

Understanding return on investment of sub-surface water management options for waterlogged areas in the Western Region (Albany Port Zone)

Hosts: Perrilup and Cranbrook – Allison and Preston Family

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KEY MESSAGES:

- Yield gains from implementing sub-surface drainage at the Cranbrook sub-surface drainage demonstration site equated to a net -10kg/ha to +420kg/ha for Dennison wheat yield in 2023.
- Yield gains from implementing sub-surface drainage at the Perillup sub-surface drainage demonstration site equated to a net +180kg/ha yield increase in DS Bennett long-season wheat in 2023.
- While yield improvements were seen across both demonstration sites, yield was impacted by heat-stress & drought-stress during flowering & grainfill for 2023.
- Sub-surface drainage is a waterlogging management solution that requires substantial upfront investment from growers, with fully "installed" costs typically estimated around \$15,500 - \$17,000/km*.

Background

Waterlogging is a common problem within the southwest region of Western Australia, particularly in the wetter months of winter, and typically occurs when rainfall exceeds the ability of soils to drain away soil moisture. Under these conditions, the excess water within the root zone creates anaerobic conditions (conditions without free oxygen) and prevents the plant from performing gaseous exchange with the atmosphere or biological activities with the oxygen in the soil, air & water. Left unmanaged, waterlogging can lead to soil structural decline and has the potential to create nutrient deficiencies & toxicities (such as Iron & Manganese toxicity), cause root death/reduced plant growth, or, worst case, result in death of the plant.

This project investigates the viability of sub-surface drainage to alleviate waterlogging and increase yields on paddocks that do not perform well due to being too wet.

Methodology/Treatments

Two subsurface demonstration sites have been established in the Albany Port Zone, with demonstration sites established West of Cranbrook (2021) and Perillup (2022). At each demonstration site, Drainage Downunder installed

a 100mm slotted pipe at depth in the pre-selected trial area. The process involves running a mechanical chain-saw-styled trencher through the ground sub-surface to leave a trench, inserting the slotted pipe into the ground, and then in-filling above the pipe with limestone caprock to allow water permeability. The drainage was designed with GPS elevation data to ensure that there was sufficient fall in the pipe to allow the water to flow freely without impediment. Each trial site comprises sub-surface drainage (slotted pipe) installed at depth across a minimum of 2 hectares. A control region prone to waterlogging (no pipe installed) and a non-waterlogging site located upslope are utilised within the same paddock to enable the ability to do a comparative yield analysis.

Trial Results

Trial Site 1: West Cranbrook Site

2023 was the third year of field measurements for the Cranbrook demonstration site. Despite a drier start and finish to the season, the seasonal conditions finished with above-median rainfall. Annual rainfall was 573mm for the year, with a growing season rainfall recorded of 443mm. Unlike the previous years, 2023 had limited periods of waterlogging experienced in the control (undrained) trial

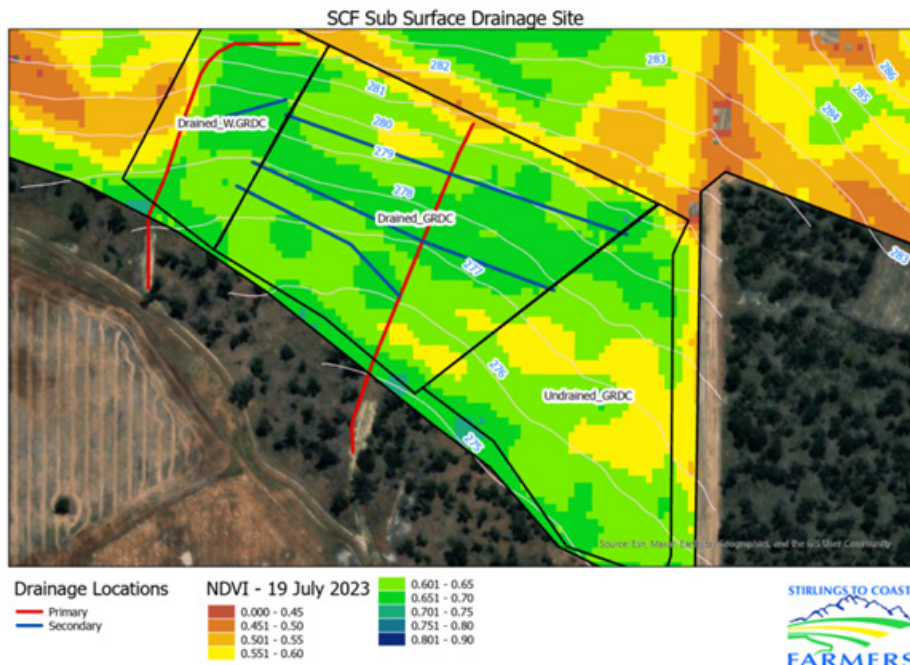


Figure 1: NDVI values captured at the Cranbrook demonstration site 19th July 2023 (Source: Planet Laboratories)

compared to the drained regions. The trial site was sown to Dennison wheat on 16th May 2023 at a rate of 120kg/ha, with the addition of SE14 wetter, in-furrow fungicide, liquid fertiliser and granular fertiliser mix. Plant nutritional & fungicide requirements were met throughout the growing season through the use of granular and liquid fertilisers and foliar sprays.

Overall, the 2023 growing season rainfall levels led to waterlogging conditions being experienced in the control section of the drainage trial. NDVI imagery captured via satellite indicated marginally higher biomass where sub-surface drainage existed in the paddock, with NDVI values of 0.6 to 0.75 in drained, compared to NDVI values of 0.45-0.7 in the undrained regions for 17th July 2023. As of 21st September 2023, NDVI values were again higher in the drained section compared to the undrained.

The paddock was harvested on 15th December 2023. Generally speaking, there was a positive benefit to the implementation of sub-surface drainage, as an average, across both trial sites. Yields for the control region where subsurface drainage wasn't installed, averaged a total of 3.45t/ha, with 3.44t/ha and 3.87t/ha recorded where subsurface drainage had been installed (Figure 2). Two additional areas were also assessed at harvest, where no sub-surface drainage was installed and where it was deemed unlikely to suffer from waterlogging. These areas across medium (mid-slope) and high-performing (upper-slope) soil landscapes represent the maximum potential yield should an area not express the yield penalty effects from waterlogging. When we compare the drained GRDC trial regions against non-waterlogging high-performing areas, there was a potential yield opportunity of up to 0.58t/ha more yield potentially available (Figure 2).

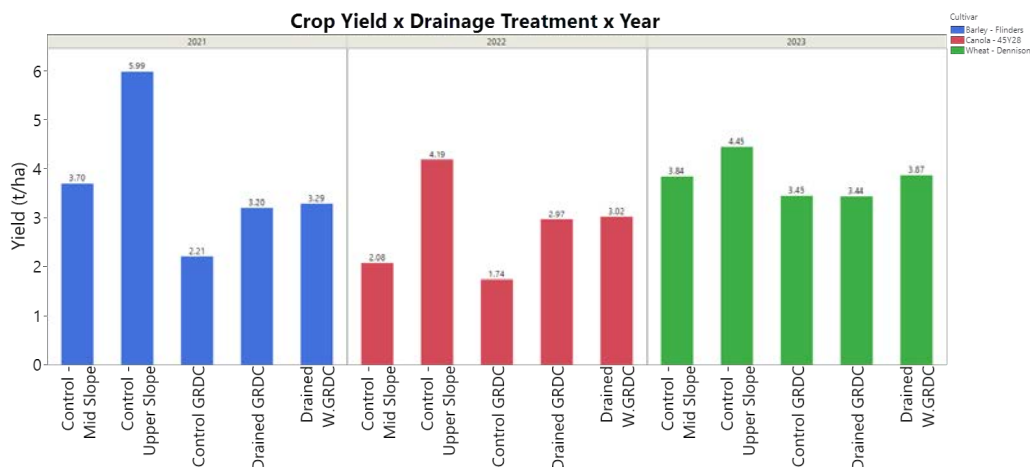


Figure 2: Final yield results (t/ha) achieved at the Preston Sub-Surface Drainage site at Cranbrook in 2023.

Trial Site 2: Perillup

Similar to the Cranbrook trial site, there was also a dry start recorded at the Perillup site and a rather dry finish recorded throughout the maturity of the crop phase. Growing season rainfall was 529mm, with an annual rainfall of 639mm for the year. Rainfall was heavily distributed within June to August, with rainfall plateauing from September to November. Overall, soil conditions for sowing were relatively dry in early (4th) April despite the previous seasons' rainfall, and germination was patchy and initially dependent on soil type within the paddock. Overall, rainfall generally tracked below the median 20-year average until June.

The DS Bennett wheat crop was harvested in December, with yield data analysed for the drained region, undrained control, and upslope (non-waterlogging) control regions within the paddock. Overall, yield benefits for the installed sub-surface drainage medium were positive but minimal, with 5.13t/ha yield recorded in the drained and 4.95 tonne/ha recorded in the undrained control (Figure 3). The upslope control located nearby, within the same paddock, yielded less than the drained/undrained, with a final yield of 4.22t/ha. This was noted due to differences in the soil type and waterholding capacity of the soil.

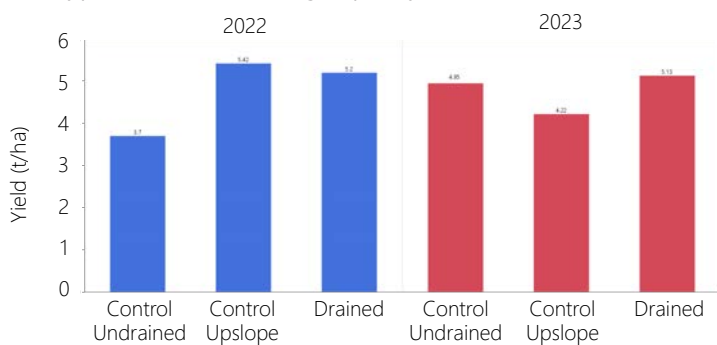


Figure 3: Final yields recorded at the Perillup Sub Surface Drainage Demonstration Site for the 2023 growing season.

Discussion

The use of sub-surface drainage has shown a positive effect on final yields obtained for 2023. However, with a dry start and drier finishing period, the benefits of implementing sub-surface drainage were limited to -10kg/ha to +420kg/ha in Dennison wheat in Cranbrook & +180kg/ha in DS Bennett in Perillup for the 2023 growing season. 2023 represents the final year of monitoring for these trial sites under the GRDC grant.

Taking into consideration previous yield increases seen in 2021 & 2022, in conjunction with the 2023 trial data,

all trial sites received improved yields overall across the sub-surface drained trial sites. Previous yield increases in 2021 acknowledged a 47% yield increase (RGT Planet barley) in Cranbrook, with a 72.5% yield increase in 2022 (45Y98 canola) and a 6% yield increase in Dennison wheat in 2023. At Perillup, there was a 39% yield improvement (45Y95CL canola) in 2022 and a 3.6% yield improvement in DS Bennett wheat in 2023.

All three seasons resulted in an above-median rainfall value; however, their distributions throughout the year were completely different. 2021 saw rainfall track above median throughout the whole year, after the 21st January 2021. 2022 started drier for both sites, tracked near median rainfall throughout April to late September, and then tracked above median rainfall thereafter.

2023 saw a very dry start, followed by below median rainfall levels to April (Perillup) and June (Cranbrook), with the season's rainfall plateauing for both trial sites from mid-late September, which is the critical flowering and beginning of the grain-fill period for wheat. It is assumed that rainfall within this later period of the year would have had an improved yield potential overall and a larger potential difference between treatments. This is due to the fact that the hot, dry period seen in 2023 occurred within the grain fill/grain set period. These dry events effectively capped the yield potential of the crop, rather than the biomass itself, which was determined & grown throughout the year.

It is important to note that while yields were generally improved across all treatment locations through the implementation of sub-surface water management, it is also an important consideration to select for varieties that can better mitigate drought/heat stress during critical grain fill periods (as experienced in 2023) to maximise yield potential in these types of seasons. This may include the use of a longer-season wheat variety if early soil moisture is available and it is anticipated to finish well; however, if the season starts dry and ends dry, a shorter-season variety may be more beneficial to have for yield production in the mix.

As noted in the previous annual reports, with installation costs in the order of approximately \$15,000 - \$17,000 per kilometre fully installed (purchase of pipe, limestone rubble, mobilisation & installation charges)*, getting the installation locations of pipework perfected will continue

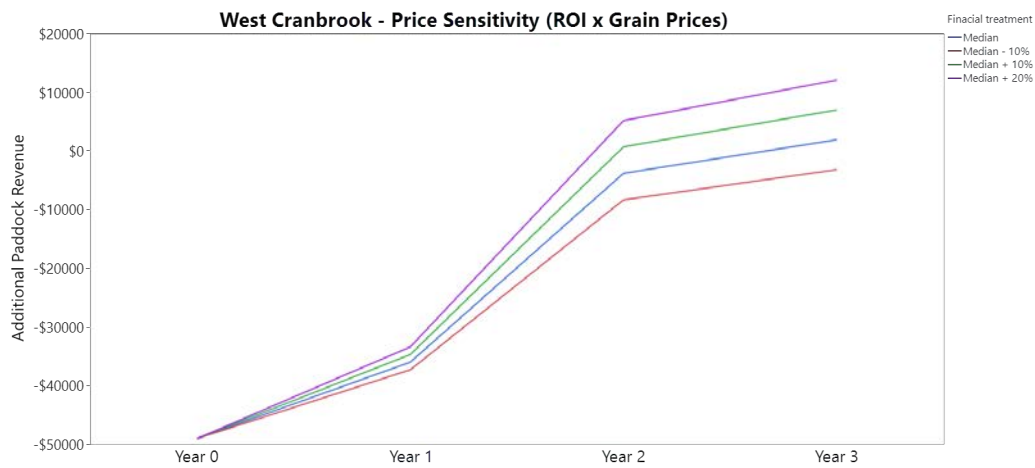


Figure 4: Potential estimated return on investment paddock values under various grain pricing (\$/t) structures (median, median -10%, median + 10%, etc.)

to be critical to ensure that the economic efficiency of sub-surface drainage is maximised. Return on investment results from back-of-envelope calculations identified that applying drainage to the remaining waterlogged regions of the West Cranbrook demonstration site varied considerably with the different seasons (Figure 4).

- In 2021, there was a potential payback period of approximately 3.8 years to occur, pending a median barley grain sale price (\$250/t) being achieved and similar yield differences,
- In 2022, a potential payback period of 1.5 years to occur, pending a median canola price of \$580/t was achieved and/or
- In 2023, an estimated potential payback period of 8.6 years would occur under a dry-finish wheat on an assumed \$300/t median grain price.

When accounting for all of these years together, the combined benefit of installing sub-surface drainage across the proposed area equates to a net payback period of approximately 3 years utilising median prices. Where annual grain prices have the opportunity to exceed median pricing, then the payback period will often be earlier.

Conclusion

In conclusion, implementing sub-surface drainage has resulted in improved production at the trial sites located in Cranbrook & Perillup, with initial payback periods based on a median grain price being just under 3 years. It is important to note that despite 2023's limited yield response due to seasonal conditions, there were no significant differences or negative effects on final yield between the drained & undrained trials, when the season finished significantly drier, with no significant rainfall events between flowering & grain-fill. This should give farmers increased confidence to investigate the implementation of sub-surface drainage on their own farms.

Acknowledgments

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** Pricing is based upon a wide range of factors including area drained, drained soil types, availability of drainage pipe, freight and availability of limestone rubble, access to machinery and associated mobilisation/ installation costs.*



Field walk at the Perillup sub-surface drainage trial site, July 2023.

