

# Cultivar differences in root development and depth of forage legumes

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**ILS4**

Fourth International  
Legume Society Conference



Photos: NR Dhamala

**Fro**afgiftsfonden



**BELOWGROUND  
CROP ECOLOGY**  
Groundbreaking

# Background

## Root system development and function

Crop resource use efficiency



Environmental impacts

Climate resilience

Forage legumes are not investigated much for the **root traits**, and knowledge of cultivar differences in **root system development and function** is lacking

More knowledge on **belowground traits** is important for future breeding of resource-efficient and climate-resilient forage legumes



Photo: NR Dhamala

# Objectives

- ❑ To investigate **cultivar differences** in root **growth and depth** over time of the three important forage legumes:
  - Red clover** (*Trifolium pretense* L.),
  - White clover (*Trifolium repens* L.), and
  - Lucerne** (*Medicago sativa* L.)
- ❑ To support **future breeding** of more robust, climate and environmentally friendly forage legumes

# Material and method

## Rhizotube experiment

- 2 m and 0.5 m tall and Ø: 10 cm

Lucerne (LU)	Red clover (RC)	White clover (WC)
Cigale	Elara	Silvester
Musette	Amos	DLF TRF 3536
Mezzo	Callisto	Brianna



Tubes at crop harvest at 118 days after transplanting (DAT)

## Measurements

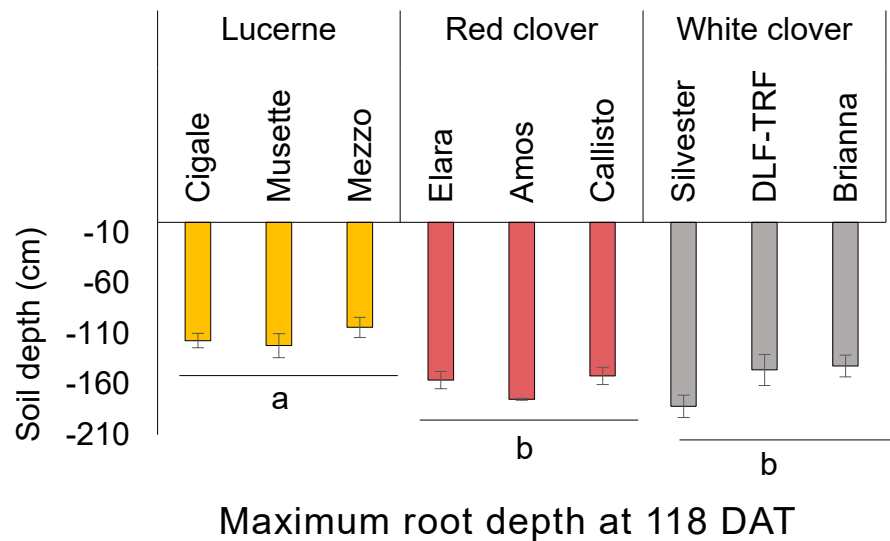
- Early establishment
- Root system architecture
- Root growth development

(Root depth, imaging, and image analysis with **RootPainter** software)

# Results

- ❑ Differences in early **root architecture** between species and cultivars
- ❑ Faster **initial root growth** of Lucerne  
(Lucerne > Red clover > White clover)
- ❑ Deeper root depth of white clover

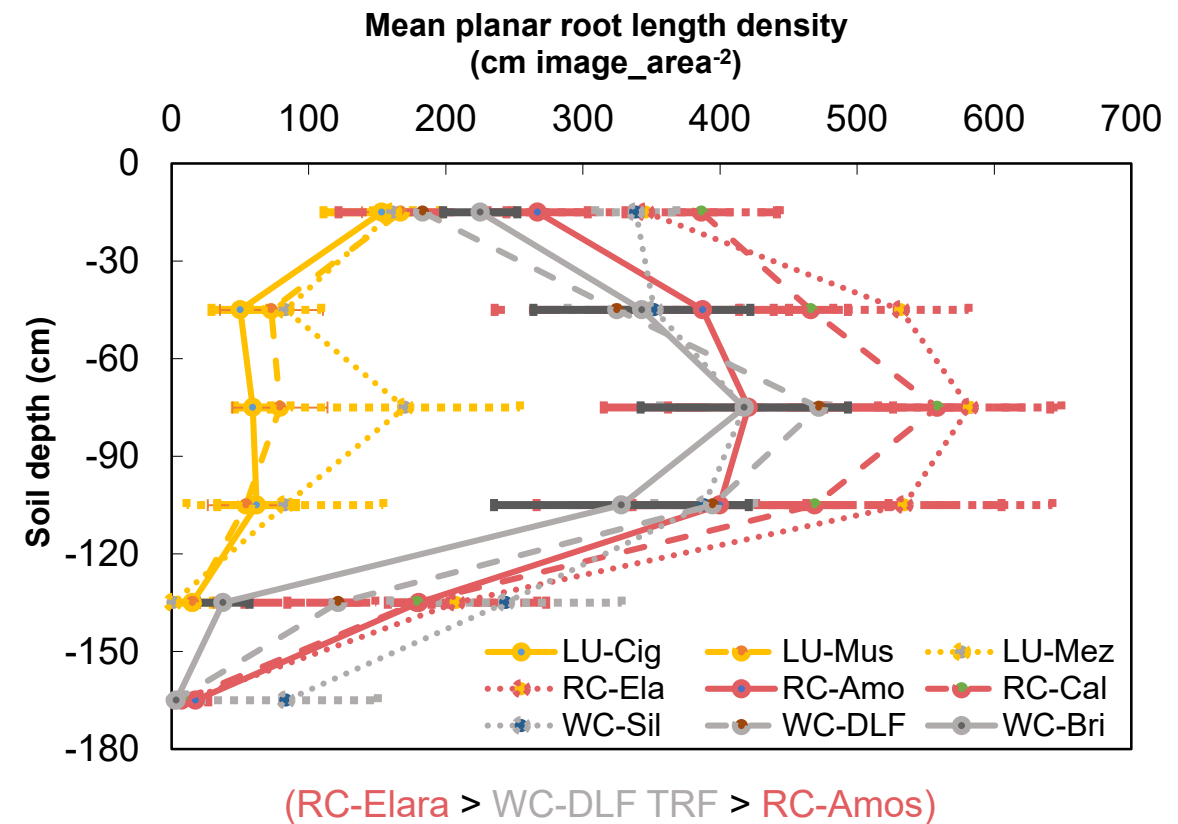
White clover = Red clover > Lucerne



The deepest root depth of the **white clover cv. Silvester** (1.82 m)

## Planar root length density (pRLD)

Red clover = White clover > Lucerne at 0.3 to 1.2 m soil depths (p<0.001)



pRLD determined from the root images taken in 2 m rhizotron tubes at 118 DAT

# Conclusions

- ❑ Differences in root growth between the species and cultivars of **red clover**, white clover and **Lucerne**
- ❑ Contrary to the general perception, **deep root growth** of **white clover**
- ❑ Insights into the **deep-root development** of three forage legumes, with **implications for future breeding**
- ❑ Ongoing study to **validate** the rhizotron study in the **field** and in **4 m tall rhizoboxes**, including **root function** studies based on **tracer uptake**.



4 m tall rhizoboxes (root towers)



Field plots



# Poster: S4-14

## Cultivar differences in root development and depth of forage legumes

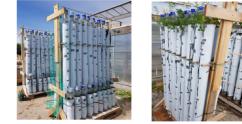
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### Introduction

Root system development and depth are key to efficient resource use and improved crop agronomic and environmental performances. However, forage legumes are not bred for the belowground traits, and knowledge of cultivar differences in root system development and function is lacking. We investigate cultivar differences in root growth and depth over time of the three important forage legumes: red clover (*Trifolium pretense* L.), white clover (*Trifolium repens* L.), and lucerne (*Medicago sativa* L.).

### Methods

**Rhizotube experiment**  
2 m and 0.5 m tall and Ø: 10 cm



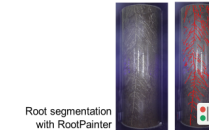
- Measurements**
- Early establishment
  - Root growth development
  - Root image analysis with RootPainter<sup>1</sup> software
  - Root system architecture



Tubes at crop harvest at 118 days after transplanting (DAT)

### Cultivars

Lucerne (LU)	Red clover (RC)	White clover (WC)
Cigale	Elara	Silvester
Musette	Amos	DLF TRF 3536
Mezzo	Callisto	Brianna



Root segmentation with RootPainter

### Results

#### (1) Early root system architecture



Figure 1: Roots recovered and washed in 0.5 m rhizotron tubes at 28 DAT

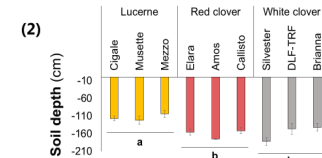


Figure 2: Maximum root depth at 118 DAT

(1) **Faster initial root growth of Lucerne**  
(Lucerne > Red clover > White clover)

(2) **Maximum root depth at DAT 118:**  
White clover = Red clover > Lucerne.  
The deepest rooting depth of the white clover cultivar Silvester (1.82 m)

(3) **Larger pRLD of Red and White clover compared to Lucerne at soil depths between 0.3 and 1.2 m** ( $p < 0.001$ )  
RC-Elara > WC-DLF TRF > RC-Amos

#### (3) Mean planar root length density (cm image\_area<sup>-2</sup>)

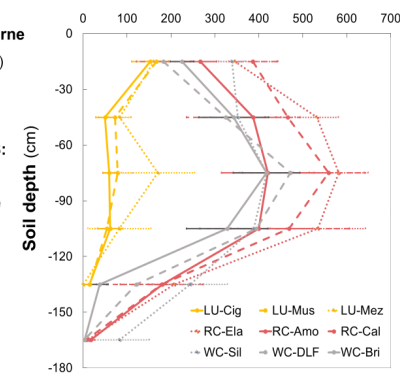


Figure 3: Planar root length density determined from the root images taken in 2 m rhizotron tubes at 118 DAT

### Conclusions

Contrary to the general perception, our results showed **deep root growth of white clover**. The study provides insights into the **deep-root development** of three forage legumes, with **implications for future breeding**. The rhizotron study is currently being **validated** in the field and in **4 m tall rhizoboxes**, including **root function** studies based on **tracer uptake**.

### References

[1] Smith et al. (2022) RootPainter: deep learning segmentation of biological images with corrective annotation. *New Phytologist*



# Acknowledgment

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