SMART CHEMISTRY WITH CHARACTER.

A Report Concerning

MITIGATING DRAINAGE AND ENHANCING WATER RETENTION ON BOUNDARY BEND SANDY LOAM AND ROBINVALE CLAY LOAMS.

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Boundary Bend Sandy Loam - Drainage and Retention

Executive Summary

A dynamic infiltration rate test for Boundary Bend Sandy loam is recorded via time lapse photography at CHT Australia comparing the water movement through control and treated soils. The video can be found here

The tests concluded that the Aqua-Sil 2650 treatment results in the lateral movement of water thereby increasing water retention in a wider zone around the emitter and concurrently reducing the draining rate through the profile by 30% thereby providing an avenue for adapting irrigation programs for better deployment of water with substantial savings on water loss through mitigating drainage through the soil profile.

Introduction

The hydraulic conductivity of Agriculture Soils is extremely difficult to profile without significant cost outlay which makes the process of soil amelioration somewhat of an art rather than a science, this, has in effect arrested the investigation of alternate remedies for optimising water retention and mobility through soil profiles.

The current paradigm of soil amelioration rests on established practices of the use of Gypsum, Polyacrylamides or Organic matter and surfactants, the latter being short lived and the former highly localised to the application interface with the soil as well as being slow to manifest a behaviour change to the soil.

The CHT Australia concept to soil amelioration is somewhat counter intuitive; it is a new concept of amelioration that seeks to diffuse irrigation water at the impingement point to a greater mass of soil thereby increasing the infiltration of water by greater lateral movement from the impingement point.

NB *This concept is distinctly contrary to the application of organic surfactant solutions that accelerate infiltration by increasing drainage*

The expectation of these tests is to demonstrate with scientific effort that such a concept would have meaningful, immediate and long lasting changes to soil so that water loss due to excessive drainage or run off is now much more manageable through the irrigation program.

Content

Test layout

Boundary Bend Sandy loam is placed upon a bed of builder's sand and irrigated via drip irrigation emitters at 1.3 litres per hour to equilibrium where irrigation water equals drainage. *Please be aware that this test has dimensional limitations at its extremities that define the equilibrium point.*

The test will endeavour to quantify wetting rate of both control and treated soils from dry to saturation determined by the draining behaviour to equilibrium using visual, colorimetric and physical attributes.

Figure 1 Start of Test – where container 1 is control, container 2 is low dose treatment and container 3 is high dose treatment.

Observations

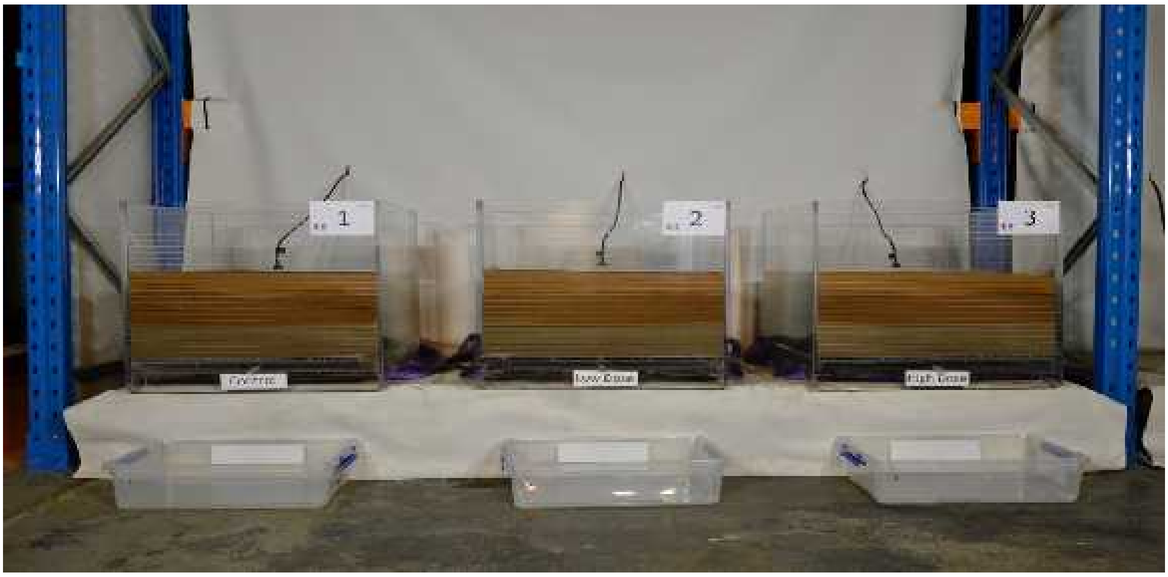


Figure 2 half way through test

At this point, for the same amount irrigation time, the control container is displaying the changes in colour intensity in both soil horizons, consistent with higher wetting compared to the two treatment containers. It is clear that the control rig exhibits greater vertical (downward) movement of water than both the treatment rigs.

From the varying colour (wetting) intensity, it is also clear that at this point that the expected drainage is likely to occur first at Control followed by the high dose treatment and then the low dose treatment.

The fact that the high dose treatment is likely to drain faster than the low dose treatment appears to be that the irrigation water is reaching the horizontal extremities of the test rig faster. This is in fact what occurs in real time as can be seen in the time lapse recording.

It is also very clear that the treated sandy loam is slower at reaching wetting colour in intensity and is substantially more level than in the control, indicating higher lateral distribution of water in the loam zone and less water in the sand bed.

Wetting Tendency

The change in wetting rate of both the sand bed and the loam is measured through changes in colour depth and a colour gradient established from dry state through to the point of first drain.

The results are shown below

Wetting Rate of Sand Bed

Figure 3 control Grey wetting gradient to first drain – dry to wet left to right

Figure 4 low dose Grey wetting gradient to first drain– dry to wet left to right

Figure 5 high dose Grey wetting gradient to first drain– dry to wet left to right

As can be seen above, the changes in the colour of sand bed directly below the emitter, correlated with wetting intensity demonstrates quicker wetting of the sand in the control, followed by the higher dose, while the low dose had the most delayed infiltration .

When these colour depths are assigned a numerical value, the relative intensity from beginning to end can be charted as in figure 6 below.

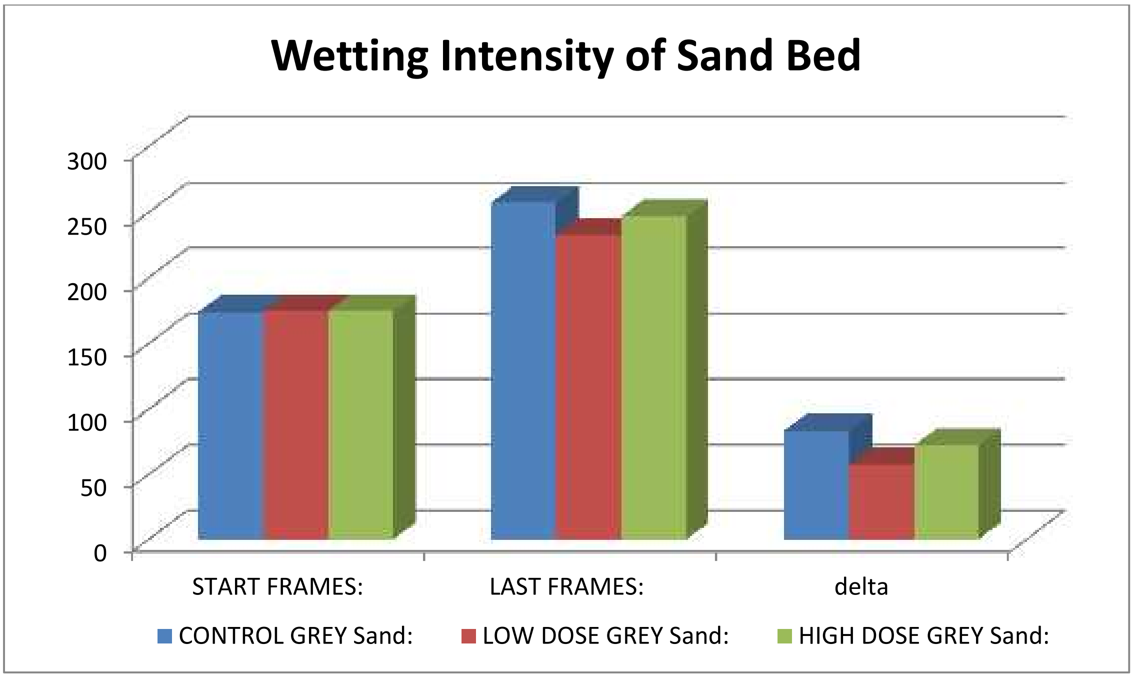


Figure 6 Wetting intensity of Sand Bed to first drain

We can now interpret the relative wetting strength (read water load) by inference.

This result is graphically represented, confirming that the lower dose treatment was more efficient at reducing drainage, but this could be simply a consequence of the limitation of the test rig and that on a larger scale the higher dose may in fact be equal or better.

Wetting Rate of Sandy Loam

Figure 7 Control Loam wetting gradient to first drain

Figure 8 Low dose Loam wetting gradient to first drain

Figure 9 High Dose Loam wetting gradient to first drain

For the sandy loam, we can see that the change in colour occurs much slower in the treatments than in the control, suggesting a greater diffusion of water over a larger soil volume.

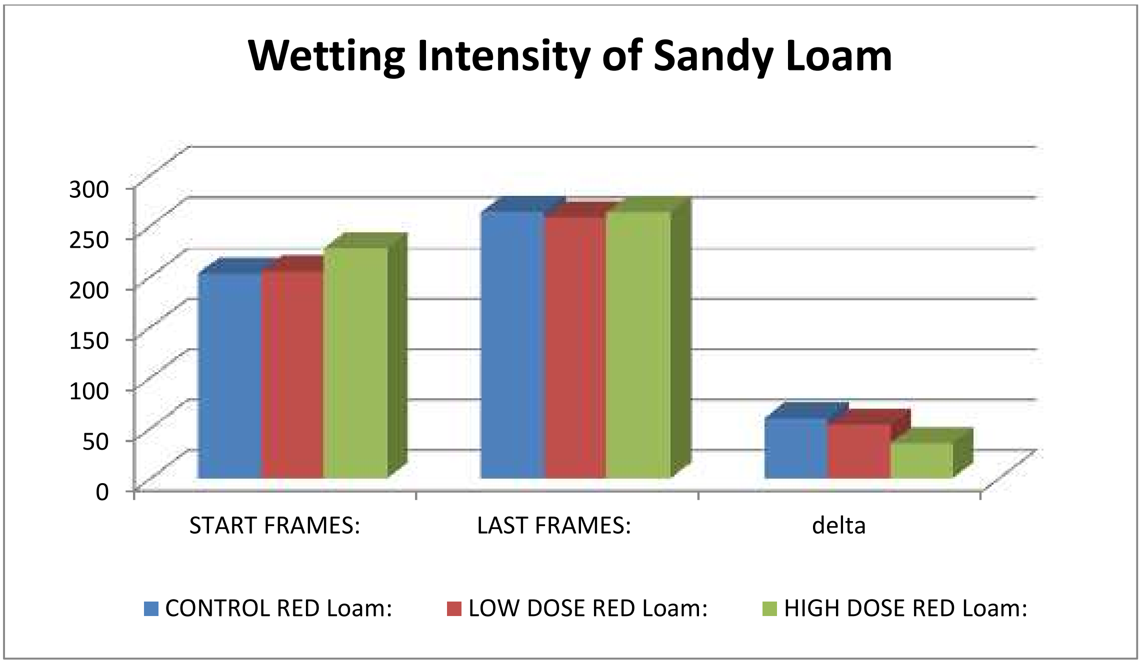


Figure 10 Wetting Intensity of Sandy Loam to first drain

Graphically we can see the same but more pronounced behaviour in the Sandy loam as in the sand bed, confirming that the treatments deliver a lateral movement of irrigation water, indicated by the reduced wetting intensity of the treated zones, and more specifically the higher dose treatment has the lowest change in depth of colour.

Drainage

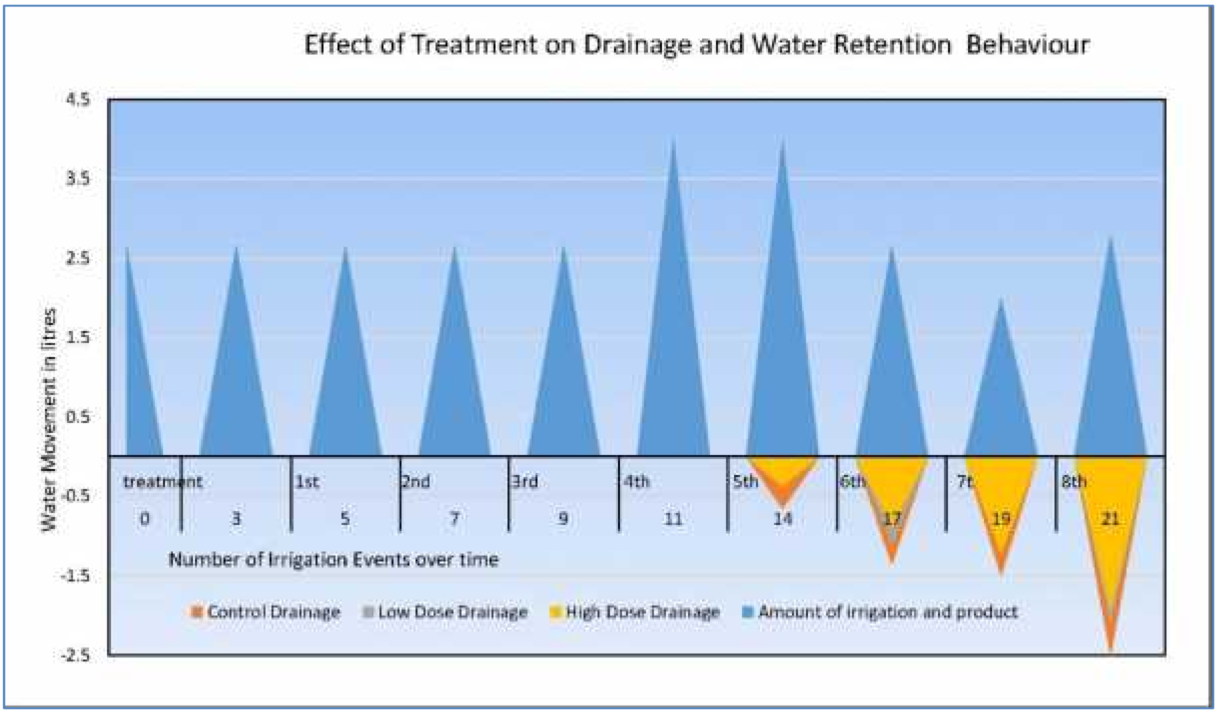


Figure 11 time to equilibrium

Figure 11 shows the combined water movement through the two soil horizons, where the control displays the earliest drain followed by the high dose and then by the lower dose treatment.

As can be clearly seen the quantum of drain is also higher in the control than in either of the two treatment test rigs.

Changes in Drain Rate with Treatment

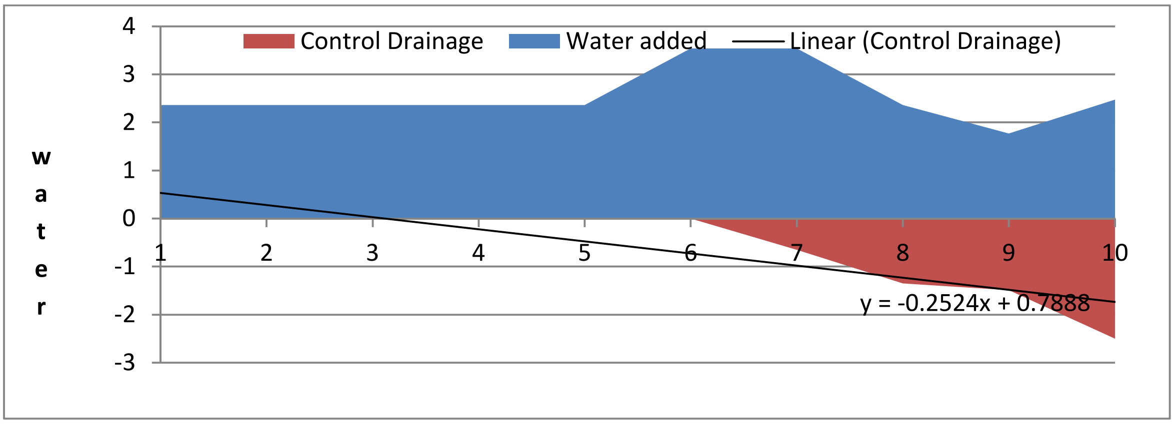


Figure 12 Drainage rate of control to equilibrium

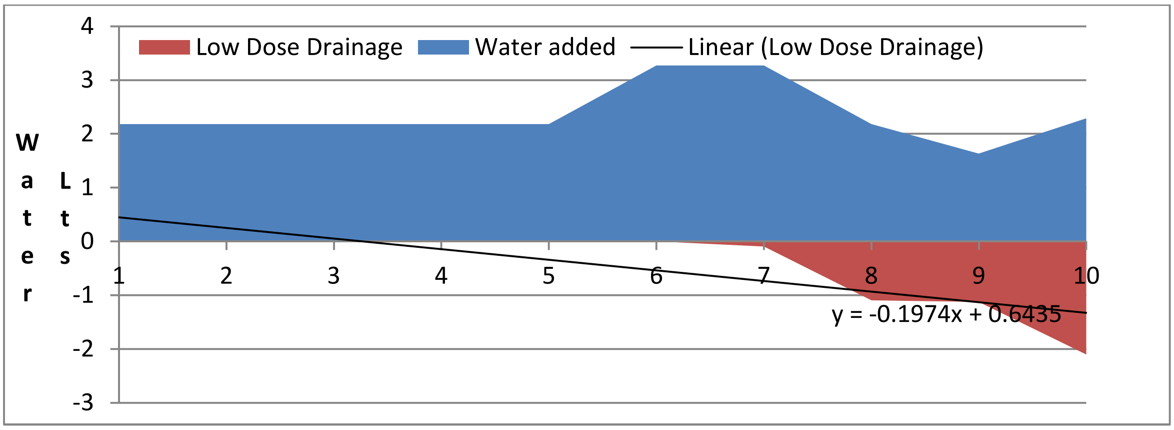


Figure 13 Drainage rate of Low dose treatment to Equilibrium

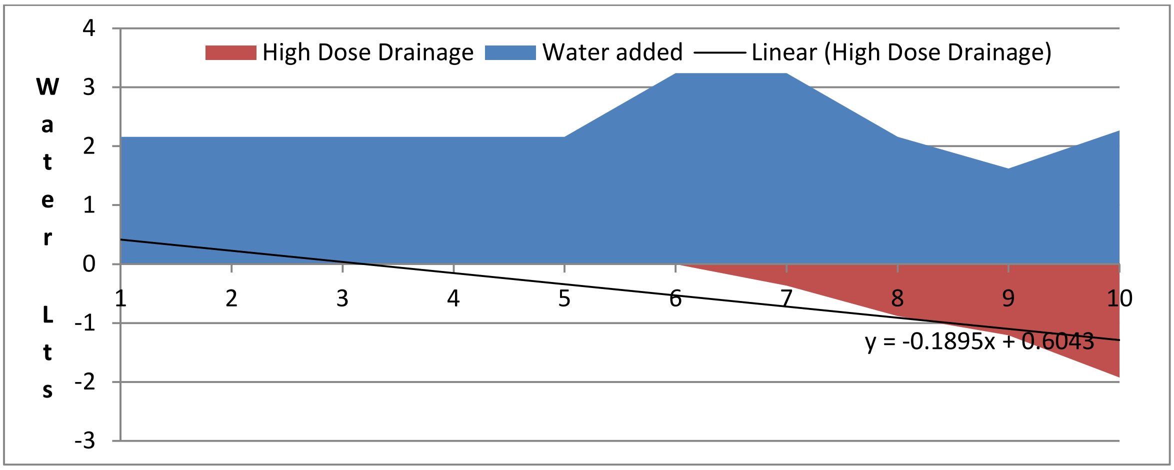


Figure 14 Drainage rate of High dose treatment to Equilibrium

The charts 12, 13 and 14 indicate the relative drain rate of each control, low dose and high dose containers over the time of test as irrigation cycles, where it is clear that the low dose treatment provides the most delayed drain, it is however expected that the higher dose would provide similar or significantly better results in the field. The rates of drain for the treatment are 30% lower than the control, suggesting greater lateral spread of water and reduce drainage. There is a high correlation of these results with Bannerton field data reported in Appendix 1.

Drainage Overview

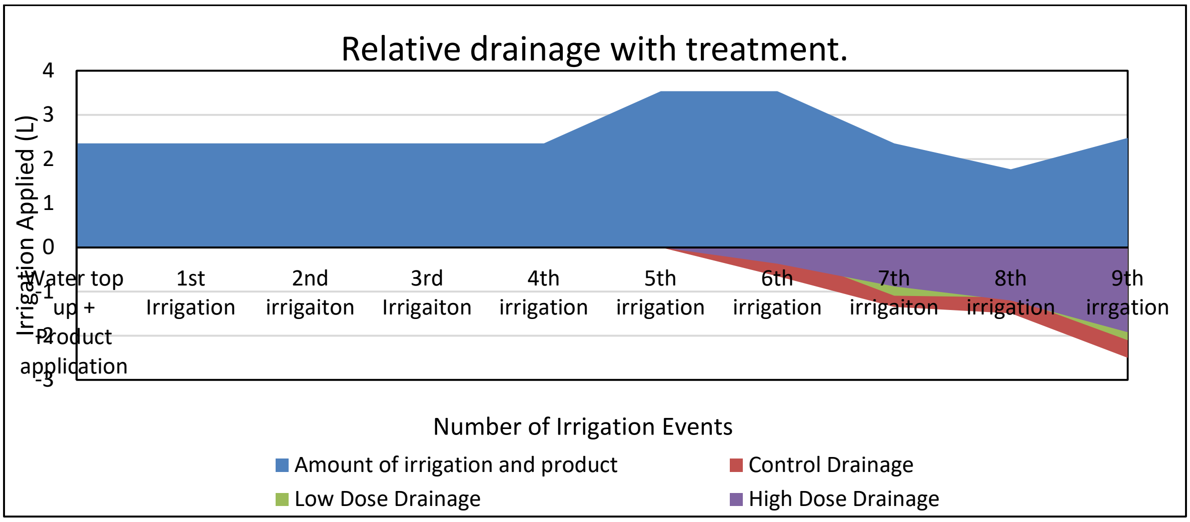


Figure 15 Overview of drainage rate

The relative drainage rate of the control and treatment are show in figure 15, and are explored separately above, and it is very clear that within the limitations of this test, the use of Aqua-Sil definitely retards drainage by promoting lateral water movement until saturation is reached.

The lateral movement of the wetted area below the emitter is much more evident in the time lapse photography of the top view of the wetting pattern of the test rigs and anecdotally correlates well with the wetting intensity and the drainage rates of the test containers.

It should not be understated that the effect of the treatment is most noticeable and tangible between the 6^{th} and 7^{th} irrigation cycles of the test, (i.e. well before equilibrium)

So if we review and compare the changes in draining rates through the test we see the following

Stage of test	Control	Low dose	High dose
Mid point	y = -0.0528x + 0.09	y = -0.035x + 0.0731	y = -0.035x + 0.0731
End point	y = -0.2524x + 0.7888	y = -0.1974x + 0.6435	y = -0.1895x + 0.6043

Table 1 drain rate mid-way and end of test

Stage of test	Control	Low dose	High dose
Mid point		33.7%	33.7%
End point		21.7%	24.9%

Table 2 change in drainage rate compared to control

Therefore tables 1 and 2 above, show that both treatments have a slower drain rate than the control at any point during the test, but that efficiency is optimised early in the irrigation cycle, and relatively maintained through the ensuing water movement.

Changes in Lateral movement of water below dripper

A further dynamic infiltration rate test for Boundary Bend Sandy loam for the lateral movement of irrigation water is recorded via time lapse photography at CHT Australia comparing the water movement through control and treated soils. The video can be found here

Below in figure 16, one can clearly see the lateral dispersal of water through the sandy loam.

Figure 16 wetted pattern at the drip point of the control

Note the colour depth of the wetted area and the dry impingent point at its centre. When this pattern is compared to the treatments, one can clearly see the enhanced lateral spread of the water ball around the treated zone of the soil indicated by a more diffuse centre, lighter colour intensity and a slightly greater spread.

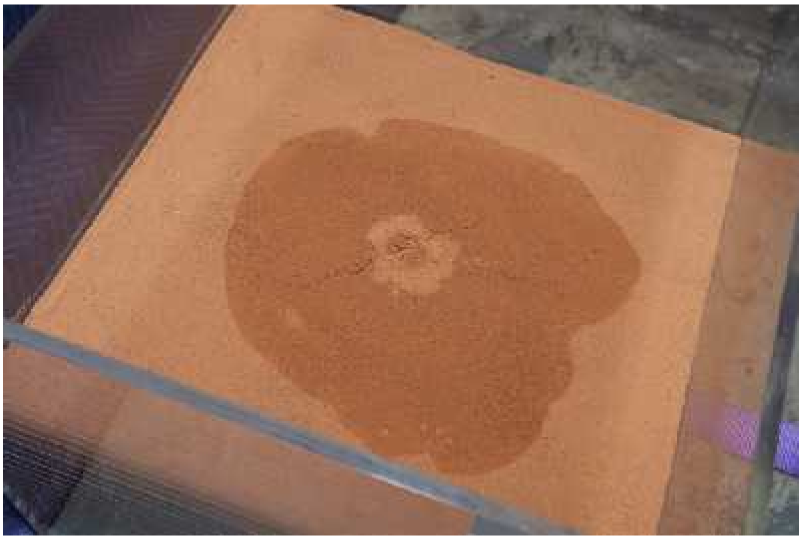


Figure 17 wetted pattern of low dose treatment

For the low dose treatment shown in figure 17, note the larger dryer centre of the water ball, the lower wetting intensity as well as the greater lateral spread of water.

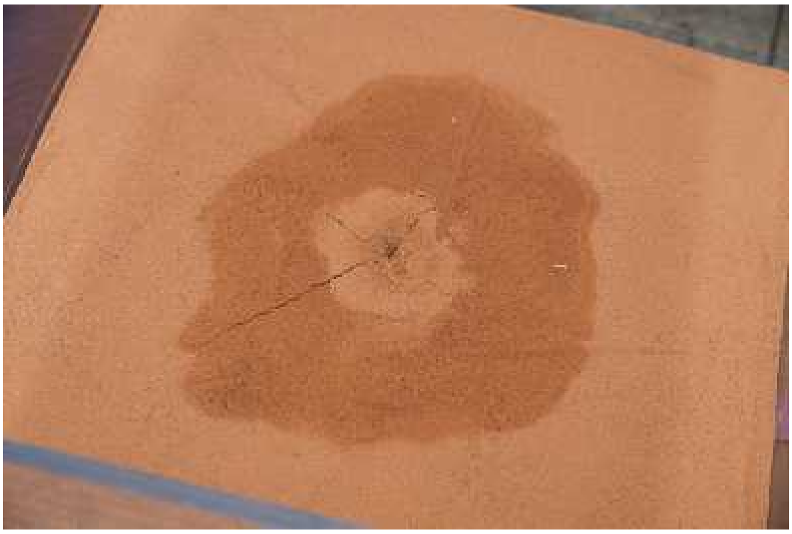
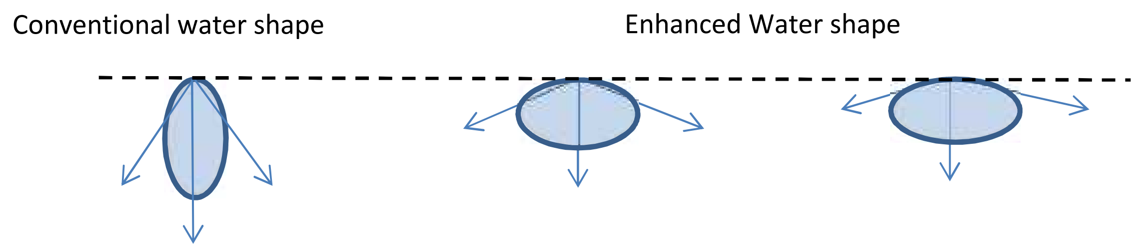


Figure 18 wetted pattern of the higher dose treatment

For the higher dose treatment shown in figure 18, note the even larger dry centre as well as the lower colour depth indicating both greater lateral and vertical movement of irrigation water.

The reason for the reduction in drain rate and the concentric circles evident at wetted surface can be explained in the surface tension that the water ball is now facing with treatments as shown in the graphic below.



In the control, the primary capillary activity is in the downward thrust, whereas in the treatment this changes significantly to flatten the water ball.

As the wetting pattern flattens from vertical oval to horizontal oval, the lateral capillaries are engaged and the water is propelled first sideways and then downwards by the now localised cationic charge in the soil below the emitter.

Finally, we need to comment on the apparent cracking that is caused by the differential drying of the soil in the vicinity of the wetted pattern. This cracking is symptomatic of the differential drying now available to the soil at the end of the test period that is in effect is caused by the accelerated and continuing diffusion of irrigation water due to the treatments effect.

Soil Water Retention

POST EQUILIBRIUM and after 5 days standing, water content nearby the emitter and in the sand bed, confirm the primary lateral movement of water away from the epicentre is in the horizontal plane, consistent with the larger wetting pattern of the surface view in the treated containers

Parameters	Container 1	Container 2	Container 3
Sandy Loam			
Sample Initial Weight	802.9	802.27	802.26
Sample Final Weight	712.51	718.7	761.85
Amount of water	90.39	83.57	40.41
Water Retention (%)	11.26	10.42	5.04
Change in water retention		0.84	6.02
% Change in water movement		7.5	53.5%
Brickies Sand Bed			
Sample Initial Wight	150.02	150.11	150
Sample Final Weight	129.4	128.55	127.62
Amount of water	20.62	21.56	22.38
Water Retention (%)	13.74	14.36	14.92
Change in water retention		0.62	1.18
% Change in water movement		4.5	8.5

Table 3 table of water retention after 5 days in grams

The table above indicates the extent that the higher dose test rig diffuses more water through the soil much more efficiently than the control and also for the lower dose treatment. However the drain quantum discussed previously indicates that the lower dose is sufficient to achieve an effect and the higher dose treatment would likely give the greater effect of better water diffusion through the soil profile were it not for the dimensional limits of the test rigs.

It is important to remember that the drain quantum is counter indicative to these results, confirming that lower retention with the lower drainage must by necessity confirm greater lateral movement.

Conclusion,

Wetting intensity over time, Time to first drain and Quantum of drain all correlate highly with water retention in the horizontal and vertical planes of this test.

Aqua-Sil 2650 expands the wetted zone of the emitter by more than 100% as well as mitigates drainage by as much as 30%

Foot Note

The behaviour change in water mobility seen in this test is equally applicable to sub surface irrigation for the purpose of mitigating consolidation of soil around the emitter.

Appendix 1

Correlation to Bannerton Test of 2017

In 2017 soil moisture monitoring at Bannerton Clay loam soils demonstrated the lateral movement and higher water retention in the Aqua-Sil treated rows.

Application notes

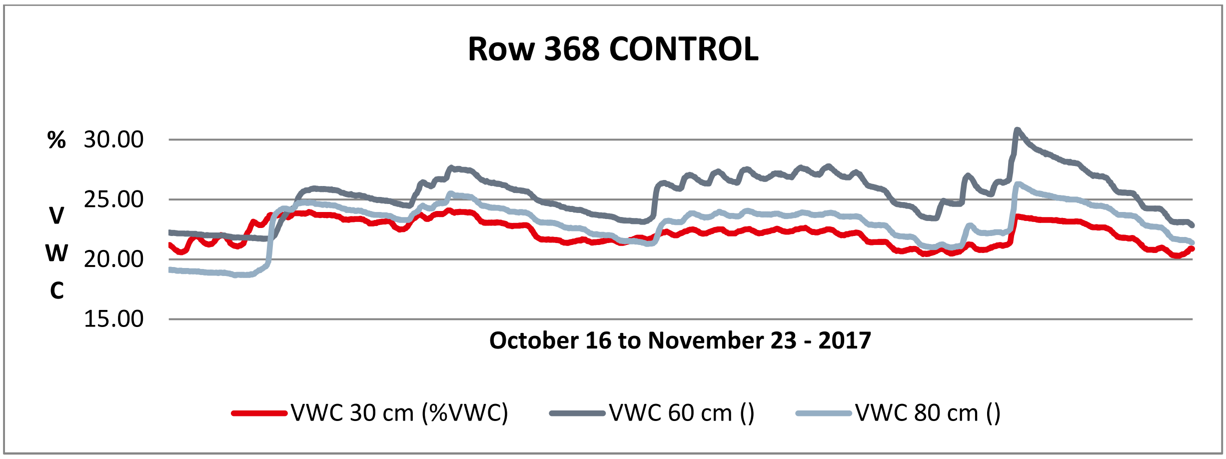
Monitoring via Wild-eye data Loggers

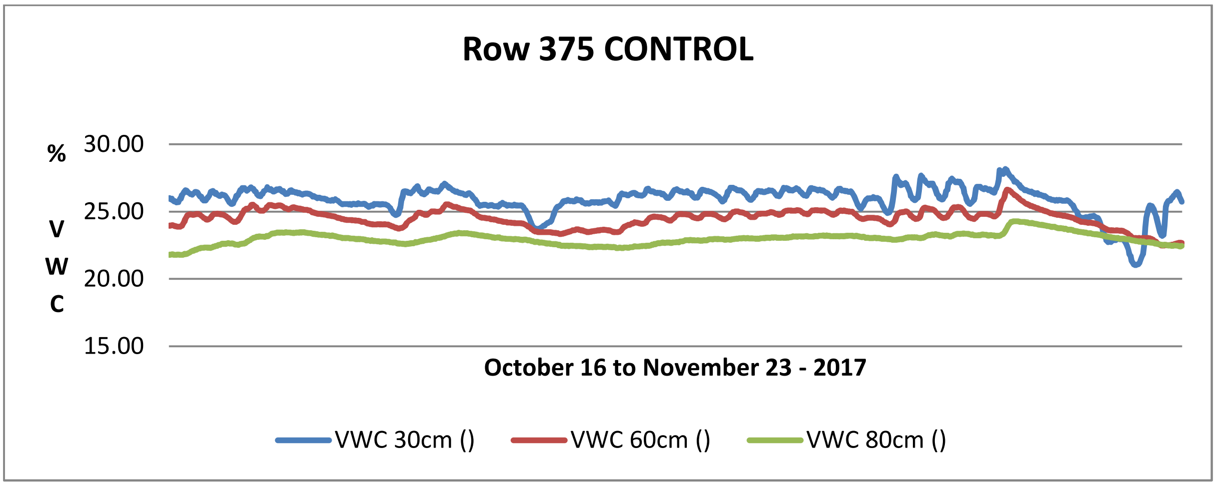
Average readings over 30 minute periods

Date Range October 16 to November 22.................... Treatment date August 2017

Treatment Product Aqua-Sil 2650 ....Dose rate 3 grams per square meter

CONTROL DATA

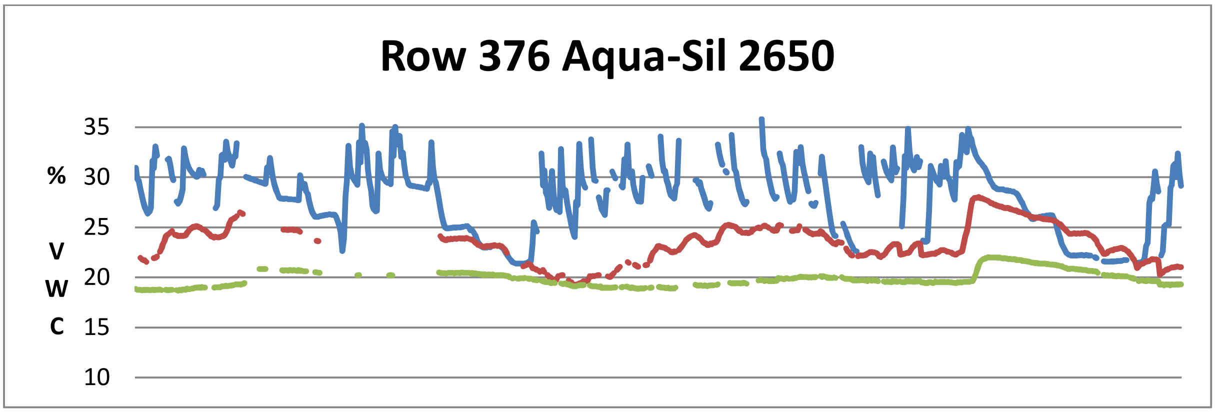


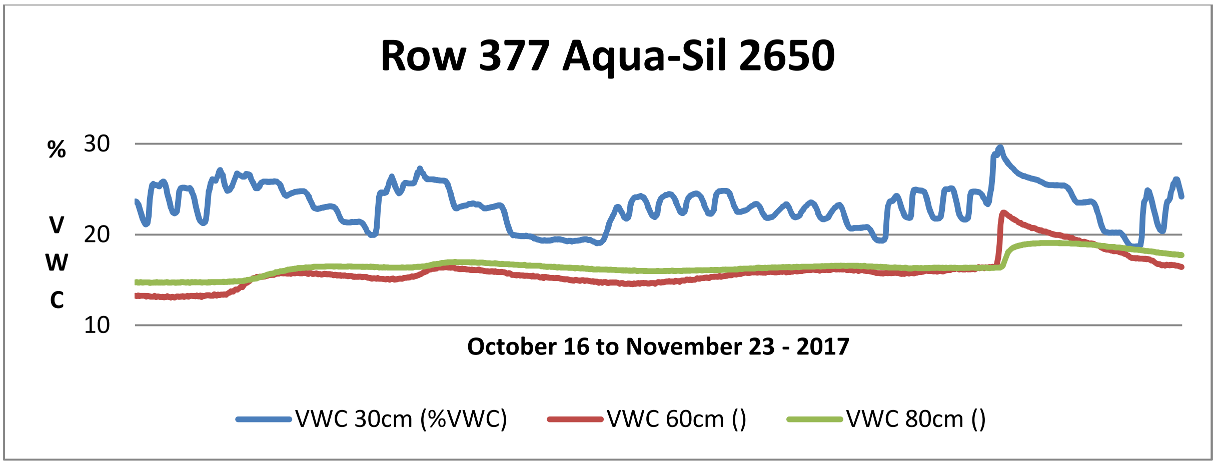


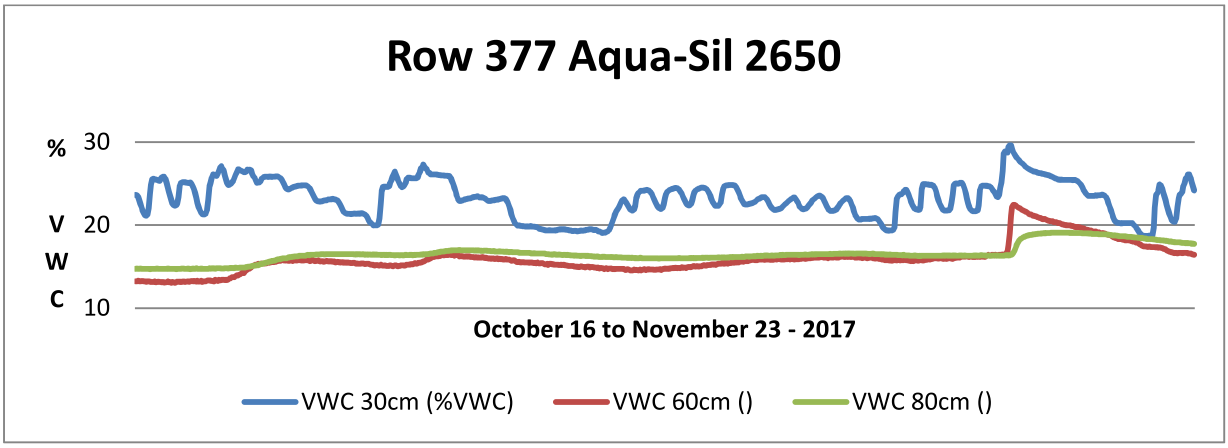
Observation of Control rows

1. Strong telegraphing of water movement through the depth
2. Narrow range of Water concentration through the depth

TREATMENT DATA







1. MUTED response of water movement through the depths
2. Relatively High RANGE of Water concentration through the depths
3. Higher concentrations of water in the shallows

Appendix 2

Cost and Pay back - example

Nominal Water consumption mega litres per hectare	Cost per Mega litre AUD$	Nominal ameliorants application tonnes per hectare	Potential Amelioration Consumable costs per tonne per hectare AUD$	Total cost of water and ameliorants per hectare AUD$	Estimate Potential saving on water	Existing yield shortfall
6	200	2	200	1600	20%	20%
Treatment level Kilograms per Hectare	Cost AUD$ per kilo	Cost per hectare AUD$	Cost recovery from above AUD$	Nett cost in first year AUD$	Payback	Potential yield gain
30	15.00	450	440	10	Well within the first year	5%

Estimate of Cost and Benefits

Nett Expense: $10 per hectare in year 1, additional treatments only if required from year 3

Potential Save: $240 on water *c*osts and $200 on ameliorants per hectare in subsequent year.

Improve water utilisation which may lead to greater yield.