Control strategies for potato early dying

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Potato early dying (PED) has been observed in various fields in Limpopo. The disease manifests as the premature senescence and ultimate death of a potato plant. The cause of PED in Limpopo was determined to be the result of a combination of soilborne pathogens and plant stress. The best long-term and environmentally friendly option for the control of soilborne diseases is through the improvement of soil health.

Soil biology is a major component of soil health and contributes significantly to soil quality and productivity. There is a great need to ensure that the introduced soil management practices improve soil quality and will also result in and maintain healthy soil.

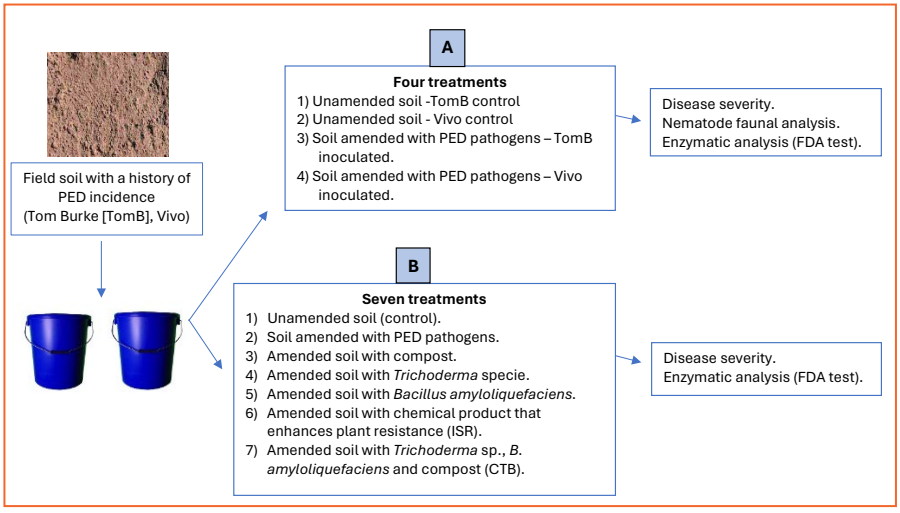
Objective A: Establishing a PED screening system

Greenhouse trial

Soil was collected from potato fields with a history of PED problems. Certified potato tubers (Mondial) were planted in 25-litre plastic buckets filled to 70% capacity. The plastic buckets contained soil either from Tom Burke or Vivo.

For the first month, greenhouse day/night temperatures were 28/13°C. In the second month, day/night temperatures were increased to 30/17°C, and further increased for the third and fourth months to day/night temperatures of 38/20°C. Pots were arranged in a randomised block design on the greenhouse benches.

Figure 1: Diagrammatic illustration of the materials and methods used.



The plants grew vigorously in the early stages without any signs of abnormality or disease. Plants showed yellowing and wilting from 12 weeks onwards.

Enzymatic analysis

Fluorescein diacetate hydrolysis (FDA) is an accepted technique and an accurate and simple method for measuring total microbial activity in a range of environmental samples, including soils. Compost materials can stimulate microbial activity and nutrient mineralisation due to their high organic matter content. An increase in total microbial activity and microbial biomass may lead to an

Figure 2: Soil enzyme activity of Tom Burke and Vivo soils before and after the greenhouse trial.

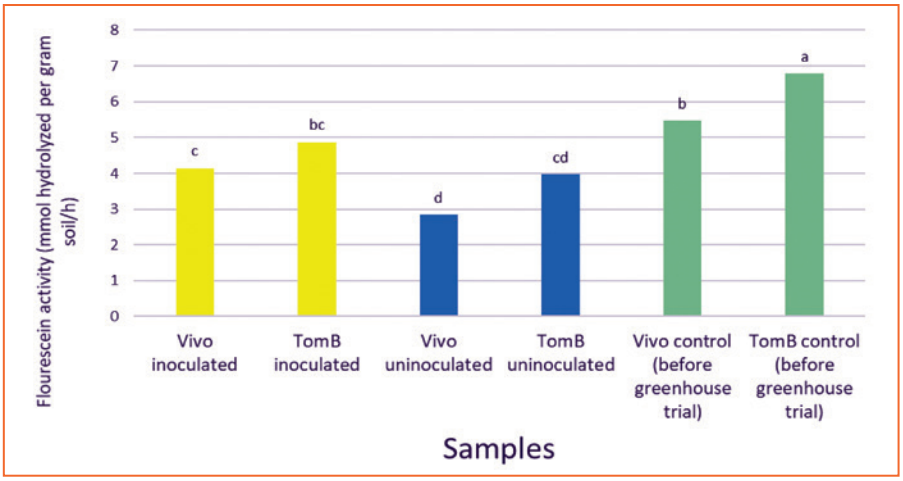
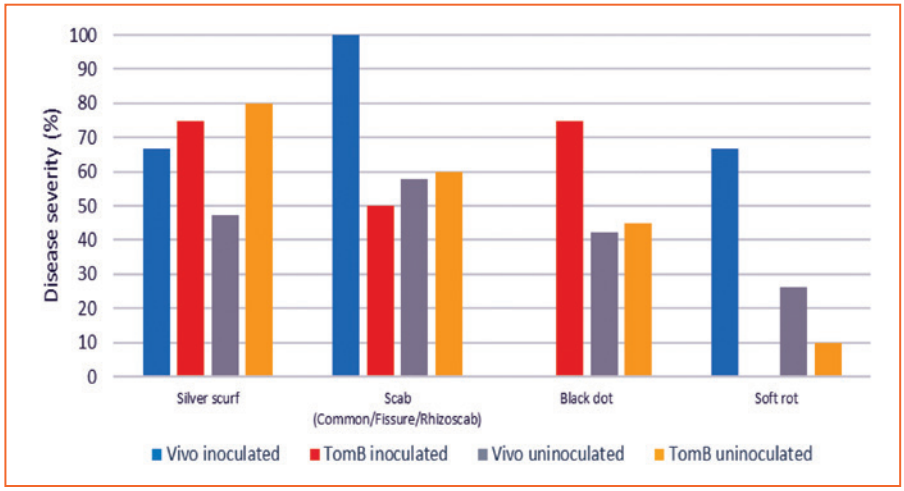


Figure 3: Disease symptoms on harvested tubers for soil collected from Tom Burke and Vivo.



increase in competition for beneficial organisms, which will suppress the pathogenic organisms in the soil.

The soil enzyme activity was high at the start of the greenhouse trial. At the end of the trial, the soil enzyme activity was significantly reduced in both Vivo and Tom Burke soils. The enzyme activity was also significantly lower in the Vivo soil that was not inoculated compared to inoculated soil. Thereby, the active biomass declined over time.

Tuber evaluations

Tubers harvested showed severe symptom development of black dot, silver scurf and scab, whereas only a few tubers showed soft rot symptoms (*Figure 3*). The high incidence of black dot on the tubers correlates with results from the fungal analysis of the plant material as several *Colletotrichum* isolates were obtained, as well as previous results from isolates obtained from diseased PED samples.

Pratylenchus sp. was isolated in very low numbers (only three individuals) from the soil. This result is similar to results obtained from samples previously collected in commercial fields with a history of PED in Limpopo. Based on these results, we do not believe that *Pratylenchus* spp. is a major role-player in PEDs in South Africa. Similar results were obtained for *Meloidogyne* spp., as only eight juveniles were extracted.

In this study, there was a high ratio of bacterial to hyphal-feeding nematodes. A high ratio of bacterial to hyphal-feeding nematodes indicates that nutrient cycling is occurring rapidly through bacterial decomposition, and it is an indication of disturbed soil. The soil used in the study was transported from Limpopo to Gauteng.

A predominance of fungal-feeding nematodes indicates that the food web is dominated by fungi and that biological nutrient cycling will be relatively slow, and soils are relatively undisturbed. The results of this study showed low numbers of fungal-feeding nematodes, therefore indicating that the soils are disturbed.

The number and biodiversity of the omnivorous nematodes were extremely low. Low populations of omnivorous nematodes indicate that the soil biology is likely to be affected by excessive fertiliser inputs, but also by disturbance through practices such as tillage. High populations of omnivorous and predatory nematodes can suppress soilborne pathogens.

Objective B: Determining the effect of soil health on the severity of PED

The goal was to determine the effect of soil health on the severity of PED. Tubers harvested had symptoms of black dot, silver scurf and scab, while only a few tubers showed soft rot symptoms (*Figure 4*). The effect of the different treatments such as compost and biological control agents on tuber diseases was also evaluated.

Table 1: Nematode analysis of soil after the greenhouse trial.

	Total plant feeder	Total sedentary parasites	*Meloidogyne* sp.	Total migratory endoparasites	*Pratylenchus* sp.	Total semi-endoparasites	Total ectoparasites	Total epidermal cell and root hair feeders
Vivo inoculated	0	0	0	0	0	0	385	0
Tom Burke inoculated	253	0	0	0	0	0	253	0
Vivo uninoculated	358	0	0	1	1	0	358	0
Tom Burke uninoculated	894	8	8	2	2	0	872	9
	Total hyphal feeders	**Total bacterial feeders**	**Total substrate ingestion**	**Total animal predation**	**Unicellular eukaryote feeding**	**Dispersal or infective stages of animal parasites**	**Total omnivorous**	**Total nematodes**
Vivo inoculated	205	2710	0	30	0	0	0	3 135
Tom Burke inoculated	20	235	0	10	0	0	0	518
Vivo uninoculated	71	293	0	13	0	0	0	735
Tom Burke uninoculated	77	417	0	13	0	0	3	1 342

However, none of the treatments significantly reduced the disease incidence.

Figure 4 indicates the effect of the different treatments on disease severity. Treatments include control (unamended soil), inoculated (soil amended with PED pathogens), amended soil with compost, amended soil with *Trichoderma* species, amended soil with *Bacillus amyloliquefaciens*, amended soil with chemical products that enhance plant resistance (ISR), and amended soil with Trichoderma sp., *B. amyloliquefaciens* and compost, *Trichoderma* sp. and *Bacillus amyloliquefaciens* (CTB).

The soil enzyme activity was relatively high at the start of the greenhouse trial. The addition of compost and CTB significantly increased the soil enzyme activity. Higher soil enzyme activity may result in an increased active biomass in the soil leading to increased competition with the pathogen complex. At the end of the greenhouse trial, the soil enzyme activity was significantly reduced in the control (uninoculated and inoculated).

Figure 4a: Effect on common scab.

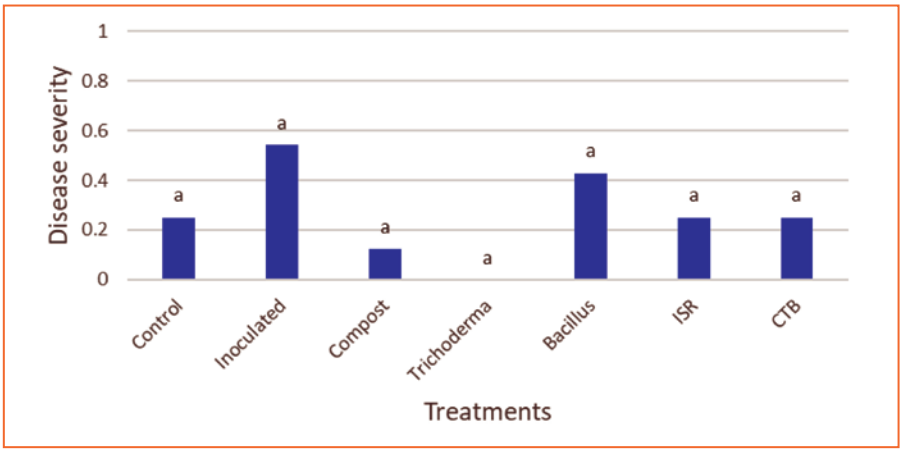
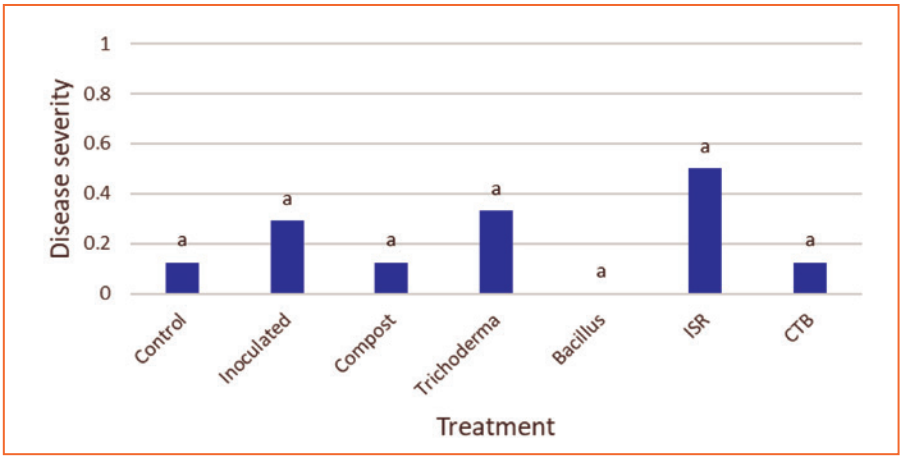


Figure 4b: Effect on fissure scab.



The depletion of nutrients in the soil through bacterial uptake can negatively influence the microbial biomass in the soil, thereby lowering the enzyme activity. There was no significant difference in the soil enzyme activity after the trial in the following treatments:

- Soil inoculated with *Bacillus*.
- Soil inoculated with *Trichoderma*.
- Amended soil with chemical products that enhance plant resistance.

Mondial plants after eight weeks in the greenhouse trial. The tubers were planted in 25ℓ buckets with either soil from Tom Burke or the Dendron area, with a history of potato early dying.

Conclusions

Certified potato tubers (Mondial) were planted in soil that was collected from sites with a history of problems with PED. The trial was conducted under greenhouse conditions with cooler nights at the beginning of the trial and extreme heat stress in the latter part of the study. Plants showed typical PED symptoms after 12 weeks.

Several fungal pathogens were isolated from root and stem tissues and included *Verticillium* sp., *Colletotrichum* sp., *Fusarium* sp., *Rhizoctonia* sp. and *Alternaria* sp. These isolates correlated with the pathogens isolated from diseased plant material samples previously collected in commercial fields with

Figure 4c: Effect on silver scurf.

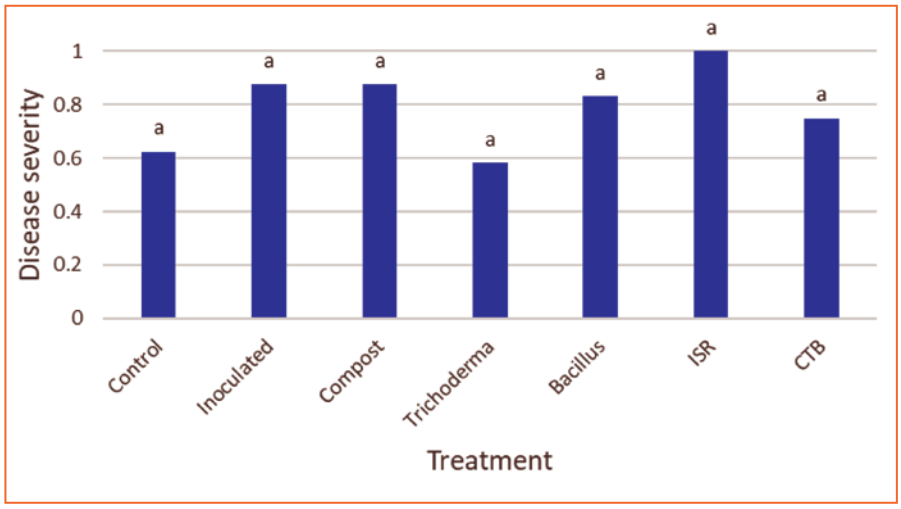


Figure 4d: Effect on soft rot.

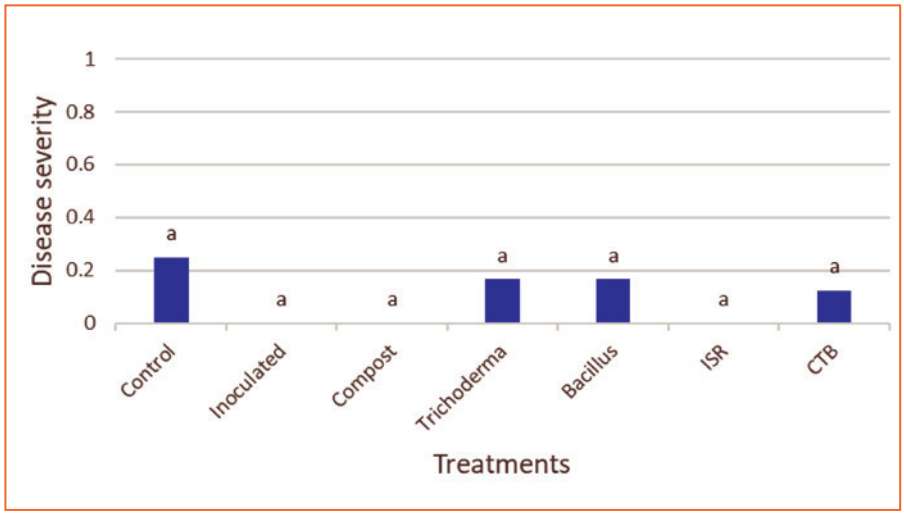
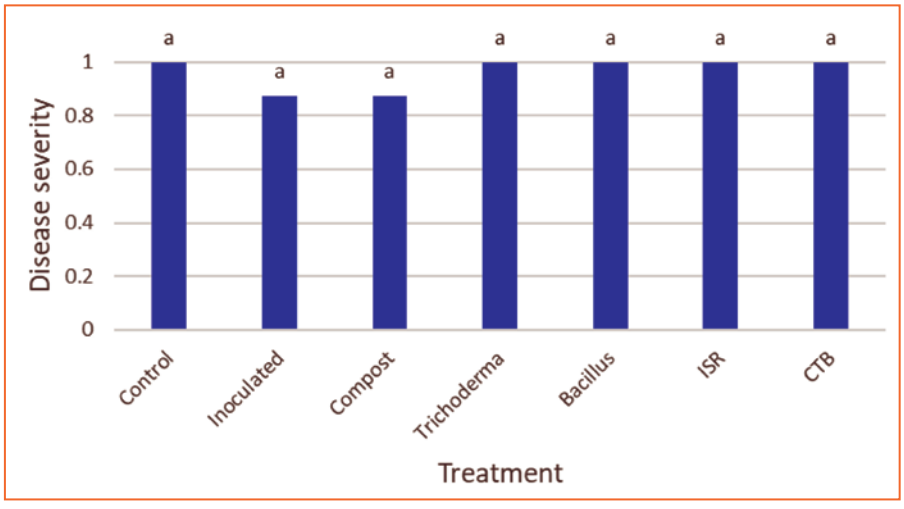


Figure 4e: Effect on black dot.



Mondial plants after 14 weeks. Plants showed signs of early dying.

a history of PED in Limpopo. Thus, a screening system against PEDs was established under greenhouse conditions.

The addition of compost and two biological control agents did not significantly reduce the disease severity in the greenhouse trial. Commercially available biocontrol agents may not be able to cope with the high heat stress conditions that lead to PED.

Further studies should be conducted to identify strains that may be better adapted to the conditions in Limpopo and may be better able to compete with the PED pathogen complex. Global warming is a reality and will increase stress conditions in plants.

Likely, PED will dramatically increase in the future as it is linked to plant stress. Using greener technologies to increase plant resilience and reduce disease severity and incidence is vital. We suggest that field trials should be performed to assess the effectiveness of various biocontrol agents under field conditions.

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