Does slow and steady win the race? Root growth of metalicolous and non-metallicolous Arabidopsis halleri in response to excess trace metal elements

Charlotte C. Dietrich, Kamil Bilnicki, Urszula Korzeniak, Christoph Briese, Kerstin A. Nagel, Alicja Babst-Kostecka

FNP POWROTY / REINTEGRATION Programme

European Funds Smart Growth

FNP Foundation for Polish Science

European Union
European Regional Development Fund

The problem: TME contamination

- Trace Metal Element contamination

- Includes plant essential (e.g. Zn) and ballast elements (e.g. Cd)

- Negatively affects human & plant health

- Long half-life of TME poses long-term risk

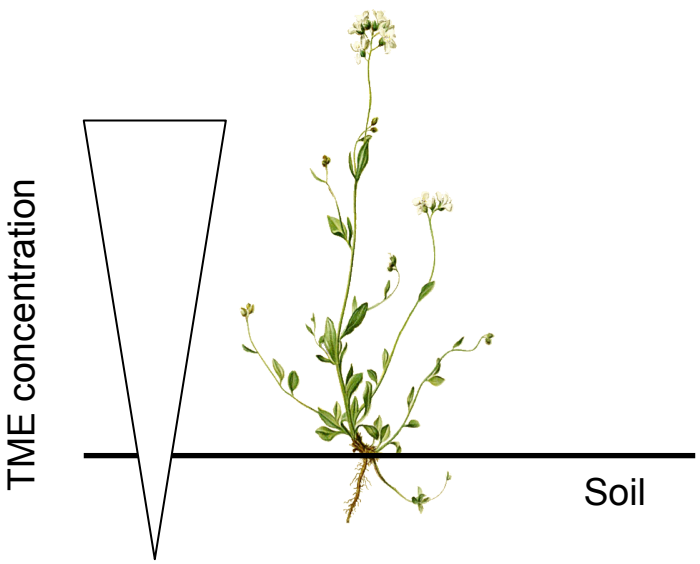
FNP POWROTY /
REINTEGRATION Programme

European Funds
Smart Growth

FNP Foundation for Polish Science

European Union
European Regional Development Fund

The solution? Phytoremediation



- TME contamination prevents colonization by plants

- TME removal by hyperaccumulators

- Altered physiology allows TME uptake

- Hyperaccumulator shoot TME > root TME

- Cost-effective method

FNP POWROTY /
REINTEGRATION Programme

European Funds
Smart Growth

FNP Foundation for Polish Science

European Union
European Regional Development Fund

The model Zn/Cd hyperaccumulator

- *Arabidopsis halleri*
- Pseudometallophyte
- Grows on
  - Non-metalliferous sites (NM)
  - Metalliferous sites (M)
- Phytoremediation needs healthy root system

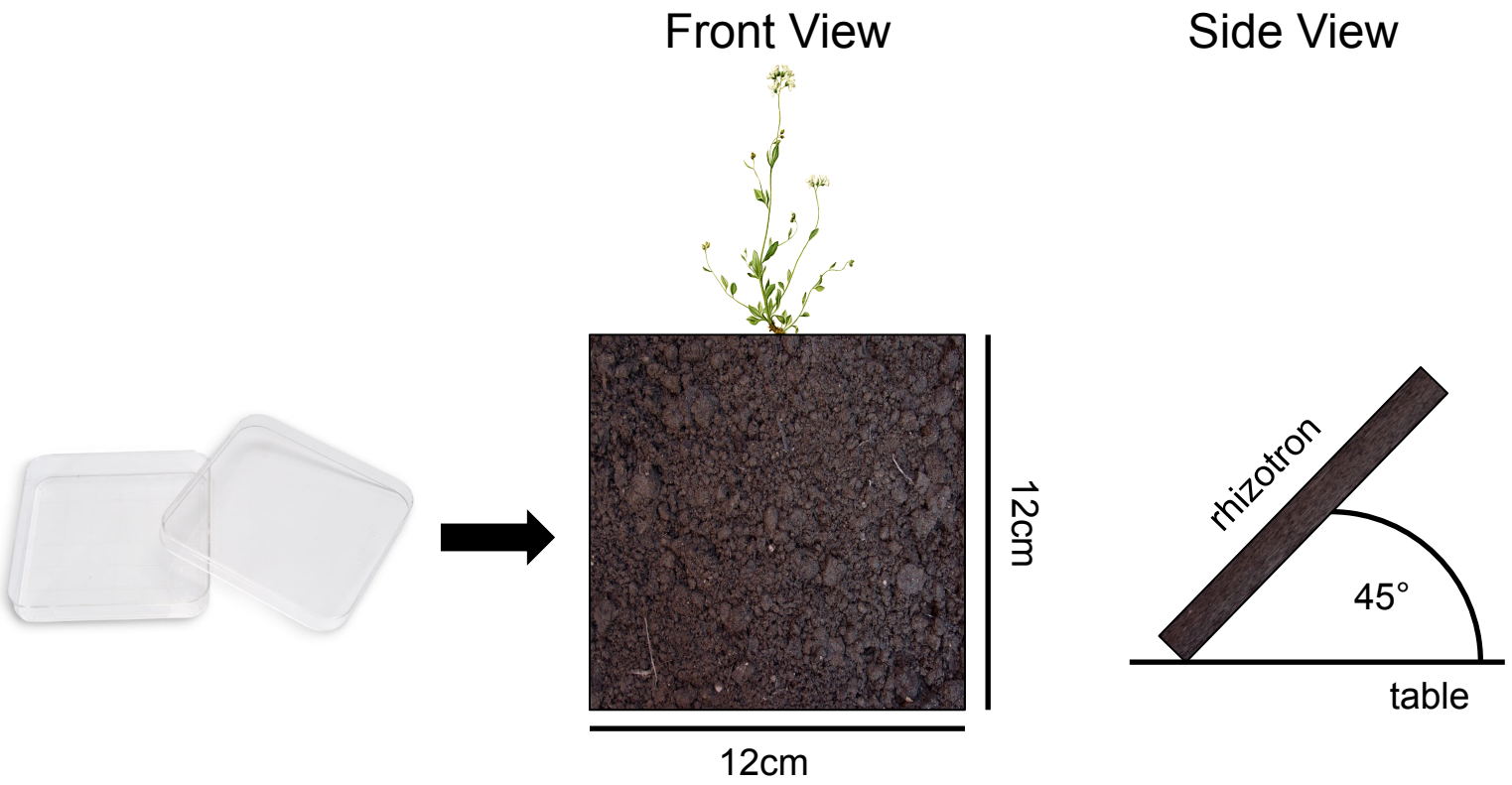
FNP POWROTY /
REINTEGRATION Programme

European Funds
Smart Growth

FNP Foundation for Polish Science

European Union
European Regional Development Fund

The hidden half: Root phenotyping



FNP POWROTY /
REINTEGRATION Programme

European Funds
Smart Growth

FNP Foundation for Polish Science

European Union
European Regional Development Fund

Customization of phenotyping equipment

- Build a platform
- Sterilization before usage
- Allow for water leakage
- Similar soil compression
- Allow for soil aeration
- Minimize root light exposure
- Constant root temperature

FNP POWROTY /
REINTEGRATION Programme

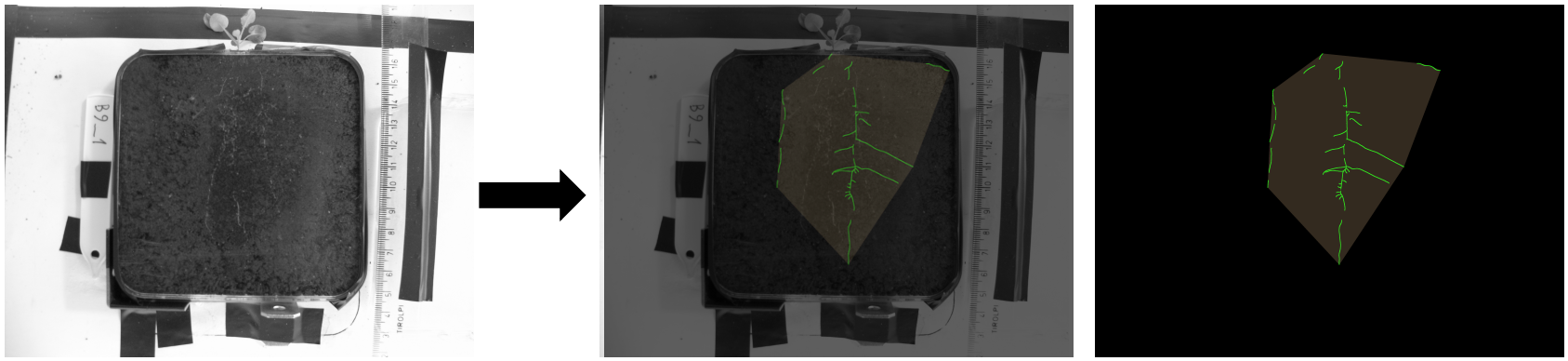
European Funds
Smart Growth

FNP Foundation for Polish Science

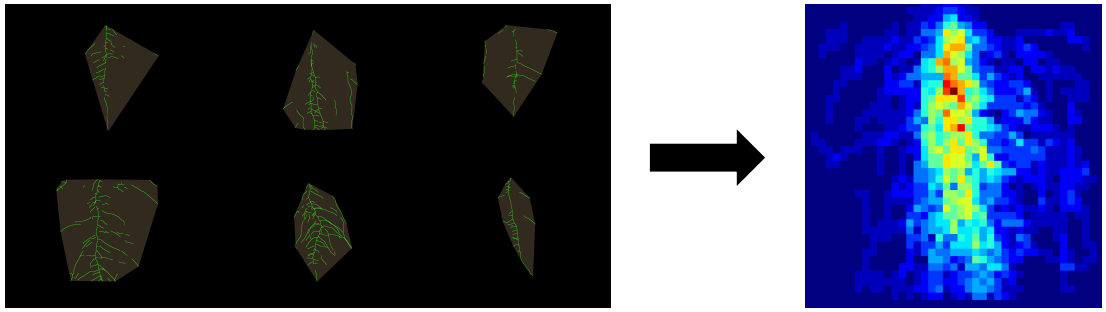
European Union
European Regional Development Fund

Root system generalization

1st step: „Drawing“ the roots based on root pictures



2nd step: Generalizing root systems for each treatment



FNP POWROTY /
REINTEGRATION Programme

European Funds
Smart Growth

FNP Foundation for Polish Science

European Union
European Regional Development Fund

Experimental design

Dietrich et al. 2019

- Two NM ▲ and M ● populations each

- Different hyperaccumulation capacities between ecotypes

- Populations aggregated into ecotype after preliminary analysis

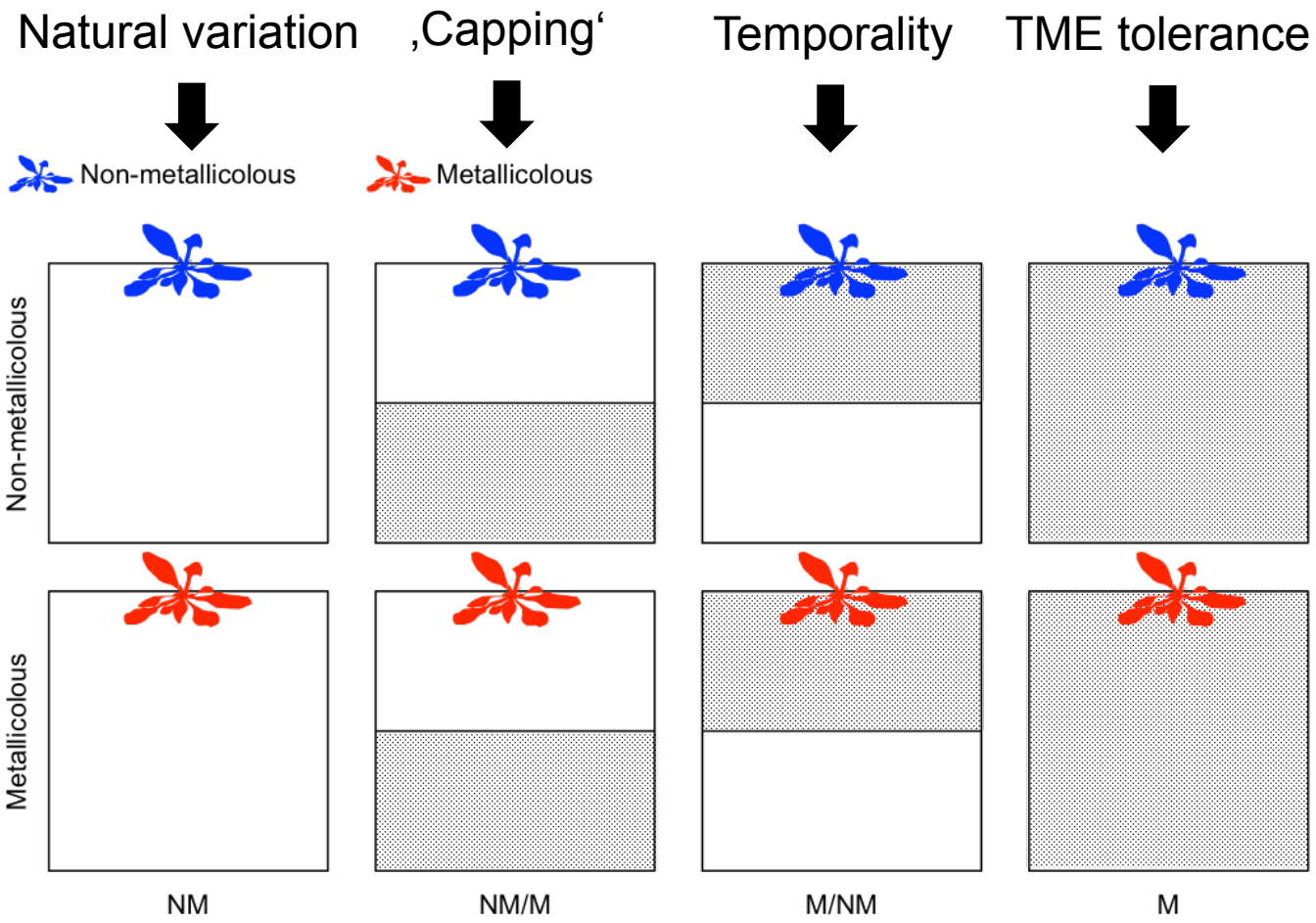
FNP POWROTY / REINTEGRATION Programme

European Funds Smart Growth

FNP Foundation for Polish Science

European Union
European Regional Development Fund

Experimental design: Treatments



Dietrich et al. 2019

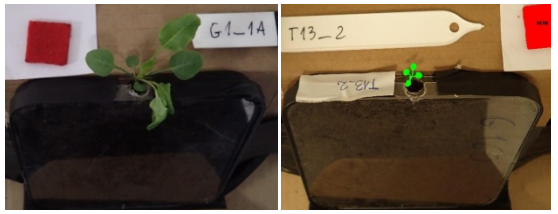
FNP POWROTY /
REINTEGRATION Programme

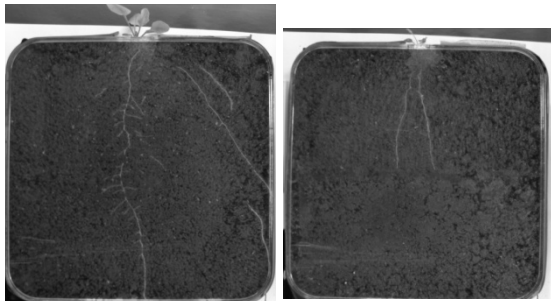
European Funds
Smart Growth

FNP Foundation for Polish Science

European Union
European Regional Development Fund

Plant parameters





- 20 days after sowing experimental run, 5 intermediate harvests

- 20 replicates per ecotype, totaling 800 pictures

- Soil from natural sites

- Non-invasive phenotyping

  - Above-ground: leaf nr., leaf area

  - Below-ground: total root length (TRL), TRL in the upper layer, TRL in the bottom layer, rooting depth, rooting width, root system size

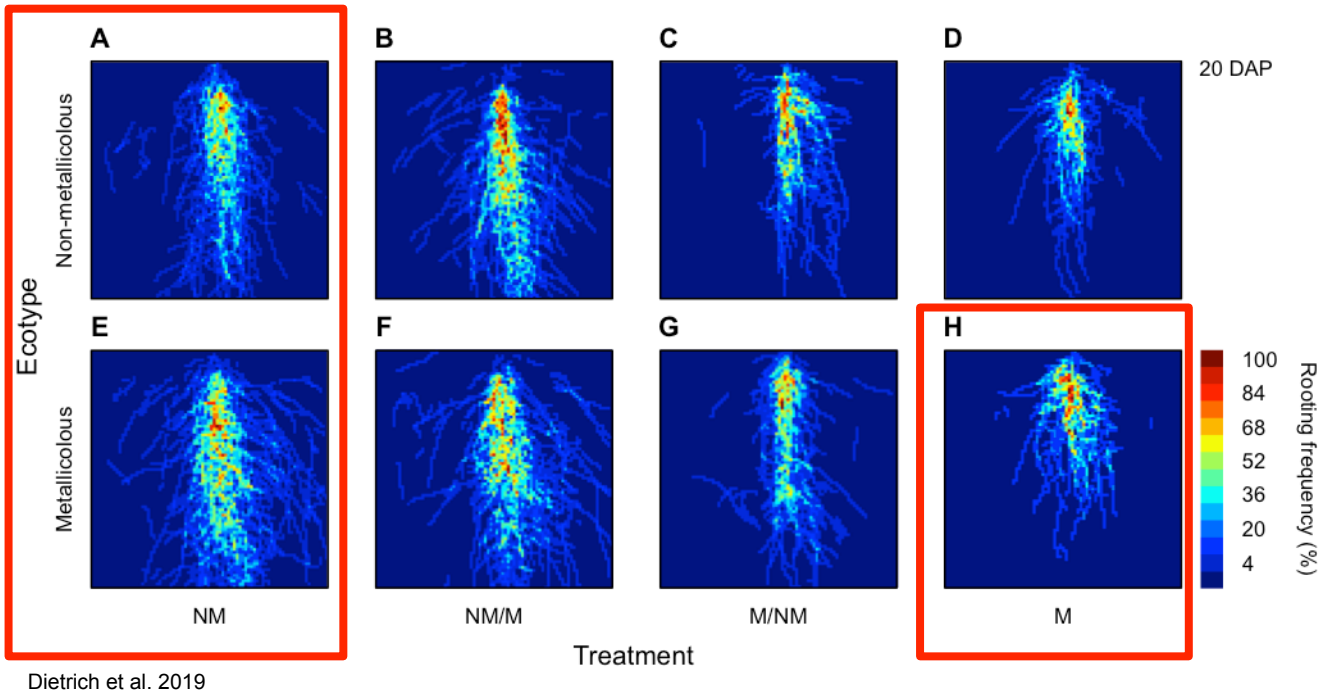
FNP POWROTY /
REINTEGRATION Programme

European Funds
Smart Growth

FNP Foundation for Polish Science

European Union
European Regional Development Fund

Natural variation effects



Dietrich et al. 2019

- TME tolerance costs in M soil
- Root foraging behaviour in NM soil

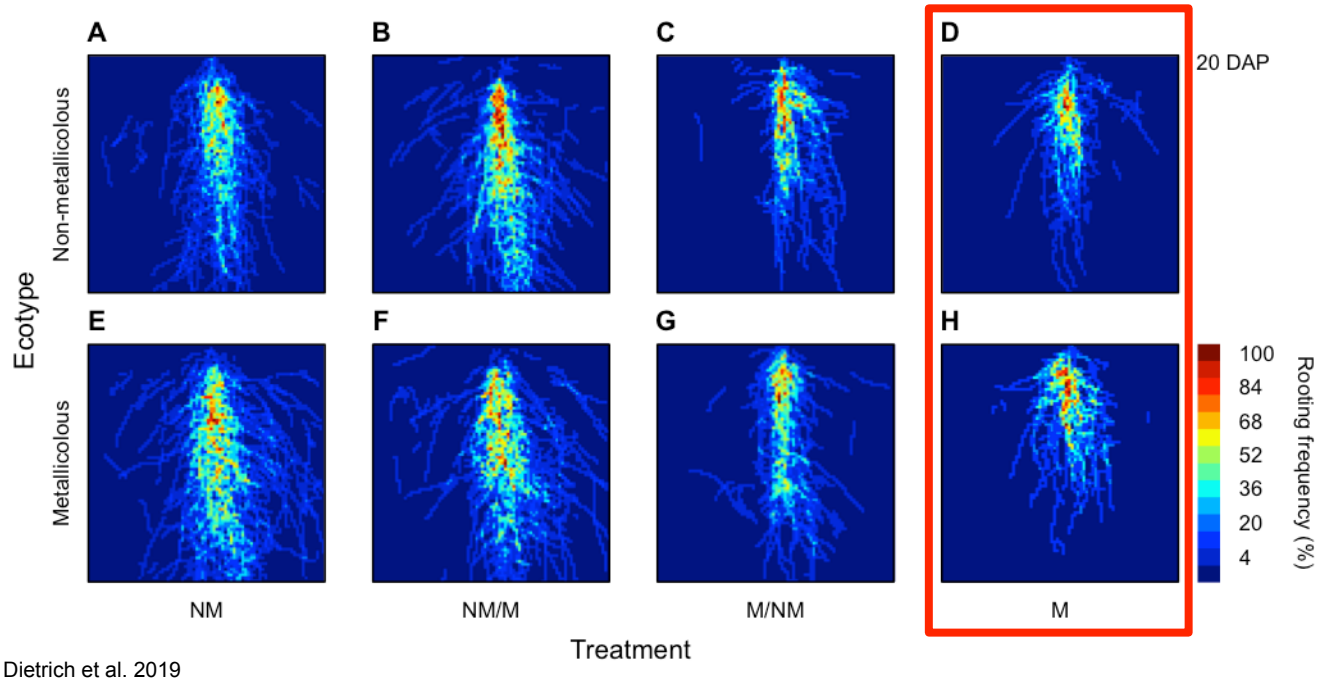
FNP POWROTY /
REINTEGRATION Programme

European Funds
Smart Growth

FNP Foundation for Polish Science

European Union
European Regional Development Fund

TME tolerance effects



Dietrich et al. 2019

- No ecotypical variation (!) in TME tolerance

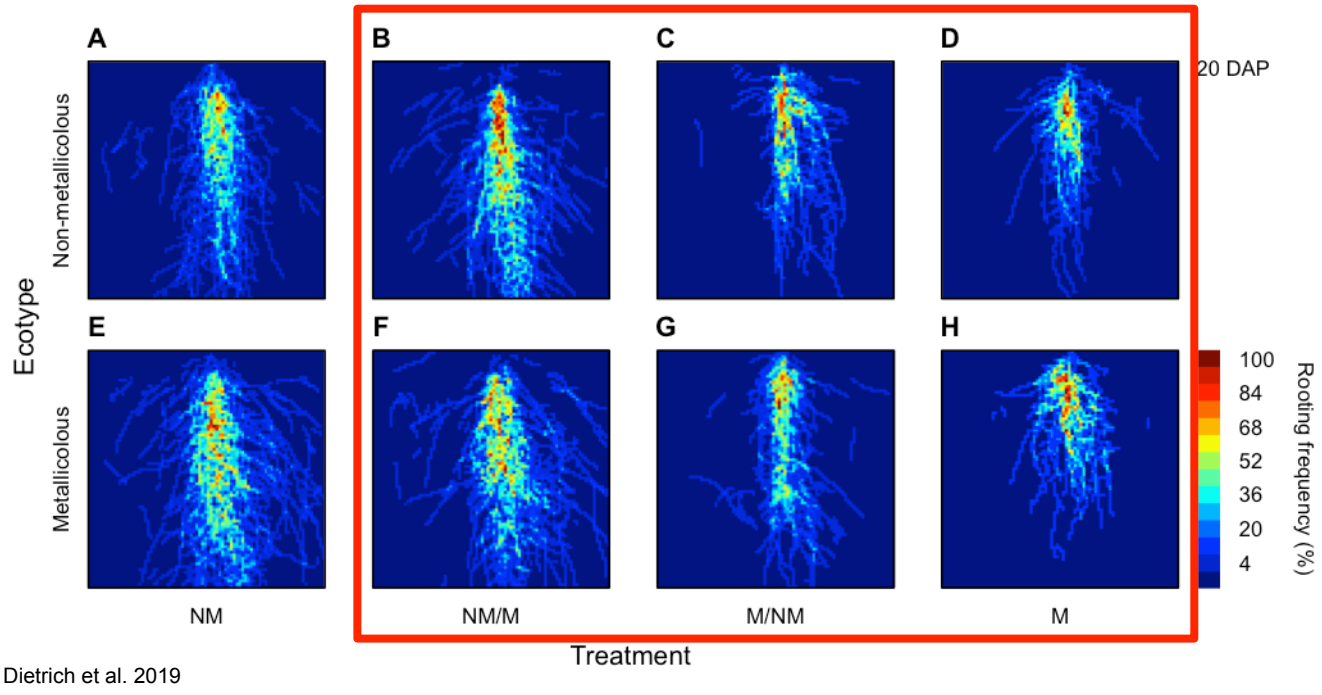
FNP POWROTY /
REINTEGRATION Programme

European Funds
Smart Growth

FNP Foundation for Polish Science

European Union
European Regional Development Fund

Temporal effects I



Dietrich et al. 2019

- Plant age deciding factor in root system development in TME contaminated soil

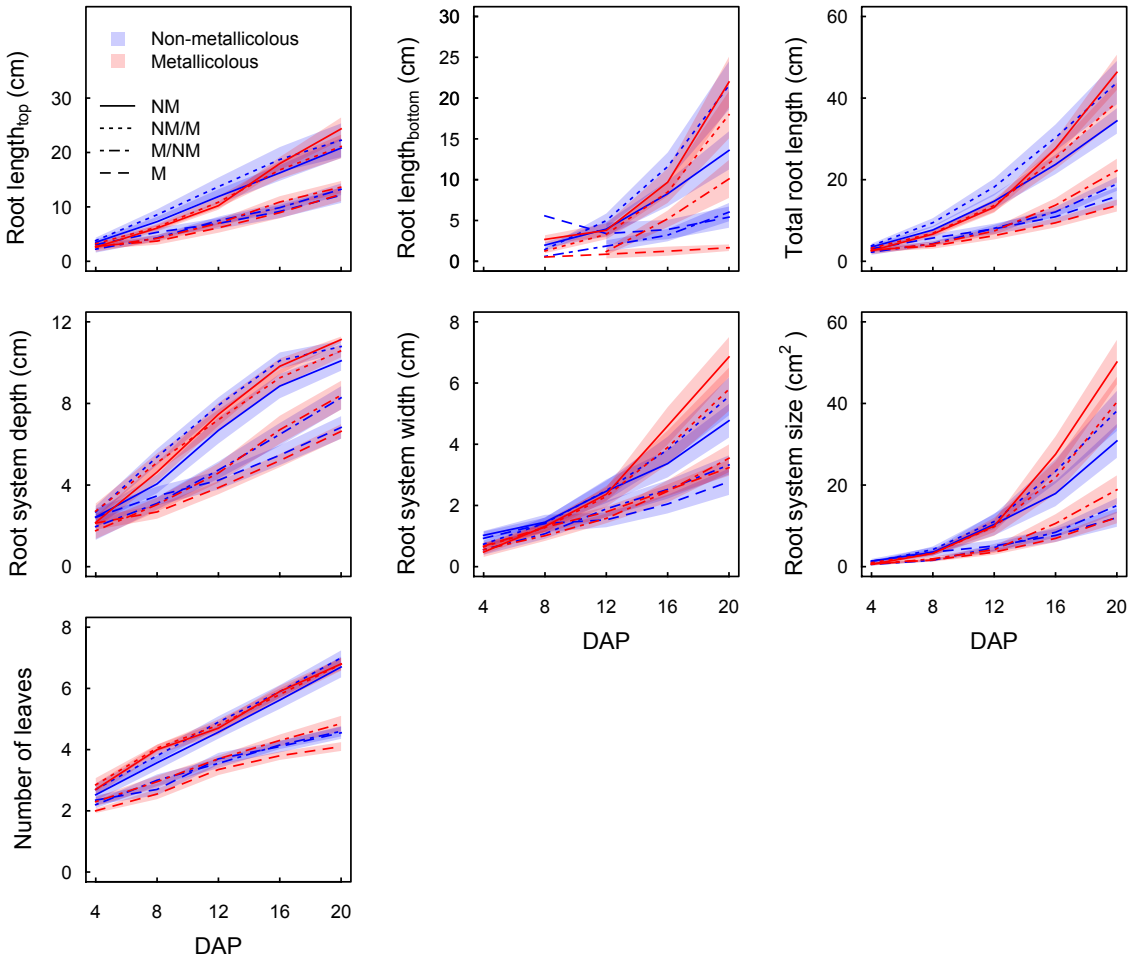
FNP POWROTY /
REINTEGRATION Programme

European Funds
Smart Growth

FNP Foundation for Polish Science

European Union
European Regional Development Fund

Temporal effects II



Dietrich et al. 2019

- Uniform response in all parameters
- TME = negative response
- Except in NM/M layer treatment (= ‚Capping effect‘)

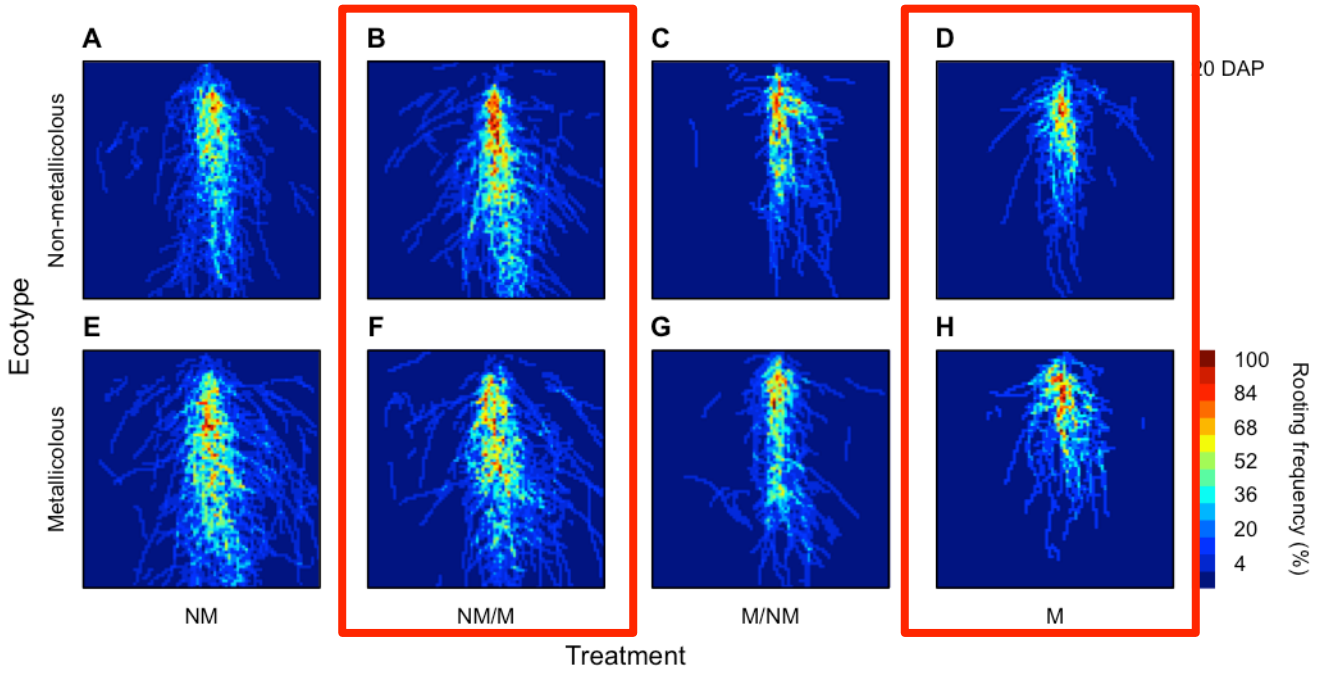
FNP POWROTY / REINTEGRATION Programme

European Funds Smart Growth

FNP Foundation for Polish Science

European Union
European Regional Development Fund

‚Capping‘ effects



Dietrich et al. 2019

- Root development toward contaminated layer

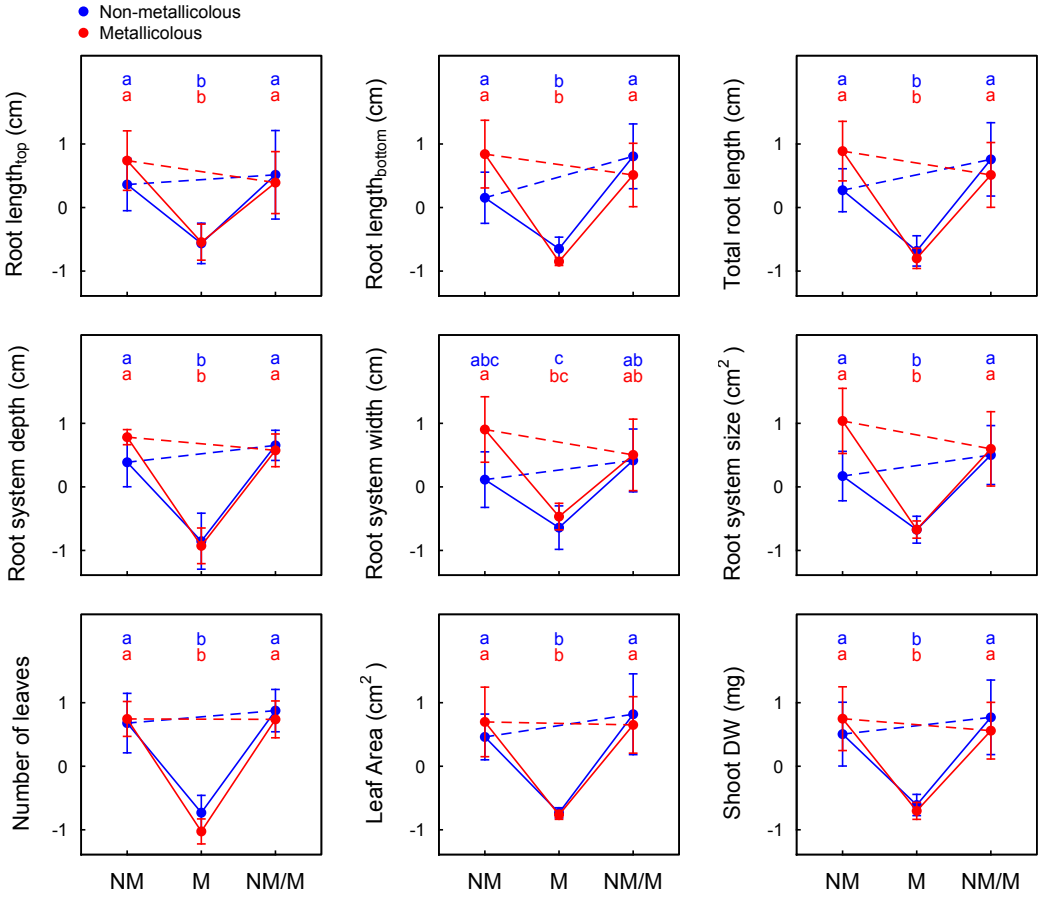
FNP POWROTY /
REINTEGRATION Programme

European Funds
Smart Growth

FNP Foundation for Polish Science

European Union
European Regional Development Fund

‚Capping‘ effects



Dietrich et al. 2019

- Uniform response

- Above- and below-ground parameters linked

- No TME tolerance costs in NM/M layer treatment

- Instead exploration of contaminated layer

> Important for application context

FNP POWROTY / REINTEGRATION Programme

European Funds Smart Growth

FNP Foundation for Polish Science

European Union
European Regional Development Fund

Summary

-Ecotype not as important as environment

-First study to go below-ground

-Practical application of capping

-For more details: Dietrich et al. (2019)

https://www.sciencedirect.com/science/article/abs/pii/S009884721930930X

FNP POWROTY /
REINTEGRATION Programme

European Funds
Smart Growth

FNP Foundation for Polish Science

European Union
European Regional Development Fund