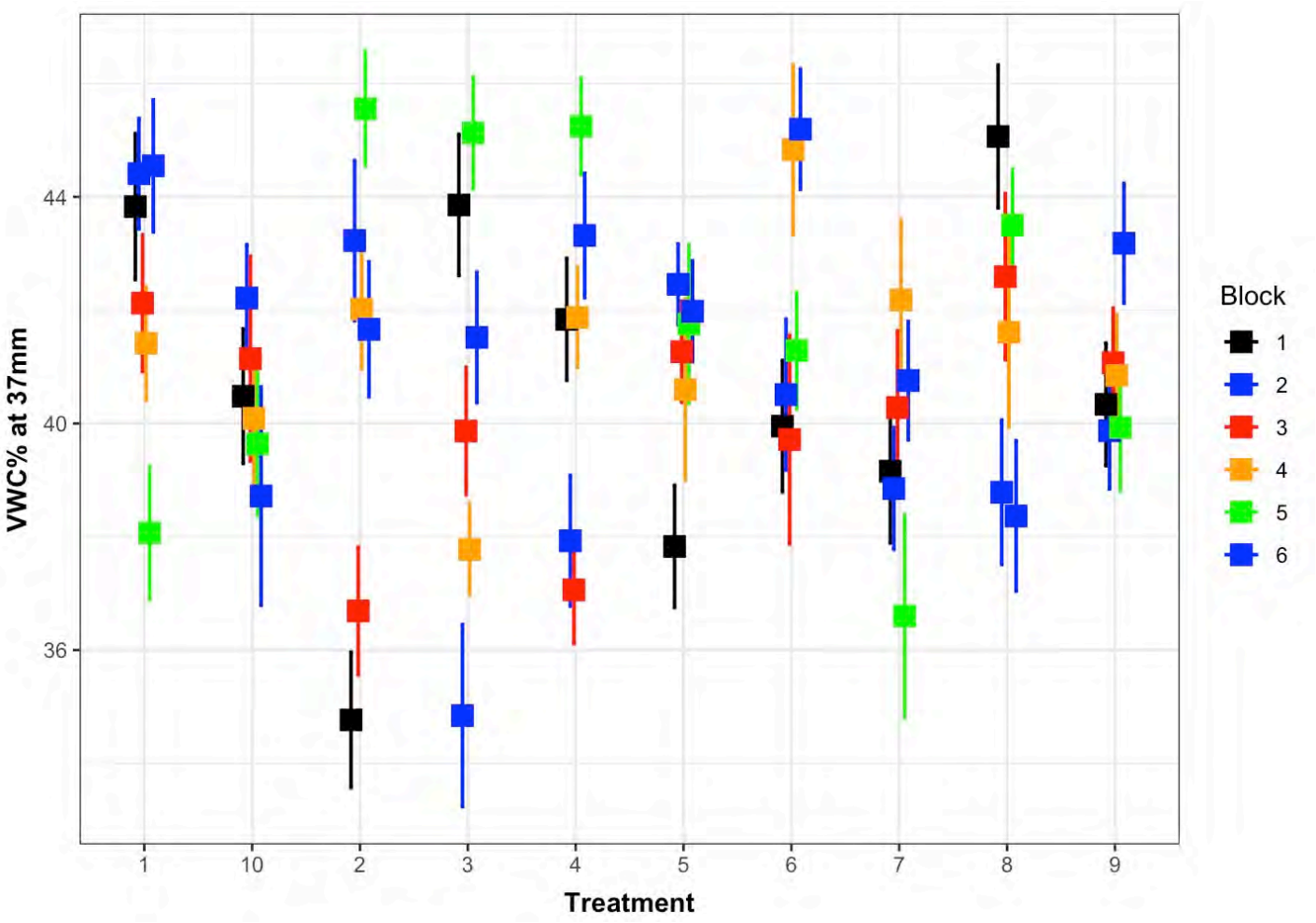
The fact that some of these wetting agents seem to hold water potentially has both positive and negative impacts. In our 2022 work we found that 7 out of 10 soil wetting agents cause softer greens.

As we didn't measure soil moisture at 37 mm, we cannot conclusively say that this is the reason but Bauer (2017) found that wetting agent applications influence surface firmness in 2017 work.

6.4 Moisture Uniformity.

The other key requirement from a soil wetting agent is uniformity. In this trial, Tour Turf FTE , the proprietary mix and HydroForce Ultra appeared to give more consistent results at a depth of 37 mm. There are minimal 'spikes' or 'troughs' in soil moisture when you use these.

Figure 22. Uniformity between Blocks with Soil Wetting Agent Treatments



6.5 Water Droplet Penetration Test (WDPT).

There is a lot of variation between wetting agents. Some soil surfactants are more persistent than others, and taking the samples three weeks after the 2nd treatment is well within the application intervals on their labels.

H2Pro performs well in this test, but the fact that the H2Pro rate reduces to 10L/Ha after the initial 25L/Ha, suggests that if we carry out the same test at the lower rate, that it may not perform as well. Further work needs to be done to confirm this.

The H2Pro Trismart treatment performs extremely well in the upper 1cm of the rootzone and gives a consistent rapid movement of water away from the soil surface. This was significantly faster than the Tour Turf FTE and Hydrahawk treatments.

At the three-week testing interval post treatment there is a strong indication that the H2Pro Trismart, HydroForce Ultra and Proprietary mix all still work at the 1cm depth. This contrasts with the Tour Turf FTE and Penterra treatments.

Despite these performing well in regard to moving water away from the surface, these soil surfactants have possibly stopped working after this three-week period.

At a 2cm depth H2Pro Trismart moves water quickly away from the surface. However, none of the treatments are significantly faster than the Control at this depth. The Tour Turf FTE and H2Pro Trismart both move water significantly faster than Hydrahawk.

At the 3 cm depth the proprietary treatment is the only one to show a significantly lower soil moisture content than the Control.

Overall, the results suggest that Hydrahawk does not work to move water away after 3 weeks, as it gives the lowest Water Droplet Penetration times at all depths.

The Proprietary mix, HydroForce Ultra and Tour Turf ELL have significantly lower water droplet penetration times in comparison to Hydrahawk.

6.6 Organic Matter Content (%)

HydroForce Ultra) was the only treatment that gave a significantly higher organic matter content than the untreated Control ($P < 0.05$). There were no significant differences between any of the other treatments.

As the LOI was carried out over the entire core depth it is difficult to be conclusive as to where this organic material was. The fact that the top 1cm was removed from the cores suggests that this is not a result of the build-up of thatch. However, there is a strong reason to believe that it is due to increased root growth at depth. Further work is needed to confirm this.

7.0 Conclusions.

Considerable variations exist in the performance of these wetting agents in this trial. Some of the findings confirm findings from previous work, but soil wetting agent technology is advancing rapidly. Now soil wetting agents don't just "wet the soil" but can move water quickly away from the soil surface, retain it in the profile or do both.

The ramifications of this work have raised a lot of questions regarding turf management.
Bearing in mind fungal pathogens require water does the fact that a soil wetting agent holds water in the profile mean you are likely to get more root disease?

The flipside of this is if a soil wetting agent moves water away from the surface does this mean the turfgrass is going to be more likely to suffer from moisture stress, especially on golf greens where turfgrass where tends to be shallow rooted?

The pleasing finding from this work is that some of these products do seem to have plant health benefits.

This 2023 work suggests that products like HydroForce Ultra can increase root growth. This was also found in work by Indigo Specialty in 2020.

Figure 23. Significant Increase in root growth in a couch bowling green in May, 2020 in QLD.

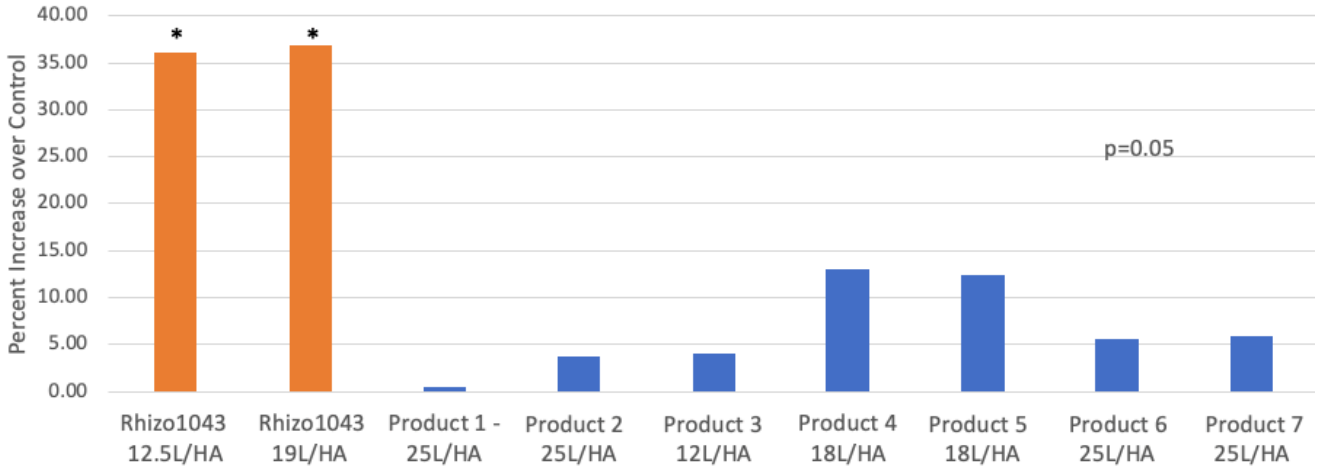


Image 3. Control vs HydroForce Ultra comparative root growth.

Although not visible to the naked eye the Tricure and H2Pro Trismart treatments did appear to cause phytotoxicity, and on this basis immediately watering in of these products is recommended. This is despite the label for Tricure stating that immediate watering is not necessary.

If these were applied in hot periods and there was a delay in irrigation or watering in, the concern would be that the level of phytotoxicity would become an issue.

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