The effects of seed- and soil-borne disease and soil physical quality on potato production

A three year Sustainable Farming Fund project (project number P15-01, 2015-18) has shown that potato crop performance can be negatively affected by poor soil structural conditions and the presence of seed- and soil-borne diseases, and that these two main yield limiting factors are often inextricably linked. The degree of severity of these factors is in turn influenced by the cropping history of a field (for example, variations in cultivation intensity, crop organic matter recycling, hosting of soil-borne disease), along with disease management of preceding seed generations (including during crop growth, winter storage and handling).

All 35 crops monitored in the first two years of this study exhibited *Rhizoctonia* stem canker symptoms with potential to limit growth during the tuber bulking phase. This was especially true for the crops grown in poorly structured soils (19 fields) that also harboured other pathogens, particularly *Spongospora* (21 fields). The work showed that yield could be maximised by using whole seed (more vigorous than cut seed) and choosing fields with enhanced soil structure resulting from 7+ years of uninterrupted restorative crop growth (for example, grass). This was despite the continued presence of soil- and seed-borne disease and the fact that pre-plant potato cultivation negatively impacted some of the soil structural gains from the restorative grass phase.

During the first and second years, the project also investigated the effectiveness of biofumigant crops for controlling soilborne disease in potato. Four replicated treatments of fallow, Caliente™ mustard, oats and radish were established in the autumn of 2015–16, before a spring potato crop. In late winter the crops were mulched and worked in, left to break down for three weeks before bed forming and potato planting. Soil-borne pathogen DNA amounts were measured before and after biofumigant crop growth. Plant health in each plot was monitored four times during crop growth and yield measured at final harvest.

Radish and mustard whole-crop incorporation and breakdown actually elevated the amounts of R. solani AG2.1 DNA, compared to pre-plant levels, however Rhizoctonia and Spongospora disease severity and incidence (moderate to severe) in the potato crop, along with final potato yield, were similar for all biofumigant treatments. Possible reasons for ineffective soil-borne disease control included insufficient biocidal activity from these winter-grown crops, or the re-introduction of diseases via the planted potato (cut) seed.

Work in the third year concentrated on seed health. Firstly, a line of ‘Russet Burbank’ whole seed tubers was graded for visible *Rhizoctonia* black scurf (the resting structure or sclerotia, which can later cause stem canker) severity, using a standardised scale of 0%, 5%, 20%, 46%, 60% black scurf coverage. The tubers were either dipped or not dipped in formalin solution, and then planted in pathogen-free growing medium in planter bags (10 replicates). The resulting *Rhizoctonia* stem canker on the growing plants was just as severe for the 0% black scurf coverage treatment (treated and untreated with formalin) as it was for the other four severity categories (formalin treatment average), with formalin treatment reducing overall severity by only 30% compared with the untreated controls. Implications are that the *R.Solani* pathogen can be invisibly present on seed, or can spread from infected tubers in the same population, which can then result in severe stem canker infection of the following crop if conditions are favourable. Formalin seed treatment may be only partially effective at controlling this disease.

Secondly, the health of seven commercial ‘Agria’ crops (harvested as G5, 2017–18) was monitored and compared with in-season health of the preceding seed lines (harvested as G4, 2016–17). The G5 seed was grown as whole seed in sterile potting mix in a controlled disease-inducing environment to estimate the potential presence of seed-borne pathogens. Incidence and severity of *Rhizoctonia* stem

canker were low in the G4 seed crops, low to moderate in G5 glasshouse plants and low in all but one daughter crop, the latter of which was subjected to drought and flood conditions (Manawatu) during growth. *Spongospora* disease was scarce in the G4 seed crops and G5 daughter crops (some were grown in 'supressive' Pukekohe soils), but severe in the G5 glasshouse plants (this polycylic pathogen multiplies rapidly in optimum conditions). These results show that the presence of seed-borne inoculum is often highly likely, but if amounts are minimised through the supply chain, the impact on well-managed crops can also be minimal.

This project has shown that continued improvement of potato yields will be primarily dependent on planting healthy seed in fields with optimised soil physical (and microbiological) conditions. In future this may improve resource use efficiency (through enhanced root growth) and help reduce dependence on pesticide use, given that more vigorously growing plants can mitigate the effects of disease.