AHDB HORTICULTURE

Grower Summary

CP 113

Investigating the cause and potential treatment of coriander yield decline

Annual 2015

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Before using all pesticides check the approval status and conditions of use.
Read the label before use: use pesticides safely.

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Project title:	Investigating the cause and potential treatment of coriander yield decline
Project number:	CP117
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Report:	Annual report (Year 1), September 2015
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Date project commenced:	1st October 2014
Date project completed (or expected completion date):	30th September 2017

GROWER SUMMARY

Headline

- Coriander yield decline was successfully induced under controlled greenhouse conditions. Traditional microbiological studies suggest that coriander has a clear effect on soil microbial numbers surrounding the plant root (the rhizosphere). Interestingly, this rhizosphere effect varied with plant age and was different between healthy plants and those showing yield decline.

Background

Approximately 1500 hectares of coriander are grown annually. However, due to a lack of space for crop rotations, coriander is grown repeatedly in the same soil in successive years. It is common for plants grown in monoculture / short rotations to suffer from yield decline and coriander appears to be no exception, with growers reporting up to 50% losses in leaf yield. Interestingly, coriander yield decline has yet to be reported in the scientific literature and the phenomenon consequently remains an observation that requires confirmation. Coriander is the biggest selling herb in the UK, with over 30 million packets and bunches being sold in 2014, and so any decline in yield has a significant impact on the UK herb industry. Therefore, it is crucial that the cause of yield decline is established for a potential solution to this issue to be investigated.

There are many different interacting factors that can cause yield decline but observational evidence suggests that this issue has a soil microbiological basis. Hence, the initial aims of this project were to:

a) establish growers' practices and experiences of yield decline using a questionnaire;

b) recreate coriander yield decline under controlled greenhouse conditions to confirm growers observations and;

c) determine the effect of coriander on soil microbial numbers in both healthy and plants showing yield decline.

Summary

The overall aim of this project is to attempt to elucidate the cause of yield decline and to subsequently investigate potential remedies. Initial work focused on the use of traditional microbiological techniques to gain an insight into the effect of cropping coriander on the microbial numbers of both bulk soil, and soil associated with coriander roots (rhizosphere soil). Future work will utilise more complex molecular techniques to investigate these microbial populations in more detail. Furthermore microbe-plant interactions will be studied in more detail to elucidate the effect that microbes could be having on the plant. It is anticipated that if a cause is found then attention can focus on soil management to prevent coriander yield decline.

Questionnaire Findings

The questionnaire asked growers to report the severity of yield decline they experienced. 2 out of 5 growers contacted reported that they suffered no yield decline. Both of these growers suggested that consistent ploughing in between crops may alleviate yield decline. Of the 3 growers who do suffer yield decline, all reported that the issue was worse earlier in the growing season and following cold, wet weather. Furthermore, 2 growers who suffer from yield decline indicated that they get higher yields of coriander when they use soil that has not experienced the crop before. One grower suggested that leaving soil clear of coriander for 4 years before replanting alleviates the issue. However another grower disagreed and reported that yield decline persists even with a 4 year break. When asked about growing regimes, all of the growers reported that they grow 2 crops of coriander in the same soil per season, though gaps left between crops in a season varies between 1 to 6 weeks. The 2 growers who did not experience yield decline had the shortest gap between crops as they ploughed between re-sowing. Most growers use a range of soil types (including sandy loam, sandy clay and silty clays) and varieties, though the most popular varieties were Santos (used by 4 growers) and Cruiser (used by 3 growers). Further communication, focusing on information required to grow coriander in greenhouse conditions, with growers took place after the questionnaire. These discussions provided information on temperature and light settings; fertiliser regimes; and varieties which were utilised in this reports experiments.

Objective 1: Can coriander yield decline be established under controlled greenhouse conditions?

Coriander var. Santos seeds were sown in pots (~12cm diameter) containing ~700g air dried sandy soil collected from a field at Newcastle University Cockle Park facilities, Northumberland with no previous history of coriander cropping. To replicate UK summer growing conditions, plants were exposed to 14 hours of light per day with a maximum air temperature of 20^{o}C during the day and 16^{o}C during the night. 10 weeks after sowing this initial crop was harvested and the same pots were replanted with coriander var. Santos seeds. Coriander var. Santos seeds were also sown in ~700g of fresh (previously unplanted), air dried sandy soil obtained from the same field. Therefore there were 2 treatments, grown under exactly the same growth conditions, with 3 replicates/ treatment: (1) coriander grown in fresh control soils; (2) coriander grown in soil previously planted with coriander once. 9 weeks after sowing both treatments were sampled for plant yield data: total plant fresh and dry weights; leaf area; and root and shoot lengths were measured.

While yield decline is observed in grower's fields, it was not known if this could be replicated under controlled conditions. However, after just 2 crops plants grown in control soil had a greater above ground biomass compared to those in previously planted soils (Fig. 1).

Figure 1. Comparison of observable difference in yield between coriander plants from control soils (treatment 1) and coriander plants from soils previously planted with coriander (treatment 2). Previously planted soil plants are shown on the right side of the picture with control plants on the left.

In particular, shoot and leaf fresh weights (above ground biomass) were over 50% greater in control plants compared to previously planted plants (Fig. 2). Therefore, this study successfully induced yield decline under controlled conditions, with plants grown in soil that had been previously planted with coriander exhibiting significant yield decline symptoms. However, further work is required to show this phenomenon occurs across a range of coriander cultivars and soil types.

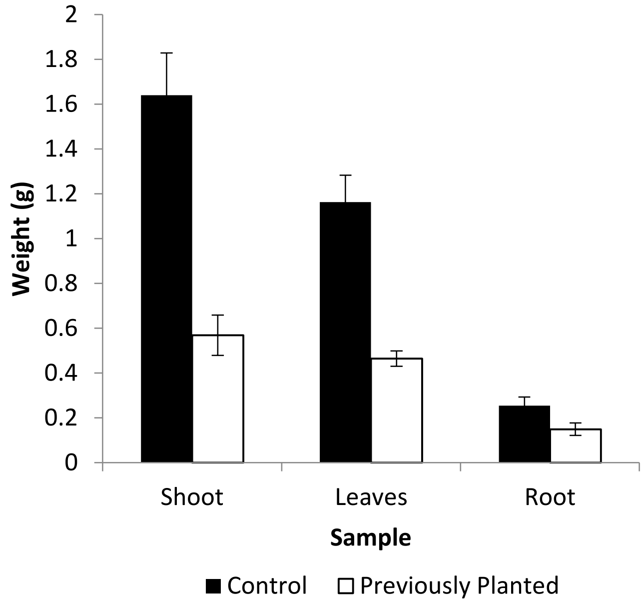

Figure 2. Comparison of mean fresh weights of different tissue types of coriander plants from control soils (treatment 1) and coriander plants from soils previously planted with coriander (treatment 2) (data for other yield parameters is shown in full science report).

Objective 2: Does the coriander rhizosphere have increased microbial numbers compared to bulk soil?

Coriander var. Santos seeds were sown in pots (~12cm diameter) containing ~700g of air dried sandy soil obtained from a field at Cockle Park, Northumberland with no history of coriander cropping. 15 plants were grown per pot with 5 pots per treatment. 2 experimental treatments were used: (1) control, fresh soil containing no coriander; (2) coriander, fresh soil with coriander planted. To replicate UK summer growing conditions, plants were exposed to 14 hours of light per day with a maximum air temperature of 20^{o}C during the day and 16^{o}C during the night. Chlorophyll content of plant leaves was used as an indicator of plant health, and was measured on a weekly basis beginning 5 weeks after sowing. Sampling took place on 2 separate dates: 9 weeks after sowing, and 10 weeks after sowing. At the 1st sampling date (9 weeks after sowing) 2 pots/treatment were sampled. Bulk and rhizosphere soils were sampled from treatment 2 (containing coriander) pots, whilst control bulk soils were sampled from treatment 1 (no coriander) pots. Rhizosphere soil samples consisted of soils adhering to coriander roots, whilst bulk soil samples were classified as soils that were not in close proximity to roots. The remaining 3 pots from each treatment were sampled, in the same manner, 10 weeks after sowing. At both sampling dates, the above ground biomass of any remaining plants from treatment 2 was removed whilst roots were left in the soil. Sampled soils were diluted and isolated on selective media before any viable microbial colonies were counted.

In week 9 coriander rhizosphere soil samples total bacterial and fungal counts were ~3.2×10^6 and ~1.4×10^4 CFU/g soil, respectively; whilst in corresponding bulk soils microbial counts were at least 50% lower. This suggests that coriander roots have a marked effect (rhizosphere effect) on soil microbial populations. The rhizosphere effect is a known phenomenon where, typically, the number of microorganisms in the rhizosphere is greater than in the bulk soil. However, in week 10 coriander rhizosphere soil samples bacterial and fungal counts were reduced to ~4.9×10^5 and ~6.6×10^3 CFU/g soil, respectively; and were no longer different to corresponding bulk soil microbial counts. Therefore, the rhizosphere effect appears to decrease with plant age and decreasing chlorophyll content (Fig. 3). Chlorophyll content was measured on a weekly basis throughout the experiment. Chlorophyll content peaked 7 weeks after sowing but had fallen by 10 weeks after sowing. This drop in chlorophyll content coincides with a decrease in viable counts of rhizosphere soils between weeks 9 and 10 (Fig. 3).

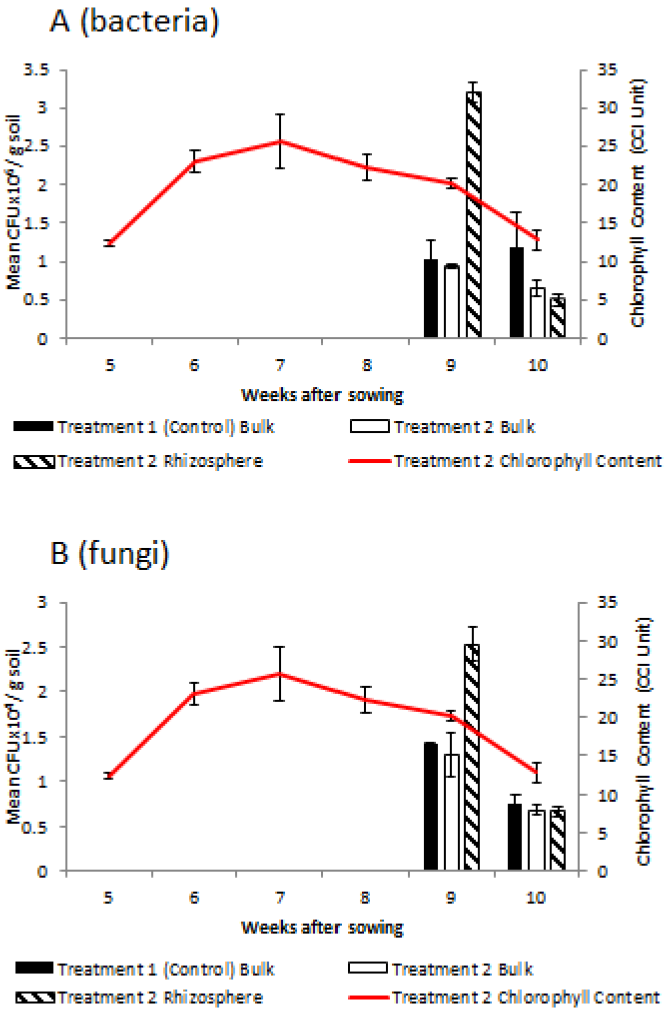

Figure 3. Comparison of mean total viable (CFU/g soil) bacteria (A) and fungi (B) from both treatment soils sampled on 2 separate dates. Sampling of soils took place at 9 and 10 weeks after sowing. Soil samples consisted of control bulk soils from fallow treatment 1 pots, and bulk and rhizosphere soils from coriander containing treatment 2 pots. The red line depicts mean chlorophyll content of the treatment 2 plants and was measured weekly beginning 5 weeks after sowing.

Objective 3: Are microbial numbers (viable counts) associated with plants exhibiting yield decline symptoms different to those found in 'healthy non – decline' plants?

The pots set up in objective 1 were also used to complete this objective. Briefly, there were 2 treatments, grown under exactly the same growth conditions, with 3 replicates/ treatment: (1) control, Coriander var. Santos grown in fresh control soils; (2) previously planted, Coriander var. Santos grown in soil previously planted with coriander once. The chlorophyll content of plant leaves was measured on a weekly basis 5 weeks after sowing. Sampling took place 9 weeks after sowing, 3 pots/ treatment were sampled with bulk and rhizosphere soils being collected from both treatments. At both sampling dates, the above ground biomass of any remaining plants from both treatments was removed whilst roots were left in the soil. Sampled soils were diluted and isolated on selective media before any viable microbial colonies were counted. Interestingly, in plants showing yield decline symptoms an increased rhizosphere soil total bacterial and fungal population was sustained over the 9 weeks of plant growth. For example, in soils obtained from plants showing yield decline, the rhizosphere bacterial and fungal counts were ~$1.6x10^6$ and ~$1.3x10^4$ CFU/g soil, respectively; whilst in soils obtained from similarly aged control plants rhizosphere microbial numbers were at least 90% lower (detailed data is shown in the full report).

Financial Benefits

It is currently too early in the project to identify and deliver any financial benefits. However, the results so far are very interesting, the evidence for a rhizosphere effect means that more fundamental work is required to gain an understanding of what is occurring at the soil microbiological level. Further understanding could lead to the development of applied management methods to alleviate yield decline. Any such remedies would then deliver financial benefit to the UK herb industry.

Action Point

No clear change of practice can yet be recommended.