The effects of soil quality and seed health on potato yields

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Background – Potato “Yield Gap” projects

- Grower initiated
- Over the past decade, potato yields have remained static at around 50-60 t/ha, becoming uneconomic to sustain
- Models predicted potato yields should be up around 90 t/ha!

Common theme

- Major yield limiting factors include

1. Presence of **soil-borne diseases** reducing underground root and stem health, and

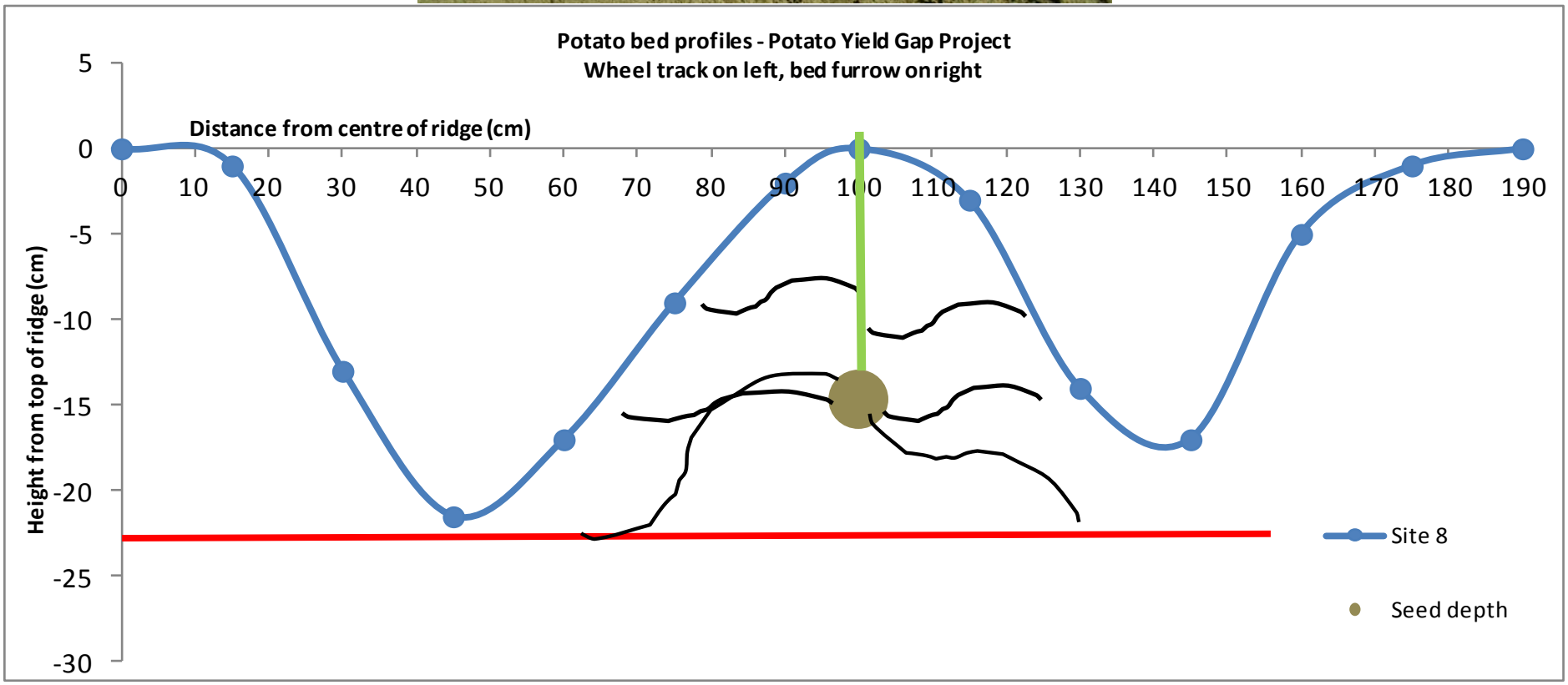
2. **Compacted, poorly structured soils** restricting root growth and reducing the crop's ability to take up water and nutrients.

Rhizoctonia stem canker

Spongospora diseases

» Spongospora root galls on stems (not often seen) and roots

Yield = 57 t/ha


Potato bed profiles - Potato Yield Gap Project
Wheel track on left, bed furrow on right
Distance from centre of ridge (cm)
Height from top of ridge (cm)
5
0
-5
-10
-15
-20
-25
-30
0
10
20
30
40
50
60
70
80
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100
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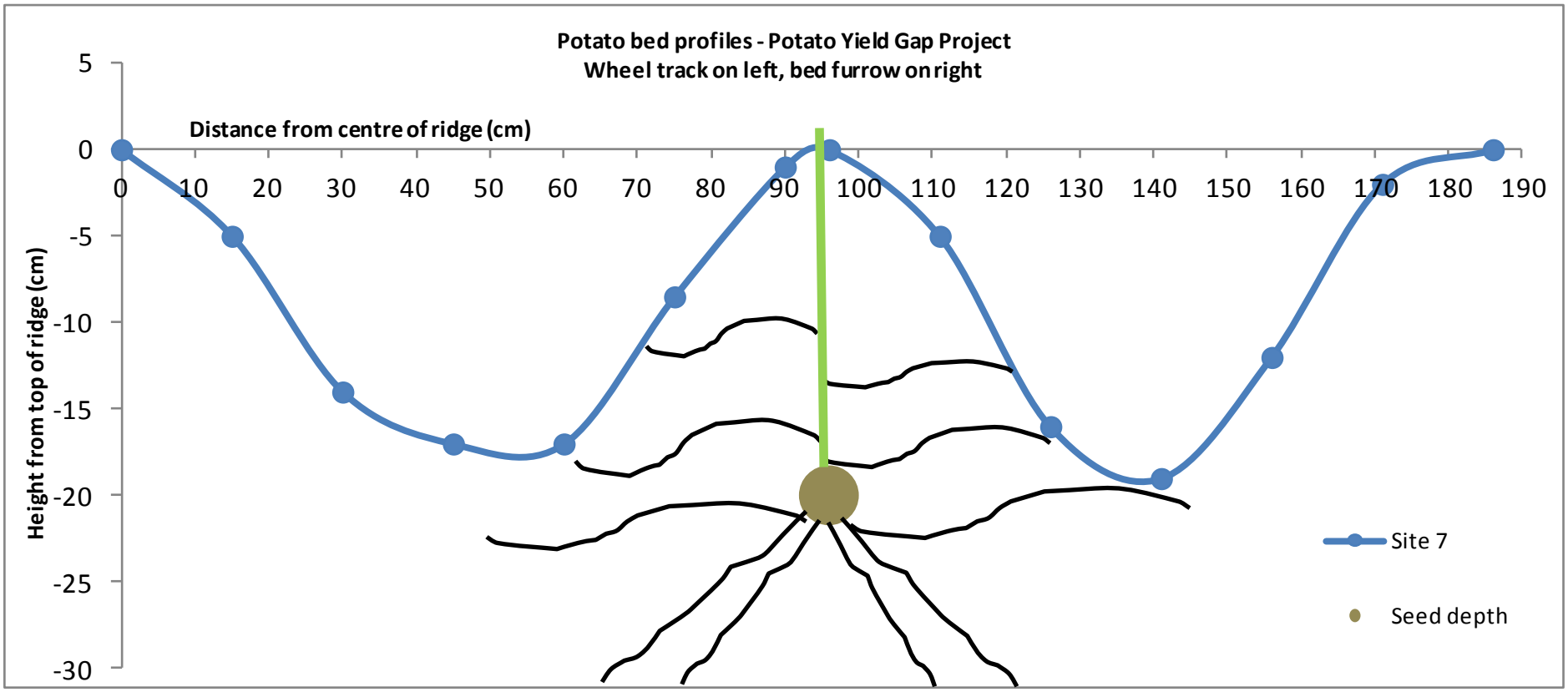
120
130
140
150
160
170
180
190
Site 8
Seed depth

Yield = 86 t/ha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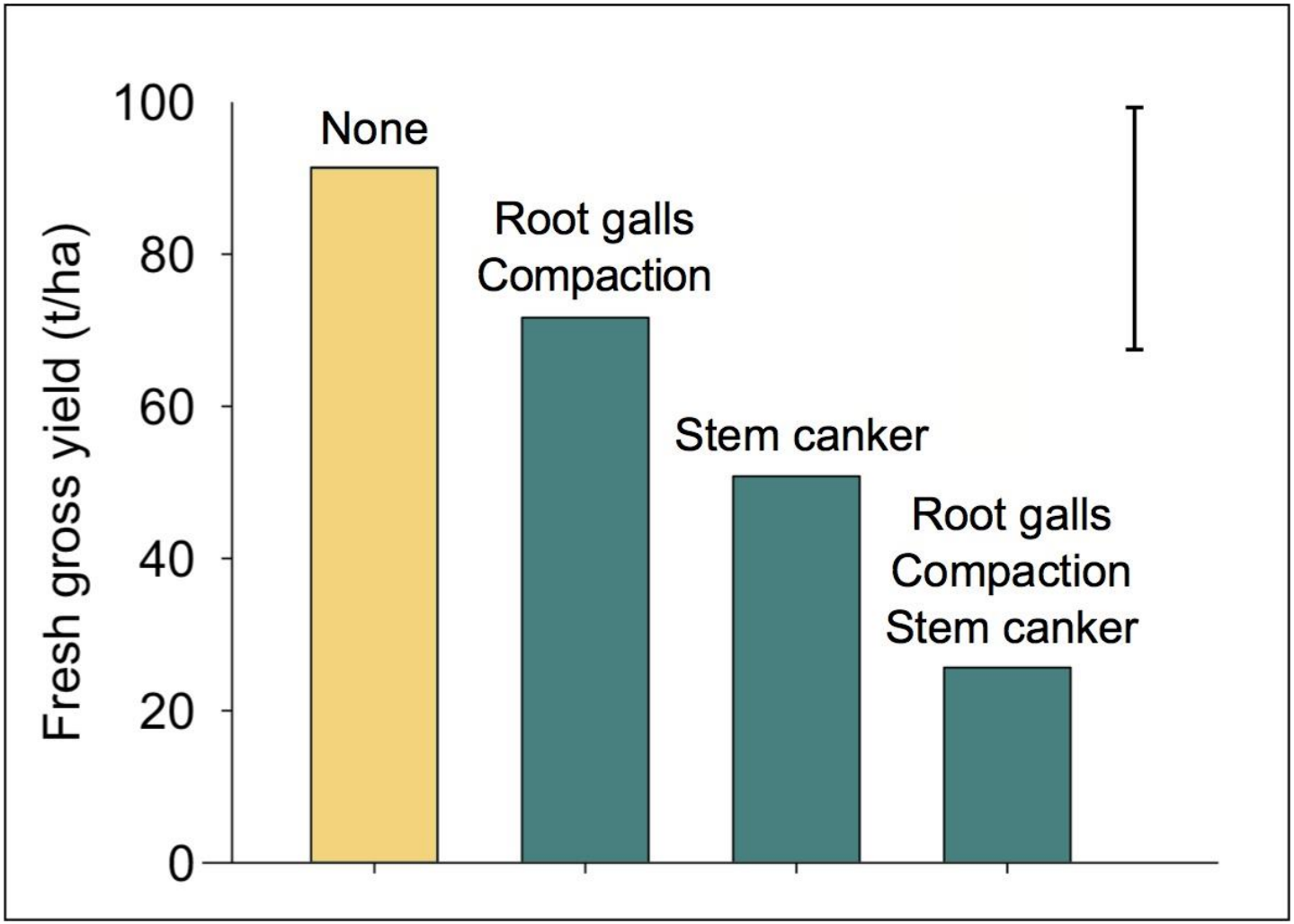
Site 7
Seed depth

Tuber yield from targeted areas: 2012-13 season



SFF Year 1 – Crop monitoring

- 18 potato crops monitored
  - Three in Pukekohe/Pukekawa
  - Three in Manawatu
  - 12 in Canterbury
- Shadehouse experiment
  - Soil collected from the 18 crops
  - Formalin dipped seed of the same line planted

SFF Year 1 - Summary

- Severities of rhizoctonia and spongospora diseases were less in the treated shadehouse plants than seen in the field

- This suggests that the higher disease levels expressed in the field may have resulted from **infected seed**

- Once again, dense sub-soil layers and cultivation pans are limiting deeper root growth and development

SFF Year 2 - Quantifying the impact of seed health

- One region – Canterbury
- 15 fields with four crop history types (last 10 years):
    1. **'Diseased/Good structure'** >5 years grass + 1 potato crop
    2. **'Diseased/Poor structure'** >5 years non restorative + 1 potato crop
    3. **'Clean/Good structure'** >5 years grass + NO potatoes
    4. **'Clean/Poor structure'** >5 years non restorative + NO potatoes
- One trial in each field (4 plots each):
- Two cultivars: Russet Burbank, Innovator
- Two seed treatments
    1. 'Clean' seed – formalin dipped
    2. Untreated seed.

Seedborne disease

Glasshouse:

» Random sample of dipped/undipped seed grown in sterile potting mix in glasshouse (10 replicates)

» All seed produced diseased plants (root galls, stem canker)

» Formalin only slightly reduced rhizoctonia severity

Field:

» No measureable formalin effect

Conclusion:

» Formalin dipping (commercial) was ineffective in our study

Effect of paddock history on rhizoctonia

- Stem canker incidence was affected by crop history (and seed):
  - 75% chance of disease from a potato-free 10 year rotation
  - 92% chance from having **potatoes previously**
  - 70% chance of disease from a 6 - 9 year cropping history
  - 83% chance from a 7-10 year **grass history**

Effect of paddock history on spongospora

- Spongospora root gall and powdery scab disease incidence was affected by crop history (and seed):
  - 24% chance of disease from a potato-free 10 year rotation
  - 73% chance from having **potatoes previously**
  - 3% chance of disease from a 6-9 year potato-free cropping history
  - 46% chance from a 7-10 year **grass history**

However!

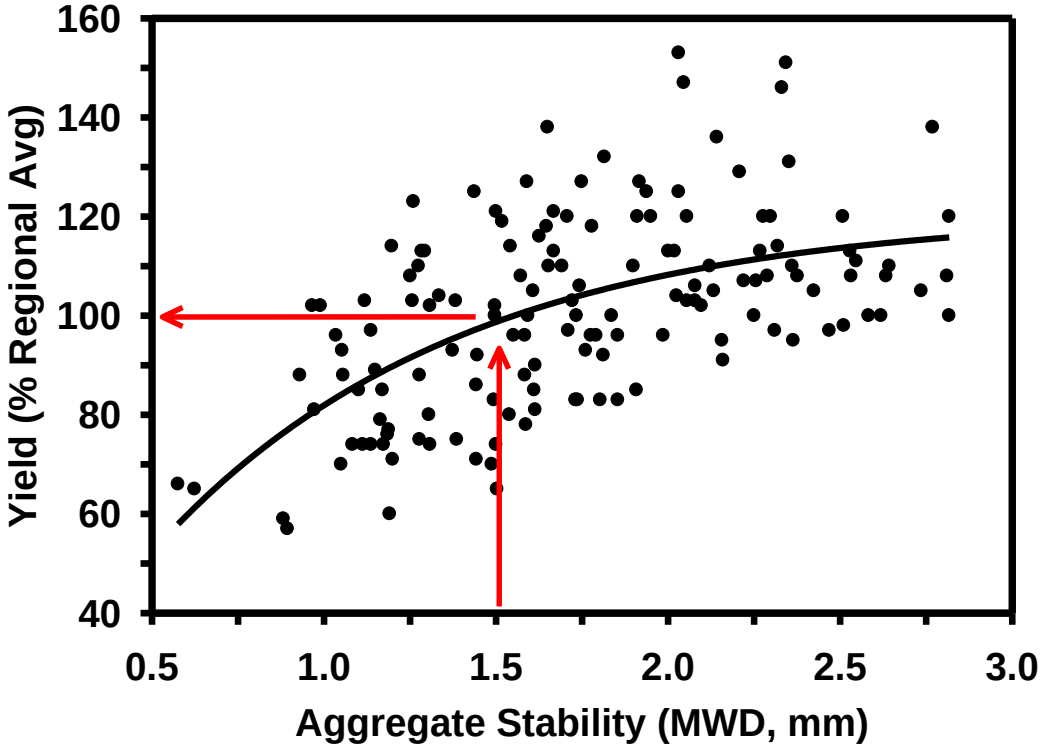
- There was **no yield reduction** from these increased disease levels resulting from a grass and/or potato history
- In fact, marketable **yield was greater** from a grass history:
  - Grass = 79 t/ha
  - Cropping = 69 t/ha

- Soil physical quality…our other main yield-limiting factor

How was soil structure related to yield? Methods

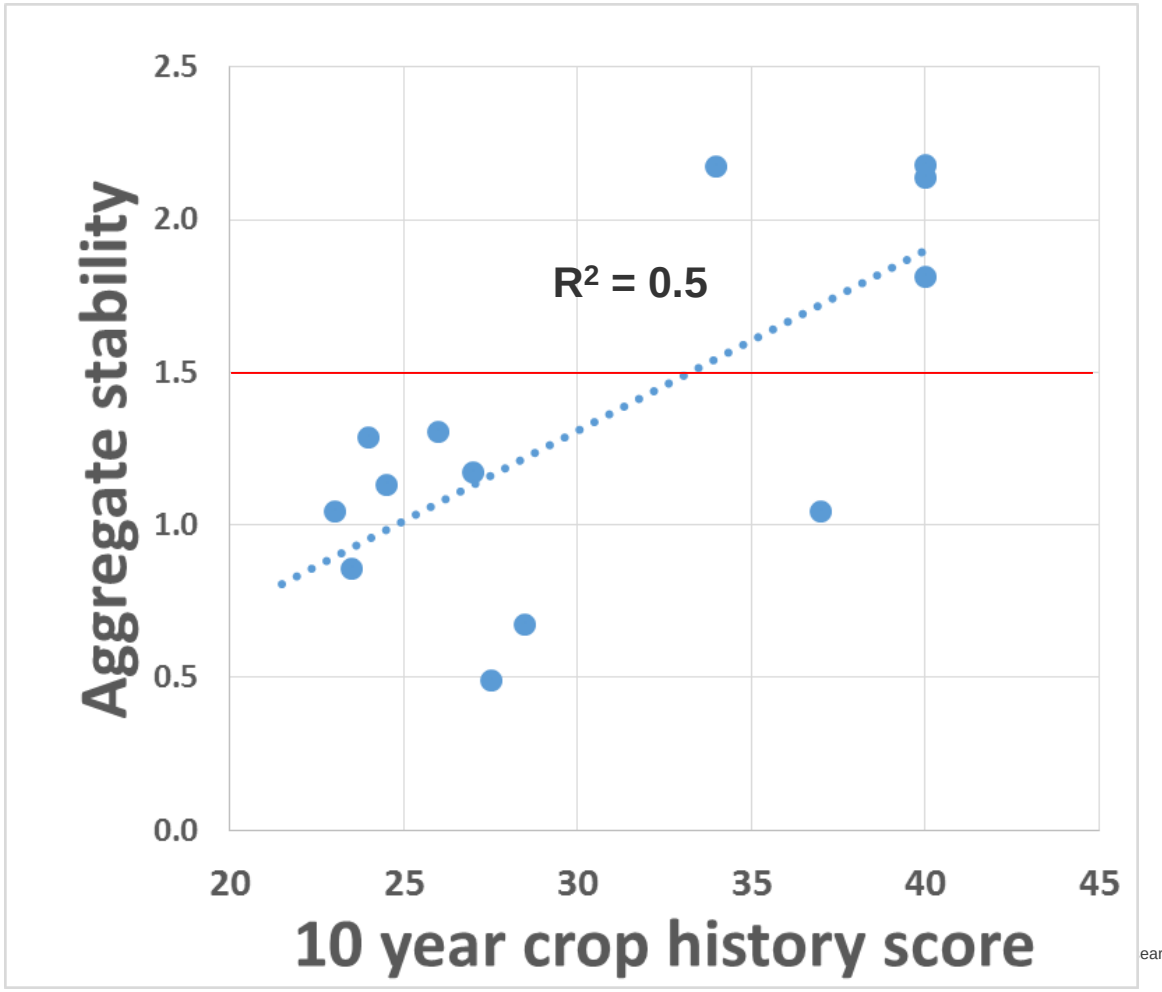
10 year Crop History Score

- 0 = fallow
- 1 = e.g. potatoes
- 2 = e.g. peas
- 2.5 = cereals
- 4 = grass



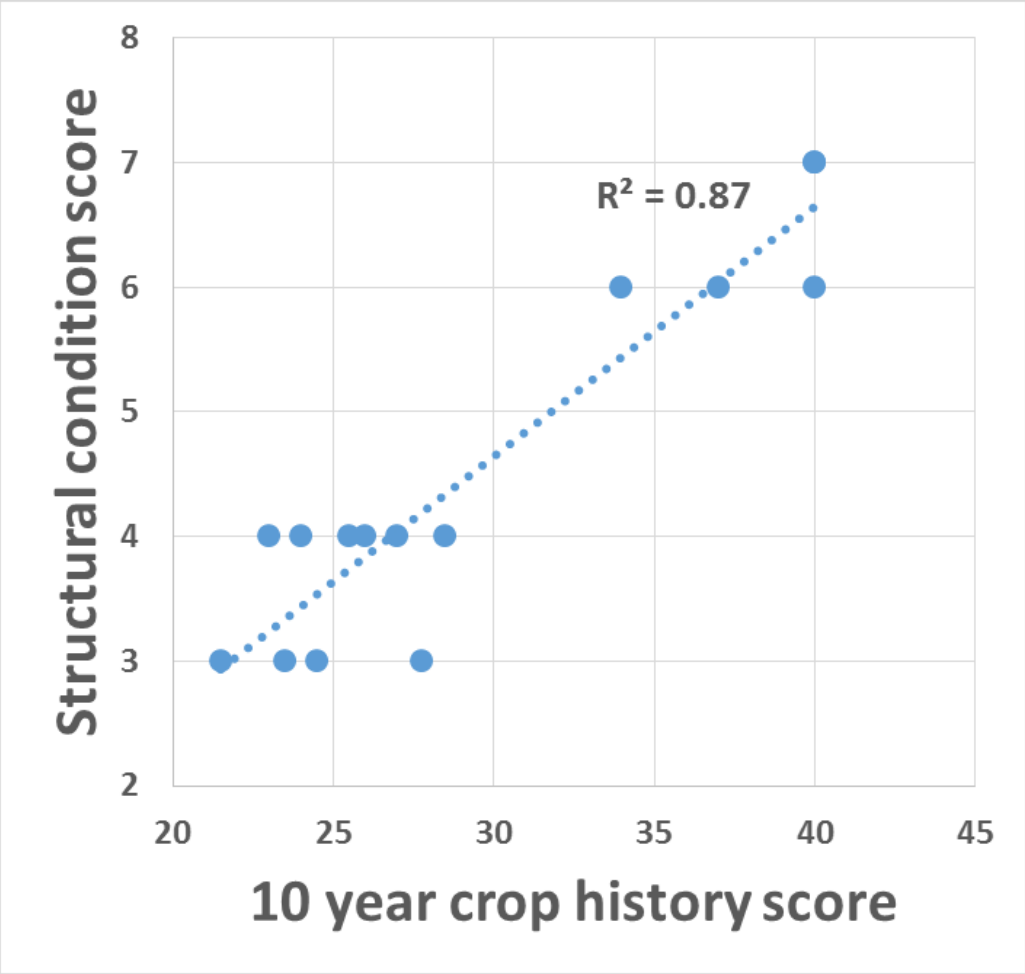
Aggregate stability and crop history

- A higher Aggregate Stability (AS) = improved **soil resilience**
- Crop History Score correlated well with AS (higher = more grass)

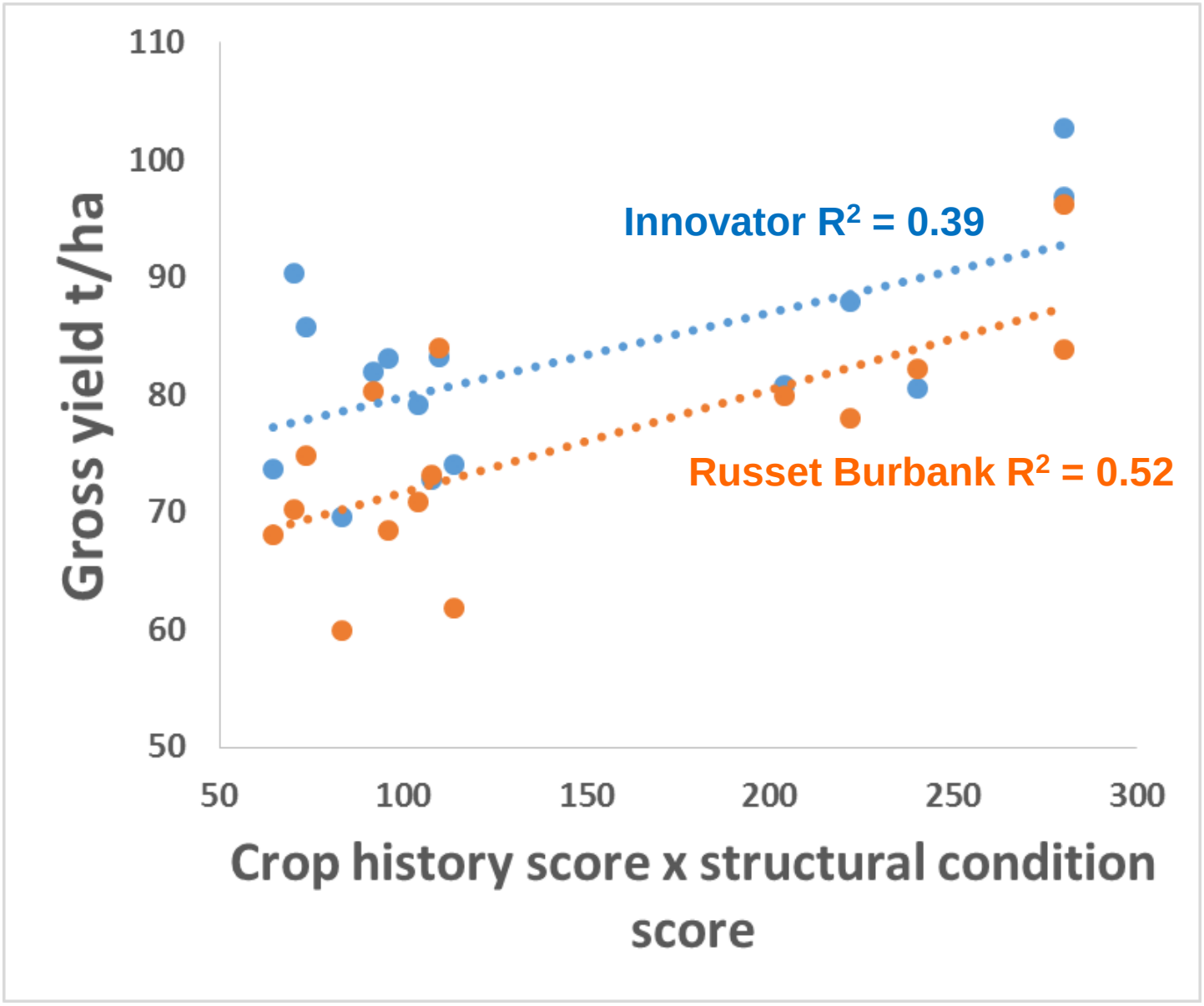


Structural condition score and crop history

- A higher Structural Condition Score = better **root hospitality**
- SCS correlated well with Crop History Score (higher = more grass)



Yield vs our two soil quality measures (P = 0.007)



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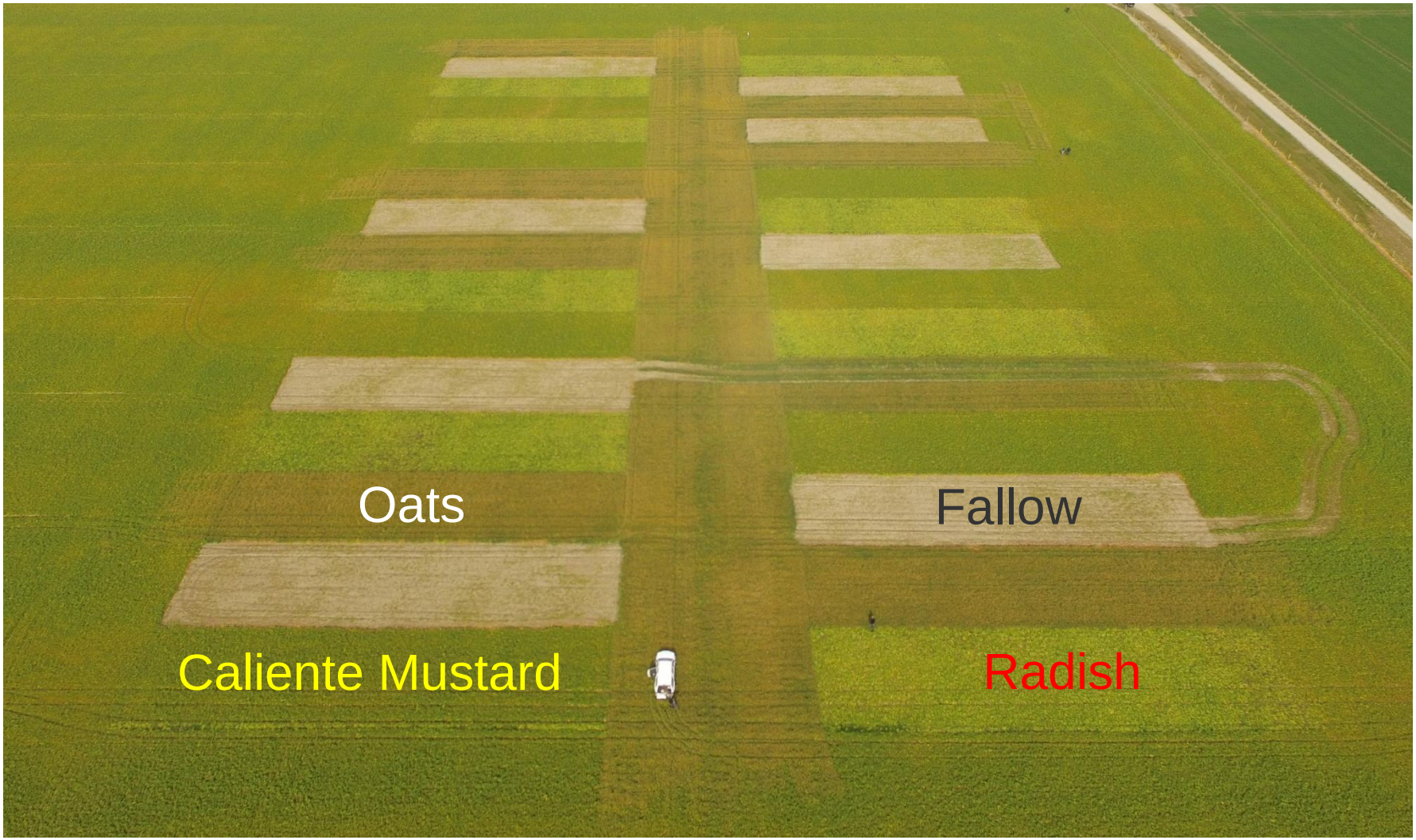
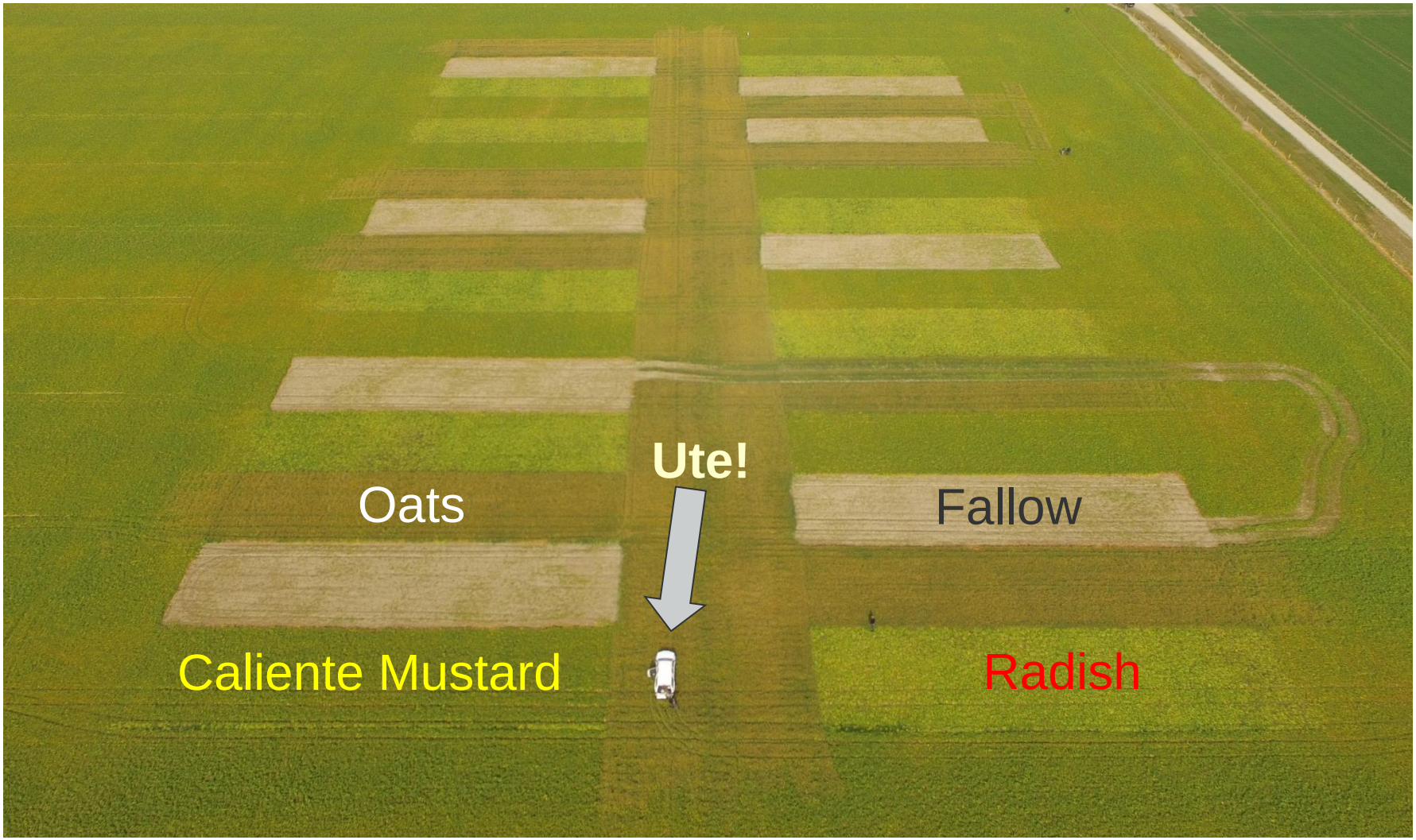
SFF Year 2 – Can biofumigation control soilborne disease?



SFF Year 2 – Can biofumigation control soilborne disease?



SFF Year 2 – Bio-fumigation trial

- Sown – 30th March 2016
- Mulched/Incorporated – 6th September 2016
- Yield (t DM/ha):

Fallow	0.7
Mustard	3.1
Oats	3.8
Radish	4.7

- Potatoes planted – 19th October 2016
  - No in-furrow treatment was applied

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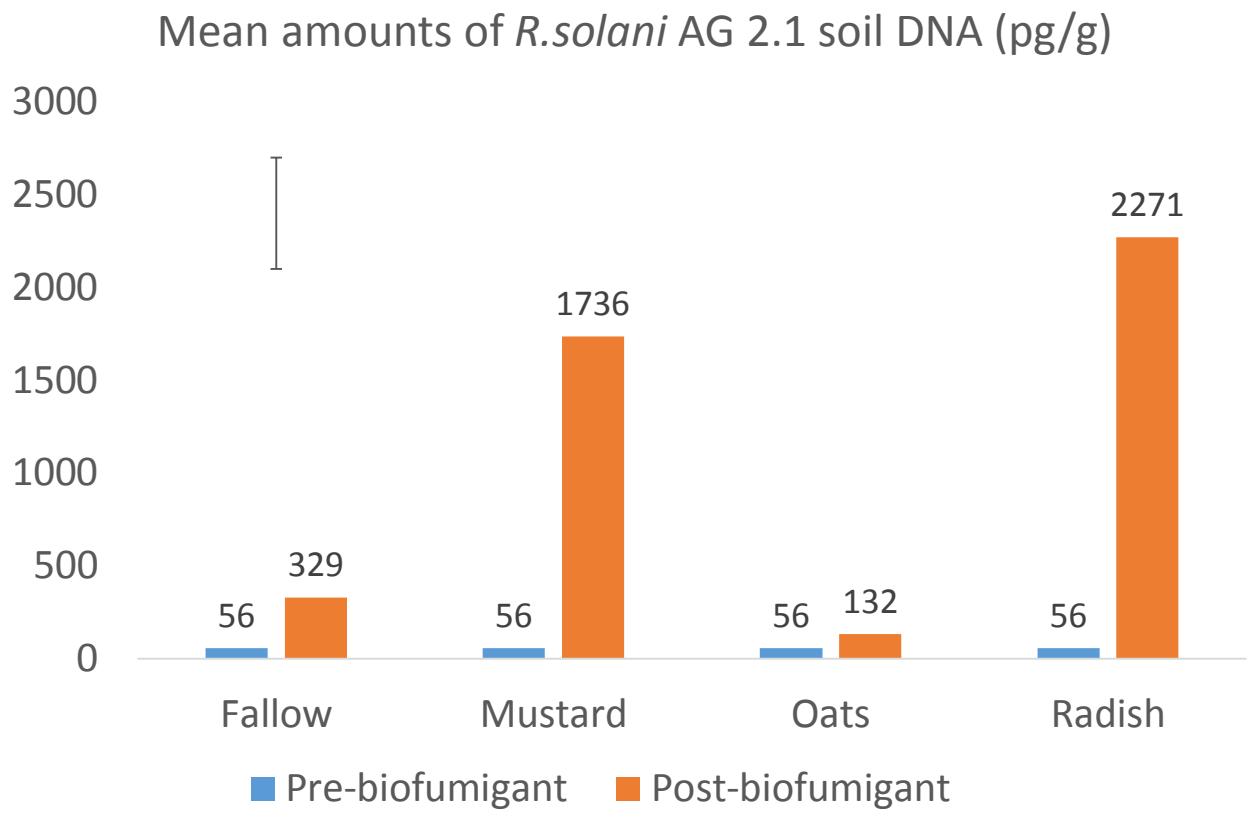
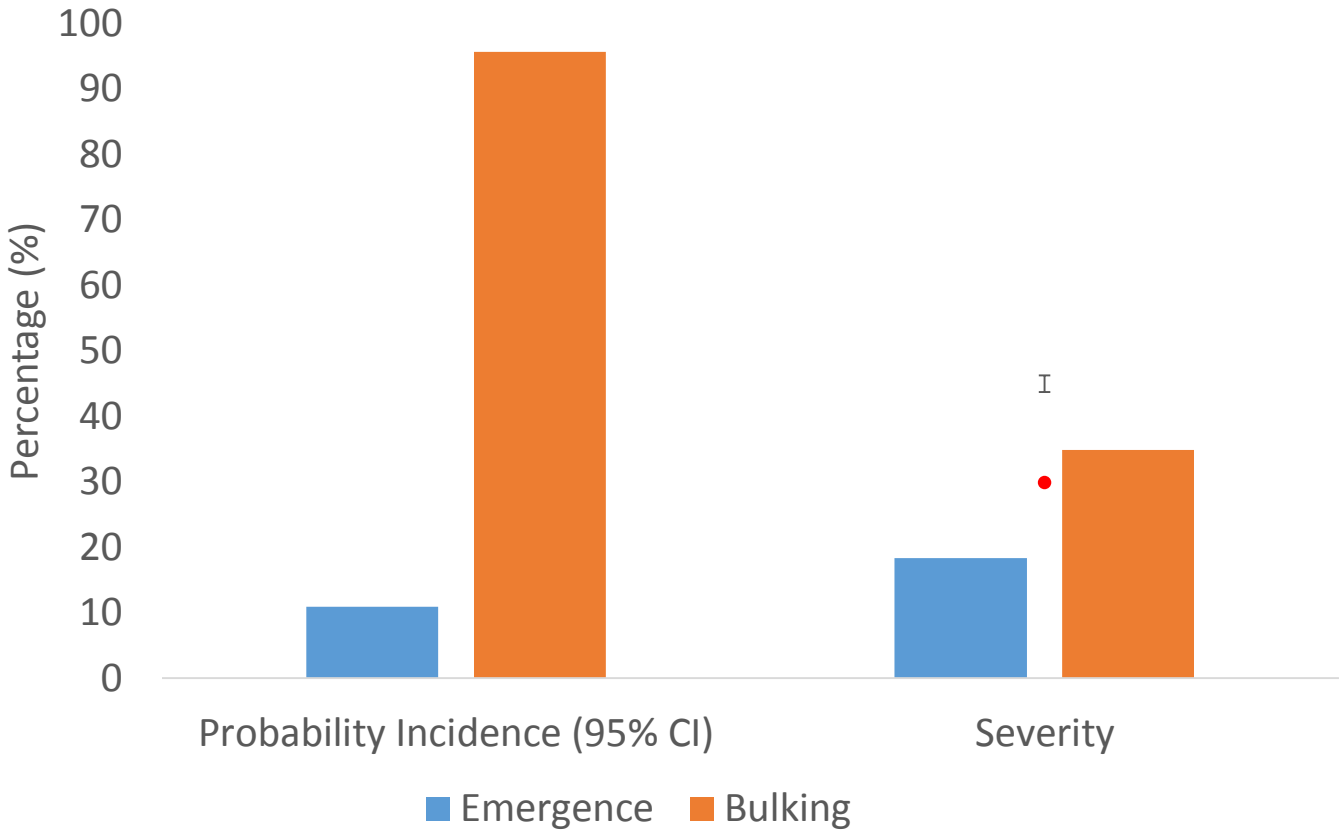


- Increased levels of *Rhizoctonia solani* observed in mustard and radish treatments
- DNA amounts in the soil of all other pathogens including *Spongospora subterranea* did not change

Rhizoctonia incidence and severity



- High incidence of rhizoctonia stem canker late in the season
- >30% severity has been shown to reduce overall potato yield

Spongospora subterranea

Crop	Root gall severity (2 = 5-20 galls/plant)	Powdery scab severity (1 = 5%)
Fallow	1.71	0.25
Mustard	1.58	0.30
Oats	**1.25**	**0.17**
Radish	1.75	0.20
l.s.d	0.37	0.10

» Root gall and powdery scab severity was lowest in the 'Oat' treatment

No difference in yield was measured

Marketable yield = 74 t/ha

Summary

- Seed used in the trials was contaminated and must have contributed to disease levels in the field.
- Disease levels in the trials were increased by grass and previous potatoes in the history.
- However, soil physical structure was improved under long-term grass and contributed to increased potato yields.
- Biofumigation crops were ineffective in controlling soilborne disease in our potato crop.

Thank You!