DFG FOR 1320 Crop Sequence and the Nutrient Acquisition from the Subsoil

Root-length densities of spring wheat and mallow in subsoil biopores

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Introduction

Biopores are created by roots or earthworms and/or other soil faunae and can possibly facilitate the access of roots to water stored in the subsoil. To date, few attempts have been made to quantify root growth in biopores. Spring wheat and mallow roots were investigated in a field trial in which the taprooted alfalfa and chicory were grown as precrops continuously for one or two years in order to increase the number of biopores.

Aims

The aim of this study was to quantify root-length density (RLD) of a taproot system and a fibrous root system and to compare their use of biopores. Therefore mallow (*Malva sylvestris* L.) and spring wheat (*Triticum aestivum* L.) were established after the following precrops:

- 1 or 2 years alfalfa (*Medicago sativa* L.), taproot system
- 1 or 2 years chicory (*Cichorium intybus* L.), taproot system

Experimental site

- Research station Klein-Altendorf near Bonn, Germany (50°37'N, 6°59'E)
- Mean annual temperature: 9.6 °C
- Mean annual precipitation: 625 mm
- Haplic Luvisol derived from loess

Soil depth [cm]	Horizon (WRB 2006)	Bulk density [g·cm^{-3}]
0–27	Ap	1.29
27–41	E/B	1.32
41–75	Bt1	1.42
75–87	Bt2	1.52
87–115	Bt3	1.52
115–127	Bw	1.46
> 127	C	1.47

Profile wall method

- Trenches were established with an excavator to 1.8 m soil depth, vertical walls smoothed with a flat spade
- Roots protruding from the wall were cut, 0.5 cm soil washed away with a pressure sprayer and a scraper
- Frame size: 100 x 60 cm, grid of 5 x 5 cm
- Root length units (RLU) of 5 mm each were determined in every square
- RLU in visible biopores were recorded separately from the RLU in the bulk soil
- RLD [cm·cm^{-3}] = $\frac{\text{RLU}\cdot 0.5\text{cm}}{5\text{cm}\cdot 5\text{cm}\cdot 0.5\text{cm}}$

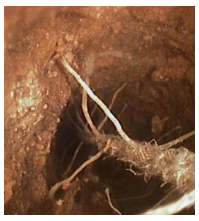
Endoscopy – Method

- An insight into biopores was achieved using a flexible video endoscope (Karl Storz GmbH, Germany) with an outer diameter of 3.8 mm (Köpke & Kautz 2010)*
- Endoscopy allows displaying root morphology and position inside larger sized biopores (> 5 mm) under field conditions
- A horizontal soil area was created by excavating laterally into the wall of a prepared trench
- The endoscope was inserted into the pores from the bottom up
- Real-time pictures are provided and snapshots can be saved

* Plant Biosystems, Vol. 144, No. 2, June 2010, pp. 440-442

Endoscopy – Results

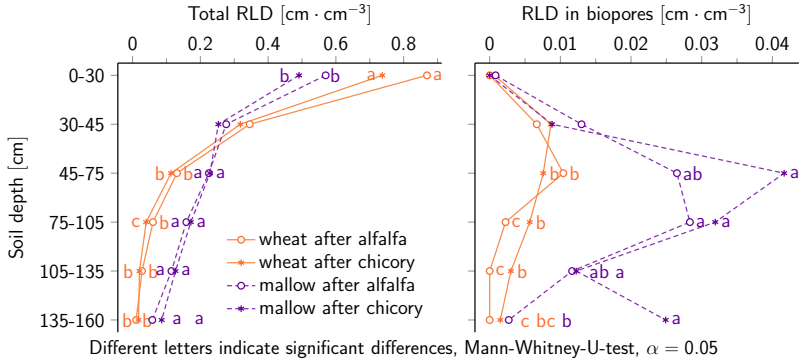
- View inside a biopore in the direction of the soil surface
- Typical pictures for the growth of roots of different architecture have been selected:
- Mallow taproots vertically follow the biopore
- Spring wheat roots predominantly grow through biopores, entering/leaving from/to the bulk soil



Mallow roots

Spring wheat roots

Root-length density (RLD)



Different letters indicate significant differences, Mann-Whitney-U-test, $\alpha = 0.05$

In the topsoil (above 45 cm soil depth) wheat had higher total RLD than mallow which changed for the subsoil (45-160 cm) as the decline of RLD with depth was steeper for wheat. The relative amount of roots in subsoil biopores was for both crops highest after chicory and reached up to 18 % of the total RLD. Generally, the share of roots in biopores was higher for mallow than for wheat after both precrops.

Conclusions

It is concluded that the relevance of biopores in the subsoil for facilitating root growth depends on the specific characteristics of the root system. This is also supported by visual impressions gained by endoscopy. The results indicate that response of root growth to the presence of biopores is more pronounced for taproot systems than for fibrous root systems . For mallow and wheat the amount of RLD in biopores was tendencially higher after chicory than after alfalfa. This might be due to higher biopore densities (>2 mm) after chicory (366 m^{-2}) in comparison to alfalfa (304 m^{-2}) (data not shown). The steep decline of root-length density in biopores below 105 cm might indicate that in the C-horizon biopores are less relevant than in the comparatively dense Bt-horizon.

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