Recolonization of root-induced macropores

Mirjam Zörner, Andrea Schnepf, Jan Vanderborght, Harry Vereecken

Agrosphere Institute (IBG-3), Institute for Bio- and Geosciences, Forschungszentrum Jülich, Germany

Introduction

Understanding the distribution of root systems in soils is crucial for the evaluation of their water and nutrient uptake abilities. The vertical orientation of growth is not only driven by physical parameters but also by biotic factors: stable channels created by roots can be used as a predefined growth direction of the subsequent roots. These "root-induced macropores" (RIMs) are discussed in different studies (e.g. Rasse & Smucker, 1998; White & Kirkegaard, 2010). RIMs are formed by the mechanical reorganization of soil particles during primary growth of the root apex, by the subsequent amalgamation of those particles with mucilage of root and microorganism origin, and the stability improvement via fungal mycelia (Ghestem et al., 2011).

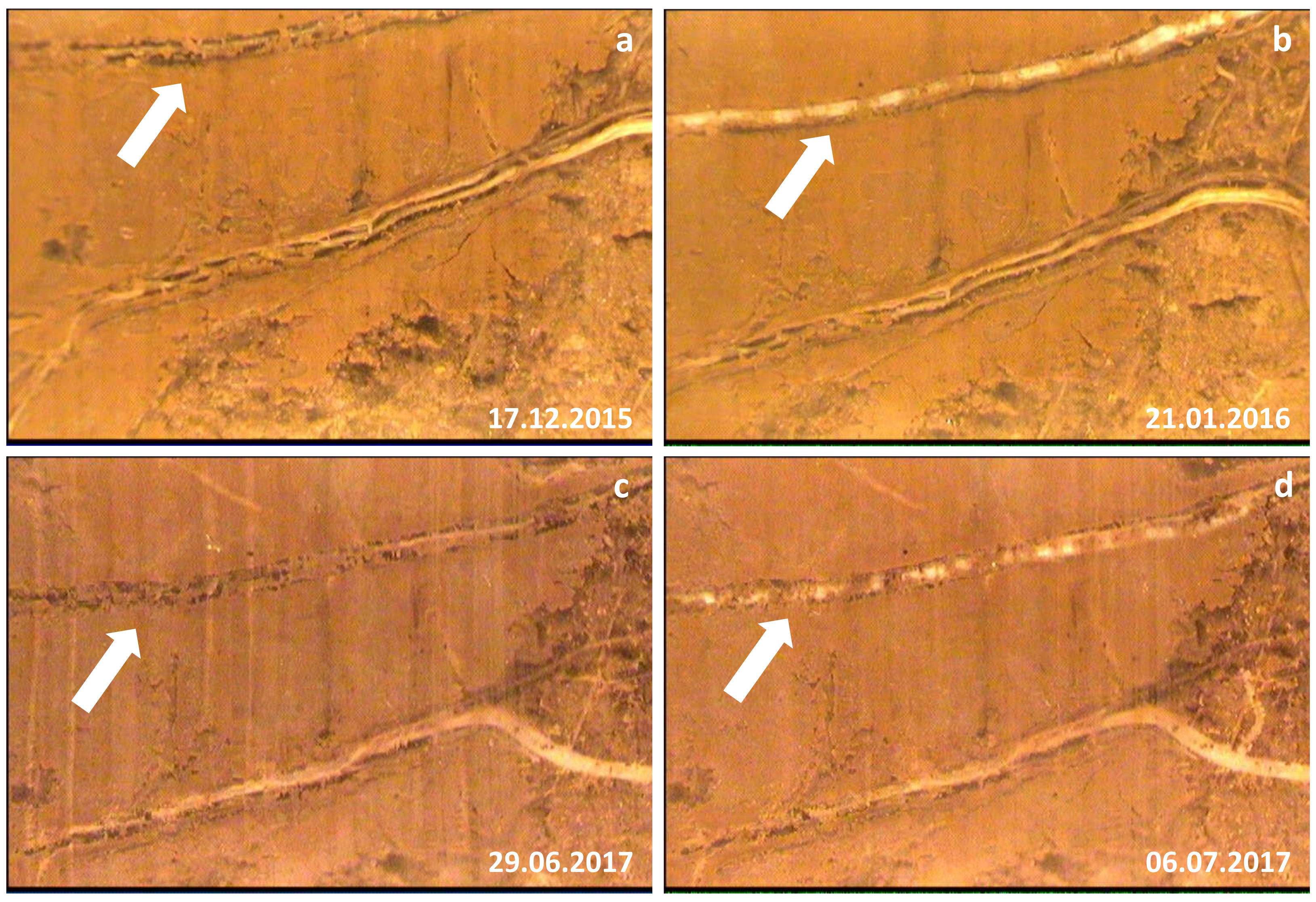


Fig. 1: The images show exemplarily a root-induced macropore after the season of summer wheat (*a*) being recolonized by a winter wheat root (*b*) and being recolonized a second time by a maize root (*d*). In image *a* and *c* some residues of the previous roots can be seen inside the macropore.

Fig. 2: Interior view of a rhizotron facility in Selhausen.

Characteristics compared to bulk soil

- Lower density ("pathway of least resistance")
- Higher organic carbon content
- Higher availability of nutrients (e.g. root exudates)
- Different microbial community, increased metabolic activity
- Preferential flow paths

The aim of this study was to quantify recolonization events as function of soil type, soil depth, crop rotation, and water treatment.

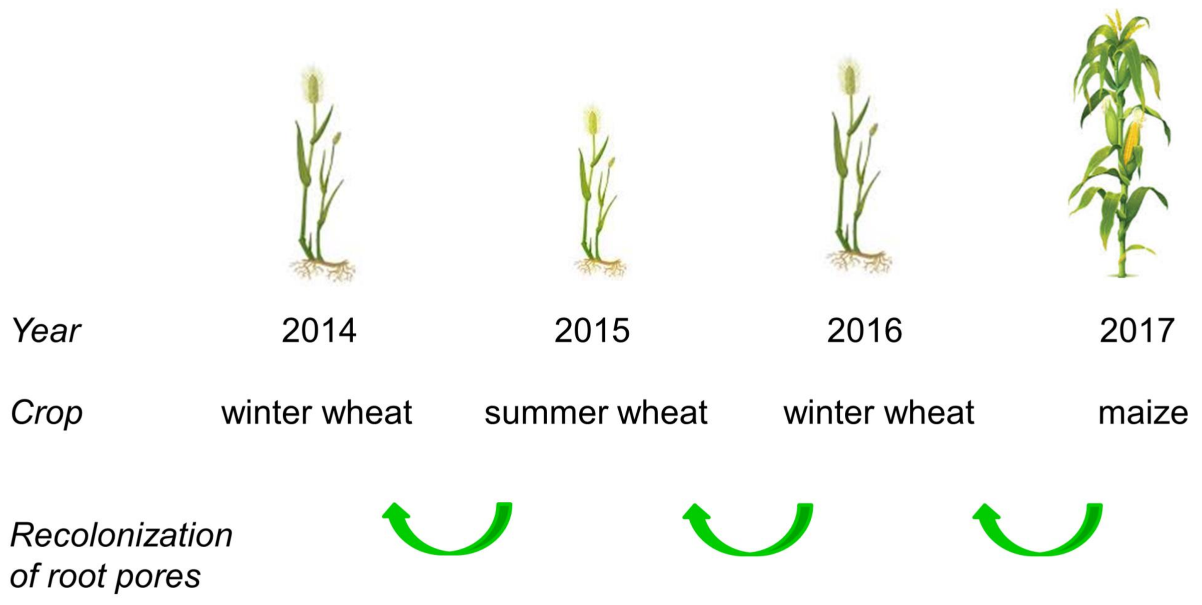


Fig. 3: Crop rotation on the rhizotron fields. RIMs are recolonized by roots of the subsequently growing crop (green arrows).

Methods

Study site: two rhizotron facilities in Selhausen, Germany; consisting of stony soil (facility F1) and silty soil (F2)

Crop rotation: winter wheat (2013/2014), summer wheat (2015), winter wheat (2015/2016), and maize (2017)

Water treatment: each facility was divided in three plots; canopied (p1), rainfed (p2), and irrigated (p3)

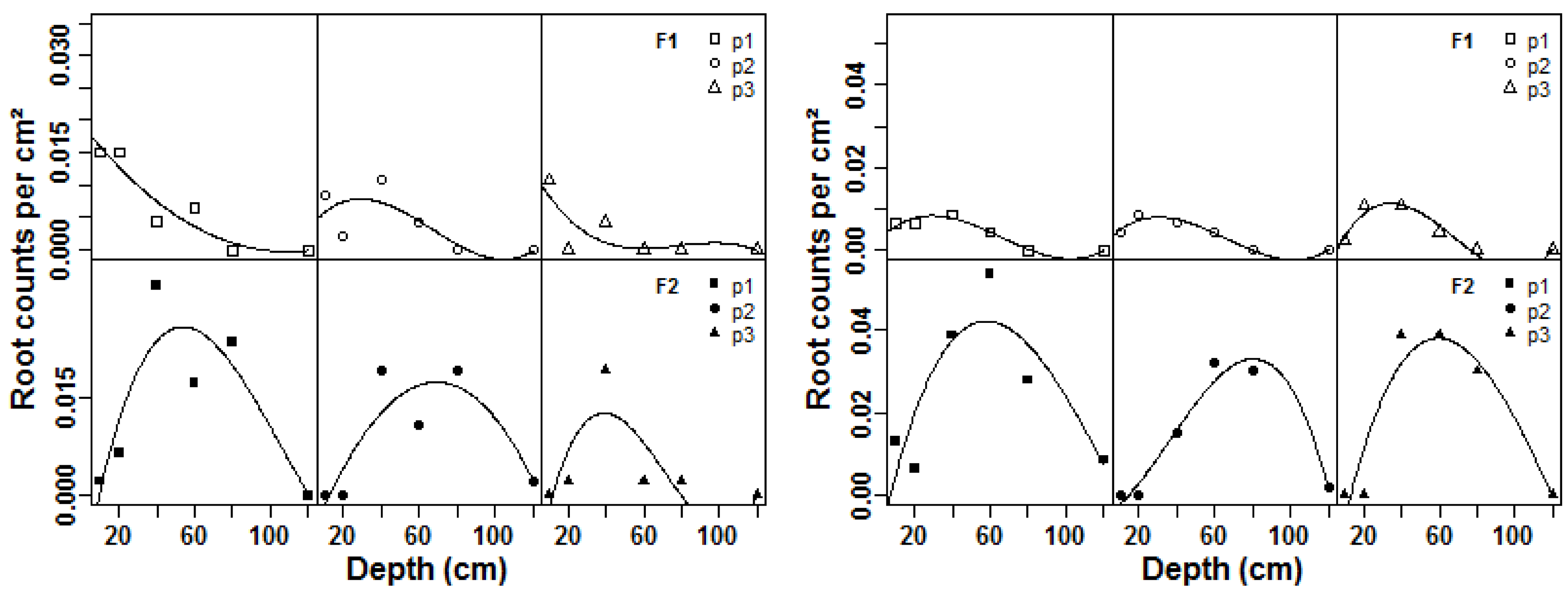
Measurements: root growth over depth was observed with a minirhizotron camera via 7-m-long acrylic glass tubes installed horizontally in six soil depths (10, 20, 40, 60, 80 & 120 cm).

Evaluation: to quantify the recolonization of root-induced macropores, the root count density of all observed roots at the end of every growing season and the density of those roots that growth in RIMs were analyzed. For each season the fraction of macropores recolonized by successive roots as well as the proportion of roots that recolonized RIMs were calculated.

Results

- Differences in the quantity of recolonization events could be found between the different crops, the two soil types and the soil depth
- Differences were not significant between the water treatments

Table 1 shows exemplarily the percentages of recolonized macropores for the irrigated plot in facility 2: most of the recolonization events took place in 40-80 cm depth and for maize following winter wheat. For summer wheat following winter wheat almost no recolonization events occurred



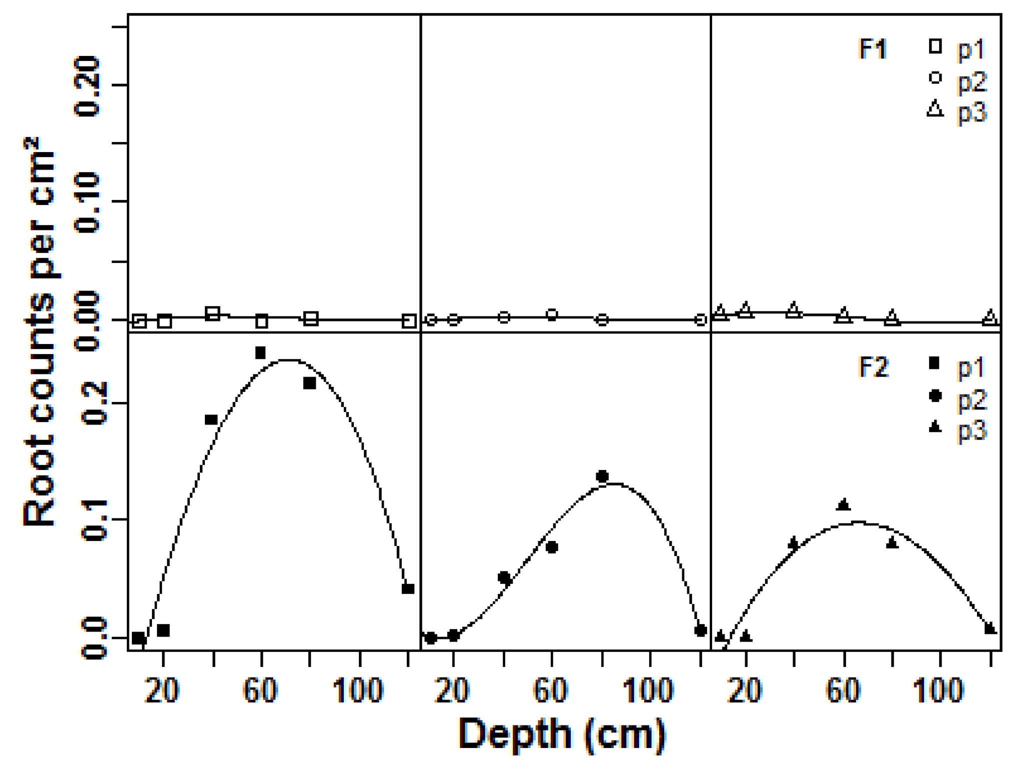


Fig. 4: Density of those roots which recolonized root induced macropores of the previous season (2015,top left; 2016, top right; 2017 bottom right).

Tab. 1: Percentages of recolonized root-induced macropores (for the irrigated plot in F2).

Depth (cm)	2014/15	2015/16	2016/17
10	0.0	0.0	0.0
20	0.39	0.0	0.0
40	2.65	4.17	19.37
60	0.20	9.84	24.07
80	0.21	13.33	10.91
120	0.0	0.0	1.67

Discussion

The results show higher root biomass and more frequent recolonization in the silty soil; the stony soil has shallow and sparse rooting and comparatively fewer stable channels due to the soil structure. Higher numbers of recolonization could also be found when maize was following wheat compared to wheat following wheat; one reason could be the presence of crop specific pathogens in the pores. An influence of the water treatment on the creation and recolonization of macropores could not be observed.

Conclusion

In summary, the results illustrated higher root biomass and more frequent recolonization in the facility with silty soil; the stony soil showed sparse rooting and comparatively fewer stable channels. It is assumed that the recolonization of root-induced macropores is amongst others a function of soil type, soil depth, and crop rotation.

References

Ghestem, M., Sidle, R. C., & Stokes, A. (2011). The influence of plant root systems on subsurface flow: implications for slope stability. *BioScience*, *61*(11), 869-879.

Rasse, D. P., & Smucker, A. J. (1998). Root recolonization of previous root channels in corn and alfalfa rotations. *Plant and Soil*, *204*(2), 203-212.

White, R. G., & Kirkegaard, J. A. (2010). The distribution and abundance of wheat roots in a dense, structured subsoil–implications for water uptake. *Plant, Cell & Environment*, *33*(2), 133-148.