

# Linking Volatile Organic Compounds from Agricultural Soil to the Microbiome

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## Introduction

Soil health indicator devices such as the electronic nose ('E-nose'), provide rapid information to land managers about soil conditions, enabling them to make decisions in a more efficient, timely and cost-effective manner.

These devices detect and measure a range of soil properties but have so far overlooked **Microbial Volatile Organic Compounds (MVOCs)**.

### What are MVOCs?

- Organic chemicals produced by microorganisms that easily transform into a gas or vapour.
- Capable of travelling great distances through soil.
- Can indicate soil health and fertility by reflecting microbial activity, diversity, and interactions.

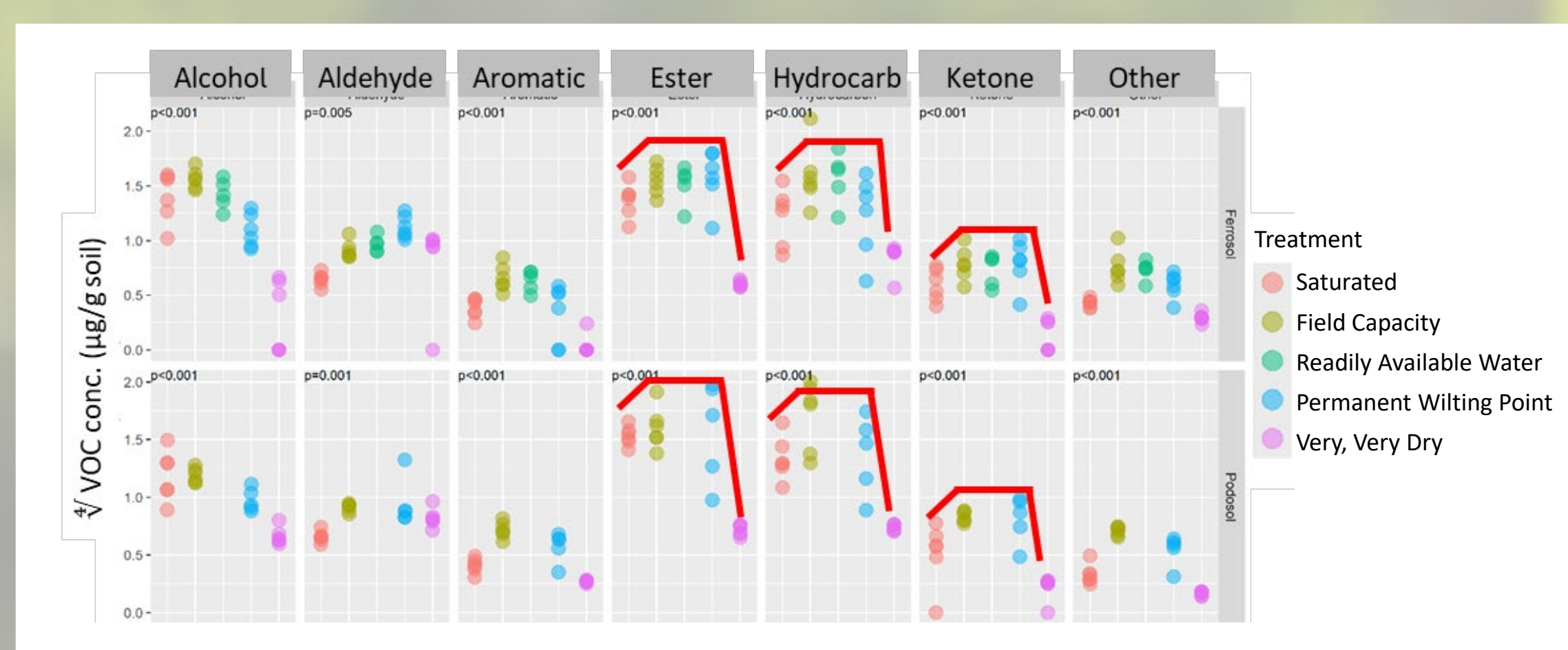
➔ My research investigates the potential use of MVOCs as a soil health indicator that could be detected by an E-nose.

## Step 1a: MVOC and Microbiome Relationship

Initially, I explored the effect of environmental changes on MVOC levels under controlled conditions, using water availability as a stressor.

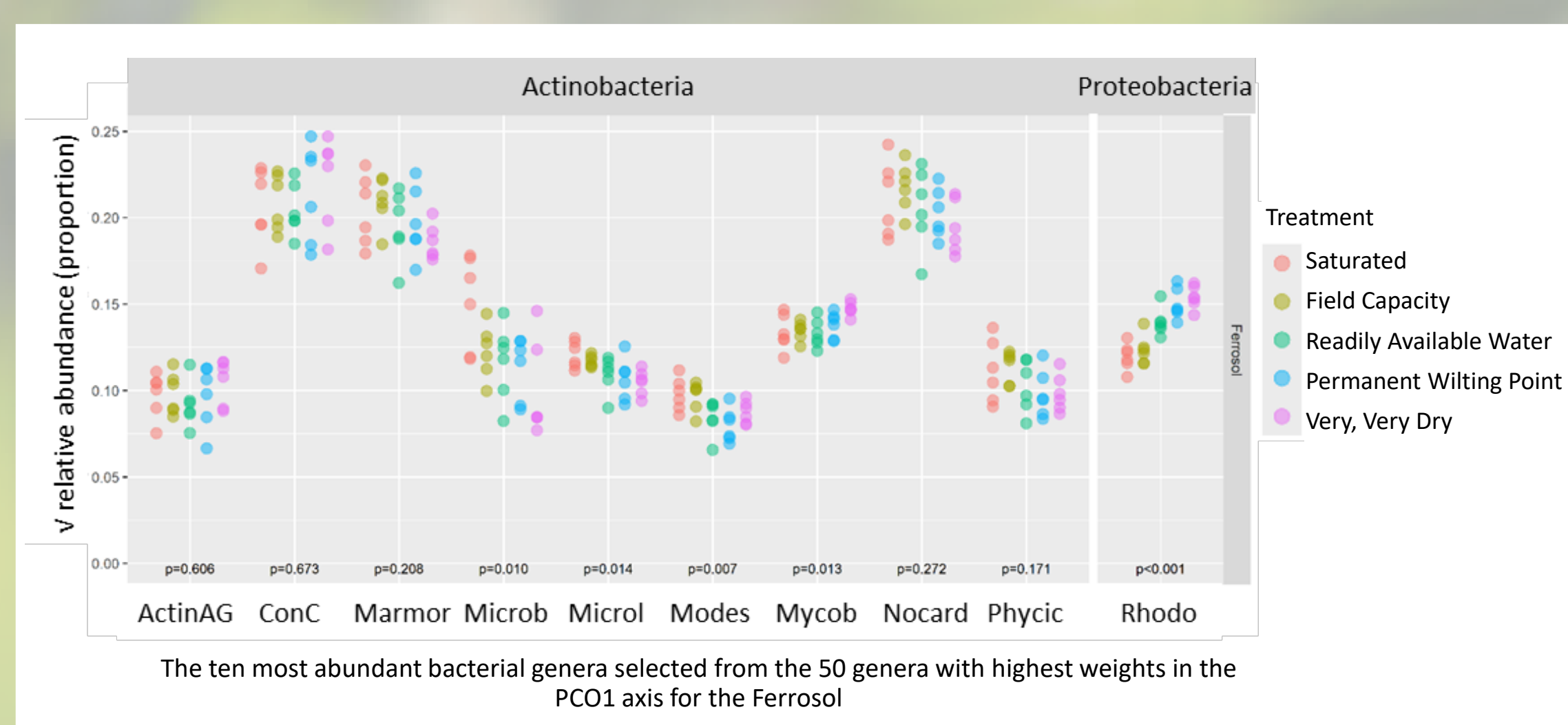
- MVOC levels changed as the soil progressed from saturated to extremely dry.
- Changes in MVOC emissions were consistent across two contrasting soil types.
- Two main patterns of MVOC emissions were detected (Fig 1):**
  - A **'Plateau'** pattern (red lines), where MVOC levels were higher in mesic conditions and lower in extremely high or low water treatments.
  - A more **'linear'** pattern (no lines), with a steady increase or decrease in concentration.

Fig 1:



These patterns were also detected in the relative abundance of both the bacterial and fungal communities (Fig 2).

Fig 2:

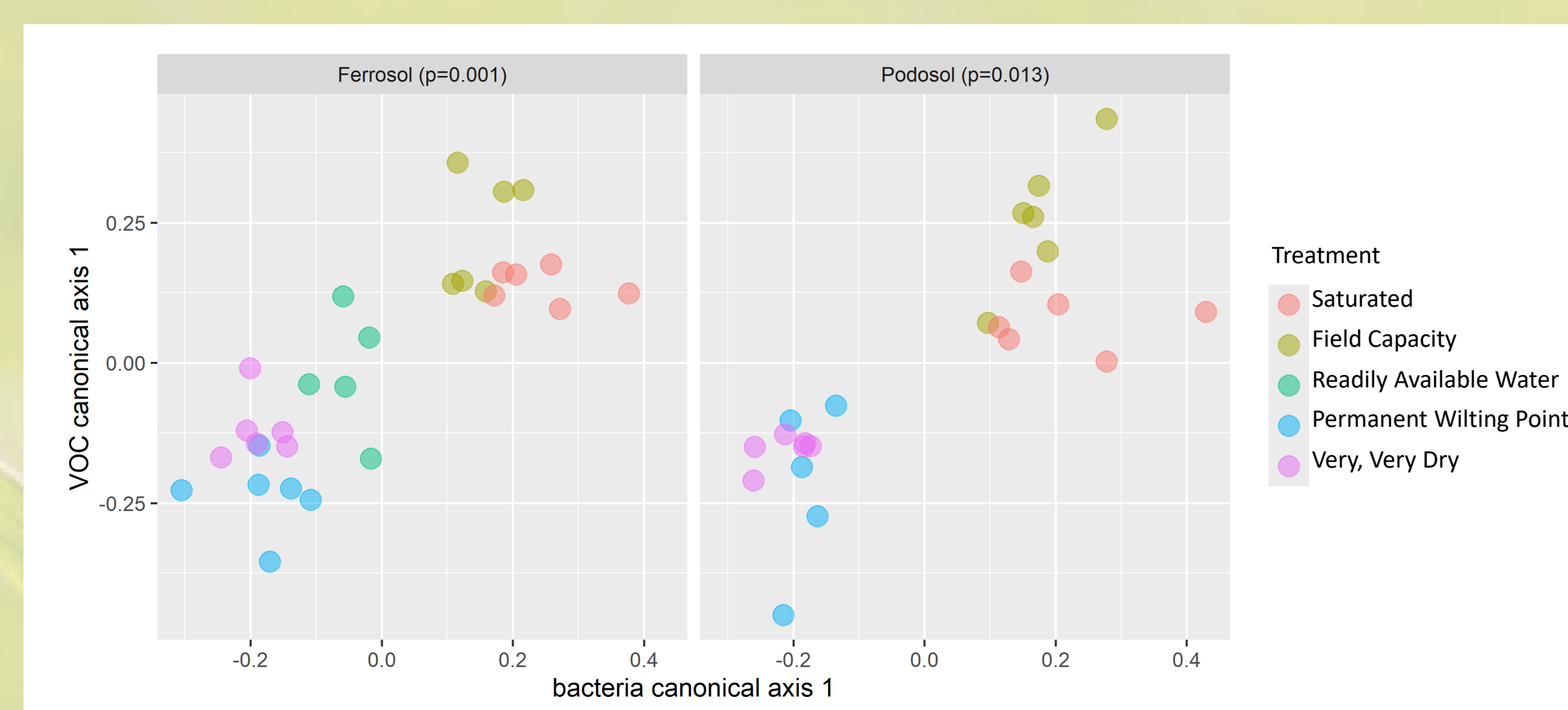


## Step 1b: Canonical Analysis

The MVOCs and both the bacterial and fungal communities followed similar patterns under soil moisture stress.

A canonical correlation analysis demonstrates a clear link between bacterial community composition and the MVOCs being emitted (Fig 3).

Fig 3:



## Step 2: Field Trials

The next step assessed the link between MVOCs and the microbiome of two Tasmanian apple orchards. Soil samples were taken at two depths under various mulch treatments and analysed to determine (a) **microbial biomass carbon (MBC)**, (b) the **bacterial and fungal communities** present, and (c) the **MVOCs** that were being produced.

- MBC was affected by soil depth and mulch treatment in both orchards.
- Relative abundance of both the bacterial and fungal communities were affected by both soil depth and mulch treatment.
- Regressions indicate that a depth effect was found across most VOC groups, especially Aldehydes, Esters (Fig 4), and Alcohols (Fig 5). Compost treatment samples tend to have lower levels of particular alcohol VOCs and higher levels of certain hydrocarbons (Fig 5).

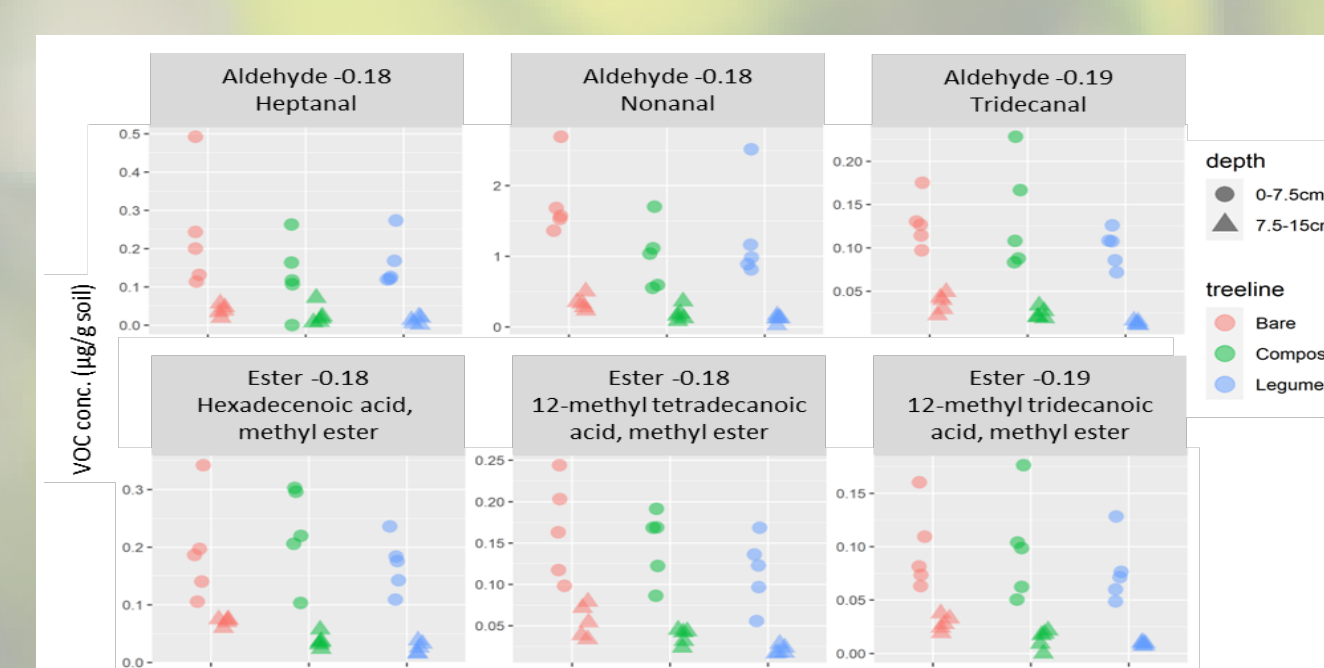


Fig 4: Concentrations of six VOCs with most extreme PC axis weights in PC1 of orchard 1 analysis. Weights are shown adjacent to VOC group names.

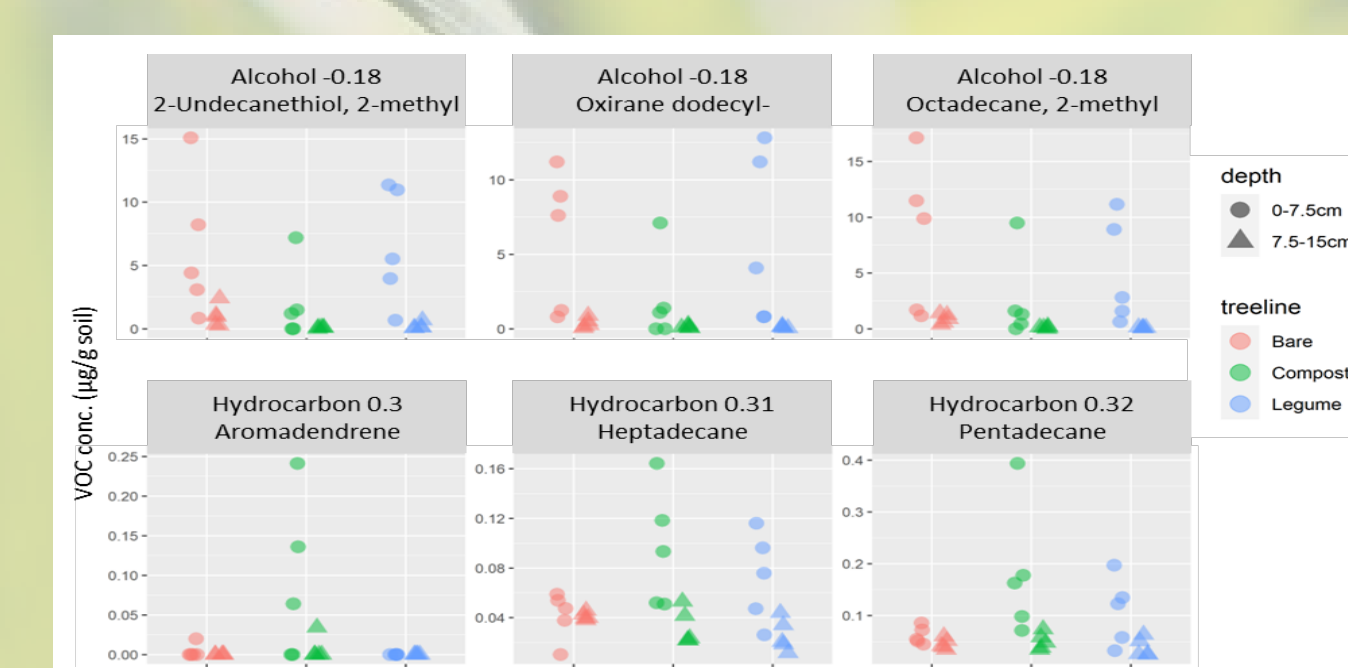


Fig 5: Concentrations of six VOCs with most extreme PC axis weights in PC3 of orchard 1 analysis. Weights are shown adjacent to VOC group names.

## Key Findings

- Both the soil microbiome and MVOCS have a significant relationship with moisture stress and follow similar patterns.
- There is a clear canonical correlation between the microbiome and MVOCs.
- These correlations and relationships have been demonstrated across **laboratory and field settings**, various **soil types**, under different **treatments** and under various **environmental conditions**.

- ➔ Demonstrates certain compound groups can be associated with tried and tested soil health indicators.
- ➔ Validates the concept that MVOCs could potentially be used as soil health indicators in E-nose devices.