Quantifying the potato yield gap – three case studies in Canterbury

Sarah Sinton, Plant & Food Research, Lincoln

Introduction

Current production costs for process potatoes grown in Canterbury mean that those yielding less than 55 t/ha often result in financial losses for growers. To achieve sustainable profits, yields should be at least 70 t/ha, but the current average in the region is only 60 t/ha. A previous survey of 11 crops in the 2012-13 growing season provided evidence that the main factors limiting yields are related to the presence of soil-borne diseases, as well as root restriction zones in the soil and inadequate water supply. In the same survey, fertiliser trials showed that nutrient supply was not usually limiting yield.

In the 2014-15 growing season, the next step for the yield gap research was to put more certainty around contributions of various yield-limiting factors. This was done by firstly measuring crop water balances, determining whether water was limiting yield, and if not, identifying other causes of yield losses.

Three Canterbury processing potato crops (≈25 ha each) were intensively monitored, as with previous yield gap investigations, but with additional measurements of daily irrigation, rainfall, solar radiation and temperature, fortnightly soil water content to 800 mm depth, and five in-season growth assessments at eight observation sites in each field. These data were compared with Potato Calculator predictions. From these comparisons, yield reductions caused by lack of water could be quantified and the remainder of the losses then attributed to other factors.

The project was funded by the New Zealand Institute for Plant & Food Research Limited, the McCain Grower Group, and CropLogic.

Summary:

- Crop #1 (Table 1) had adequate irrigation to achieve potential yield, but suffered a 36 t/ha yield loss through high incidence and severity of two soil-borne diseases (*Rhizoctonia* stem canker and *Spongospora* root galls).
- A cropping history that included potatoes within the last 6 years increased the risk of occurrence of soil-borne diseases for Crop #1 (confirmed in a recent crop survey).
- Crop #2 had an incidence of soil-borne disease unlikely to have contributed to the 23 t/ha yield loss. Instead it was probably the result of inadequate water supply caused by regional water restrictions, combined with a root-restricting soil compaction zone at 300 mm depth.
- Crop #3 had adequate irrigation to achieve potential yield and low disease incidence but still experienced a 16 t/ha yield loss. This was traced to detrimental soil physical properties caused by previous cropping history.

Table 1. Field and crop information, potential yields (indicated from computer modelling with the Potato Calculator), field yields (measured by the growers), yield gaps and likely yield gap causes, for three commercial potato crops grown in Canterbury in 2014-15.

	Crop #1 'Russet Burbank'	Crop #2 'Russet Burbank'	Crop #3 'Innovator'
Location	Dorie	Orton	Barhill
Soil type	Eyre/Templeton	Stony Templeton	Deep Templeton
Depth to stones	400 mm	300 mm	No stones to 800 mm
Soil compaction	No	Yes	Yes
Last potato crop	2008	2007	> 2005
Potential yield (t/ha)	88	89	86
Field yield (t/ha)	52	66	70
Yield gap (t/ha)	36	23	16
Main cause	Soil-borne diseases	Lack of water	Variable soil quality

Results

Using local weather data, customised soil descriptions (including observed crop rooting depth) and measured inputs of rainfall and irrigation from the three fields, Potato Calculator-modelled crop water balances mostly matched field measurements throughout the season, giving confidence that Potato Calculator yield predictions were likely to be accurate with respect to crop water supply. The deviation which occurred later in the season for Crop #1 (Figure 1) was attributed to the high incidence and severity of soil-borne diseases in the crop (Figure 2, Figure 3) slowing plant growth and water use. At present, the Potato Calculator model does not account for the effects of soil-borne diseases.

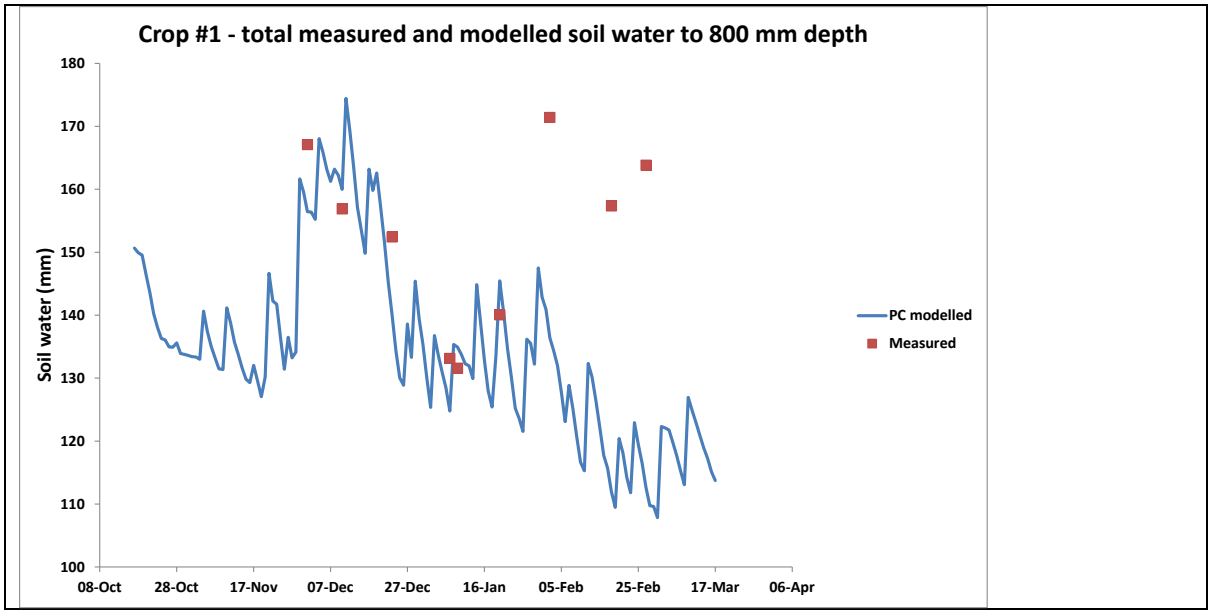

Figure 1. Total measured and Potato Calculator (PC)-modelled soil water content to 800 mm soil depth for commercial potato Crop #1 grown in Canterbury in 2014-15.

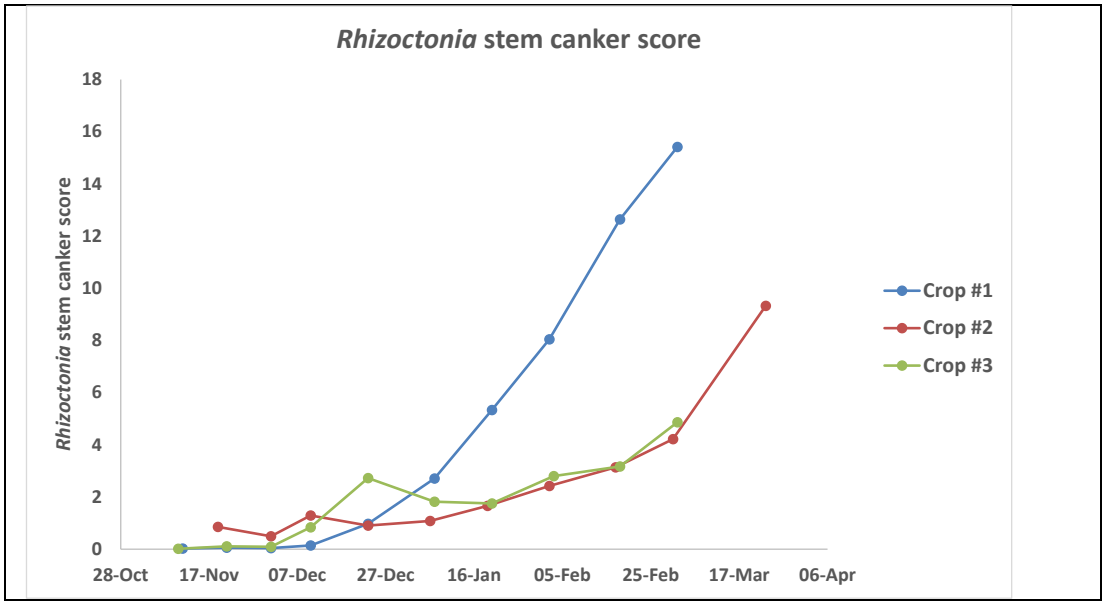

Figure 2. Mean Rhizoctonia *stem canker severity scores for commercial potato Crop #1, Crop #2 and Crop #3 grown in Canterbury in 2014-15; 0 = no infection, 5 = 30% of the stems affected by canker, 18 = stem dead.*

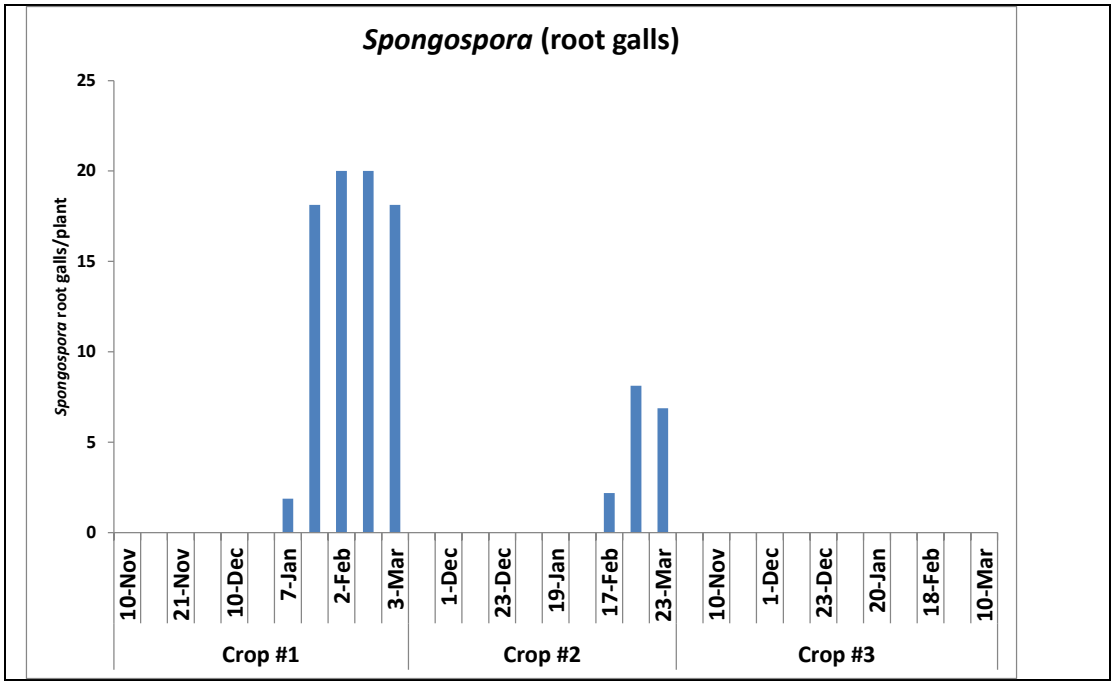

Figure 3. Mean numbers of Spongospora *root galls per plant for commercial potato Crop #1, Crop #2 and Crop #3 grown in Canterbury in 2014-15. Twenty galls per plant is considered a severe infection.*

Water supply (13 mm every 5 days on average) was not enough to achieve potential yield in the Crop #2 (Figure 4). For the average application amount of 13 mm, the Potato Calculator model predicted that a return rate of 4 days would have been required to achieve potential yield.

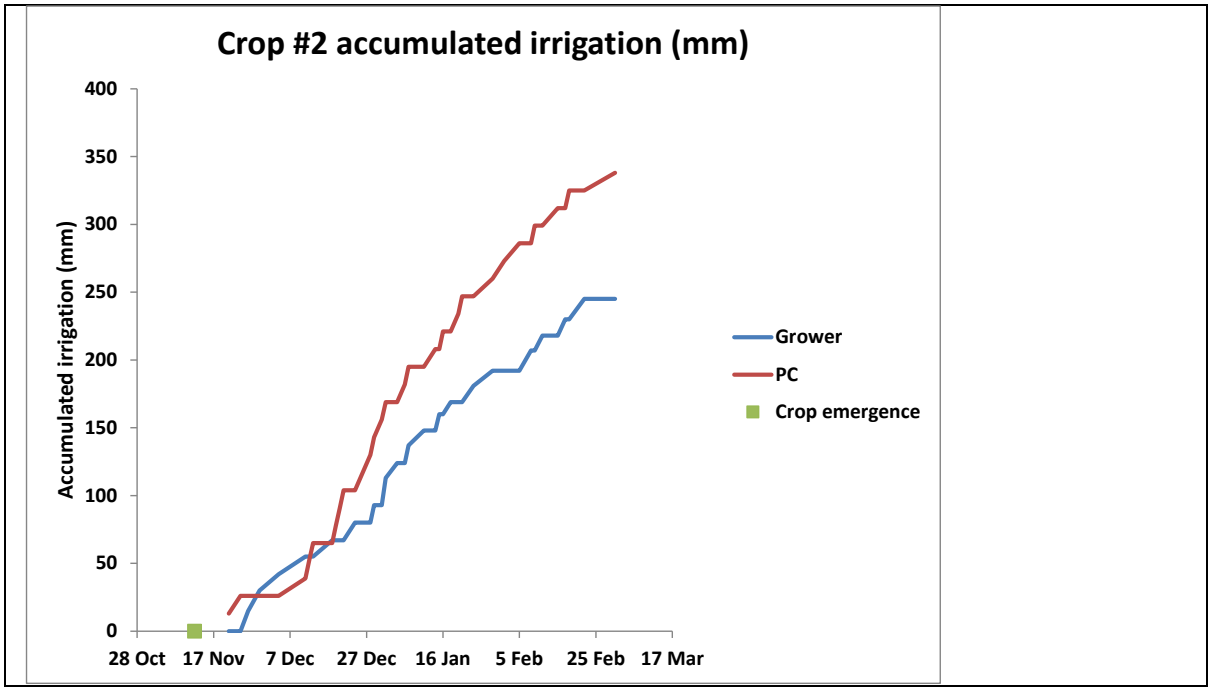

Figure 4. Potato Calculator (PC)-modelled and grower irrigation for commercial potato Crop #2 grown in Canterbury in 2014-15. On average, the grower applied 13 mm of water per irrigation event; the same amount was set in the PC to run an irrigation regime to achieve potential yield.

Some observation plots in Crop #3 achieved the potential yield (Figure 5), showing that resources were not limiting at those sites, and that the Potato Calculator model-predicted potential yield was possible. For this crop, water supply was adequate and disease pressure was low, but yields were lower at the east end of the field (average 69 t/ha) compared to the west end (average 90 t/ha). This yield variation coincided with a previous configuration of two fields (Figure 5), where differing soil conditions at the eastern end may have reduced water holding capacity of the 0-20 cm layer in that area.

Figure 5. Observation plot locations for commercial potato Crop #3 grown in Canterbury, and their associated final yields in the current field (2014-15, left) and the same plot locations superimposed on a field configuration that existed until 2007 (right).

Closing the yield gap

By anticipating potential factors that may cause yield gaps in future crops, a system could be developed to help plan the best-case scenario for high yielding crops:

- Test seed tubers for presence of pathogens; use only disease-free seed. Consider using uncut seed as a way of reducing potential disease spread
- Continue to test alternative in-furrow pesticides, fungicides and rates
- Test soils for likely presence of soil-borne pathogens, by checking crop history and using a DNA testing service. Develop benchmark values for major soil-borne pests and pathogens, above which planting potato crops is not recommended
- Alleviate potential root impediments with deep cultivation. Calculate water storage potential in root zones. Plan irrigation regimes accordingly
- Continue managing adequate nutrient input, and foliar pests and diseases
- Pursue long-term (multi-year) plans to use crop types and rotations to 'clean' pathogen-infested fields.

Acknowledgements

The growers who provided the three crops for detailed survey are thanked for allowing access and for routine monitoring.

Contact

Sarah Sinton sarah.sinton@plantandfood.co.nz

Richard Falloon richard.falloon@plantandfood.co.nz