OPTIMIZATION OF PHYTOMANAGEMENT STRATEGIES ON SOILS CONTAMINATED WITH METALS (Cd, Pb, Zn) TO PROVIDE BIOMASS FOR CLEAN BIOFUEL PRODUCTION – LESSONS FROM A POT TRIAL

Felix OFORI-AGYEMANG, Christophe WATERLOT, Michel MENCH, Nadège OUSTRIERE

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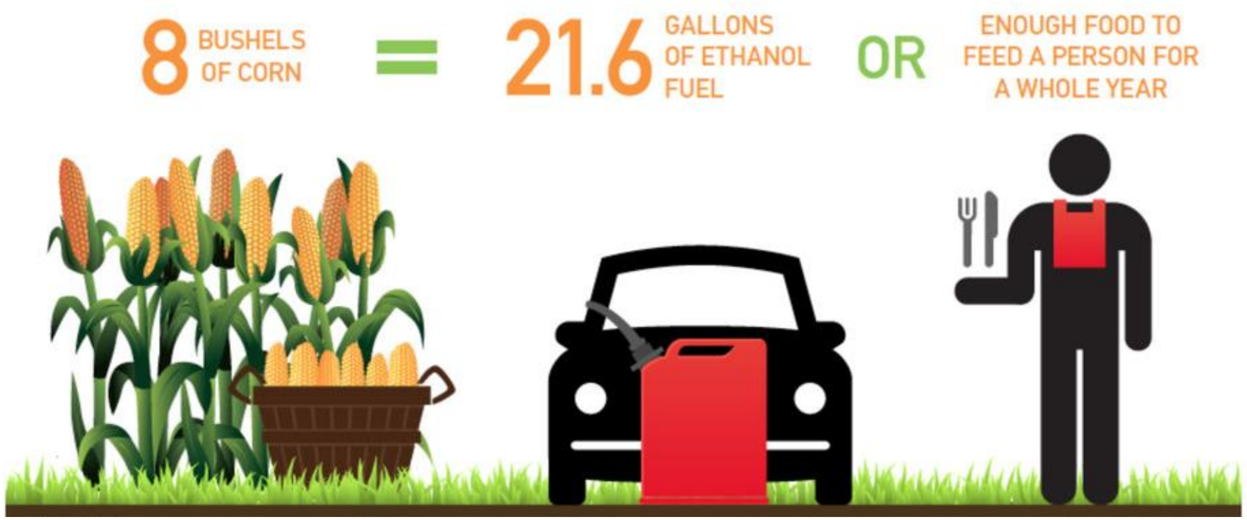
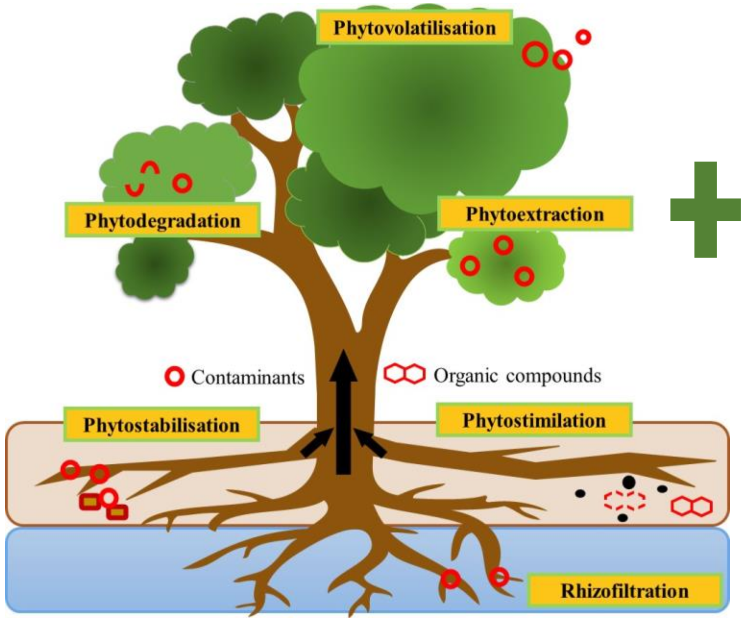
Food vs fuel competition





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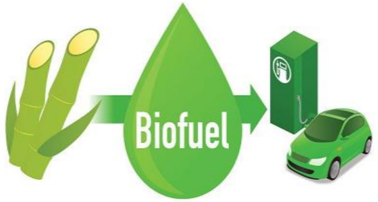
Sustainable site management



- Increase in degraded and contaminated lands
- Increase in population
- Increasing demand for food and fuel

Growing plants on degraded and contaminated soils to restore them while producing biomass

GOLD Project

- An EU Horizon 2020 programme
- 19 partners; 8 universities, 9 research institutions and 2 companies
- € 2 999 950

Contaminated soils:
- ~2.5 M sites in Europe
- Can't be used for food
- Phytoremediation is a "green" and economical way for soil restoration

Bridge the gap

Biofuels with low land-use change risk:
- Crops can be cultivated contaminated soils
- 14% for biofuels, by 2030
- Energy crops could fill this need for biomass

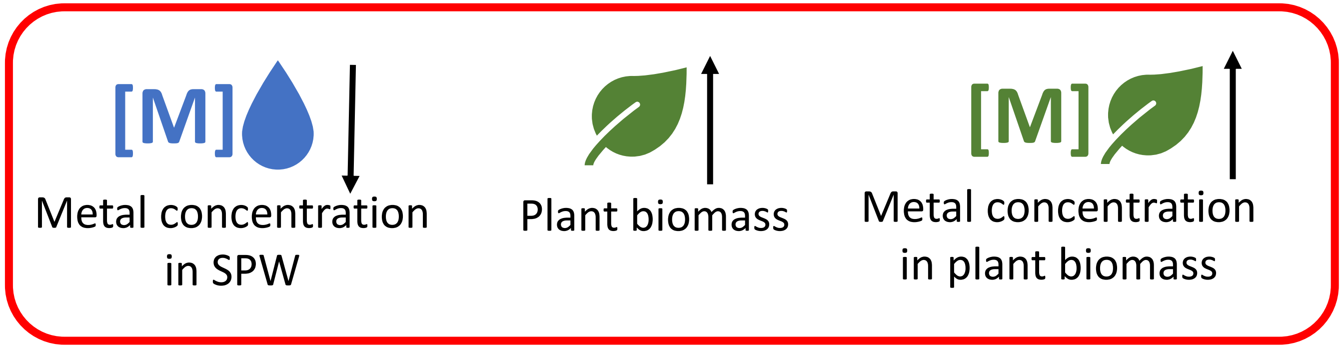
Growing energy crops on contaminated soils

Biofuels with low land-use change risk

Optimized value chains in terms of costs, sustainability and SDGs

Objectives

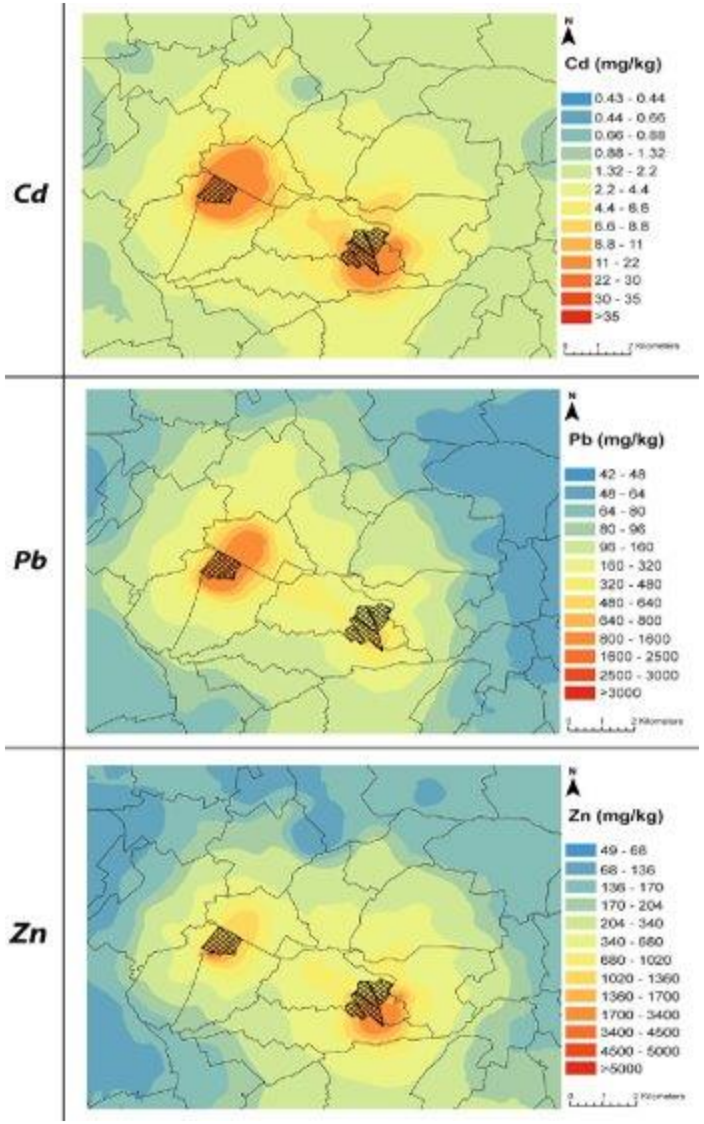
- To study the effect of different treatments on the behaviour and transfer of Cd, Pb and Zn to lignocellulosic energy crops grown on metal-contaminated agricultural soils



- To select the best performing treatments and plant species for optimizing the operating conditions for further field trials

Pot trials: the MetalEurop site

Metaleurop, former lead smelter



Regional Values			
Mean concentration ($mg\ kg^{-1}$) in Soil	Cd	Pb	Zn
	0.4	32	68

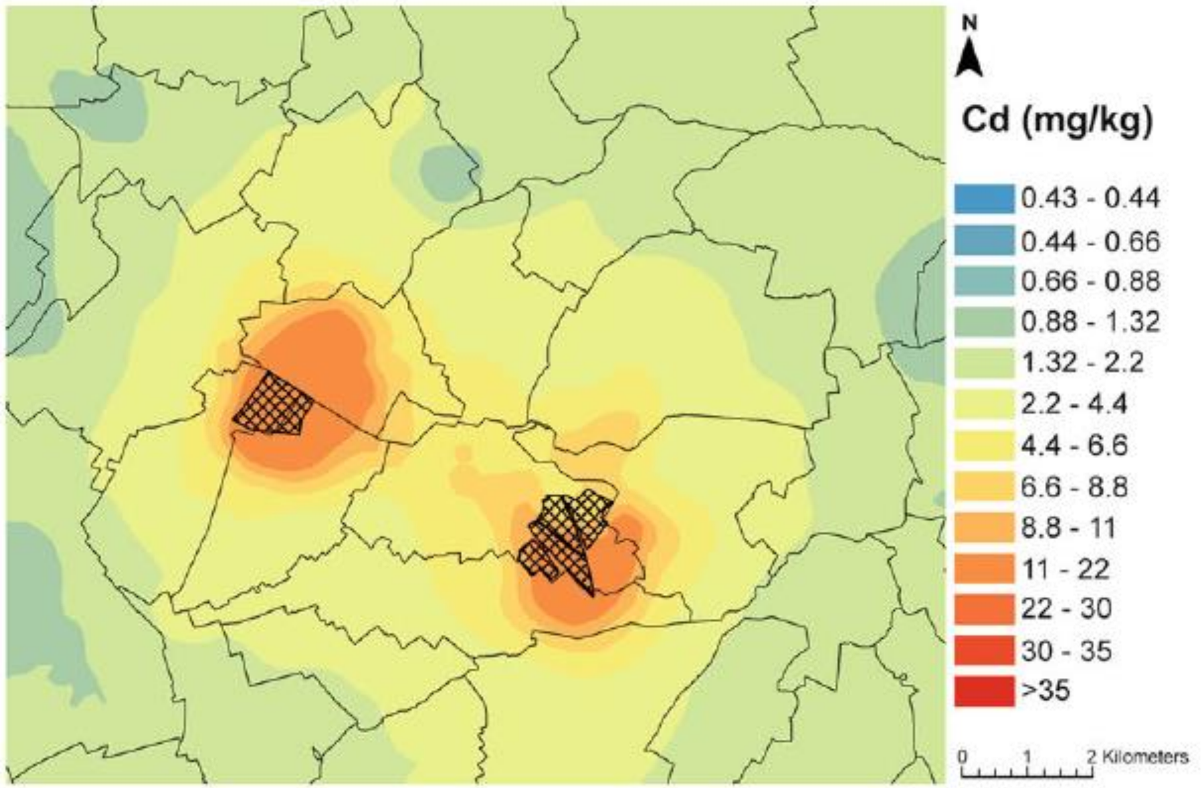
Pelfrene *et al.,2015*

Pot trials: the MetalEurop site

Metaleurop, former lead smelter

Regional Values			
Mean concentration ($mg\ kg^{-1}$) in Soil	**Cd**	**Pb**	**Zn**
	0.4	32	68

Cd



Pot trials: the MetalEurop site

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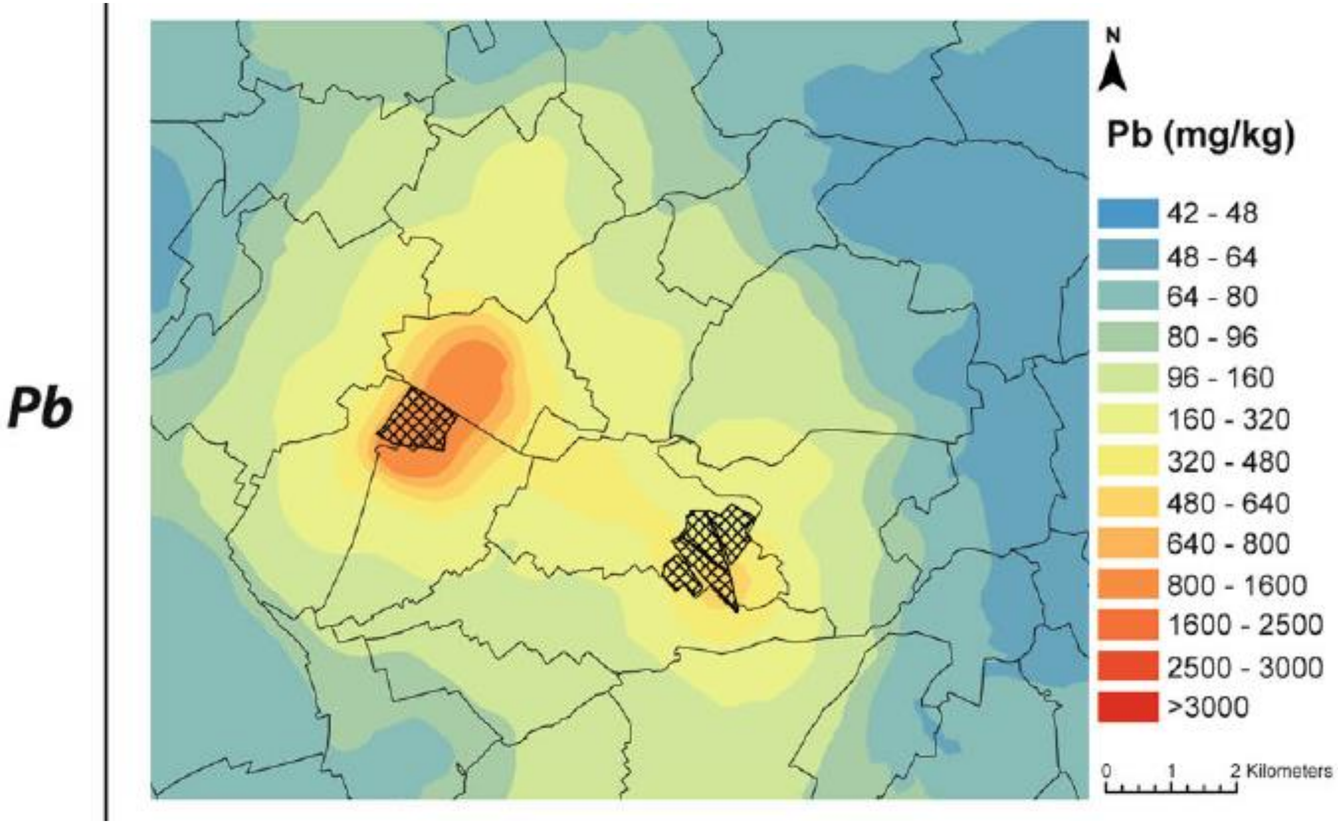

Pot trials: the MetalEurop site


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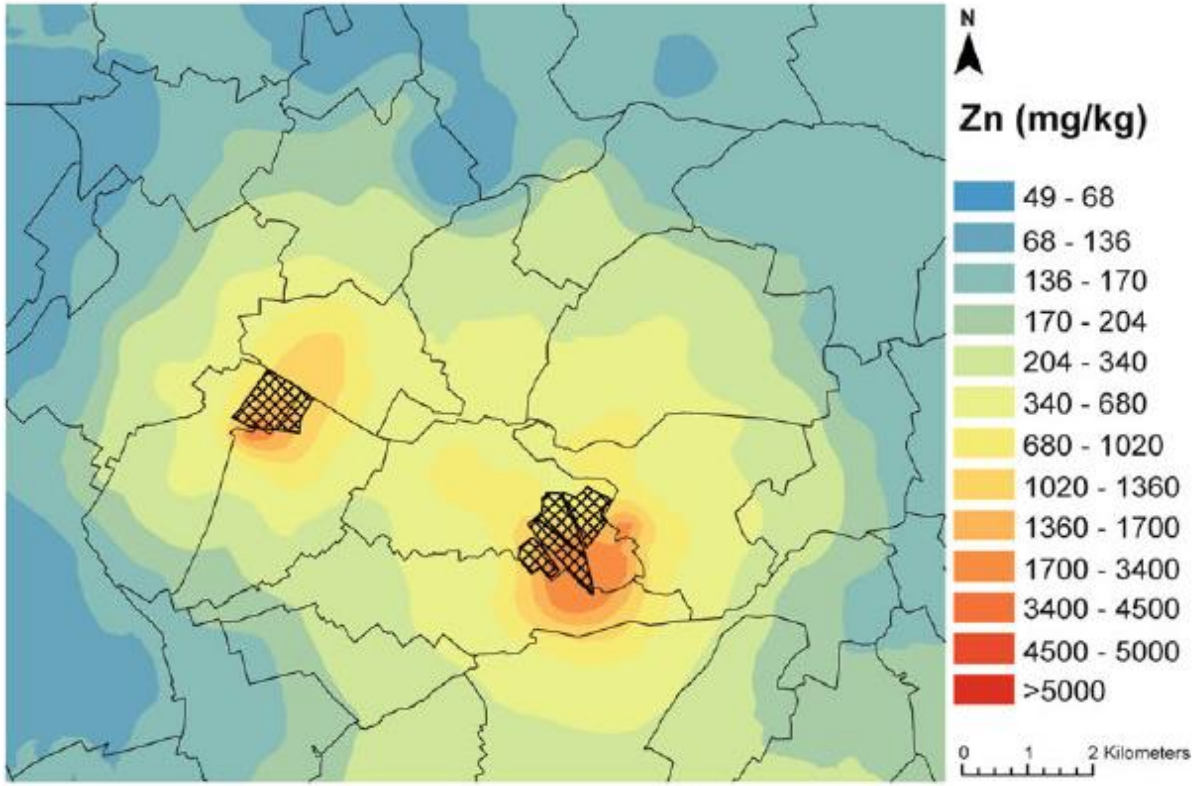
Zn



The MetalEurop site: Soil parameters at the agricultural field

The MetalEurop site (Google Earth, 2022)

Parameters	Site soil	Background levels
Clay (%)	20	
Silt (%)	53	
Sand (%)	27	
pH (H_2O)	8.2	
CEC ($cmol^+kg^{-1}$)	14.9 ± 1.6	
$CaCO_3$ ($g\ kg^{-1}$)	10.2 ± 3.3	
Total N ($g\ kg^{-1}$)	1.20± 0.03	
P_2O_5 ($mg\ kg^{-1}$)	0.16 ± 0.01	
Cd ($mg\ kg^{-1}$)	14.1 ± 1.4	0.4
Pb ($mg\ kg^{-1}$)	731 ± 67	29
Zn ($mg\ kg^{-1}$)	1,000 ± 88	67

Plant species

Cannabis sativa L.

Miscanthus x giganteus

- Tolerant to high concentrations of inorganic pollutants
- Biomass valorization (biofuels)
- Low agricultural input required

Biostimulants & Mycorrhizae

Protein hydrolysate

Humic/fulvic acids

Mycorrhizae fungi

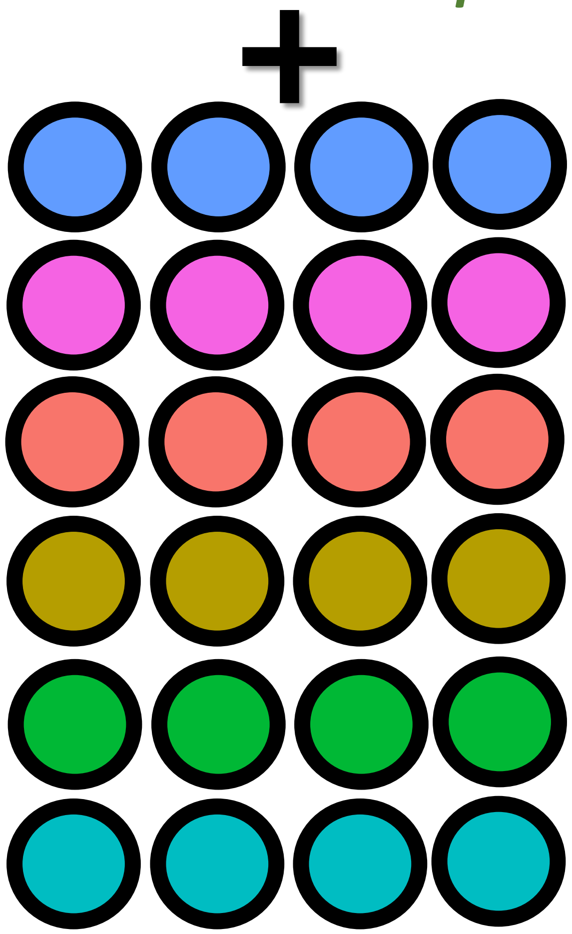
- Increased plant growth and biomass yield
- Enhanced tolerance to biotic and abiotic stress
- Enhanced nutrient uptake

Increased accumulation of metal(loids) without increasing toxicity

Increased transfer of metal(loids) from roots to shoots

Pot trials: Experimental layout

Miscanthus *Hemp*



Control

Mycorrhizae(M)

Protein hydrolysate (B1)

Protein hydrolysate x Mycorrhizae (B1xM)

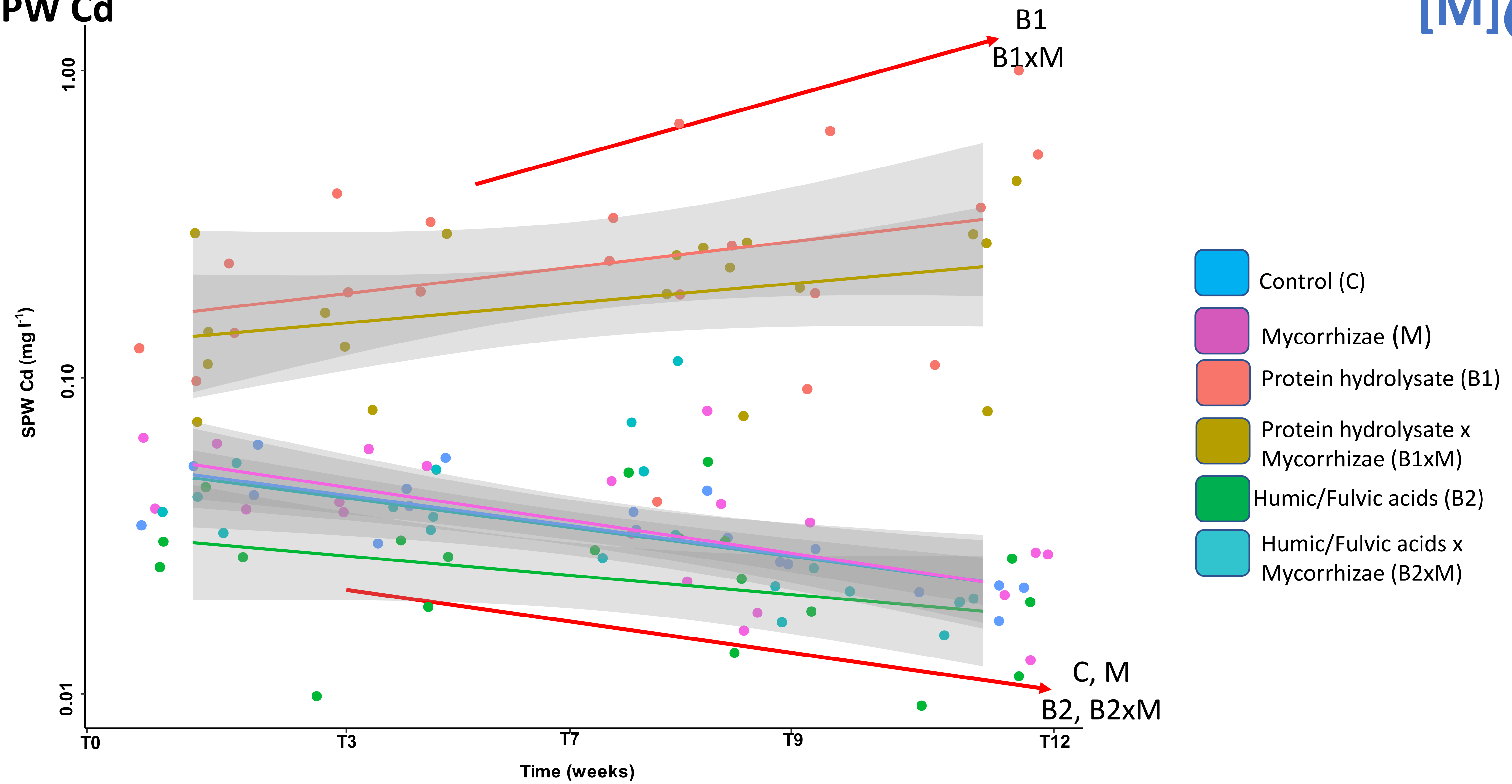
Humic/Fulvic acids (B2)

Humic/Fulvic acids x Mycorrhizae (B2xM)

Hemp at time of harvest (T12)

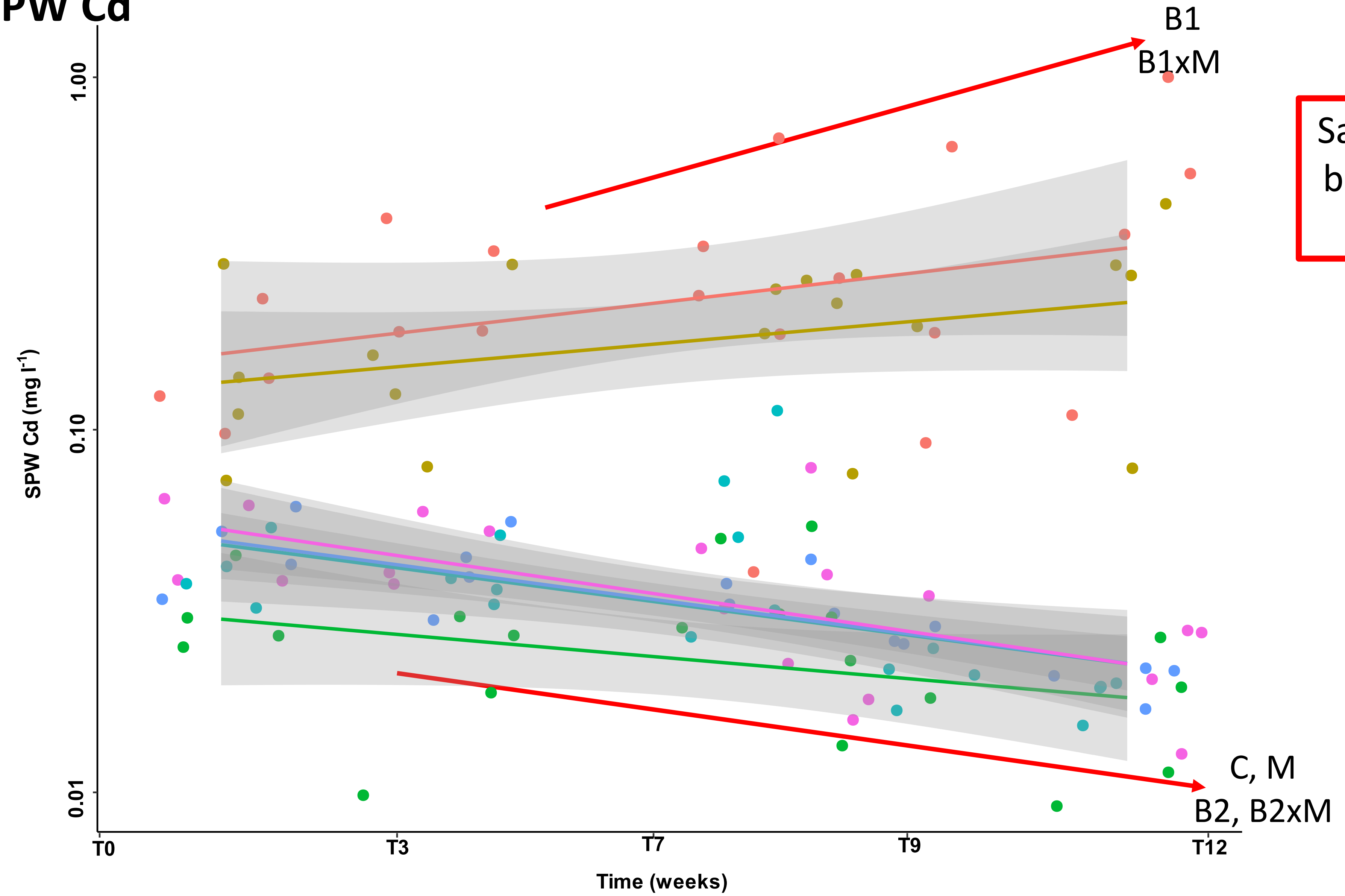
SPW Cd

[M]



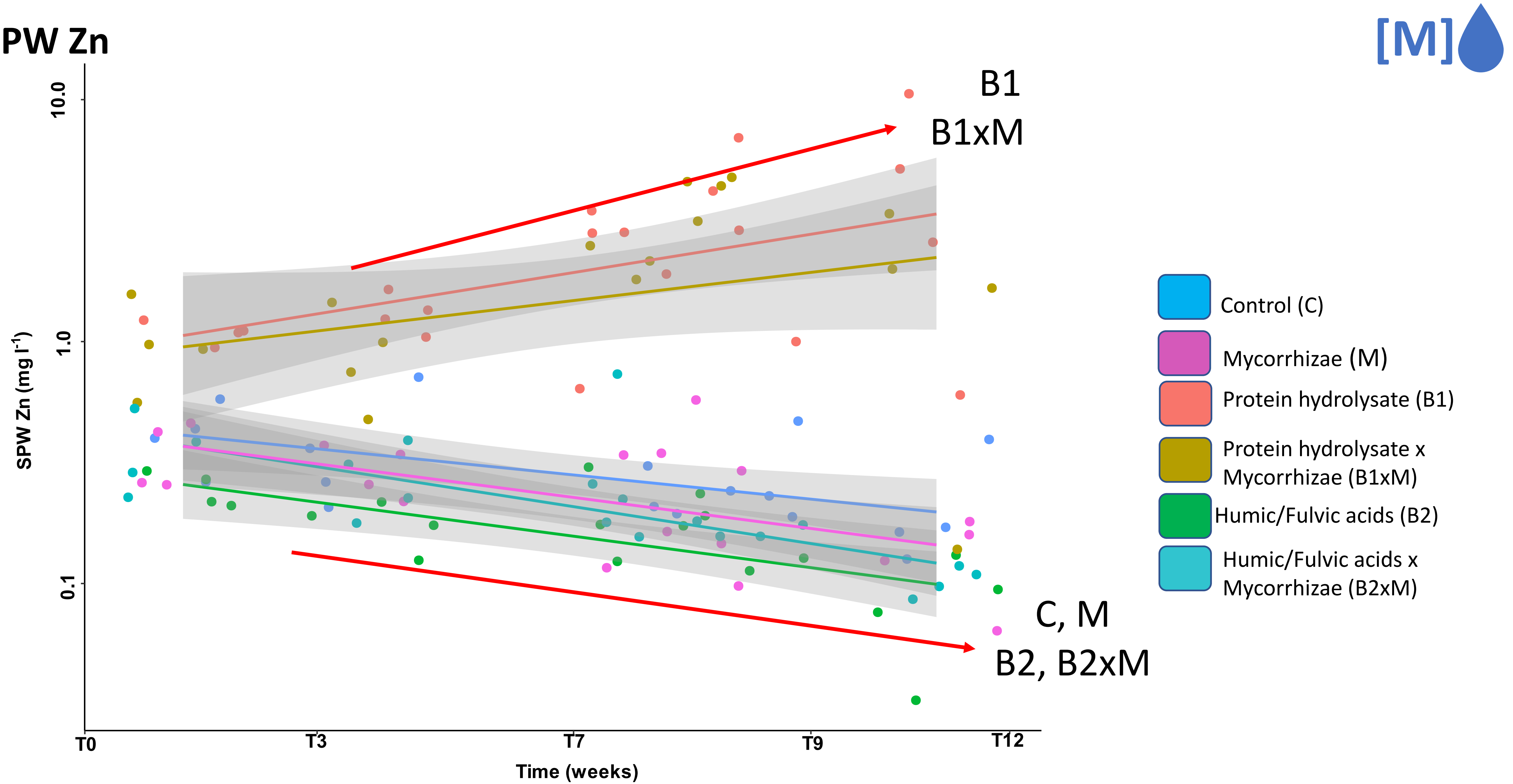
SPW Cd (mg l-1)
1.00
0.10
0.01
T0
T3
T7
T9
T12
Time (weeks)
B1
B1xM
C, M
B2, B2xM
Control (C)
Mycorrhizae (M)
Protein hydrolysate (B1)
Protein hydrolysate x Mycorrhizae (B1xM)
Humic/Fulvic acids (B2)
Humic/Fulvic acids x Mycorrhizae (B2xM)

SPW Cd



Same trend was realized for both *Miscanthus giganteus* and *Cannabis sativa L.*

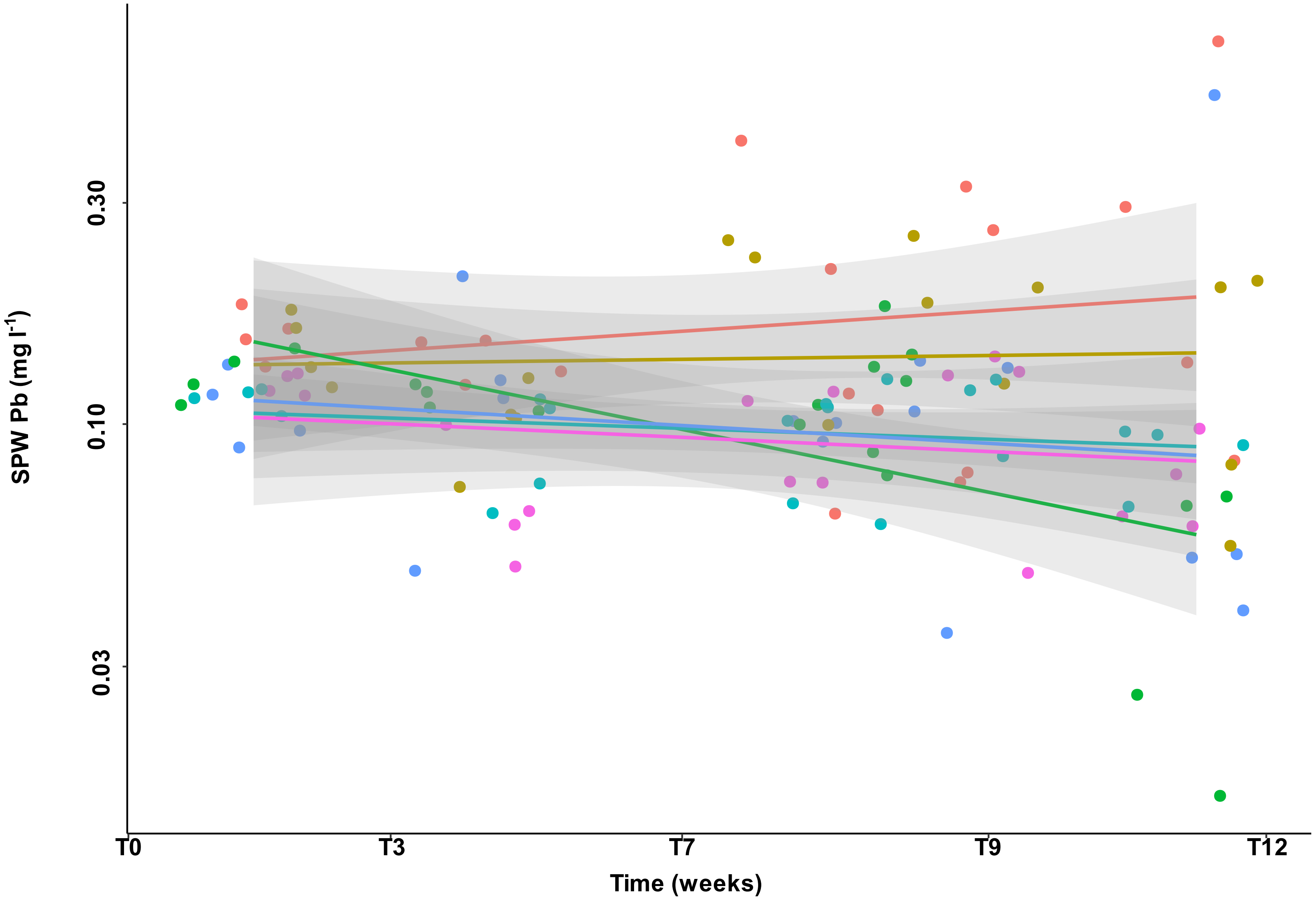
SPW Zn



[M]
10.0
1.0
0.1
SPW Zn (mg l-1)
T0
T3
T7
T9
T12
Time (weeks)
B1
B1xM
C, M
B2, B2xM
Control (C)
Mycorrhizae (M)
Protein hydrolysate (B1)
Protein hydrolysate x Mycorrhizae (B1xM)
Humic/Fulvic acids (B2)
Humic/Fulvic acids x Mycorrhizae (B2xM)

SPW Pb

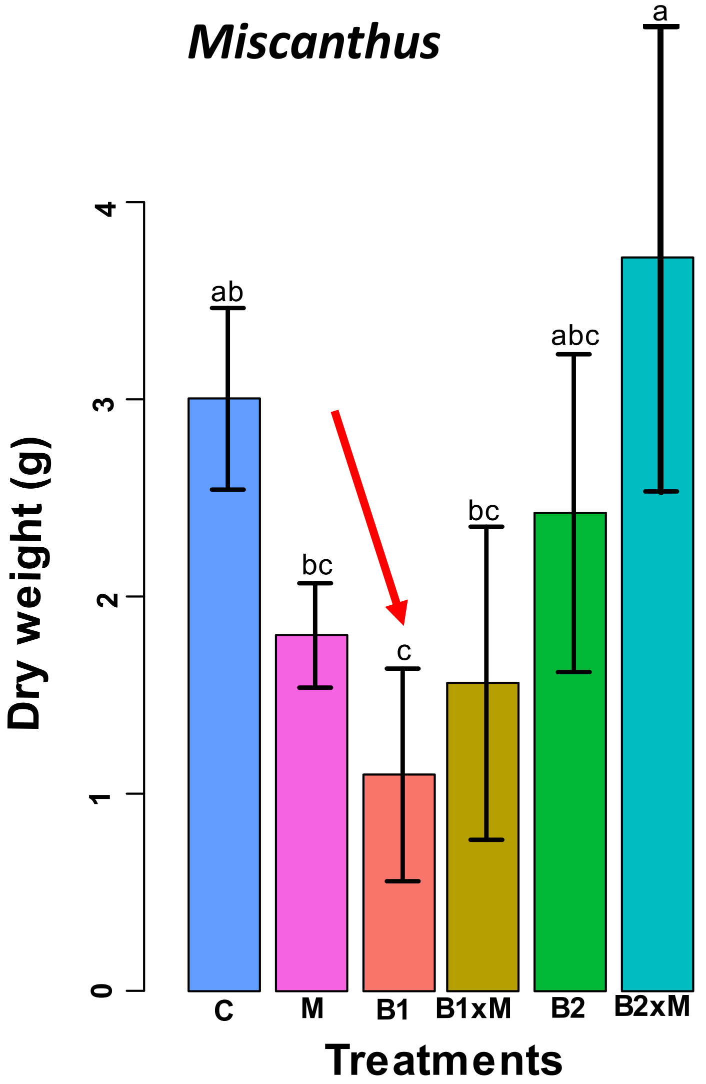
[M]

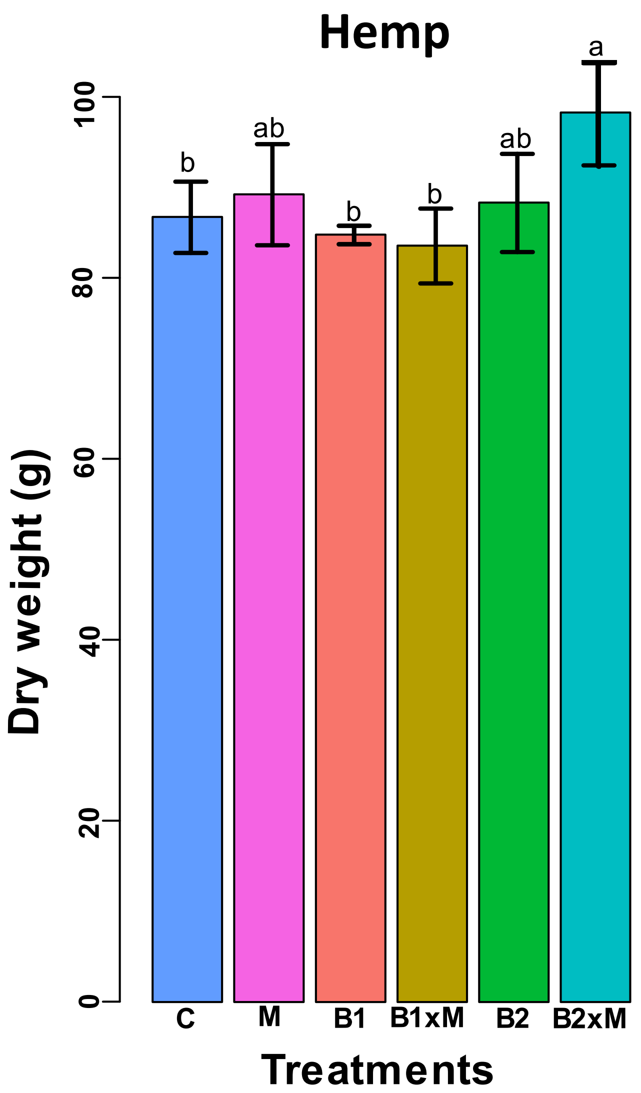


No significant effect

Control (C)
Mycorrhizae (M)
Protein hydrolysate (B1)
Protein hydrolysate x Mycorrhizae (B1xM)
Humic/Fulvic acids (B2)
Humic/Fulvic acids x Mycorrhizae (B2xM)

Shoot DW biomass





Higher shoot yield for B2xM compared to C, B1 and B1xM

- Control (C)
- Mycorrhizae (M)
- Protein hydrolysate (B1)
- Protein hydrolysate x Mycorrhizae (B1xM)
- Humic/Fulvic acids (B2)
- Humic/Fulvic acids x Mycorrhizae (B2xM)

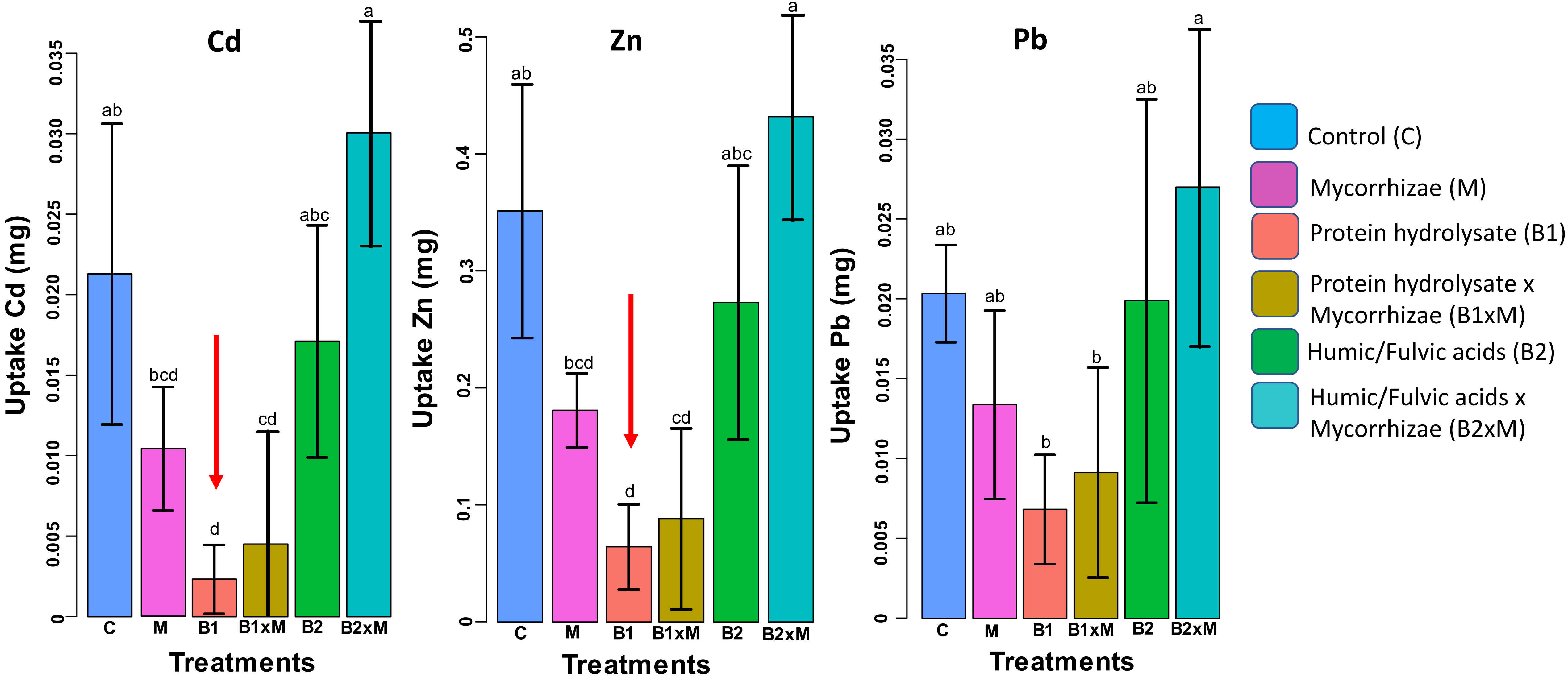
[M]

Metal(loid) concentrations in shoots (mg kg^{-1})

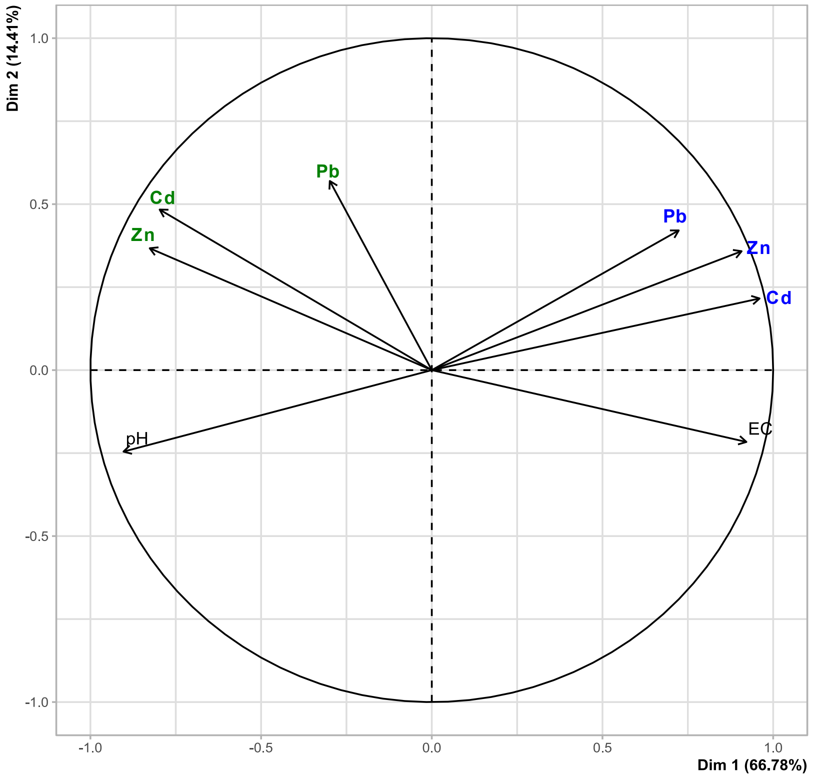
Average concentration in shoots		
Cd	Pb	Zn
0.4-2.9	0.01-5	10-150

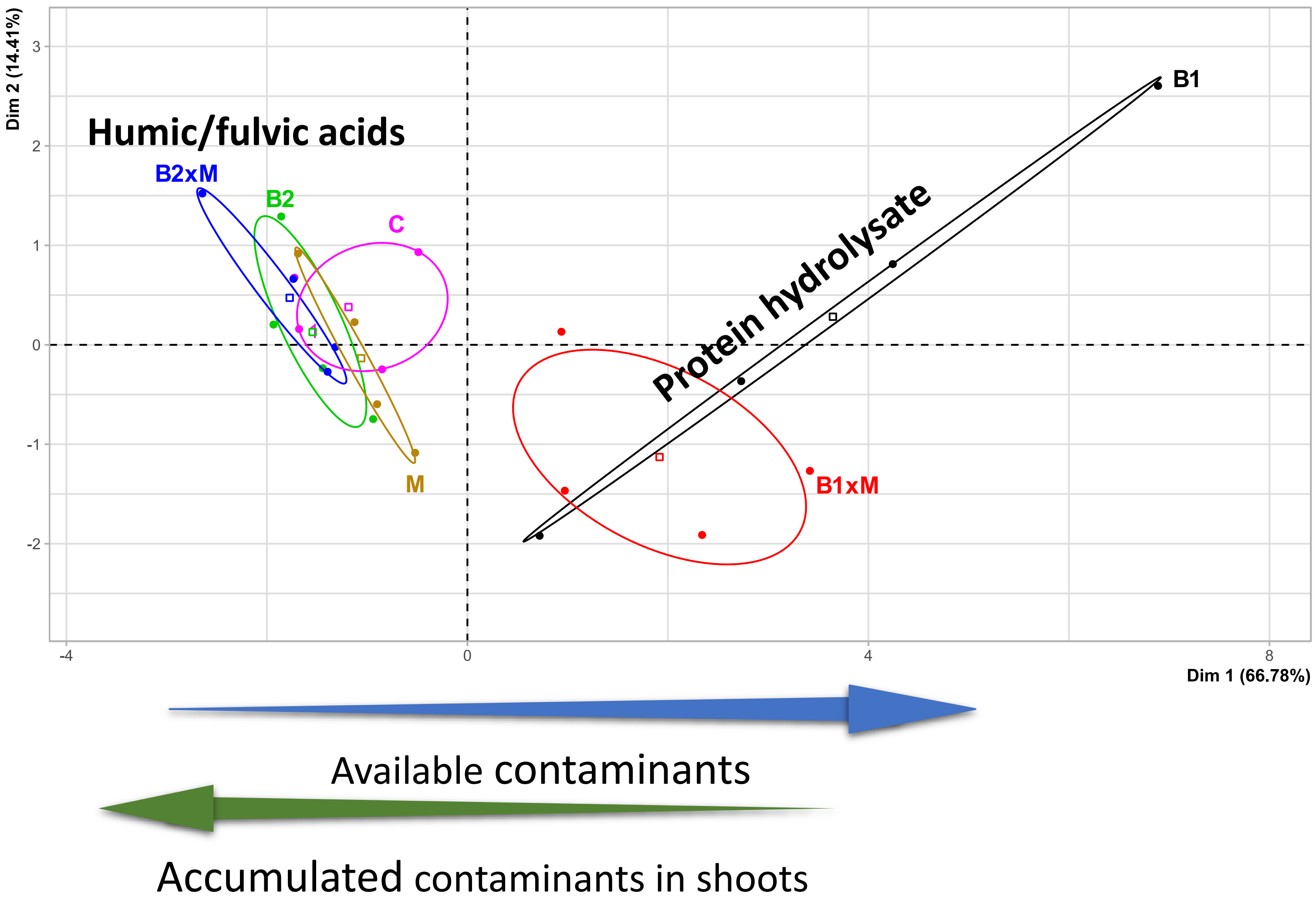
	Miscanthus			Hemp		
Treatment	**Cd**	**Pb**	**Zn**	**Cd**	**Pb**	**Zn**
C	7.0±2.5a	7.0±1.8a	115±21a	2.1±0.1ab	8.5±0.1a	59±3a
M	5.7±1.6ab	7.3±2.6a	100±11a	0.9±0.2b	10.9±1.9a	54±18a
B1	**1.8±0.9b**	6.4±1.6a	**56±14b**	4.0±0.3a	9.6±1.1a	77±15a
B1xM	**2.1±2.6b**	6.1±2.5a	**48±21b**	3.7±1.2a	8.8±1.3a	60±20a
B2	6.8±1.3a	7.7±2.4a	110±12a	1.6±0.4b	9.4±0.8a	60±4a
B2xM	8.4±2.1a	7.3±1.7a	120±18a	0.9±0.2b	8.5±0.3a	51±12a

Metal uptake (mg/pot) = shoot DW yield x shoot Metal concentration

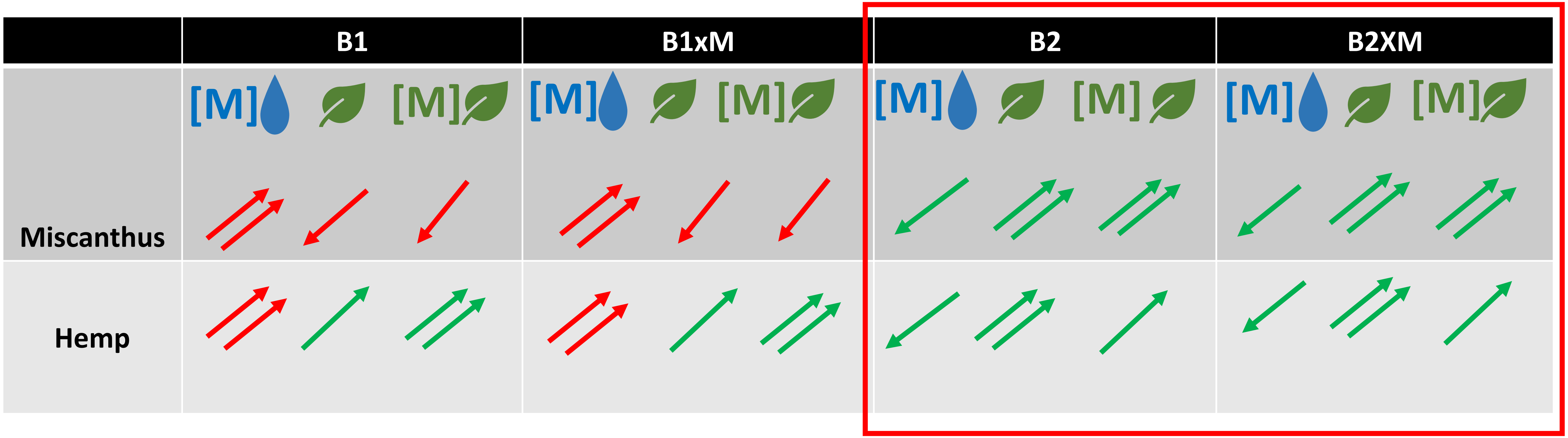


Metal in shoots vs. SPW





Conclusion



Fulvic/Humic acids treatment (B2 and B2xM) were able:

- to reduce the availability of contaminants,
- increase biomass production while accumulating metals in shoot biomass

Perspectives

- Field trial to test, validate and optimize results obtained with fulvic/humic acids treatment
- Production of biomass to converted into biofuel
- Decrease in available contaminants in the long term especially with use of annual plants e.g. hemp

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GOLD

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Horizon 2020
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merci beaucoup

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