Striving for maximum potato yields in Canterbury, New Zealand

Potato yields in Canterbury, New Zealand, have remained static at 50 to 60 t/ha (paid yield), a level of crop production that is becoming uneconomic. Computer-based modelling predicts that yields of 90 t/ha are theoretically possible.

A field study was conducted by the New Zealand Institute for Plant & Food Research (2012/13 growing season), aiming to identify factors responsible for the potato "yield gap". The project was funded by Potatoes New Zealand, the McCain Foods growers group, Ravensdown Fertiliser and Plant & Food Research.

Findings

- Current yields of processing potatoes were 20 to 40 t/ha less than potential
- Soilborne diseases *Rhizoctonia* stem canker, *Spongospora* root infection), were prevalent, probably restricting water uptake and causing premature canopy death
- In 11 surveyed crops, healthy plants produced close to potential
- Paddocks not previously growing potatoes ("new") had less pathogen inoculum than those with potato cropping histories (last 10 years; "old"). However, previous cropping history did not predict soilborne disease incidence or severity.
- Soil compaction reduced water-holding capacity and root growth.
- Current fertiliser rates are near optimum for growth and production.
- Other factors (e.g. seed tuber quality, irrigation efficiency) could also limit yields.

Approach

Eleven commercial potato crops were included in the study. They were planted with either 'Russet Burbank' or 'Innovator' cultivars. Paddocks were selected to examine yield effects of including potatoes in recent cropping histories. A representative site was chosen in each crop after planting, and soil structure, the presence of soilborne pathogens and crop characteristics were measured. Every 10 to 14 days throughout the season, each crop was checked for growth and development, and any inconsistent areas were marked for later yield assessments.

Fertiliser trials were established in four of the crops, where grower rates of nitrogen, phosphorus and potassium, double these rates, and a calcium treatment, were applied. Further applications of nitrogen during the season, as part of commercial practices, were also doubled for some treatments. Yield was measured at crop senescence.

Three measures of tuber yields were used for each crop. These were "potential yield" from a yield simulation model (using 2012/13 climate data), and "paddock yield" from the whole paddock as measured by the grower. These two were expressed as paid yield (not including tubers less than 67 mm). The third measure was "plant yield", the gross yield per plant (all tubers). This was used to compare yields between individual healthy or unhealthy plants.

Results

A yield simulation model, conducted for each season from 2002-2013, showed that the 2012/13 season gave the greatest "potential yield" at all sites, and this was used as a

baseline. High winds damaged some crop canopies in January 2013, which probably reduced final yields.

Averaged over the 11 crops, “potential yield” was 87 t/ha and “paddock yield” was 54 t/ha (Figure 1). ‘Russet Burbank’ and ‘Innovator’ gave similar yields. There was no effect of previous potatoes on the yield difference, but initial soil pathogen levels were greater in paddocks where potatoes had been recently grown.

The yield gap between the “potential” 87 t/ha and “paddock yield” ranged between 20 and 42 t/ha (Figure 1). Yield gaps were greatest where water uptake was restricted in the plants, due to damage to roots and underground stems by diseases, and through poor soil structure and compacted layers limiting soil water storage. Yield was also reduced through foliar diseases shortening canopy duration to less than optimal for completion of tuber bulking.

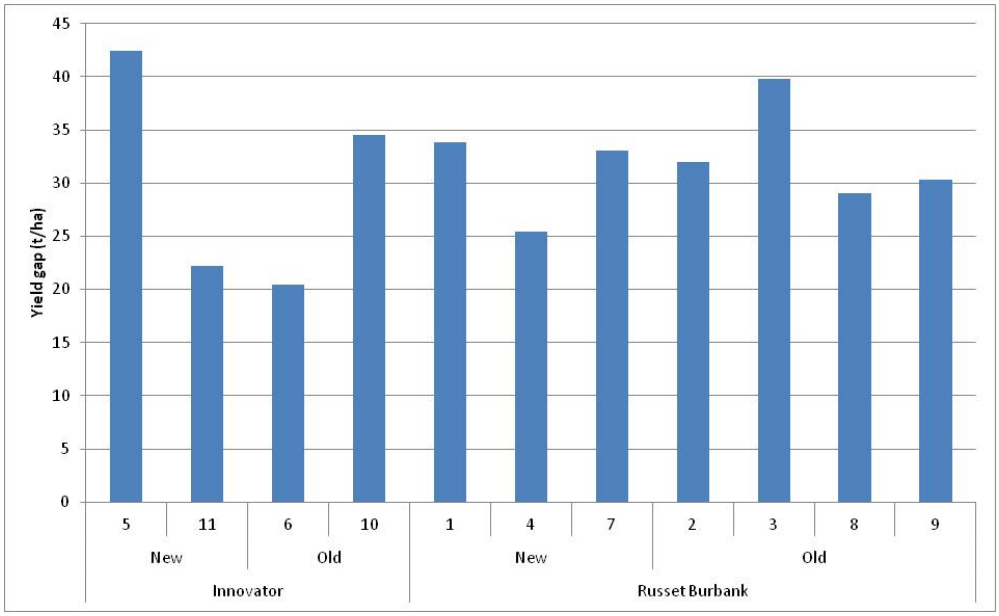

Figure 1: The yield gap (t/ha, fresh, tubers > 67mm) between “potential” and “paddock yields” for 11 monitored potato crops, of ‘Innovator’ or ‘Russet Burbank’, planted, into “new” or “old” paddocks.

Diseases were important factors associated with variability of “plant yield” within individual paddocks (Figure 2), and soil compaction produced variability between paddocks. Plants that were less severely affected by soilborne diseases and without soil compaction yielded up to the equivalent of 90 t/ha. Where plants were affected by these diseases and the soil was compacted, yield was reduced to less than the equivalent of 30 t/ha.

All 11 crops had stem canker symptoms. Six crops also had root galls caused by *Spongospora* infections, and root-limiting compacted soils (Table 1). Five crops were affected by the two soilborne diseases, and soil compaction. Four crops had shortened canopy duration, five had significant wind damage, and four had irrigation problems, highlighted in the particularly dry 2012/13 season.

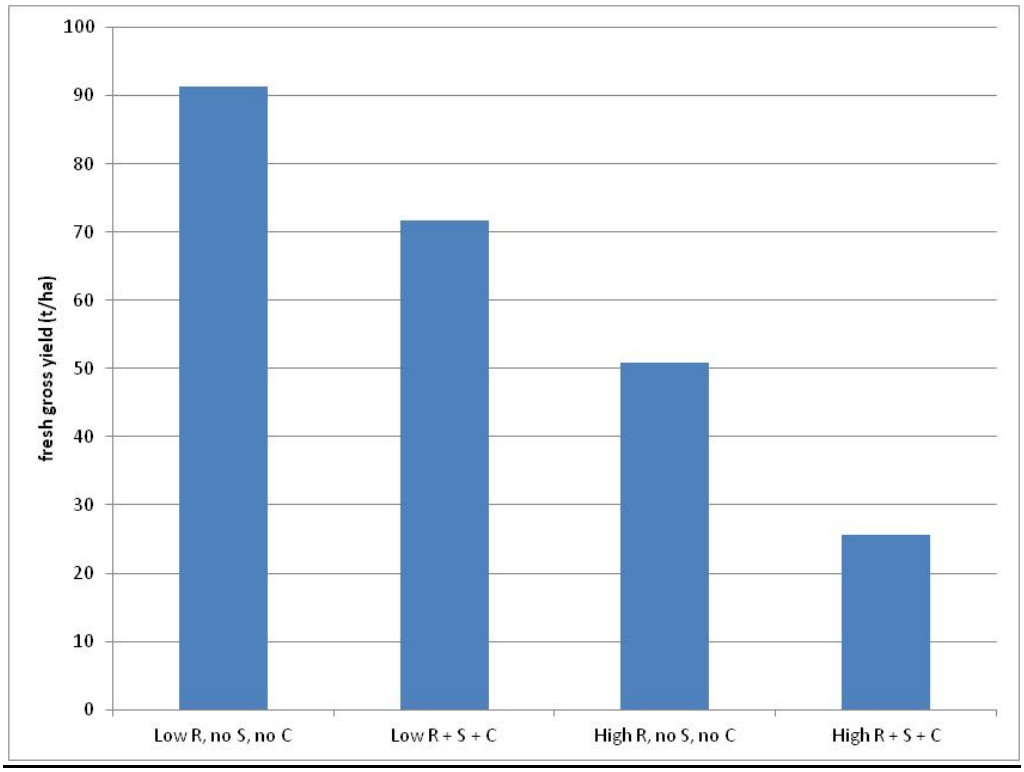

Figure 2: Averaged "plant yield" equivalent from targeted areas in 11 potato crops, categorised as having: low stem canker incidence, no *Spongospora* (root galls) and no soil compaction (Low R, no S, no C); low stem canker incidence, with *Spongospora* (root galls) and soil compaction both present (Low R + S + C); high stem canker incidence, no *Spongospora* (root galls) and no soil compaction (High R, no S, no C); or high stem canker incidence, with *Spongospora* (root galls) and soil compaction both present (High R + S + C).

Table 1: Factors contributing to yield reductions for each of 11 potato crops included in this study

Paddock	Factors
1	*Rhizoctonia* stem canker (*R* sc), *Spongospora* root galls (*S* rg), soil compaction, uneven irrigation (waterlogging and dry spots), wind damage
2	*R* sc, *S* rg, soil compaction, shortened canopy duration, uneven irrigation (waterlogging and dry spots), wind damage
3	*R* sc, *S* rg, soil compaction, waterlogging, wind damage
4	*R* sc, wind damage. Seed or psyllid problem?
5	*R* sc, diseased canopy with low vigour, wind damage
6	*R* sc, *S* rg, soil compaction, uneven irrigation
7	*R* sc, three spans of irrigator malfunctioning, wind damage
8	*R* sc, *S* rg, soil compaction, shortened canopy duration
9	*R* sc, *S* rg, soil compaction,
10	*R* sc, shortened canopy duration
11	*R* sc, shortened canopy duration, poor seed quality

Fertiliser trials

- No significant effects on yields from doubling the nitrogen rates over those used normally
- Small yield gains from doubling the rates of P and K in some cases, but no strong effects
- No significant responses to additional calcium

Recommendations

- Plant potatoes in soils that have high water-holding capacity, good drainage and no root restriction zones.
- Choose paddocks that have had long periods (at least 10 years) without potatoes.
- Soil testing for pathogen DNA indicates disease risk.
- Match crop nutrient requirement with supply, which may mean reducing some fertiliser inputs.
- Select disease-free seed tubers with high vigour for strong plant growth.

This research was guided by Sarah Sinton, Prof Richard Falloon and Dr Hamish Brown, with assistance from Craig Tregurtha, Alex Michel, Steven Dellow, Dr Sarah Pethybridge, Dr Jeff Reid and Dr Bruce Searle. Duncan McLeod (Seed & Field) and the potato growers and their agronomists are thanked for allowing access to crops.

Typical stem canker lesions

Spongospora root galls

Canterbury potato crop, surveyed in 2012/13