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HORTICULTURE

Grower Summary

CP117a

Coriander Yield Decline: potential management options

Final Report July 2018

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Location of project:	Edinburgh Napier University/SASA (Science and Advice for Scottish Agriculture)
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GROWER SUMMARY

Headlines

- Shallow soil disturbance to reduce compaction before sowing a second crop of coriander, reduced yield decline in pot trials.
- Soil drying and sterilisation, both practices that altered soil microbe populations, were effective in reducing coriander yield decline in pots, providing further evidence for a microbiological cause.
- *Soils from a healthy coriander crop had a very different fungal community to those of a coriander crop with yield decline at the same farm.*

Background

Coriander (Coriandrum sativum L.) has been grown commercially in the UK since the 1970s. It is now the UK's most economically important herb, accounting for over 25% of the fresh herb market. The crop suffers from an acute form of yield decline which has impacted field production in recent years (Figure 1).

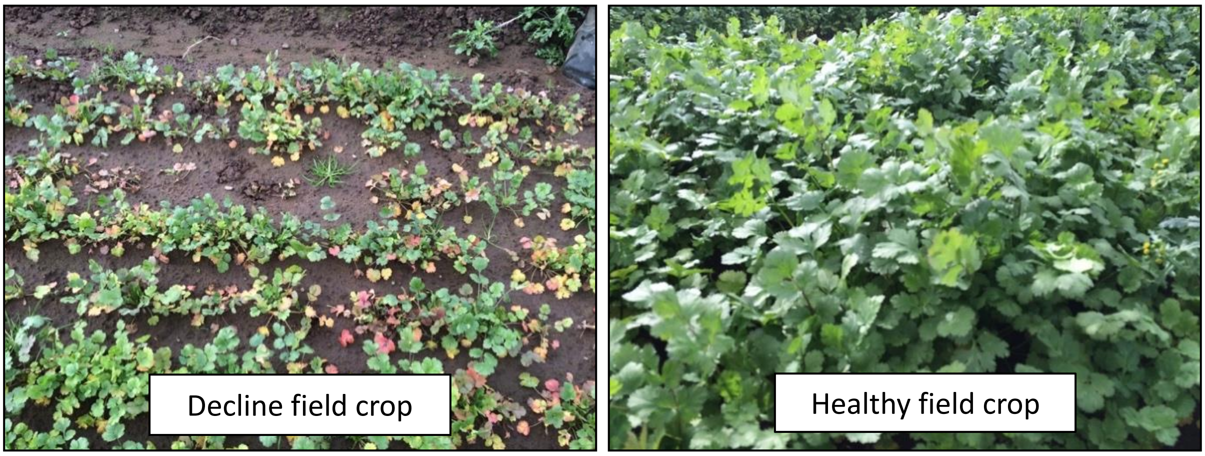


Figure 1. Comparing a yield decline coriander crop and a healthy crop

Although this problem is generally ill-defined, growers have reported yield losses of over 50%; an effect which is said to sometimes persist for up to 8 years. Growers who have access to large areas of land, tend to avoid the problem by using 4-5 year rotations. However, this is not possible for many growers, due to land availability constraints. This problem negatively impacts the UK herb market and new information and management options are urgently needed by growers. Part of the complexity of addressing coriander yield decline is the fact that coriander is grown under highly diverse agronomic practices. The present study was therefore done to i) investigate specific crop and soil management strategies which may reduce the occurrence of coriander yield decline and ii) to evaluate soil microbial communities (microbiome) associated with healthy coriander plants compared to plants showing yield decline. *Following on from CP 117, this project involved a 'proof of concept' approach to evaluate whether methods capable of changing the soil microbial community are able to prevent or reduce coriander yield decline.*

Summary

A series of glasshouse pot trials was carried out to assess crop and soil management practices to reduce coriander yield decline. Figure 2 illustrates the basic method for growing continuous coriander crops in the glasshouse. Coriander was grown for a first cycle in control soils (C1)—those without a prior coriander cropping history. Pots were then subjected to various treatments, before being sown again for a second crop cycle (C2) (using soils with one prior coriander crop) or occasionally a third crop cycle (C3) (using soils with two prior coriander crops).

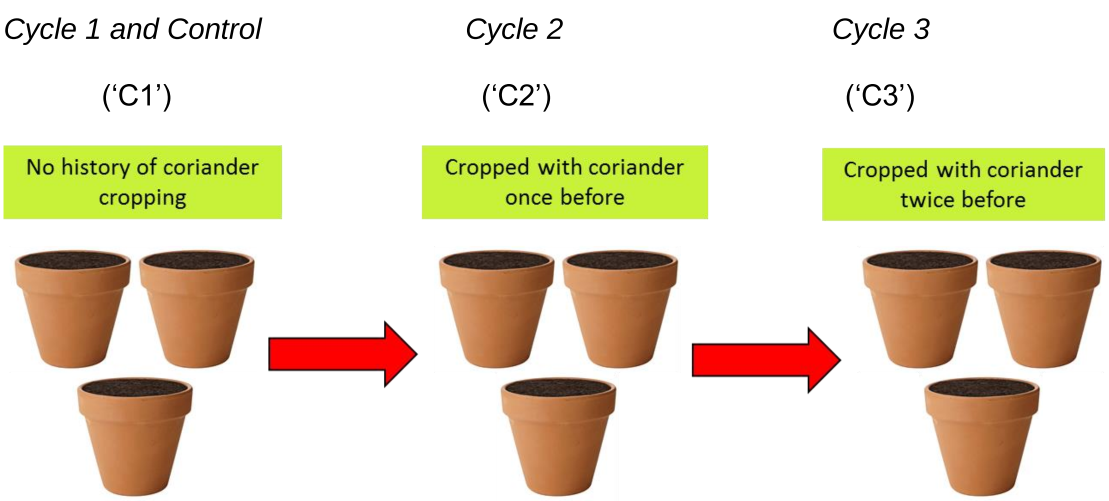


Figure 2. Basic method for growing coriander for two or three crop cycles

Above ground weights were calculated by measuring the combined shoot and leaf weight of individual plants. Total yield per pot was collected by harvesting the above ground plant material at approximately 3 cm above the soil surface.

Findings from selected pot trials are summarised below. Details of all pot trials are included in the Science Section. Overall findings were characterised by high variability within experiments, but suggested that certain practices helped to reduce levels of yield decline experienced in the glasshouse. Techniques which directly altered the soil microbiome (in particular, soil drying and sterilisation) had a greater impact on reducing the levels of decline, suggesting a partially microbiological cause. This effect was supported by the results of soil microbial community studies. While extensive soil drying and sterilisation may not be feasible for field-grown coriander in the UK, the results suggest that further investigation of practices that can 're-set' soil microbiological populations is warranted.

Assessing the impact of harrowing on coriander yield

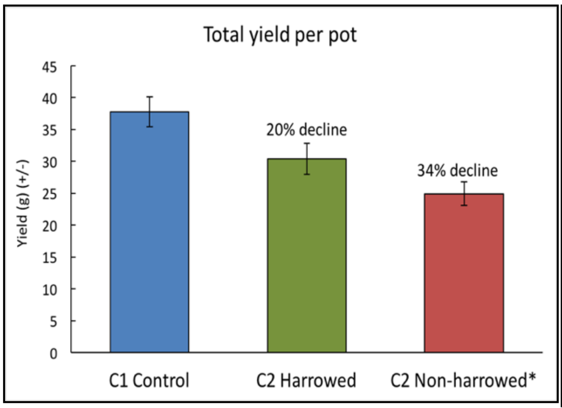
A pot trial was carried out to investigate the impact of shallow soil disturbance (harrowing) on yields of coriander grown for a second crop in the same soils. This experiment involved three treatments:

(1) Coriander grown in fresh soil with no history of coriander cropping ('C1 Control')

(2) Coriander grown in soils that had contained one previous crop, and were harrowed before sowing ('C2 Harrowed')

(3) Coriander grown in soils that had contained one previous crop, but were not harrowed before sowing ('C2 Non-harrowed')

Coriander plants grown in the fresh control soils had significantly higher above ground fresh weights (shoots and leaves of individual plants) compared to C2 Harrowed plants ($p=0.006$); and C2 Non-harrowed plants ($p=0.003$). Total yield per pot for treatments was significantly greater in C1 Control pots (37.8 g) compared to C2 Non-harrowed pots (24.9 g) ($p=0.04$). However, the difference in yield between C1 Control pots and C2 Harrowed (30.4 g) pots was not statistically significant ($p>0.05$). This was reflected in the fact that relative to the C1 Control pots, the C2 Non-harrowed pots declined by 34%, compared to a decline of just 20% in the C2 Harrowed pots (Figure 3). Results indicated that harrowing limited the level of decline experienced when coriander was grown for a second cycle in the same soil.



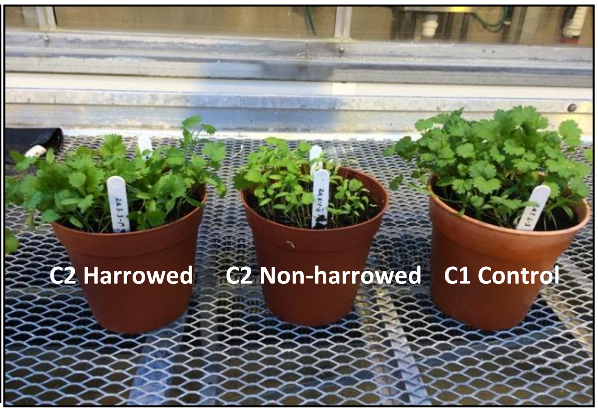


Figure 3. Comparison of mean total yields per pot for the harrowing experiment

Assessing the impact of drying out soils before re-sowing coriander

The soil microbiome of crops is highly influenced by agricultural management practices. One such practice is solarisation, which has been used in southern Spain to avoid the occurrence of coriander yield decline in continuous coriander cropping. Soil drying can perform some of the same functions as solarisation, reducing survival of soil-inhabiting microorganisms and affecting physical and chemical characteristics of a soil.

A pot trial was set up to examine the impact of drying out crop soils before sowing a subsequent crop of coriander in the same soils. This experiment involved three treatments:

(1) Coriander grown in fresh soil with no history of coriander cropping ('C1 Control')

(2) Coriander grown in soils that had contained one previous crop, where these soils were left to dry out for 4 weeks before re-sowing ('C2 Desiccated')

(3) Coriander grown in soils that had contained one previous crop, where these soils were watered daily for 4 weeks before re-sowing ('C2 Watered')

Total yields per pot for the C1 Control pots (41.2 g) and C2 Desiccated pots (39.6 g) were very similar and much larger than C2 Watered pots (16.3 g) (Figure 4). Due to inherent variability of means, this difference was not detected in ANOVA ($p>0.05$). Overall results of this experiment suggest that drying out crop soils before re-sowing coriander may help to alter soil physical or biological properties in a way which reduces the potential for yield decline to occur.

Figure 4: Coriander growth in the soil drying experiment

Assessing the impact of soil sterilisation on a yield decline affected field soil

A grower's field soil containing a healthy crop of coriander was used for a pot experiment. Prior to beginning the experiment, coriander was grown in this field soil in the glasshouse, confirming that yield decline would occur. Subsequent to this, an experiment was set up to determine the effect of sterilisation on yield decline and involved two treatments:

(1) Coriander grown in field soil that had contained one previous crop ('Non-sterilised')

(2) Coriander grown in the same field soil which was sterilised through autoclaving before sowing ('Sterilised').

Plants grown in the field soil that was sterilised produced 70% bigger plants and 50% greater yields per pot, indicating a microbiological causal agent in this instance of coriander yield decline. These differences were significant between the treatments for fresh above ground weight ($p<0.001$), and total yield per pot ($p=0.012$). Figure 5 shows the dramatically larger mean yield per pot when the soil was sterilised (13.2 g), compared to soil that remained non-sterilised (6.2 g).

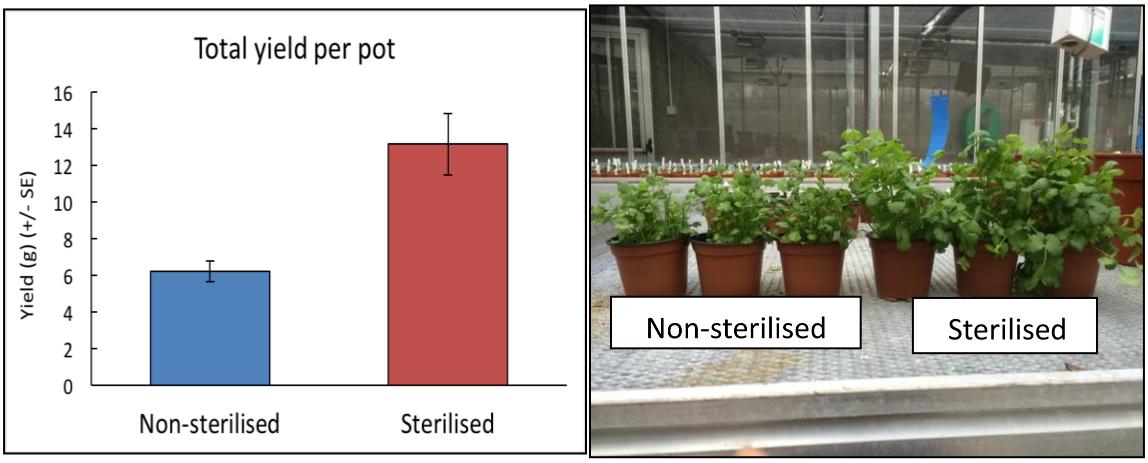


Figure 5: Comparison of Sterilised and Non-sterilised yield decline affected field soils

Microbial community studies of field soils and desiccation experiment soils

Plant and soil samples were collected from a grower's 'healthy' coriander crop and a coriander yield decline (CYD) crop in an adjacent field which showed two levels of decline (severe CYD and moderate CYD). Plants and soils were also collected from the desiccation experiment described above. DNA extracts were prepared for twelve plant samples in order to examine the associated microbial communities. Rhizosphere (RS) and bulk soils (BS) were collected, with 'rhizosphere' constituting soils clinging tightly to roots and 'bulk' soils as those not adhering to roots. Both rhizosphere and bulk soils were taken from the following six soils (for a total of 12 samples): 1) 'Healthy' field soil; 2) 'CYD Severe' field soil; 3) 'CYD Moderate' field soil; 4) Desiccation experiment control soil 'C1 Control'; 5) desiccation experiment 'C2 desiccated' treatment soil; and 6) desiccation experiment 'C2 Watered' treatment soil. DNA sequencing was carried out and classifications of fungi and bacteria were obtained for the twelve samples. Clearly defined differences in the relative abundance of bacteria were not observed within the field soils samples, or the desiccation experiment samples. However, shifts in the relative abundances of fungi were seen in both cases. This was particularly evident in the field soils (Figure 6), where the Dothideomycetes class of ascomycete fungi (with a corresponding reduction in Sordariomycetes), had a much greater relative abundance in the CYD field soil samples, compared to the healthy field soils samples. Dothideomycetes contains many agricultural plant pathogens with high economic impact. The three fungi which contributed most significantly to the abundance of Dothideomycetes in the rhizosphere of the yield decline samples were: *Bipolaris sorokiniana* (pathogen of wheat and barley); *Leptosphaeria maculans* (pathogen of *Brassica* spp., particularly oilseed rape); and *Cenoccocum geophilum* (a common ectomycorrhizal fungus). Overall results provide further support for a microbiological element (likely fungal) in the problem, at least in the case of an affected field soil.

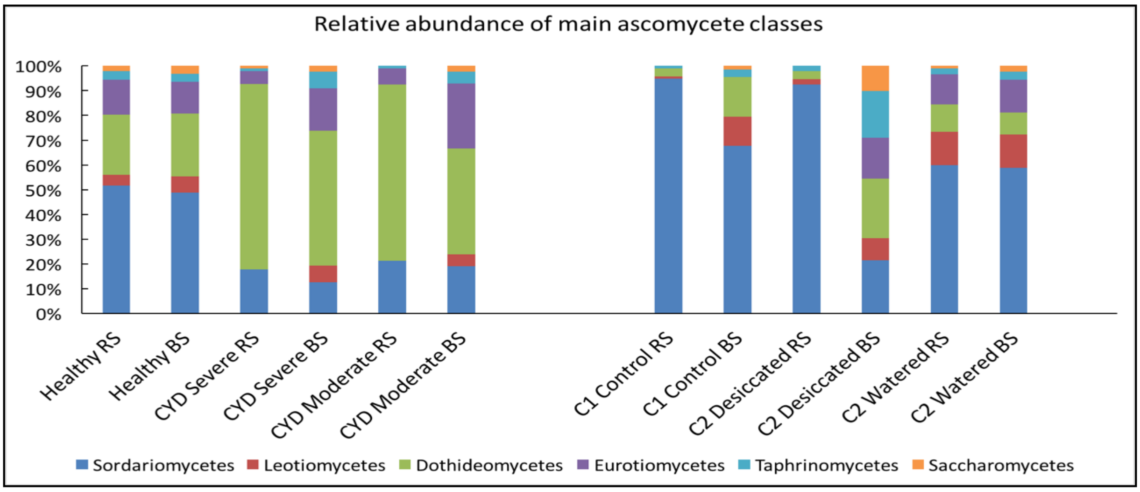


Figure 6: Relative abundance of the main ascomycete classes for two soil types

Figure shows the relative abundances of six ascomycete fungi classes for field soils (left) and desiccation experiment soils (right) with ‘RS’=rhizosphere and ‘BS’=bulk soil.

Pot trials suggested that practices such as soil drying and relieving surface compaction (e.g. harrowing) together with optimum planting densities (see Science Section) could help to reduce the impact of coriander yield decline in the field. However, these techniques need further assessment and field trials to confidently advise growers in changes to cropping practice. Soil sterilisation was effective at eliminating yield decline in an affected soil in pot trials, indicating a microbiological cause for yield decline, and that methods to alter microbial soil populations (e.g. biological soil disinfestation) warrant consideration. Results from the DNA studies also suggest that investigations into potential fungal causal agents could provide further insight into the microbiological causes of CYD.

Financial Benefits

No financial benefits have been quantified.

Action Points

There are no grower action points at this stage. Further research and/or field trials which take into account findings of this project is recommended.