Project title:	Understanding Resilience of Soil Beneficials to Combat Apple Replant Disease
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Location of project:	NIAB EMR, Kent and Cranfield University, Bedfordshire
Industry Representative:	N/A
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The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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GROWER SUMMARY

Headline

Effect of climate change stresses (CO_2 and temperature increase) on bulk soil microbiome populations over a 5 week period.

Background

There is very little information on how abiotic factors may impact the prevalence of apple replant disease (ARD). The IPCC report suggest an increase in temperature of between 2-4ºC by 2050. Atmospheric CO_2 exposure is expected to increase by at least two times of the current levels (400 vs 800-1000 ppm CO_2) (Intergovernmental Panel on Climate Change, 2014).

Elevated temperature has a profound impact on microbial activity and this reaches an optimum at around 30ºC and then declines at >30-35ºC quite rapidly (Figure 4; BÁRCENAS-MORENO *et al.*, 2009), however soil temperatures, particularly deeper soils, will be unlikely to reach these values in temperate climates. Increased temperature will also lead to increased drought stress if increased water is unavailable. Root length colonisation (RLC) by AMF is increased in drought conditions, exhibiting a shift in the reliance on the mutualistic fungus in dry conditions. This reliance is due to hyphal spanning of air gaps between shrinking roots and soil, increasing water absorption of the target plant (Robinson-Boyer *et al.*, 2009) (Augé, 2004). Drought stress genes also are supressed when inoculated with Rhizobacteria microorganisms in Arabidopsis (Zolla *et al.*, 2013) highlighting the importance of the interaction between beneficial microorganisms and plants in an increasingly stressful climate.

In conditions of elevated atmospheric CO_2, soil organic carbon degradation increases showing how carbon sinks may become carbon sources, increasing global warming (Carney *et al.*, 2007). This change was attributed to increased relative abundance of fungal populations and increased activity of soil organic matter degrading enzymes. Increased CO_2 concentrations also increase soil bacterial diversity initially but the bacterial populations decrease exponentially as atmospheric CO_2 concentrations increase from < 5000 to > 10,000 ppm (Ma *et al.*, 2017).

In this experiment, we aim to understand whether and, if so, effect climate change stresses (namely increased temperature and CO_2 elevation) will have on the bulk soil microbiome of apple orchards. We will be running short term trials exposing bulk soils from both an organic and conventionally managed plot to extreme CO_2 and temperature increases. Next generation sequencing techniques were used to see the impact on soil microbiome populations due to the climate stresses both individually and in consortium.

Summary

In this study, short term work over a 5 week period was conducted to assess the impact of extreme CO_2 and temperature increase on soil microbiome populations using sequencing technologies to compare diversity of fungal and bacterial populations. Bulk soil cores were exposed to increases CO_2 concentrations and temperature increase then populations compared between treatments. The results indicated CO_2 concentration increase did not significantly impact bacterial or fungal diversity in the soils. A temperature increase of 4ºC lowered fungal diversity but did not significantly affect bacterial diversity. Site management highlighted a 50% reduction in diversity on an organic orchard compared to a conventionally managed orchard. Further work on population and functionality differences in apple microbiome will be conducted to supplement this data. These experiments will be cross-referenced with long-term growth data to demonstrate a comprehensive assessment of the effectiveness and potentiality of standardising biological soil amendments to mitigate the effects of ARD in a wider project.

Financial Benefits

It is too early to calculate the financial benefits of this work from this early preliminary data. This work feeds into the larger project concerned with reducing the negative impacts of apple replant disease (ARD) on young replanted trees using biological soil amendments. As ARD is a prevalent disease in both nurseries and in fruit production and ARD onset can be 1-2 years after planting, significant economic losses can occur for growers from both management and prevention of ARD. Fumigation is particularly an expensive pre-plant option, so a transition to using non-chemical soil amendments applied at planting would save growers both money and time managing ARD. This work aims to identify the impact on soil microbiome bacterial and fungal populations due to climate change stresses to inform the long-term work within the project on what impacts climate change stress may have on both biological soil amendments and ARD causal agents. This will benefit growers moving away from chemical amendments.

Action Points

There are no action points for growers as the project is still at an early stage of a 4 year project.