ROOT INTRUSION IN SUBSURFACE DRIP IRRIGATION

BANROCK STATION TRIAL – FINAL REPORT TO RIVERLAND WINE INDUSTRY DEVELOPMENT COUNCIL

APRIL 2014
Root Intrusion in Subsurface Drip Irrigation

Information current as of 1 April 2014

© Government of South Australia 2014

Disclaimer

PIRSA and its employees do not warrant or make any representation regarding the use, or results of the use, of the information contained herein as regards to its correctness, accuracy, reliability and currency or otherwise. PIRSA and its employees expressly disclaim all liability or responsibility to any person using the information or advice.

All enquiries

Mark Skewes
Primary Industries and Regions SA (PIRSA)
Level 15, 25 Grenfell Street
GPO Box 1671, Adelaide SA 5001
T 08 8595 9149 F 08 8595 9199 M 0408 800 681
E mark.skewes@sa.gov.au
# Table of Contents

**Background** ........................................................................................................................................ 4

**Trial Site** ........................................................................................................................................ 4

**Methodology** ..................................................................................................................................... 5

- Flow Rate ........................................................................................................................................ 5
- Shoot Growth ................................................................................................................................. 6
- In-situ Dripline Examination ........................................................................................................... 6
- Dripline Excavation and Assessment ............................................................................................... 7

**Results and Discussion** .................................................................................................................. 7

- Flow Rate ........................................................................................................................................ 7
- Shoot Growth ................................................................................................................................. 8
- In-situ Dripline Examination ........................................................................................................... 9
- Dripline Excavation and Assessment ............................................................................................... 10

**Conclusion** ...................................................................................................................................... 16

**Further Research** ........................................................................................................................... 16
Background

In 2009 a sub-surface drip irrigation system utilising KISSS Flat geotextile covering was installed in a number of blocks at Accolade Wines’ Banrock Station vineyard near Kingston-on-Murray in South Australia. This system very quickly suffered major root intrusion, resulting in dripper blockages, resulting in poor application uniformity and patchy vine growth.

In response, a trial was established to document and investigate flow reductions in a subsurface drip irrigation system due to root intrusion. A selection of different sub-surface drip configurations was installed to compare their susceptibility to root intrusion. All configurations included encasing the drip tubing in geotextile.

Trial Site

The trial was installed in Banrock Station Block 1, a 6.82 Ha planting of Shiraz vines on their own roots, which were planted in 1995. Vines were spaced 2 m apart along the rows, and rows were 3 m apart.

The trial dripline was installed in 2011. All treatments contained the same dripline, Toro 2.2 L/h inline drippers spaced at 0.5 m, in 20 mm outside diameter tubing. Lateral lengths were approximately 150 m (NE direction from the submain) and 118 m (SW).

The dripline was wrapped in two different configurations of geotextile, with Treflan® and copper sulphate applications overlaid to give four treatments:

- KISSS Wrap® no CuSO4, geotextile fabric folded over and sewn down one edge, with an impermeable plastic membrane on the lower surface (Figure 1) (rows 28 & 29);
- KISSS Wrap®, as above, dosed twice annually with 1 kg/Ha CuSO4 (rows 30 & 31);
- KISSS Wrap®, as above, but with Rootguard® Treflan® impregnated drippers, dosed twice annually with 1 kg/Ha CuSO4 (rows 32 & 33);
- KISSS Flat Classic®, two strips of geotextile fabric glued together around dripline, with an impermeable plastic membrane on the upper surface (Figure 2), dosed twice annually with 1 kg/Ha CuSO4 (rows 38 & 39).

Irrigation for the block was supplied by two submains approximately ¼ and ⅔ distance along the row length, with each submain serving half the row length (Figure 3). Dripline treatments were established in the north-eastern half of Block 1, in two adjacent rows per treatment, without replication. Dripline laterals ran in both SW and NE directions from the submain.
Methodology

Monitoring of the subsurface drip trial site began in September 2012. A number of different investigations were carried out during the trial.

Flow Rate

Flow rate in 4 laterals per treatment (two rows in each direction) was measured on 12 occasions between September 2012 and February 2013, and once during February 2014.

Flow rate was measured by isolating each lateral from the flushing submain by sealing off the end of the lateral, to ensure that the only water entering the lateral came from the submain. The lateral was then disconnected from the submain, and a flow meter (Figure 4) installed between the submain and the lateral, using Camlock fittings (Figure 5).

Once flow through the water meter stabilised, a stopwatch was used to measure the time taken for 10 L of water to pass through the meter. This figure was used to calculate flow rate (L/s) for the lateral.

As SW and NE laterals were of different lengths, and therefore contained different numbers of drippers, flow rate was divided by the estimated number of drippers along each lateral to give flow rate per dripper. This was compared with the nominal flow rate of 2.2 L/h/dripper, as well as being compared between treatments, and between measurement dates.
Shoot Growth

In order to measure any impact of dripper blockage on vine growth, eight shoots per treatment were tagged and measured in September 2012, and subsequently re-measured each time flow rate was measured, up until November 2012. Measurements were discontinued after this due to loss of shoots as a result of spray operations within the vineyard, which damaged the growing tips and stopped growth, making growth measurements impossible.

In-situ Dripline Examination

In August 2013 the dripline was excavated and inspected on-situ at one site for each treatment (a total of four sites). This involved a simple visual inspection of the installation, as well as opening up the geotextile to inspect inside for root intrusion and deposited clay distribution.

At the same time, excavations were conducted in the SW lateral of row 38 to locate and repair a kink in the dripline, believed to exist on the basis of flow rate results from that lateral (see Results and Discussion).

Dripline Excavation and Assessment

In December 2014 Accolade Wines disconnected the subsurface drip irrigation system, including the trial rows, and began using a newly installed above ground system as the exclusive source of irrigation water for Block 1. This was in response to unacceptable vine response to the subsurface drip system across the whole of Block 1, combined with an ongoing battle with leaks in the subsurface system.

In March 2014, following the final flow rate testing in February 2014, samples of dripline and associated geotextile were collected from nine sites evenly distributed along each trial row (a total of 72 samples).

Samples were collected by excavating with a shovel to expose a length of dripline, and then cutting out a 60 cm length of tubing and geotextile, attempting to disturb the sample as little as possible in the process. The samples were then folded in the middle and sealed inside a labelled ziplock plastic bag.

The samples were later visually inspected to assess root activity on the outside surface of the geotextile, and along the outside of the seam(s) in the geotextile. The geotextile was then opened to allow the space between the geotextile and the dripline to be assessed for the presence of roots, and to inspect the seam itself for root intrusion. The distribution of clay inside the geotextile was also visually assessed. Finally the dripline was opened to gain access to the drippers themselves, which were then dissected to assess root intrusion. At each step, root presence and clay accumulation were scored on a scale from 0 to 5.
Results and Discussion

Flow Rate

The average flow rate per dripper, and standard deviation, for each treatment at each measurement date is displayed in Figure 6. Each data point is made up of four readings, comprising two laterals (SW and NE) by two rows.

![Flow Rate Graph](image)

**Figure 6: Average flow rate (lines) and standard deviation (bars) compared to nominal flow rate (broken line), (each data point represents 4 readings)**

Most readings were below the nominal flow rate of 2.2 L/s specified by the manufacturer. Standard deviation is consistently high for “KISSS Classic" and “KISSS Wrap No CuSO₄" treatments, which had the highest and lowest average flow rates for all but the final reading (February 2014).

The high standard deviation in treatment “KISSS Classic” reflects consistently low readings from one lateral (row 38 SW). Flow rate in this lateral was consistently around 65% of nominal, and it was concluded that there must be some form of blockage cutting off flow to the last third of the lateral.

Excavation of the dripline at the selected position resulted in the location of a kink in the dripline, presumably caused during installation, which was completely blocking flow of water past this point (Figure 7). This was repaired in August 2013, and as a result the average flow rate of this treatment was similar to the other treatments in February 2014 (Figure 6).

It should be noted that had this irrigation system not been installed with a flushing submain, the vines beyond this kink would not have received any irrigation. Fortuitously, the pressure and flow available via the flushing submain was sufficient to irrigate this section of vines adequately for two irrigation seasons (2011/12 and 2012/13).

The high average flow rate in treatment “KISSS Wrap No CuSO₄" was again mostly due to one lateral (row 28 SW), which consistently measured a dripper flow rate of around 3 L/s. It is believed that this reflects
the presence of leaks in the lateral, which was an ongoing problem across the wider block (i.e. in rows not included in this trial).

Figure 7: Kink in row 38 (KISSS Classic), lateral SW

There was evidence of pinching damage at the points where leaks occurred, and Accolade Wines staff concluded that the leaks were due to damage to the dripline, either during the process of wrapping the dripline in the geotextile, or during installation of the completed dripline into the vineyard soil. Finding leaks was extremely difficult and frustrating, due to the tendency for leaking water to travel along the vine row, presumably within the tunnel formed by the dripline and geotextile, and then appear above the ground surface at a point distant from the original leak. Many man hours were spent trying to locate leaks, and the futility of this effort was a key factor in the abandonment of subsurface drip at the site in 2014.

The purpose of this trial was to monitor and record the decline in flow rate over time as root intrusion reduced flow from individual drippers. The data in Figure 6 demonstrates total failure to achieve this purpose, with no consistent decline in flow rate apparent. This suggests that there was no significant root intrusion into the drippers themselves, a conclusion which is further supported by a physical inspection of the drippers (discussed later in this report).

Shoot Growth

Shoot measurements were taken on only two occasions, due to the large loss of shoots between these dates. On 23 October 2012, eight shoots per treatment were tagged and measured, giving a total of 32 shoots. By 21 November 2012 only 10 of these shoots were still growing, the growing tips on the rest had been damaged, mostly due to vineyard spraying activities. Table 1 indicates how many shoots were still active within each treatment at each date.

In addition to the loss of shoots, it was recognised that the chances of root intrusion occurring at the sites selected for shoot growth monitoring were slim, and it was most likely that the shoot growth monitoring
would not produce useful results. As a result of this and the losses suffered, this activity was discontinued after November 2012.

Table 1: Number of growing shoots on measurement dates

<table>
<thead>
<tr>
<th></th>
<th>23 October 2012</th>
<th>21 November 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>KISSS Classic</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Rootguard</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>KISSS Wrap</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>KISSS Wrap NO CuSO₄</td>
<td>8</td>
<td>3</td>
</tr>
</tbody>
</table>

In-situ Dripline Examination

The brief examination of dripline in August 2013 revealed root intrusion into some segments of the geotextile envelope (Figure 8). Only four segments of dripline were excavated and opened on this date, but two of these showed roots inside the geotextile, indicating that this was a significant issue. This led to the more extensive sampling undertaken in December 2014.

Also noted during this inspection was the presence of clay deposits within the geotextile (Figure 9). This issue will be discussed in more detail in the following section.

Figure 8: Excavated dripline in row 28 (KISSS Wrap, no CuSO₄), showing roots inside the geotextile
Dripline Excavation and Assessment

The more detailed examination of dripline samples excavated in March 2014 provided sufficient data to compare root intrusion and clay deposition between treatments. A summary of results across a comprehensive set of attributes scored is presented in Table 2.

Colloid Accumulation

Colloid accumulation showed no differences in total visual score, but significant differences in visual score at different points around the circumference of the geotextile envelope (Table 2). For most treatments there was more colloid deposited on the base of the envelope (directly below the dripline) than on the side walls, and least deposited on the underside of the top surface (directly above the dripper).

This pattern illustrates that the water emitted by the drippers initially falls by gravity to the bottom of the geotextile envelope, where a large portion of the colloidal material falls out of suspension. Some is carried in the water as it moves out to the sides of the envelope, and a small amount is carried up and around by capillary action to the upper surface.

The significant difference between treatments involves the KISSS Classic treatment, which was made up of two separate sheets of geotextile which were presumably initially glued together, but which were only held together by the pressure of the surrounding soil when the excavation took place some three years after installation. In addition, the impermeable plastic layer was glued to the upper surface of the dripline, and this bond had not broken down at the time of excavation.

The plastic layer dramatically reduced the movement of water from the geotextile into the soil, which in turn reduced the capillary movement of water (and associated colloid) from the base to the top layer. The
separation of the two layers likely further reduced water and colloid movement. Figure 10 illustrates the accumulation of colloid under the dripline and in the side seams.

Significantly, there was no evidence of colloid moving through the geotextile into the surrounding soil in any treatment. This raises the possibility that over time the geotextile envelope could become completely clogged with colloid, greatly restricting the movement of water into the soil. However, the pattern of deposition within the geotextile envelope suggests that water release from the upper surface should be least affected, and provide an escape route for some time to come.

Evidence from previous studies (Shane Phillips, pers. comm.) indicates that conventional subsurface drip with highly colloidal water can lead to clogging of the soil pores around drip tubing. It is possible that the increased surface area in contact with the soil in a KISSS type system, combined with the pattern of colloid deposition described above, may improve the longevity of subsurface drip, but further work is required to confirm or disprove this.

Table 2: Average colloid deposition and root intrusion scores by treatment

<table>
<thead>
<tr>
<th></th>
<th>KISSS Wrap, No CuSO₄</th>
<th>KISSS Wrap</th>
<th>Rootguard</th>
<th>KISSS Classic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colloid on Base of Geotextile</td>
<td>2.7b</td>
<td>2.8b</td>
<td>2.2b</td>
<td>3.7a</td>
</tr>
<tr>
<td>Colloid on Sides of Geotextile</td>
<td>2.4b</td>
<td>2.1b</td>
<td>2.6ab</td>
<td>1.9bc</td>
</tr>
<tr>
<td>Colloid on Top of Geotextile</td>
<td>1.2a</td>
<td>1.1a</td>
<td>1.0a</td>
<td>0.0b</td>
</tr>
<tr>
<td>Total Colloid Score</td>
<td>6.2</td>
<td>6.0</td>
<td>5.7</td>
<td>5.6</td>
</tr>
<tr>
<td>Roots Along Outside of Seam</td>
<td>2.7</td>
<td>2.8</td>
<td>2.8</td>
<td>2.9</td>
</tr>
<tr>
<td>Roots Through Geotextile</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Roots Through Seam</td>
<td>2.0a</td>
<td>2.3a</td>
<td>2.8a</td>
<td>0.7b</td>
</tr>
<tr>
<td>Root Mass Inside Geotextile</td>
<td>2.4a</td>
<td>2.4a</td>
<td>3.3a</td>
<td>0.4b</td>
</tr>
<tr>
<td>Roots In Dripper Outlet</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Roots In Dripper Labyrinth</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Dripper Blockage</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Treatments with the same letter across a row are not significantly different for that attribute.
Root Intrusion

Results for root presence (Table 2, Figure 11) indicate that all treatments had a moderate amount of roots (average root score 2.82) growing along the seam(s) in the geotextile, and a small amount of roots (average root score 1.00) attempting to grow directly through the geotextile envelope. The roots along the seam were thick and running directly along the seam, suggesting a preferential growing environment. Roots growing into the geotextile were unable to penetrate very far, and were not able to penetrate all the way through to the dripline.

However, in the vast majority of samples (86%) there was evidence of roots growing through the seam into the geotextile envelope (see example in Figure 12). The degree of root penetration through the seam along the length of the samples was not significantly different (at P< 0.05) amongst the two KISSS Wrap treatments and the Rootguard treatment, but the KISSS Classic treatment showed significantly less root penetration through the seam (Table 2, Figure 11). Further, the few samples which showed no evidence of root penetration were all from the KISSS Classic treatment.

This difference between treatments mirrors the difference in geometry of the geotextile covering (Figure 1 and Figure 2), and the form of the seam(s). The sewn seam in the KISSS Wrap treatments left gaps between the stitches where small roots could penetrate, and allowed room for the roots to increase in diameter as they grew inside the geotextile envelope.

On the other hand, although the KISSS Classic treatment did not have any effective bond between the two geotextile sheets by the time of excavation, the way the material was installed initially, ripped in through a tubular tine, resulted in the seams folding in against the dripline, thus sealing the seam fairly effectively against root access (Figure 13).
Figure 11: Average and standard deviation of root scores

Figure 12: Roots penetrating through the seam in row 30 (KISSS Wrap), yellow circles highlight the row of stitches which have been cut to open the seam
Figure 13: Installed KISSS Classic cross section

Figure 14: Root growth inside the geotextile, in the absence of localised root penetration through the seam, row 28 (KISSS Wrap, No CuSO₄)
The reduced penetration of roots through the seam in the KISSS Classic treatment resulted in a reduction in the mass of roots inside the geotextile in this treatment (Table 2, Figure 11). However, there were individual samples with roots present inside the geotextile, but no seam penetration in the length of the sample (approximately 600mm) (Figure 14). This was clear evidence that roots, once inside the geotextile, grew along the dripline for considerable distances.

This highlights the fact that any weakness or damage in the geotextile layer can lead to root intrusion along a large length of dripline, not just near the point of weakness or damage. Thus although the KISSS Classic treatment was less susceptible to root intrusion due to the nature of the seams and the installation method used, there were still some penetrations, and resultant root growth inside the geotextile envelope.

In some samples the accumulation of roots was very high (Figure 15). In light of such examples, it was very surprising that there were no samples with any root intrusion into the dripper outlets or labyrinths (Table 2). It is unclear whether this was due to insufficient time for roots to reach the drippers, or the fact that the geotextile resulted in water moving away from the dripper more effectively than in conventional subsurface drip, reducing the attraction of roots toward the drip outlet. However, this does not explain why the initial installation of subsurface drip with geotextile, installed in 2009, was so quickly affected by root intrusion.

There was no significant effect of either CuSO₄ treatment or Treflan® on root intrusion or quantity inside the geotextile. This is perhaps not unexpected, as in both cases the activity of chemical, and therefore the effect on root growth, would be greatest at the drip emitter, and would rapidly reduce as the chemical came in contact with air and soil once out of the dripper. In the absence of any direct blockage of drippers by roots at the site, there was no evidence one way or the other about the effectiveness of these treatments in preventing root intrusion into the dripper outlet.
Conclusion

Data from a trial of subsurface drip with geotextile wrapping, installed in 2011, demonstrated intrusion of Shiraz grapevine roots into the geotextile envelope surrounding the dripline within 3 years of installation of the dripline. The form of the seam in the geotextile, and possibly the method of installation, influenced the susceptibility of the envelope to intrusion by roots. The sewn seam of the KISSS Wrap treatments left gaps which were very open to root penetration, and as roots appeared to actively seek out the dripline, there were multiple penetrations through the seam identified in the samples taken from the trial site.

The presence of samples with no localised penetration through the seams, but the presence of roots inside the geotextile indicates the ability of roots to grow along the dripline for considerable distance once they gain access inside the geotextile. Even with KISSS Classic, which showed significantly fewer root penetrations (Table 2), there were still roots present inside the geotextile, although the volume was significantly lower than in the KISSS Wrap treatments. This suggests that any weakness in the protective geotextile layer can be exploited by vine roots, and once inside the geotextile the roots may travel extensively along the dripline.

Despite the high amount of roots within the geotextile envelope in many samples (42% of samples had visual scores of 3 or above), there was no evidence of root intrusion into the dripper outlets of the dripline. It is unclear whether this reflects the short amount of time that this dripline had been present (less than three whole seasons), or whether the geotextile layer changes the distribution of water in such a way as to draw root growth away from the outlets. However, Accolade Wines reported that the previous KISSS Flat Classic system, installed in the same vineyard in 2009, suffered significant root intrusion resulting in dripper blockage within two seasons of installation.

Sampling also indicated deposition of colloidal material within the geotextile envelope within two and a half seasons of irrigation at the trial. Although not the initial focus of the research, this issue could reduce application uniformity of the system as the amount of colloid increases and restricts water movement through the geotextile. This could be an important focus of further research as blockage of flow by colloids may be independent of root penetration in some soils.

Further Research

There will be an opportunity within the next few years to excavate both KISSS and standard sub-surface drip from another vineyard sub-surface drip irrigation trial site in the Riverland, established in 2010. This will allow a comparison of root intrusion into the drippers with and without geotextile, and answer some of the questions raised above about the effect of changed water distribution with geotextile on root behaviour.