

# Biofortifying sprouts with zinc by seed priming

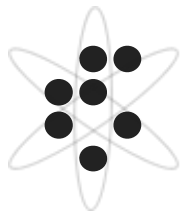
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Jožef Stefan Institute

**F2 / Department of Low  
and Medium Energy Physics**

Univerza v Ljubljani  
*Biotehniška* fakulteta



# Insufficient dietary intake of nutrients leads to malnutrition

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## Macronutrients

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**Macronutrients**

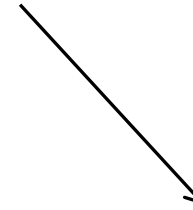
**Micronutrients**

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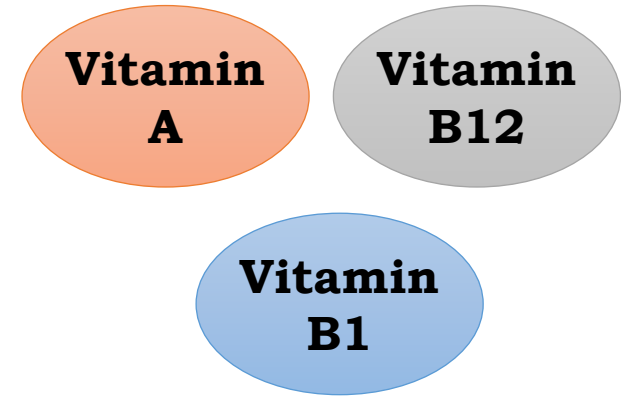
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**Macronutrients**

**Micronutrients**



**Vitamin malnutrition**

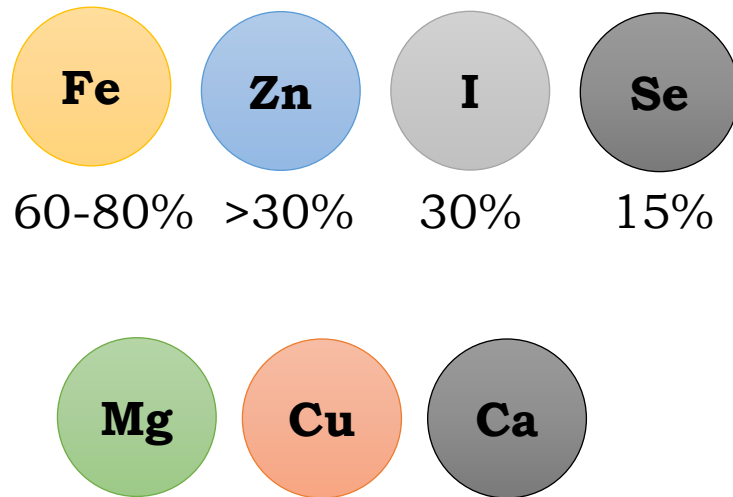


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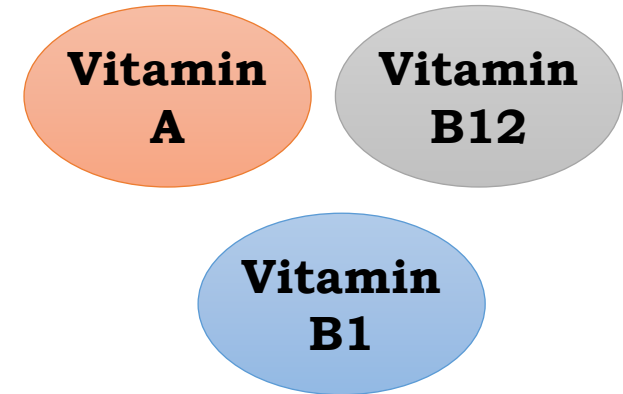
## Macronutrients

## Micronutrients

### Mineral malnutrition



### Vitamin malnutrition

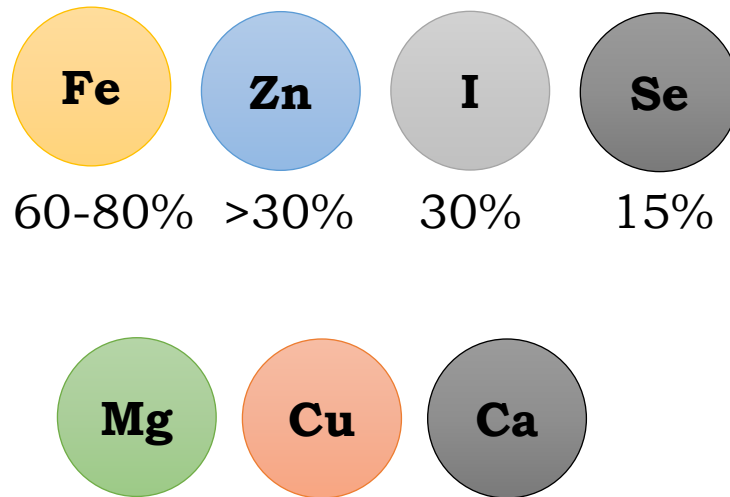


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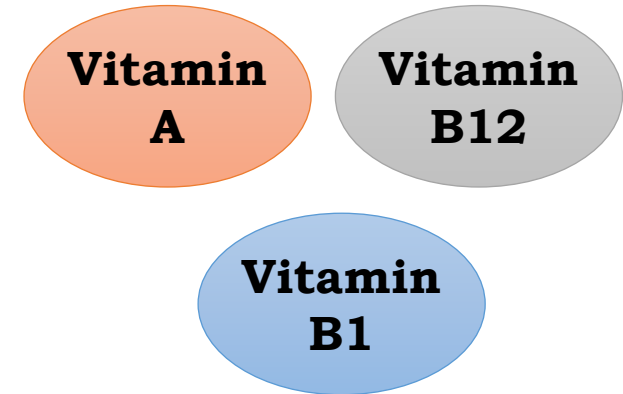
## Macronutrients

## Micronutrients

### Mineral malnutrition

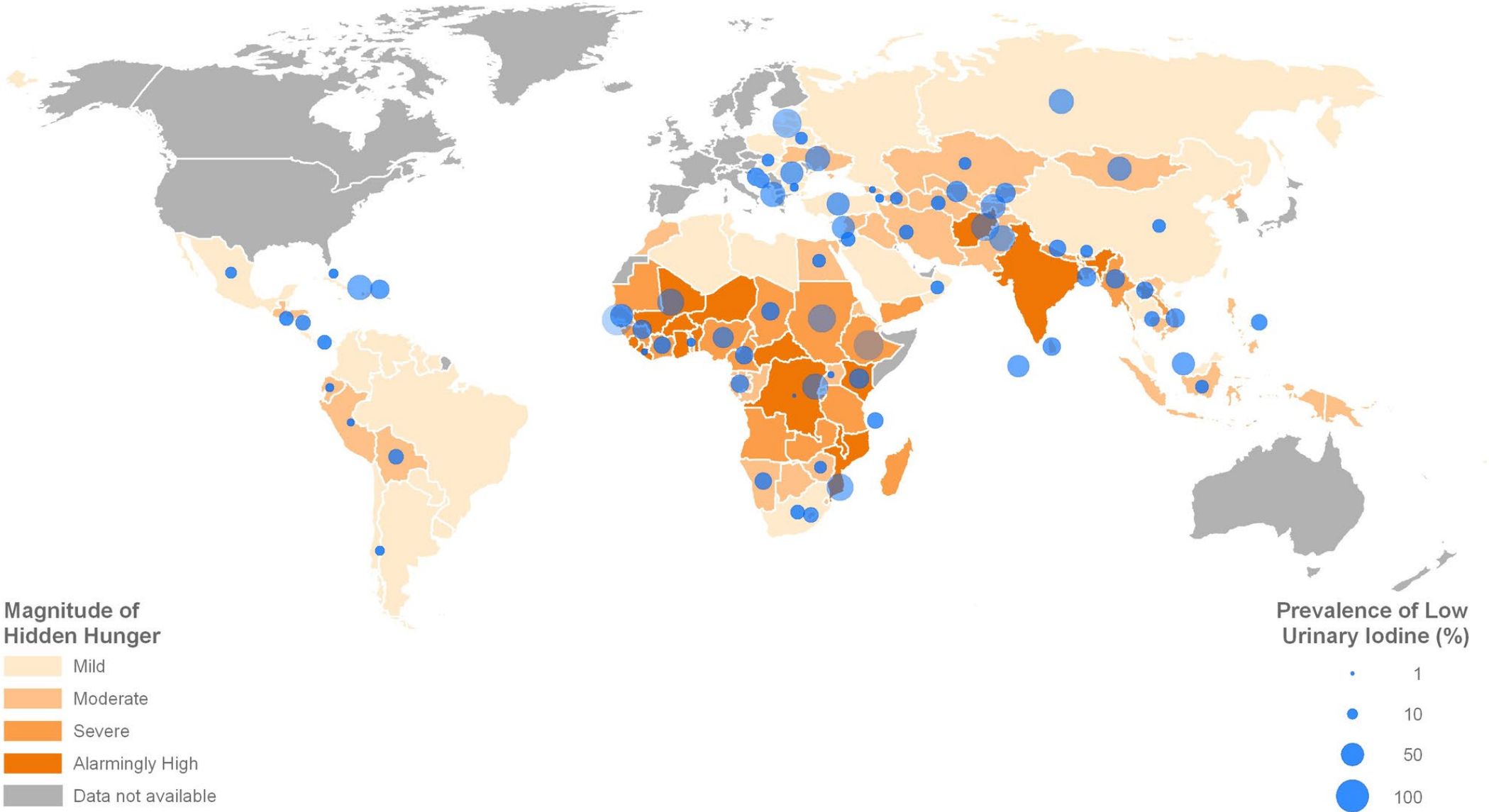


### Vitamin malnutrition



“Hidden hunger”

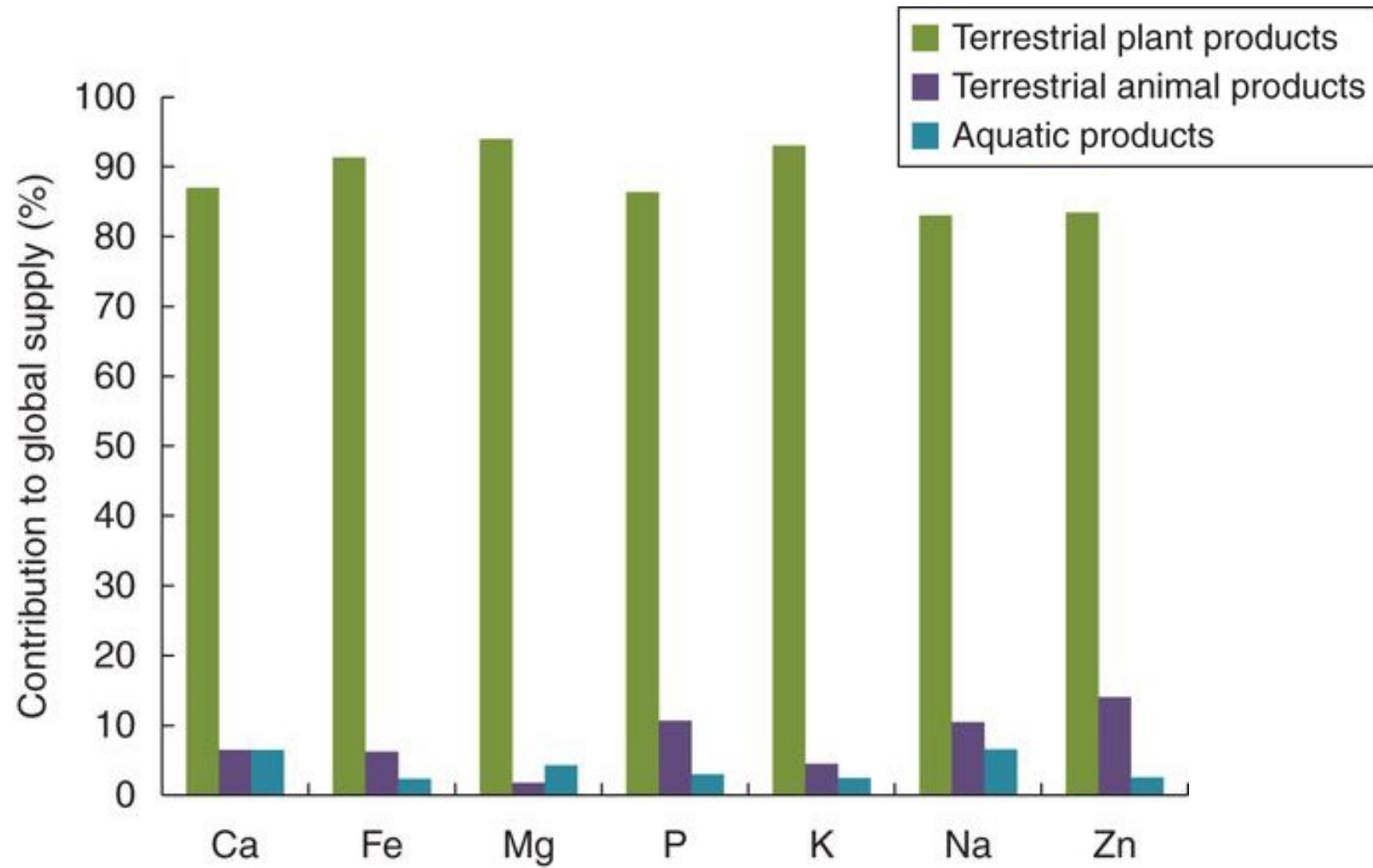
# Global map presenting hidden hunger distribution



Muthayya et al. 2013 PLOS ONE 8(6), e67860.



# Plant-based products are main contributors to our mineral supply



# Strategies to combat hidden hunger

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## 1. Diversification



<https://www.health.harvard.edu/staying-healthy/six-simple-ways-to-smarter-healthier-eating>



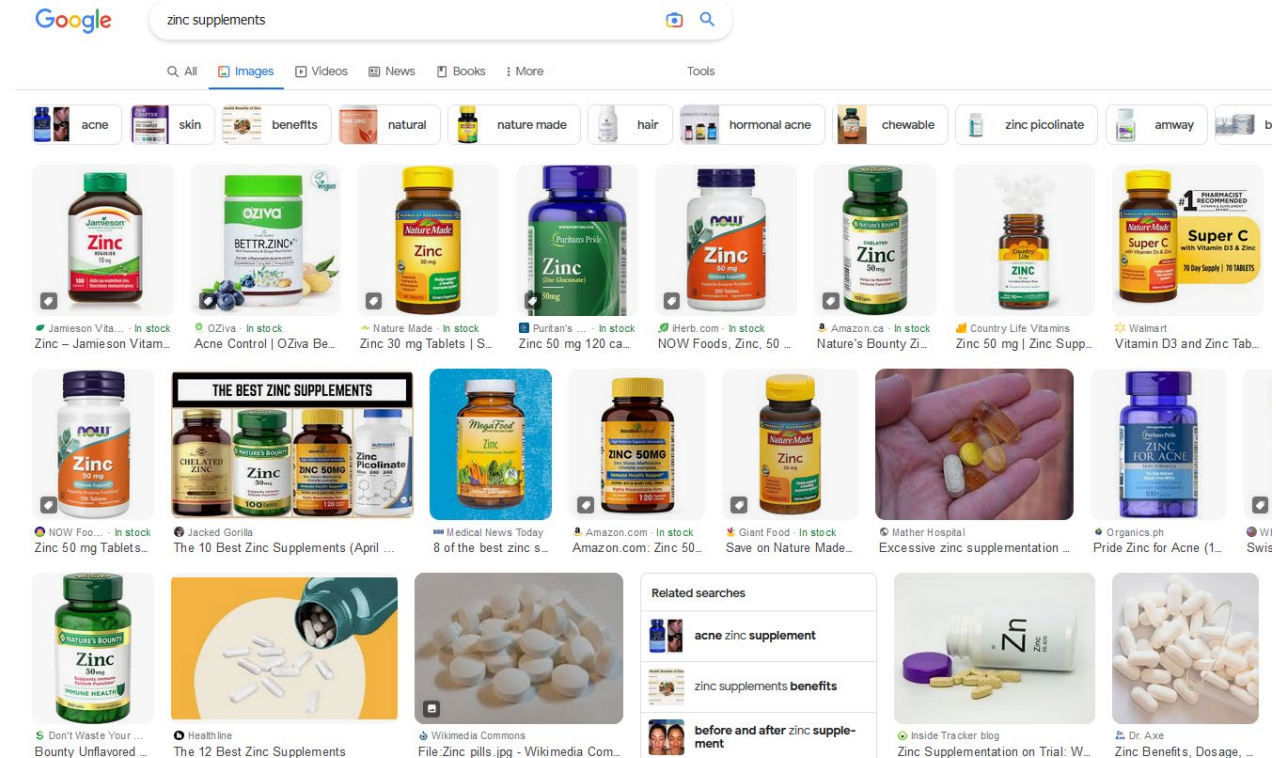
# Strategies to combat hidden hunger

## 1. Diversification



<https://www.health.harvard.edu/staying-healthy/six-simple-ways-to-smarter-healthier-eating>

## 2. Dietary mineral supplements



Google search on 21st April 2023

# Strategies to combat hidden hunger

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White & Broadley 2009 *New Phytologist* 182, 49-84; Bouis & Saltzman 2017 *Global Food Security* 12, 49-58; Bhardwaj et al 2022 *Frontiers in Plant Science* 13, 1055278.

# Strategies to combat hidden hunger

## 3. Fortification



<https://www.soline.si/>



<https://www.cheerios.com/products/multi-grain-cheerios>

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# Strategies to combat hidden hunger

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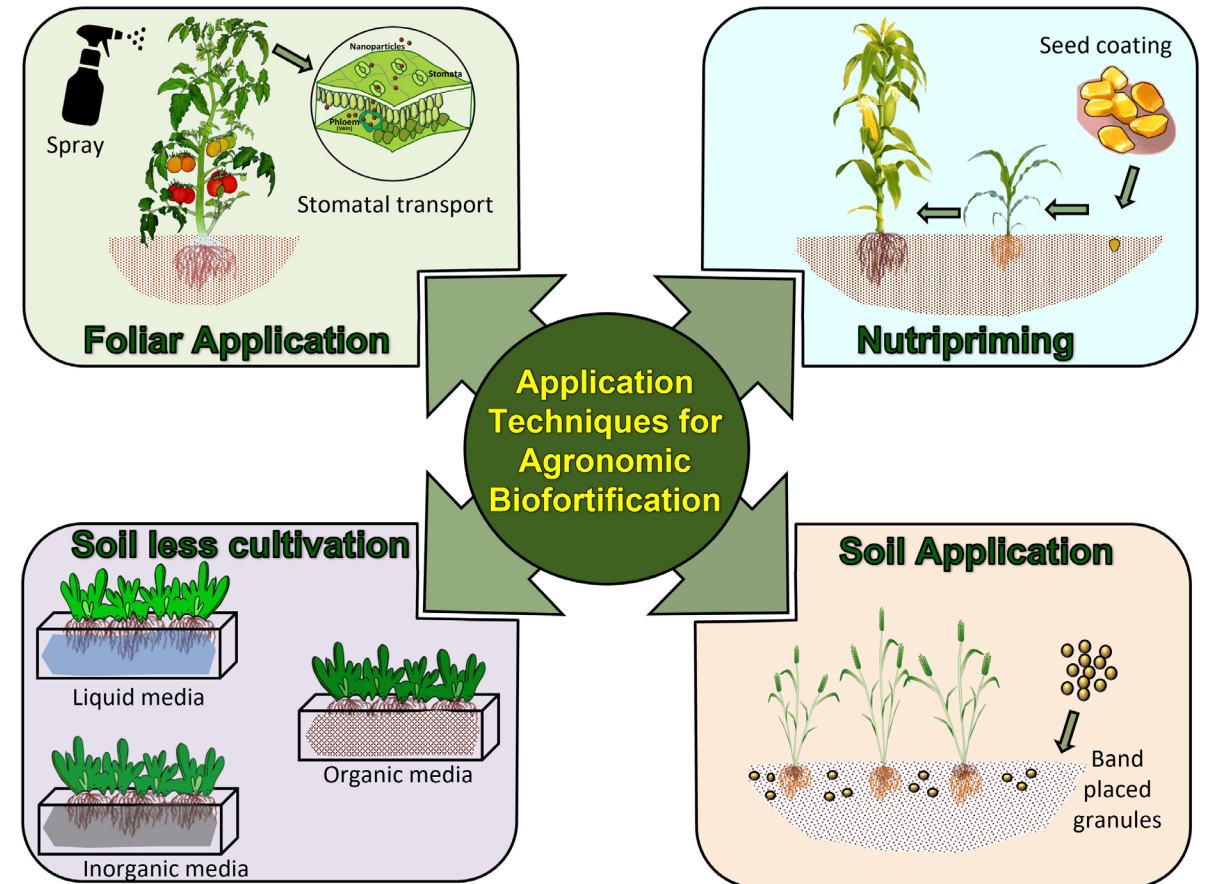


<https://www.soline.si/>



<https://www.cheerios.com/products/multi-grain-cheerios>

## 4. Biofortification: agronomic and genetic



White & Broadley 2009 New Phytologist 182, 49-84; Bouis & Saltzman 2017 Global Food Security 12, 49-58; Bhardwaj et al. 2022 Frontiers in Plant Science 13, 1055278.

# Strategies to combat hidden hunger

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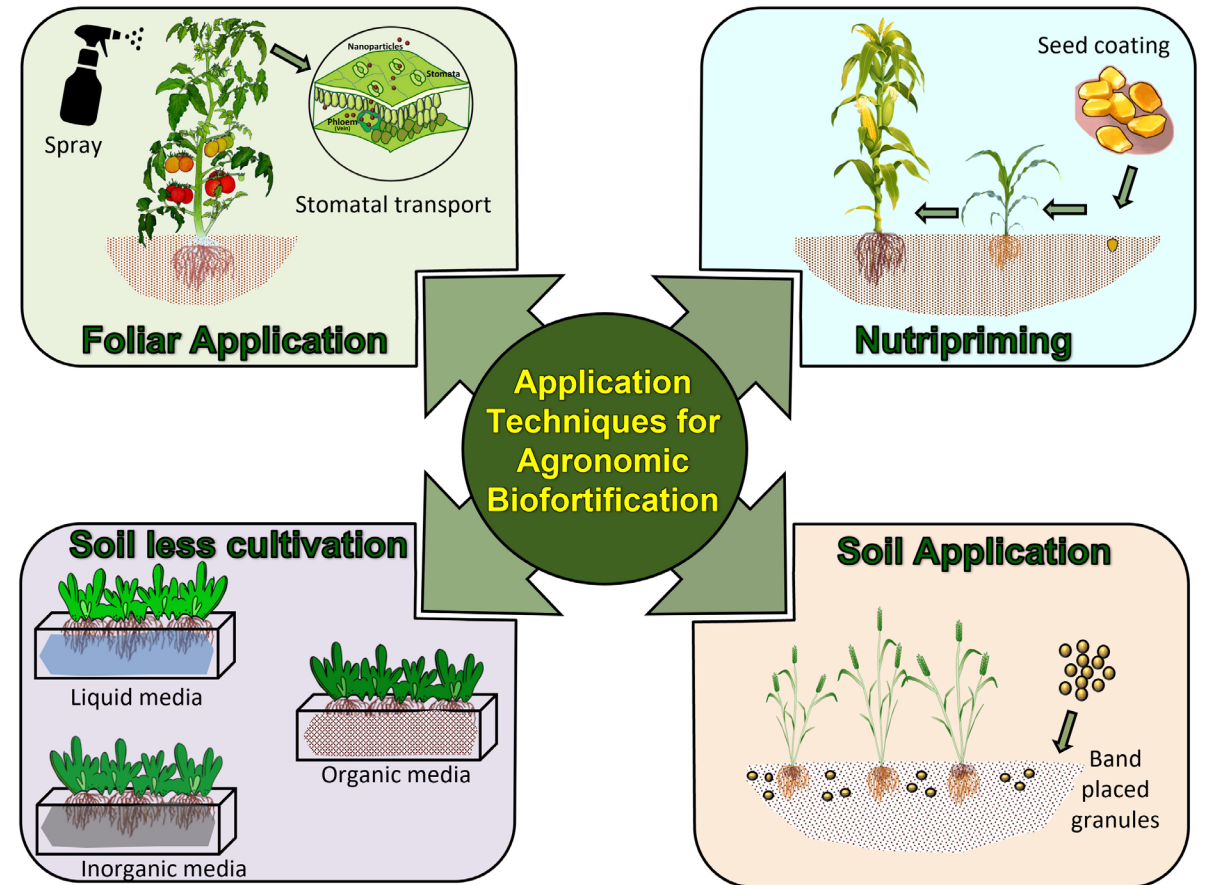


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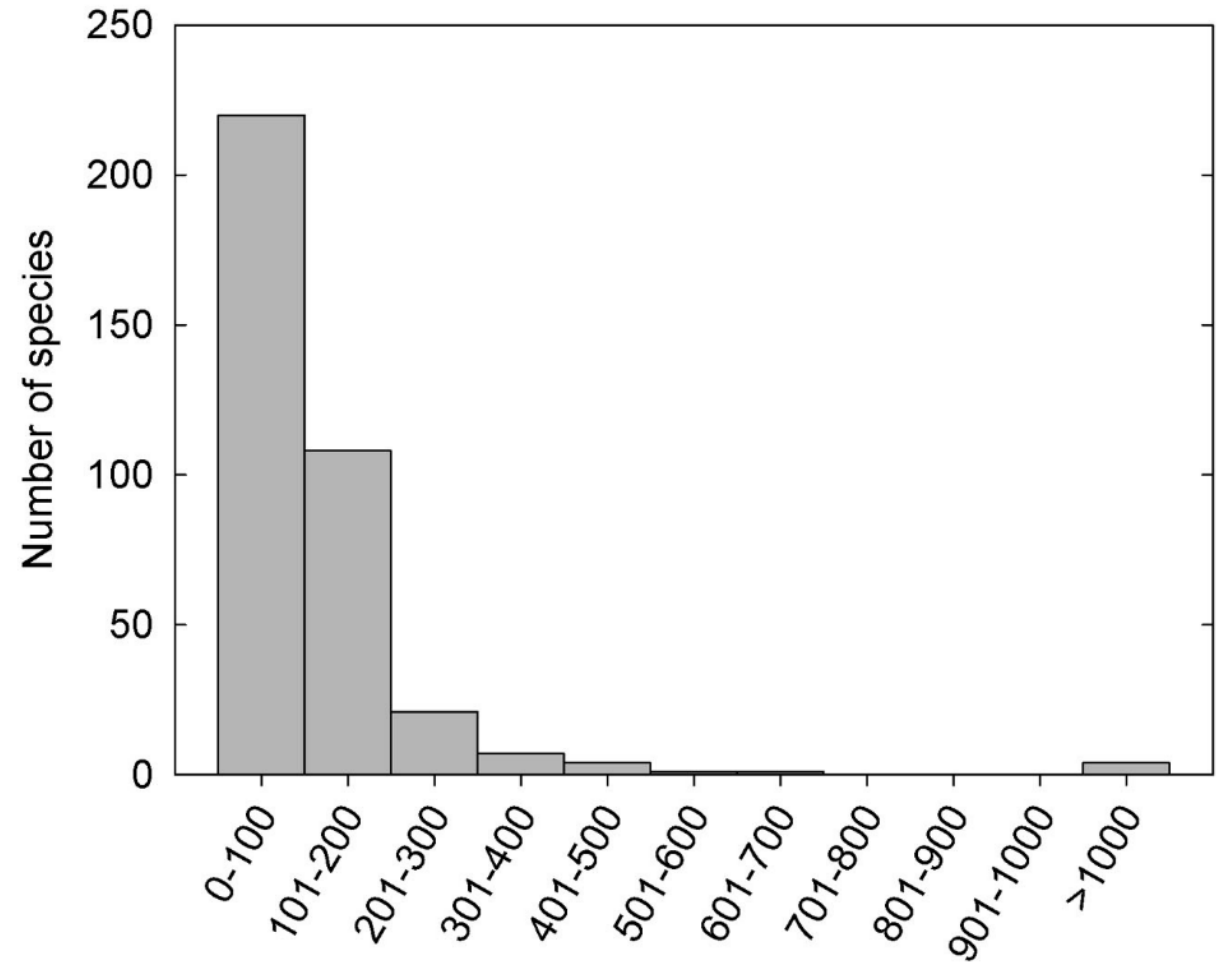
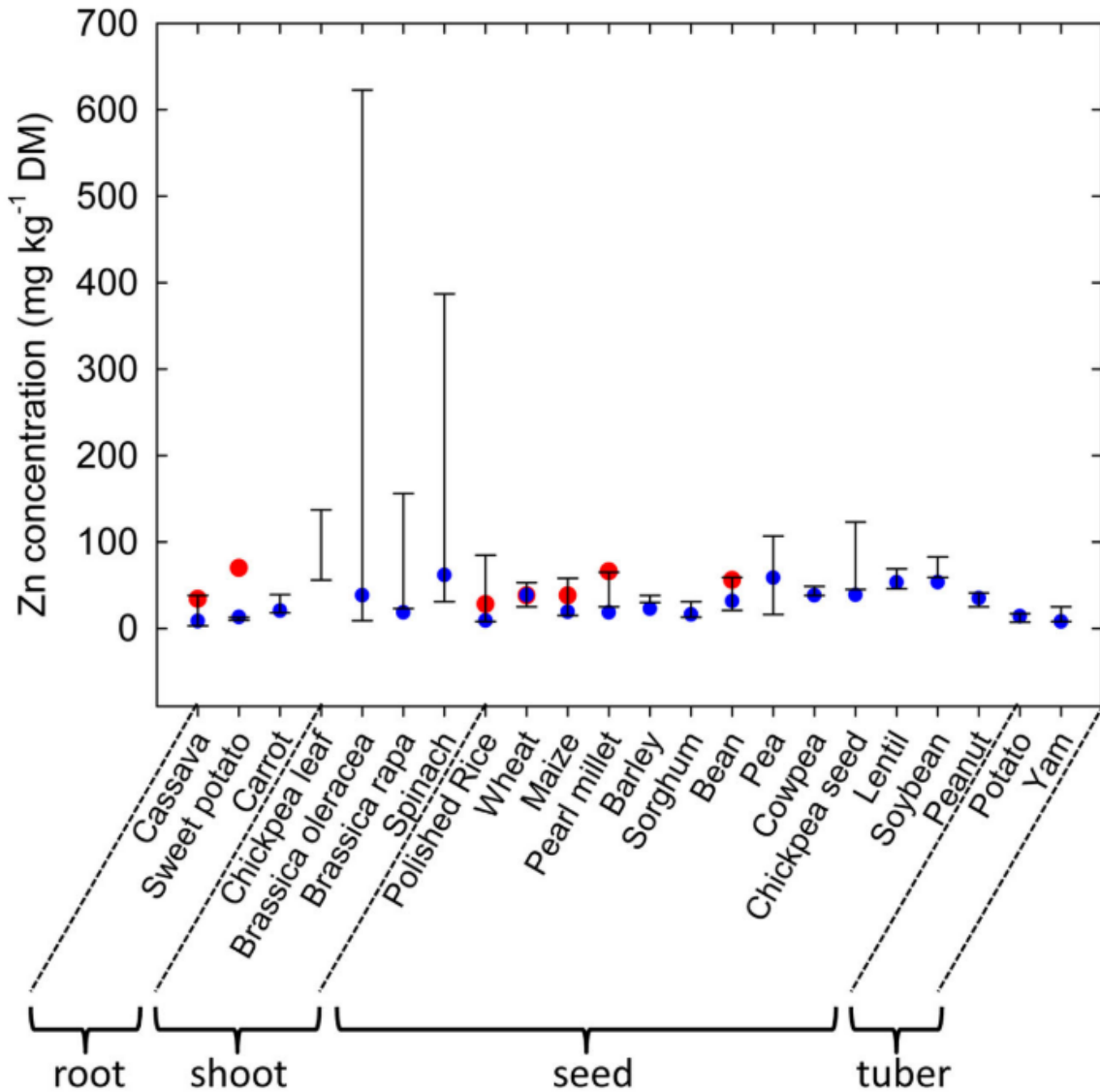


<https://www.harvestplus.org/>

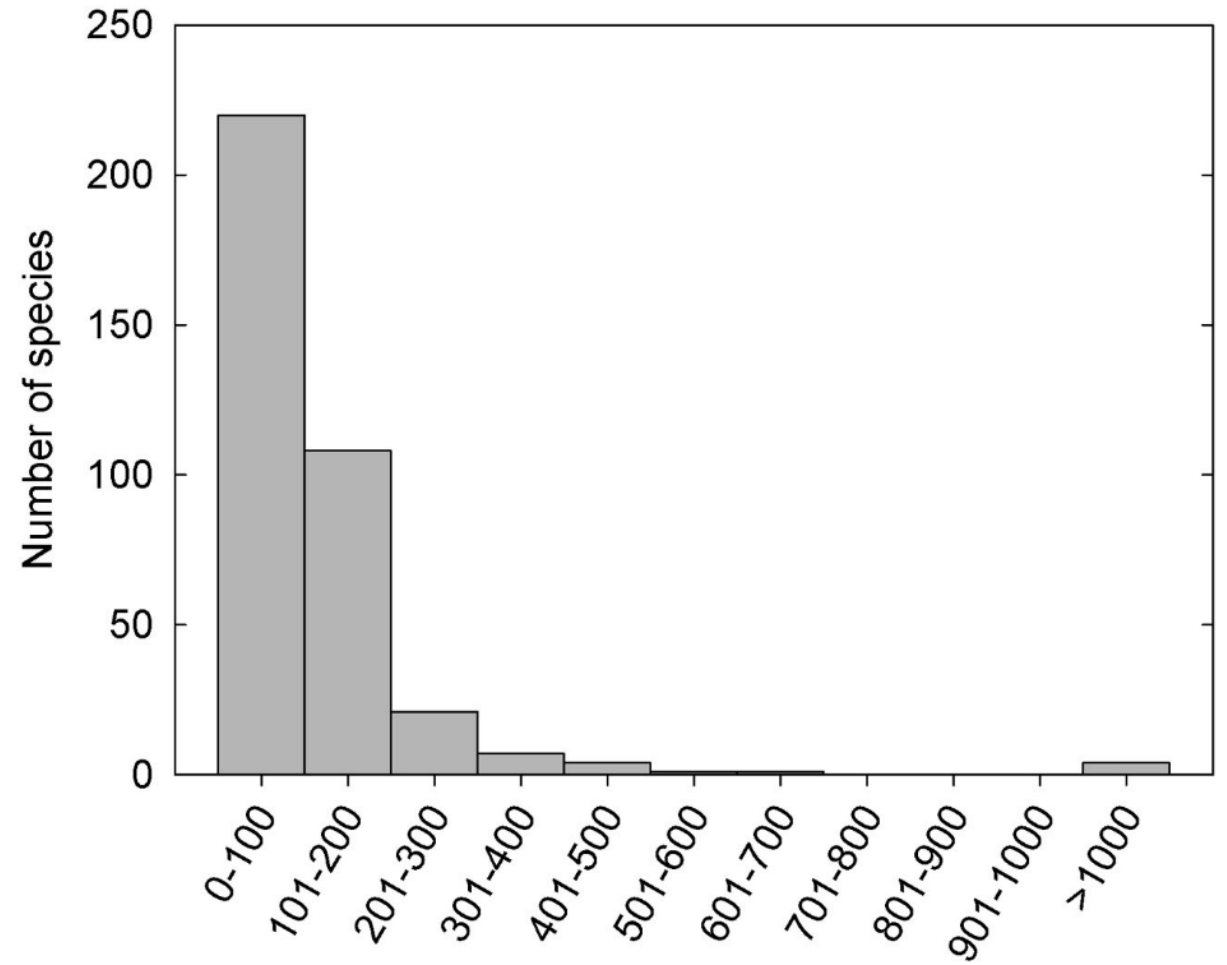
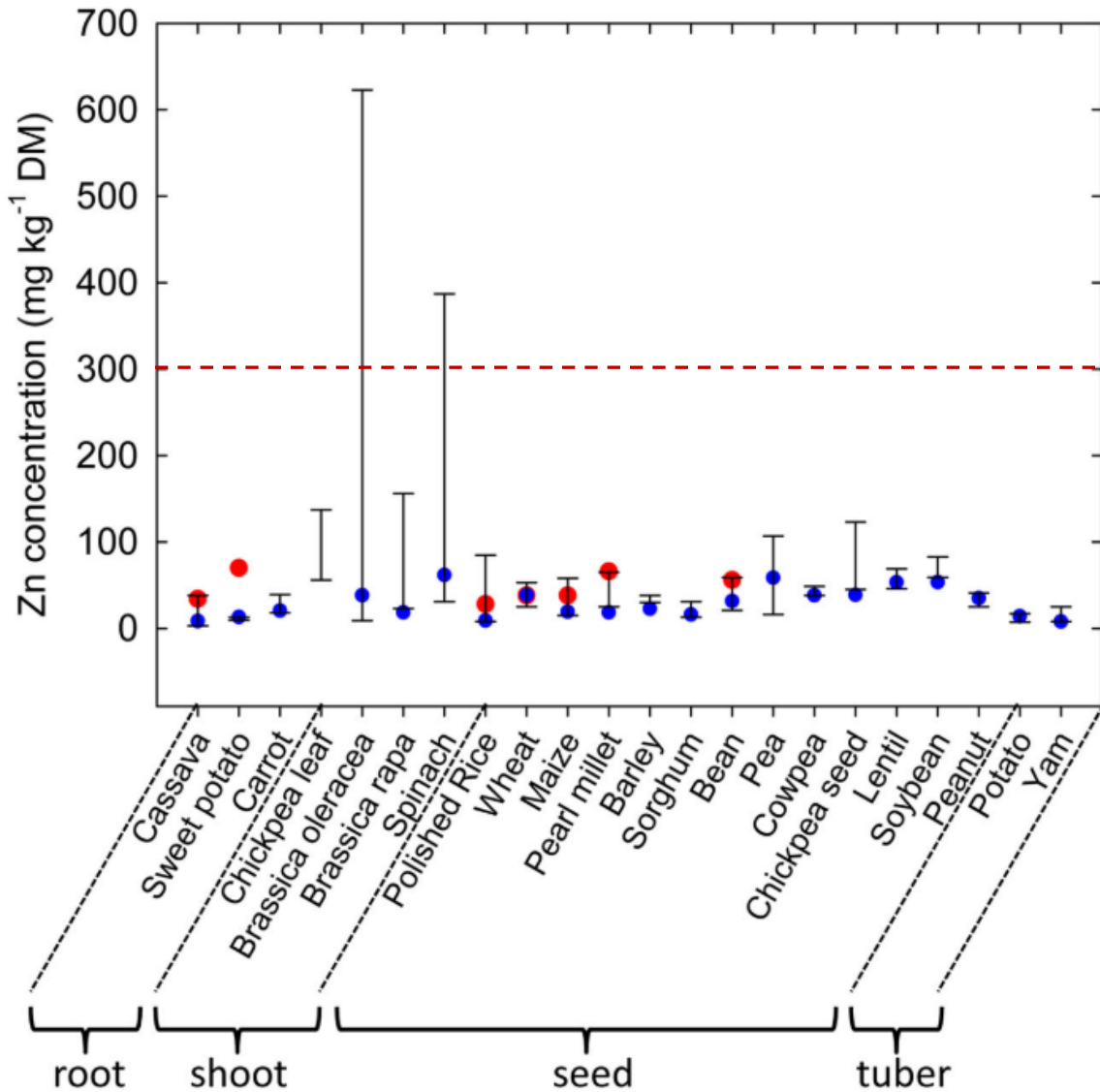
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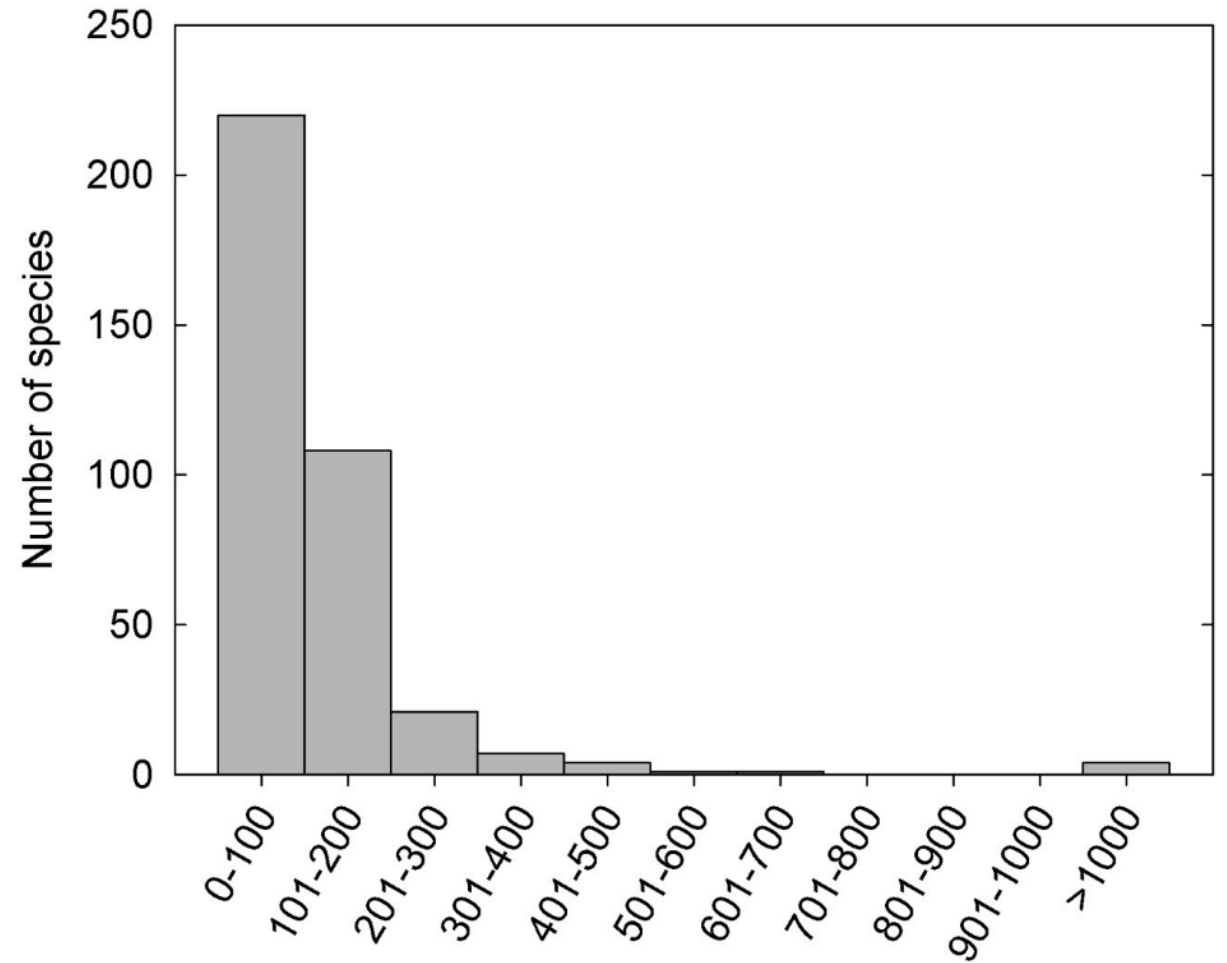
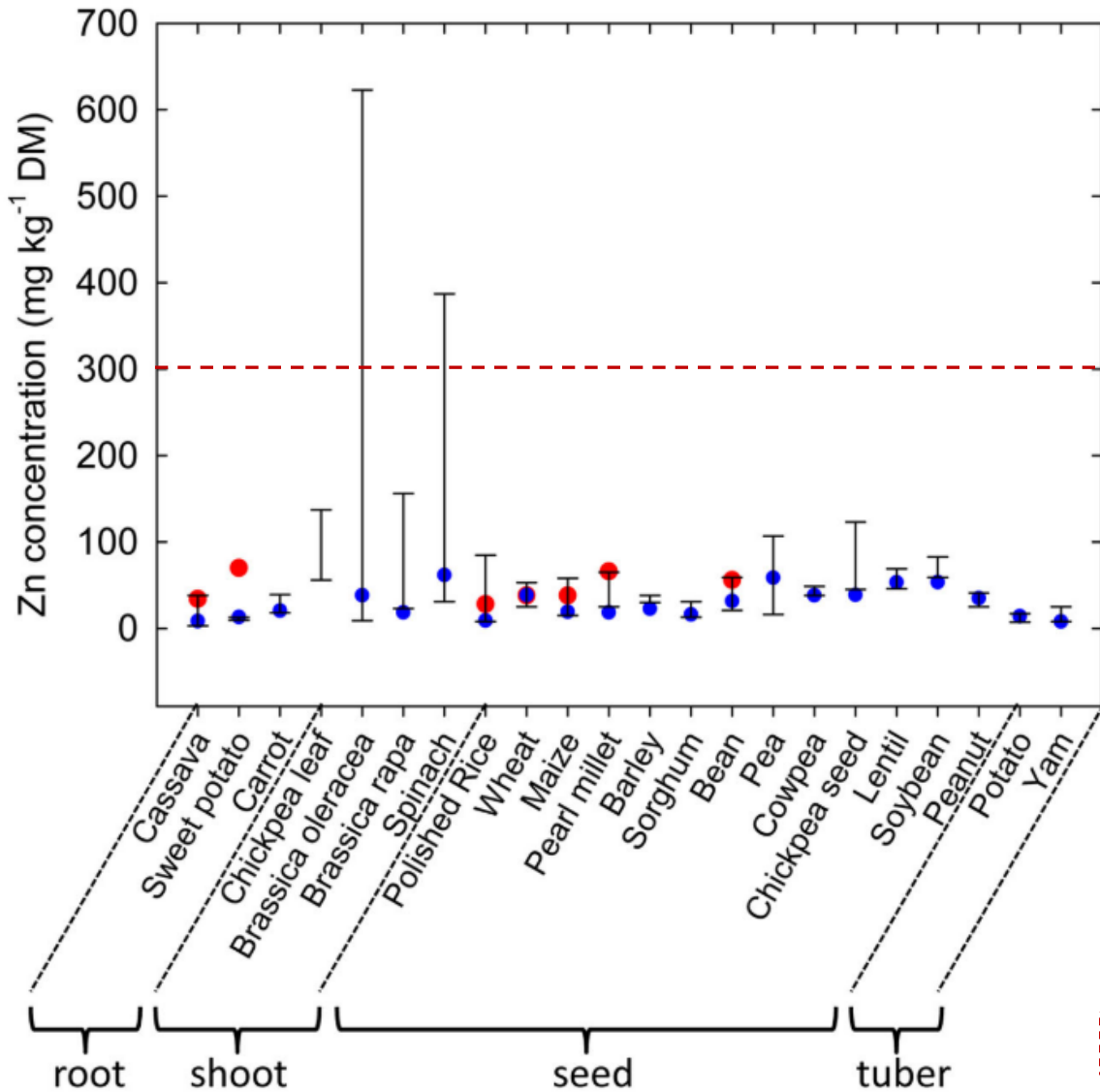
# Variability in Zn concentration in crops



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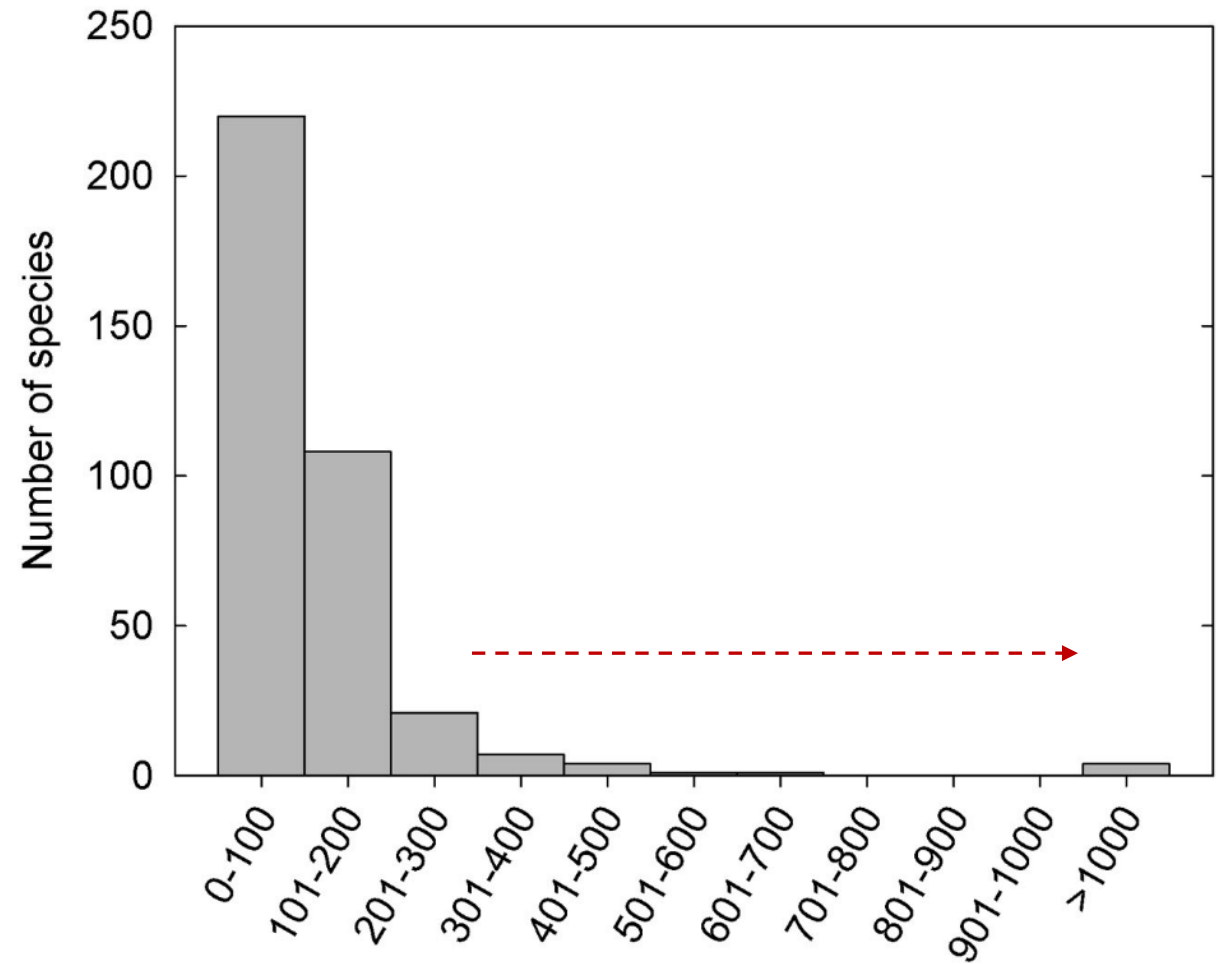
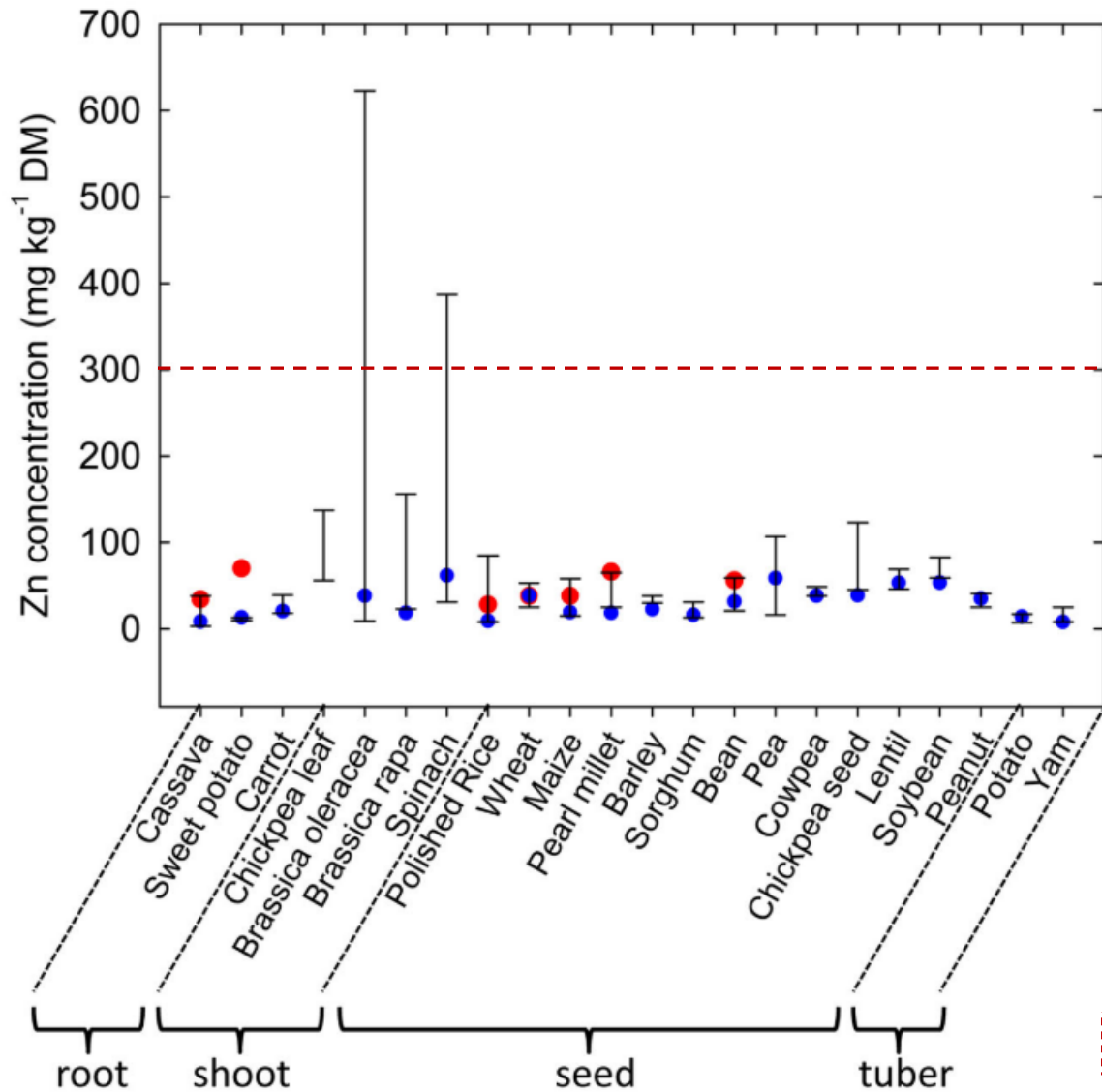


# Variability in Zn concentration in crops



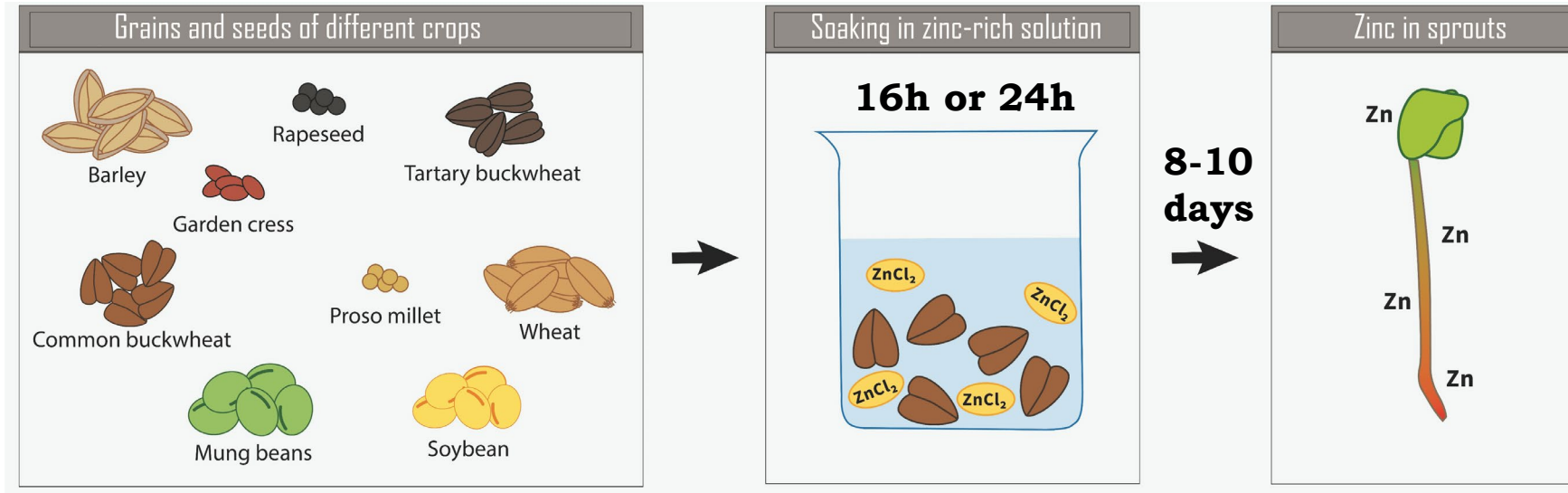
Dashed line > Zn concentration above which toxicity occurs in crops

# Variability in Zn concentration in crops



Dashed line > Zn concentration above which toxicity occurs in crops

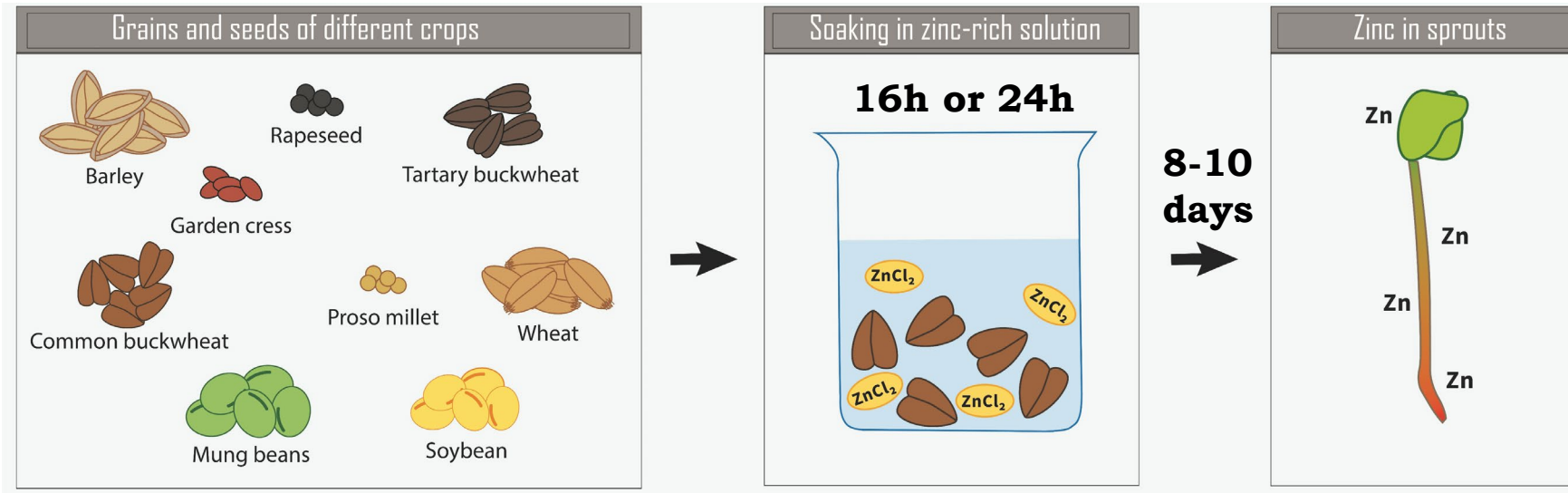
# Materials and methods



- **Germination test**
- **Growth (fresh and dry weight)**
- **Element composition (X-ray Fluorescence, XRF)**



# Materials and methods



- Germination test
- Growth (fresh and dry weight)
- Element composition (X-ray Fluorescence, XRF)



## Experiment 1: $ZnSO_4$ and $ZnCl_2$

Common buckwheat (*Fagopyrum esculentum*)

Tartary buckwheat (*Fagopyrum tataricum*)

## Experiment 2: $ZnCl_2$

Common buckwheat

Wheat (*Triticum aestivum*)

Garden cress (*Lepidium sativum*)

Mung bean (*Vigna radiata*)

## Experiment 3: $ZnCl_2$

Soybean (*Glycine max*)

Barley (*Hordeum vulgare*)

Proso millet (*Panicum miliaceum*)

Oilseed rape (*Brassica napus*)





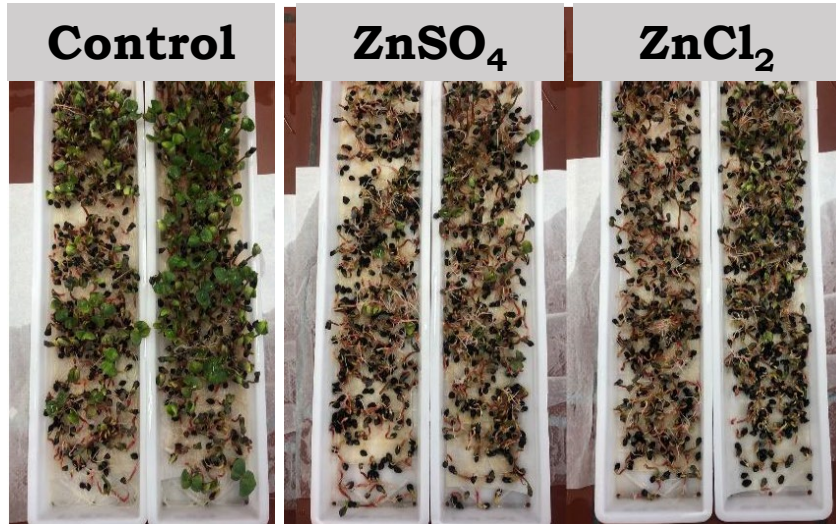
# Results

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**Experiment 1: 0 (Control), 500 mM ZnSO<sub>4</sub> or 100 mM ZnCl<sub>2</sub>**

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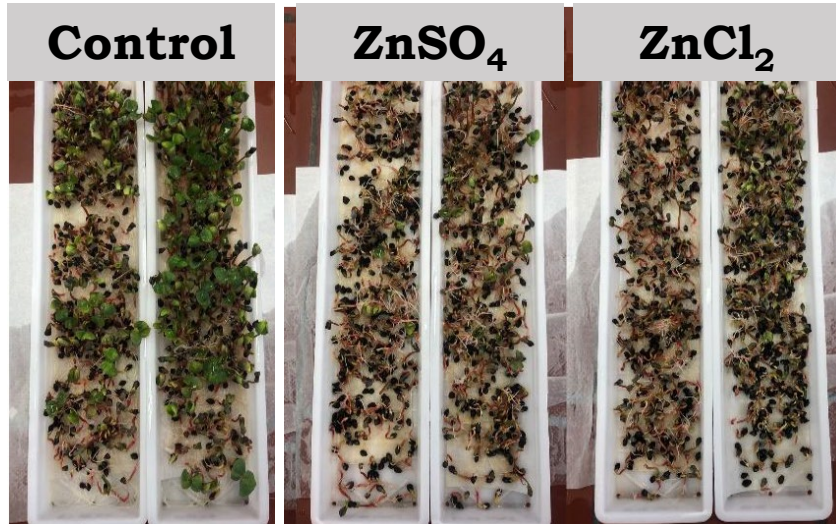




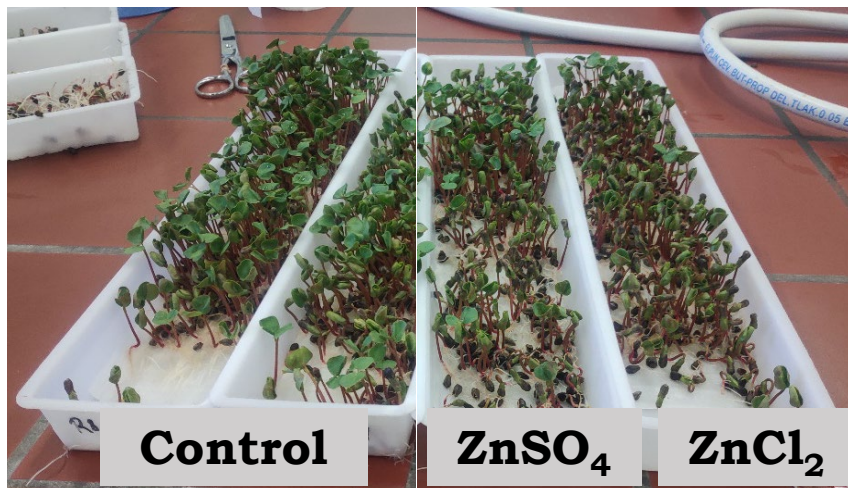
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Common buckwheat



Tartary buckwheat



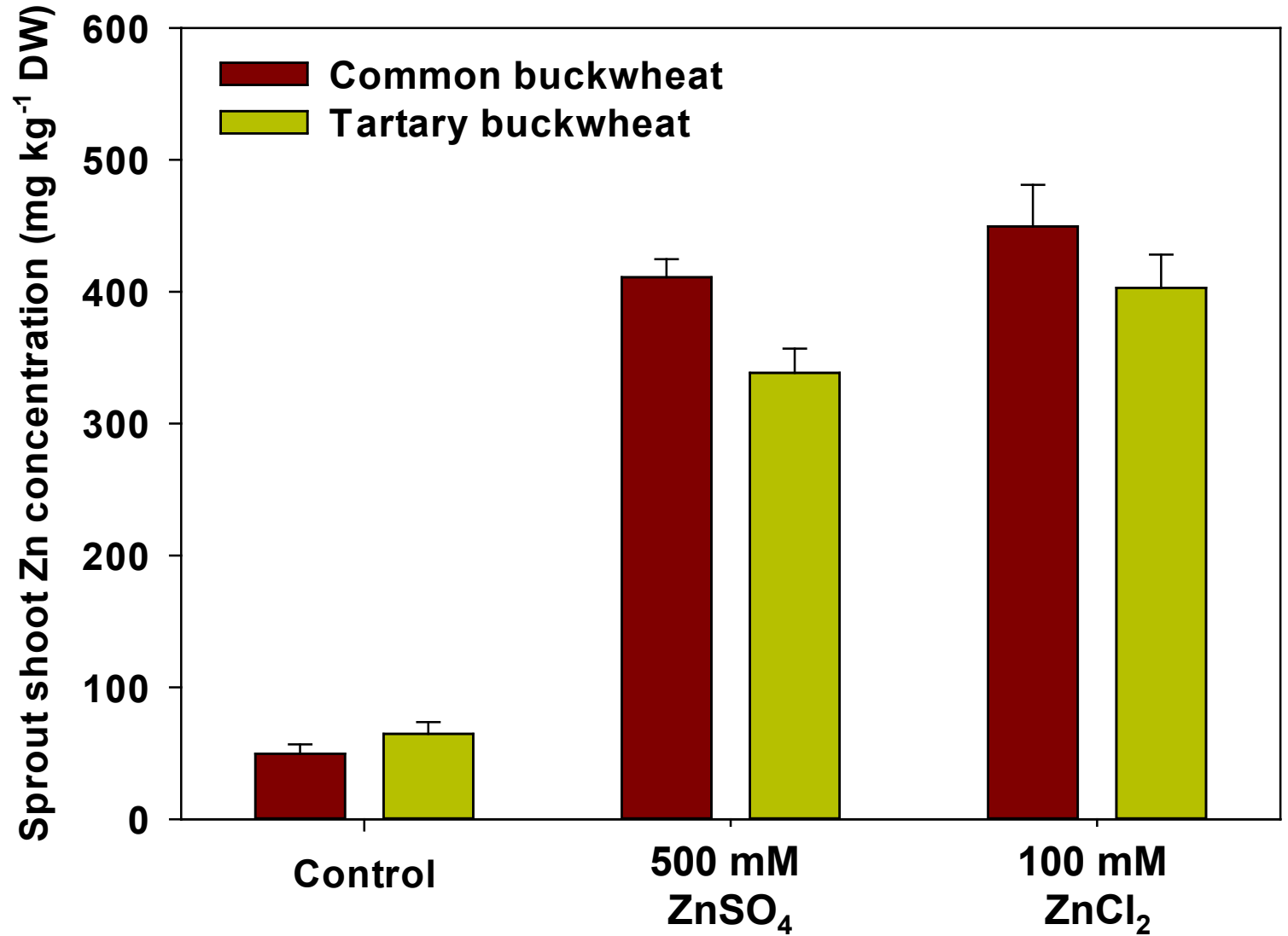
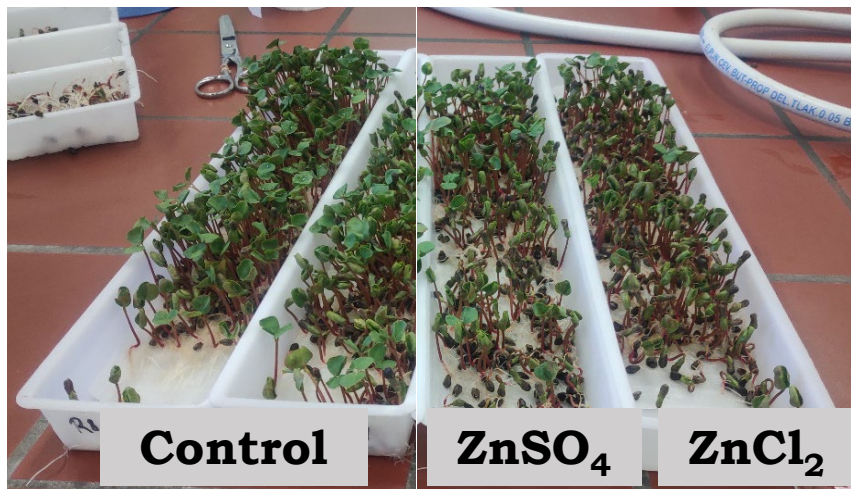
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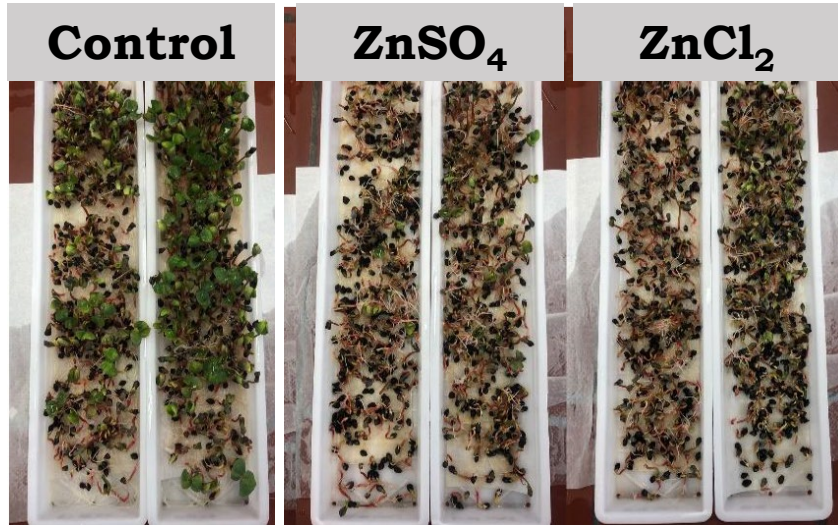




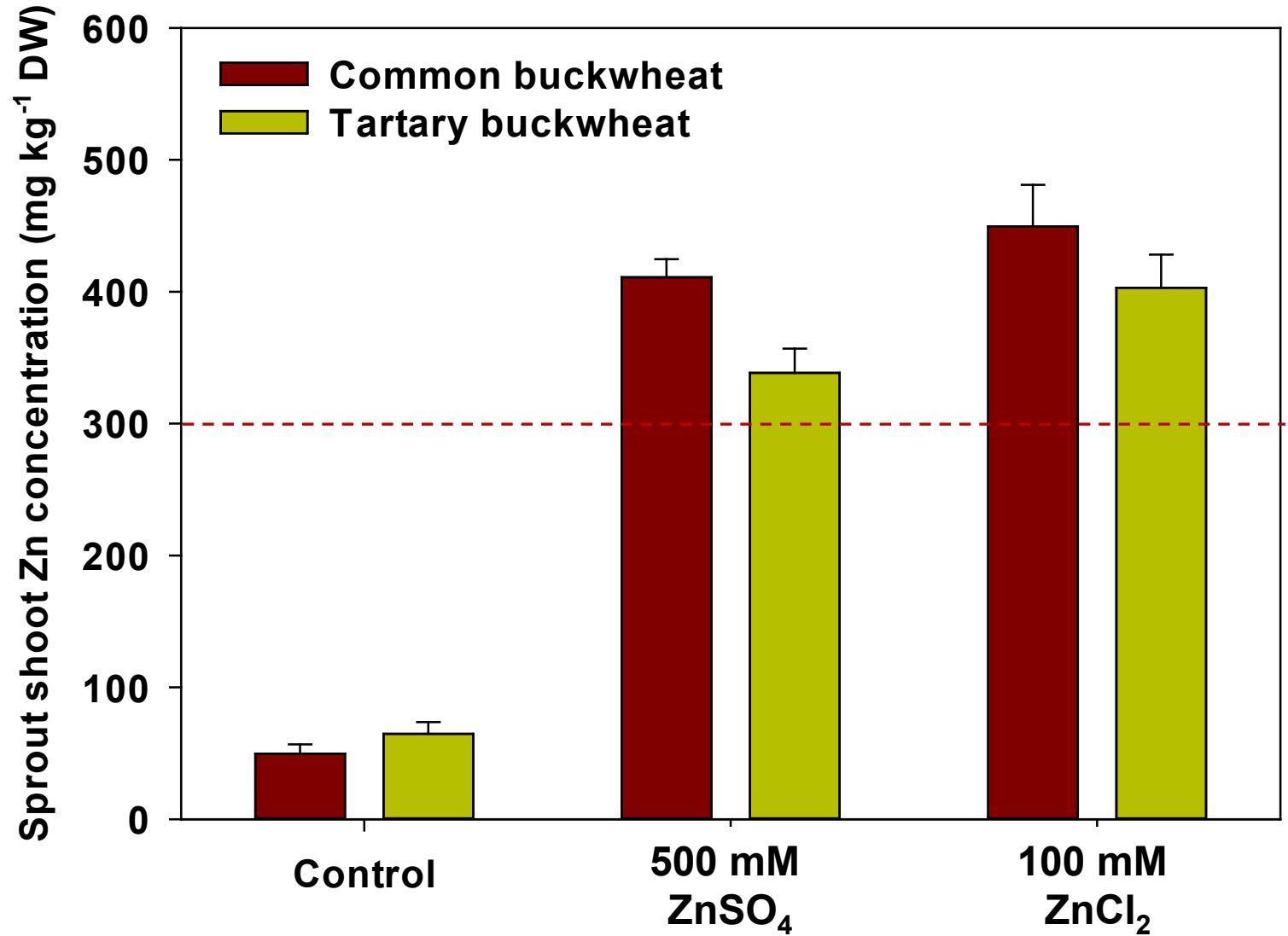
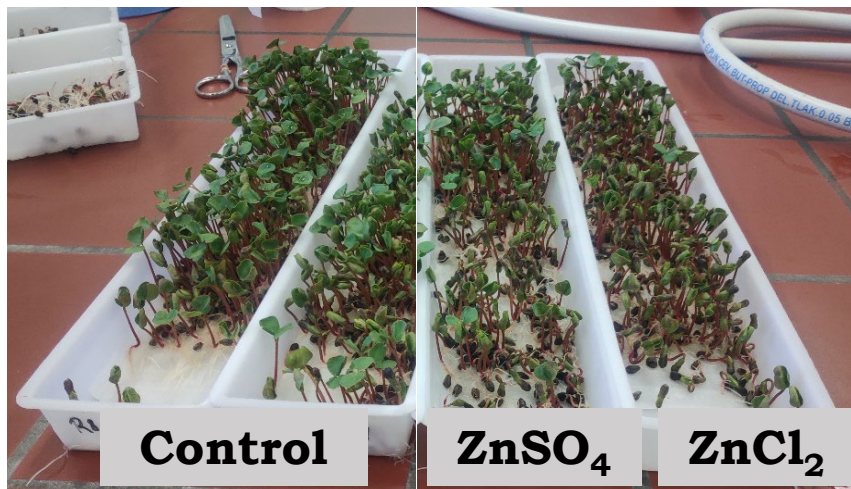
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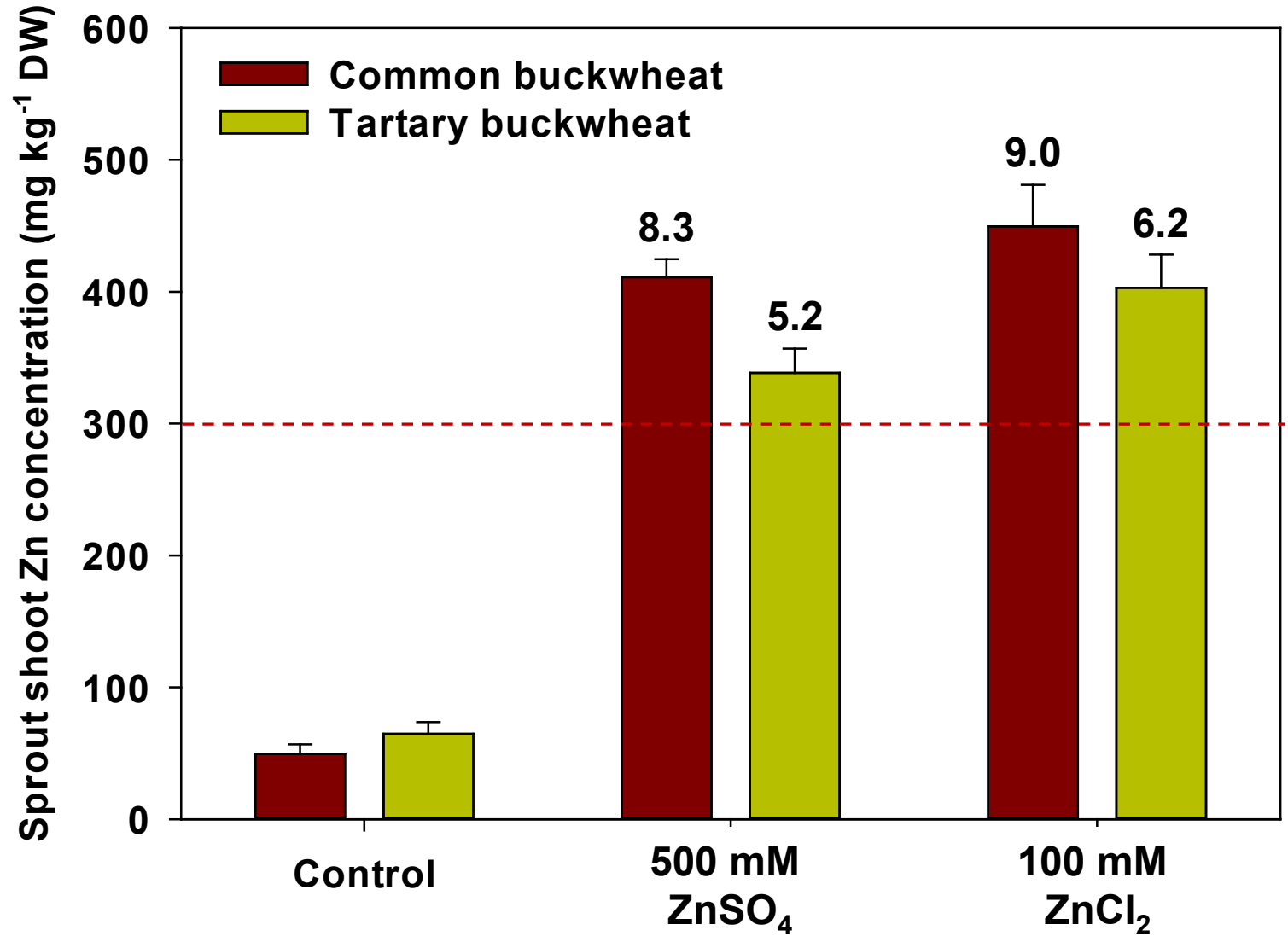
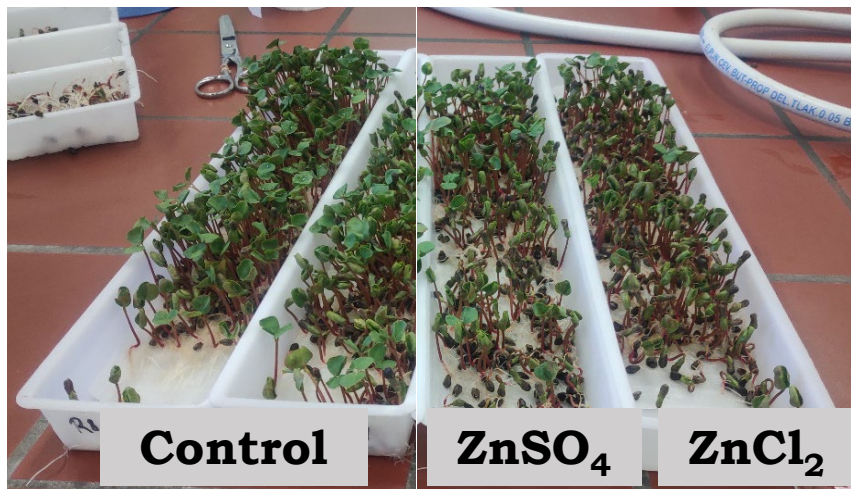
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Common buckwheat



Tartary buckwheat



# Results

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**Experiment 2:**

**0 (Control),**

**25, 50, 75, 100 mM ZnCl<sub>2</sub>**

# Results

Wheat

**Experiment 2:**

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# Results

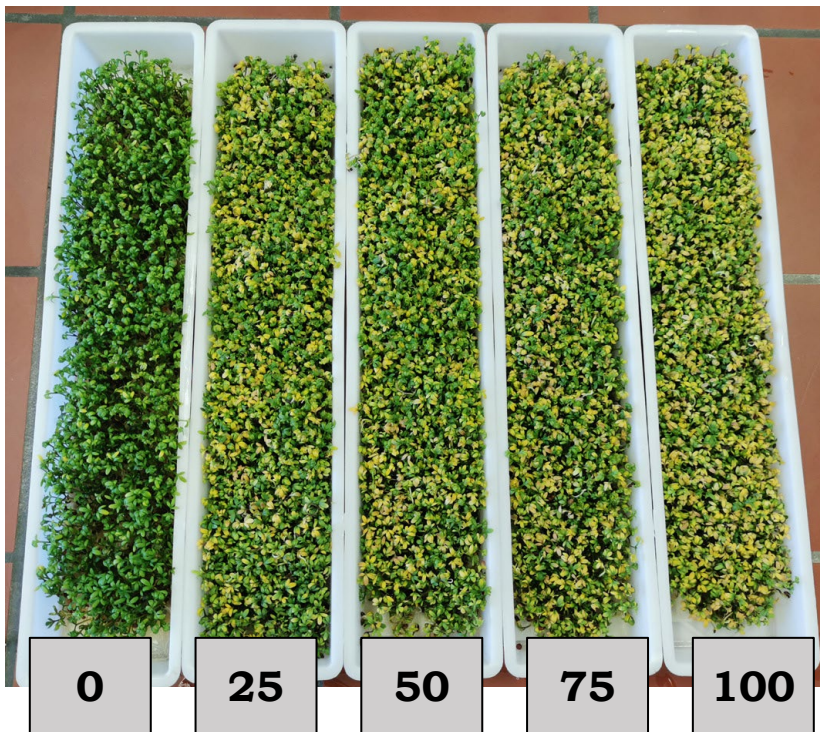
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Wheat



Garden cress



# Results

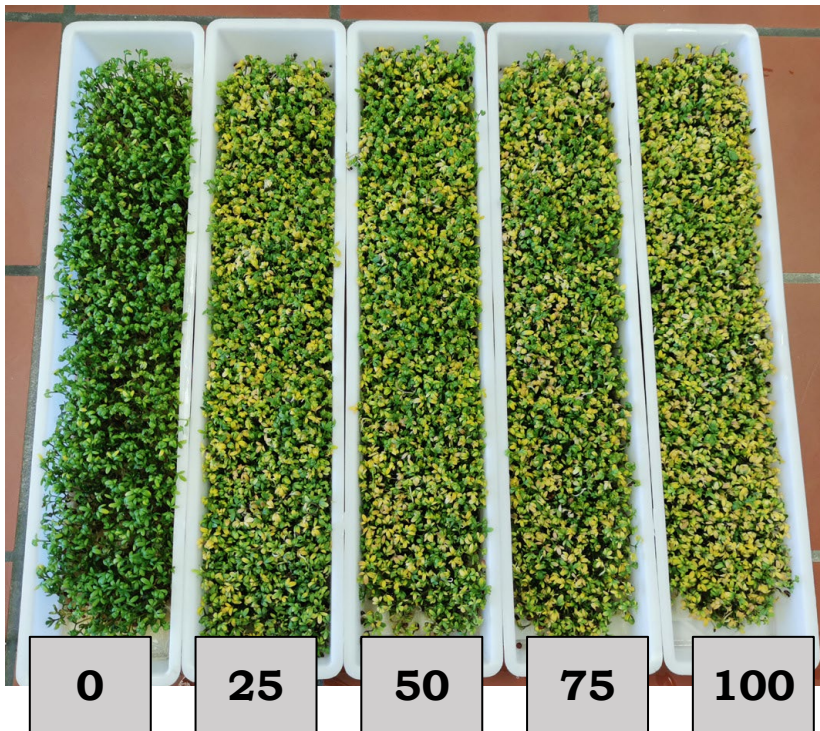
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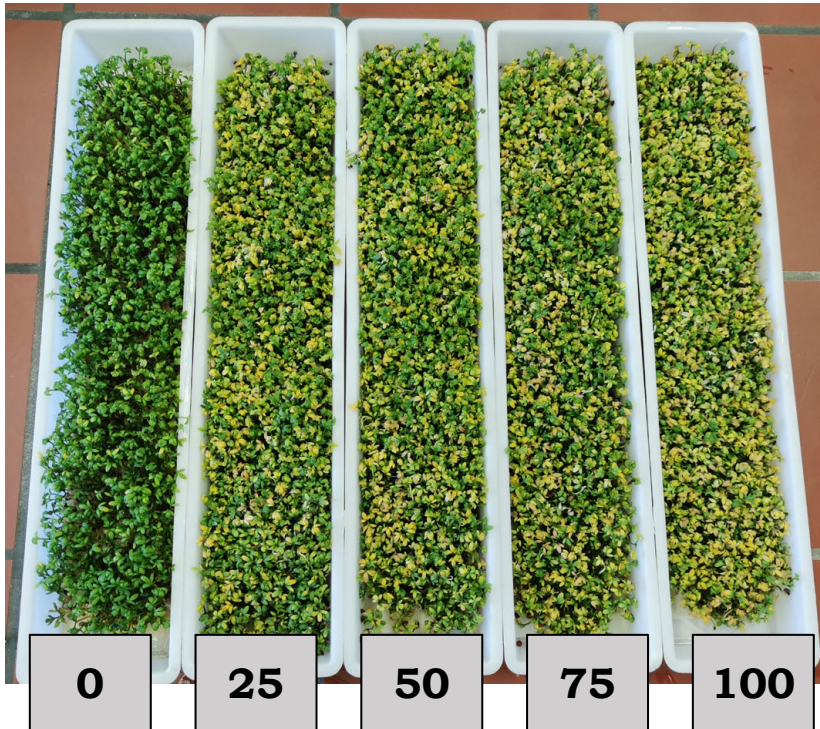
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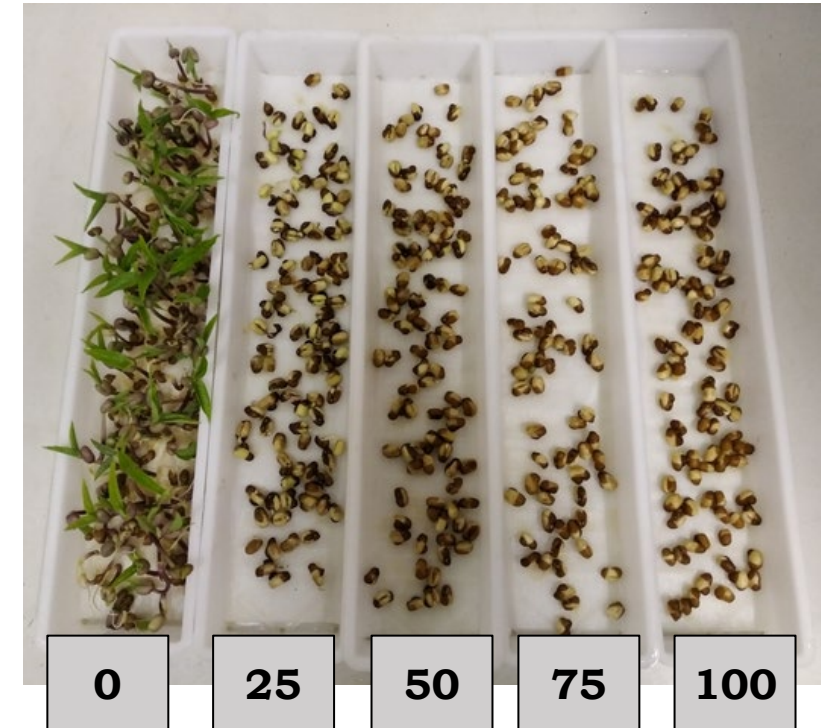
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Common buckwheat

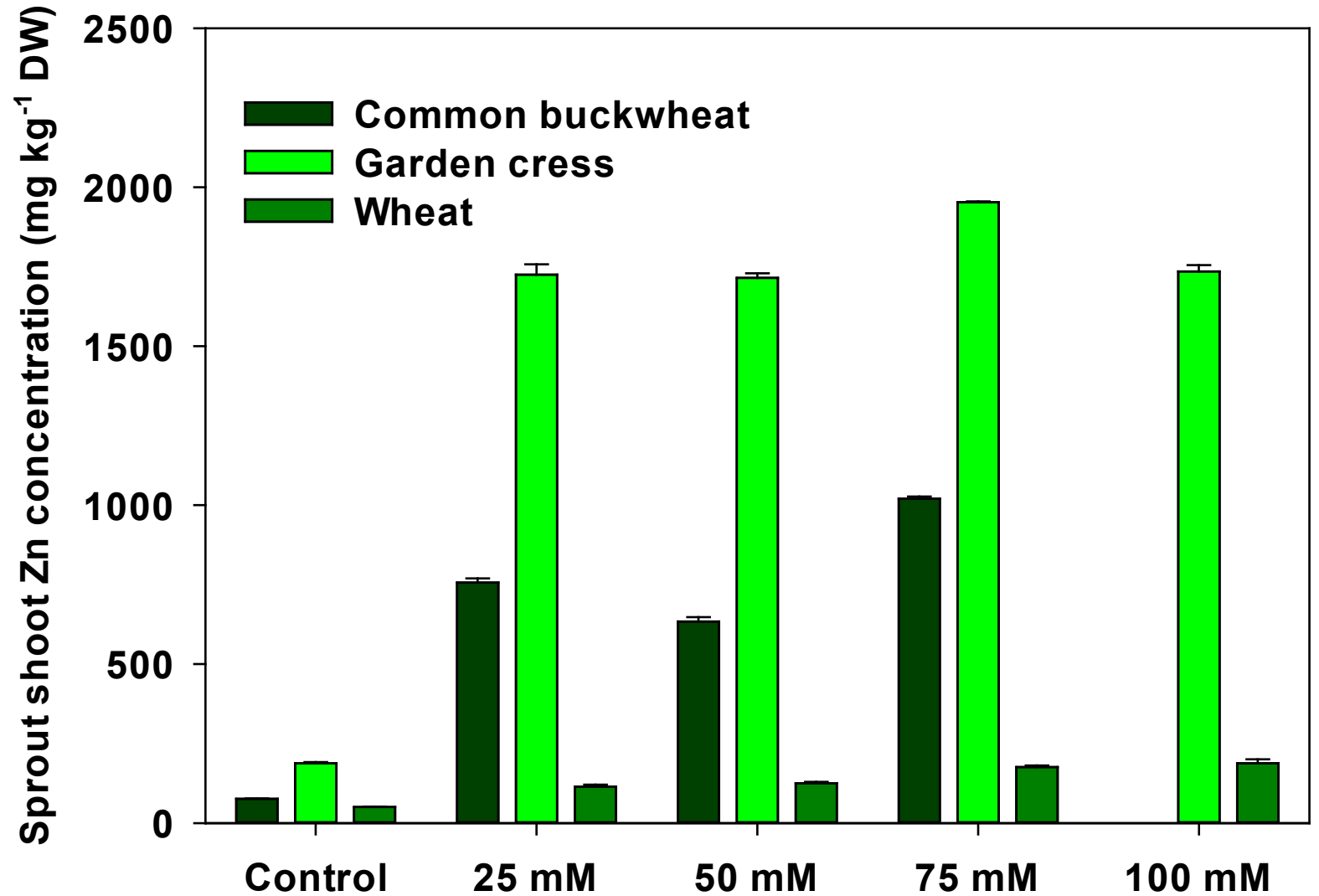


Mung bean



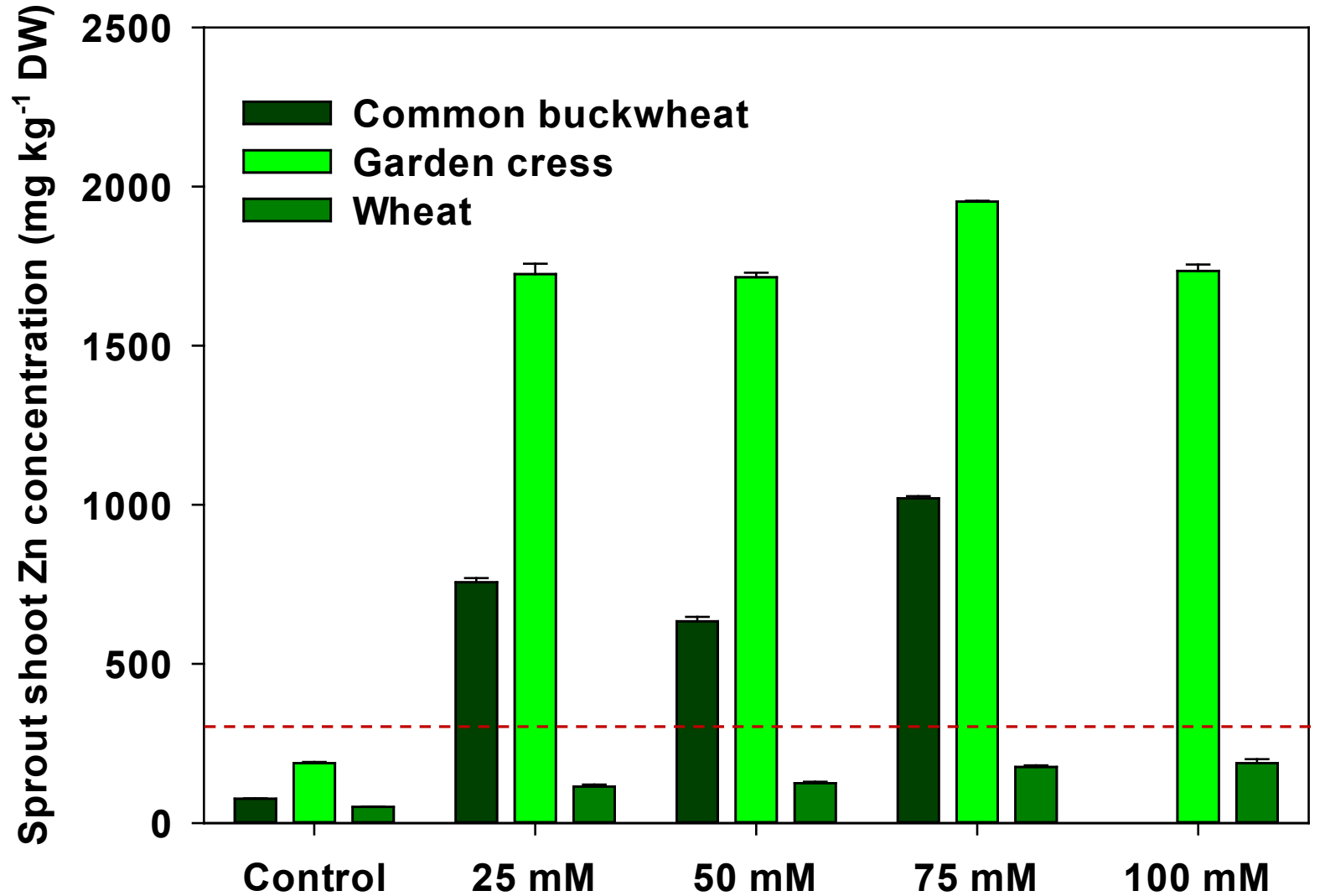
# Results

**Experiment 2 - continuation:  
0 (Control),  
25, 50, 75, 100 mM ZnCl<sub>2</sub>**



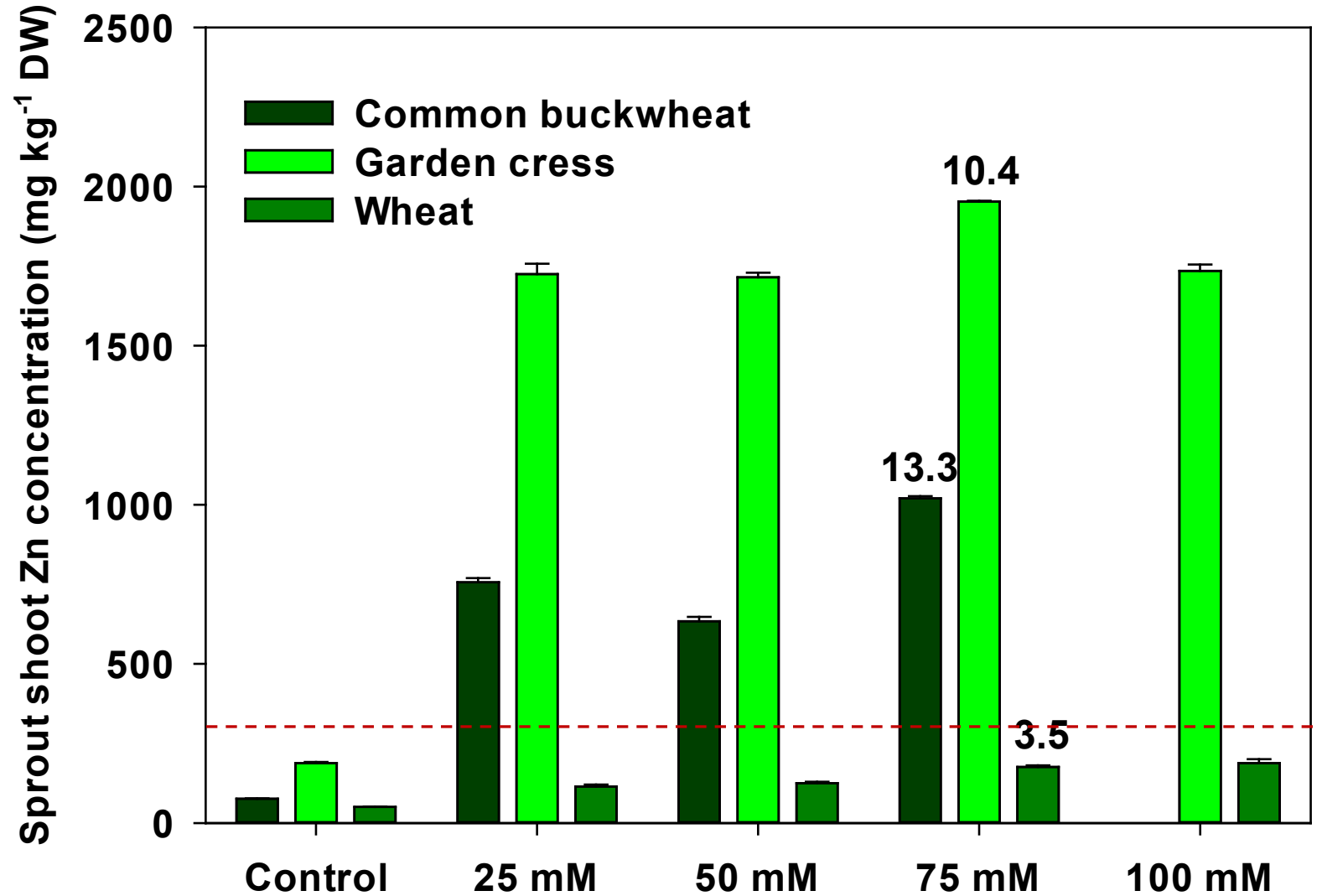
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**Experiment 2 - continuation:**  
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**Experiment 2 - continuation:  
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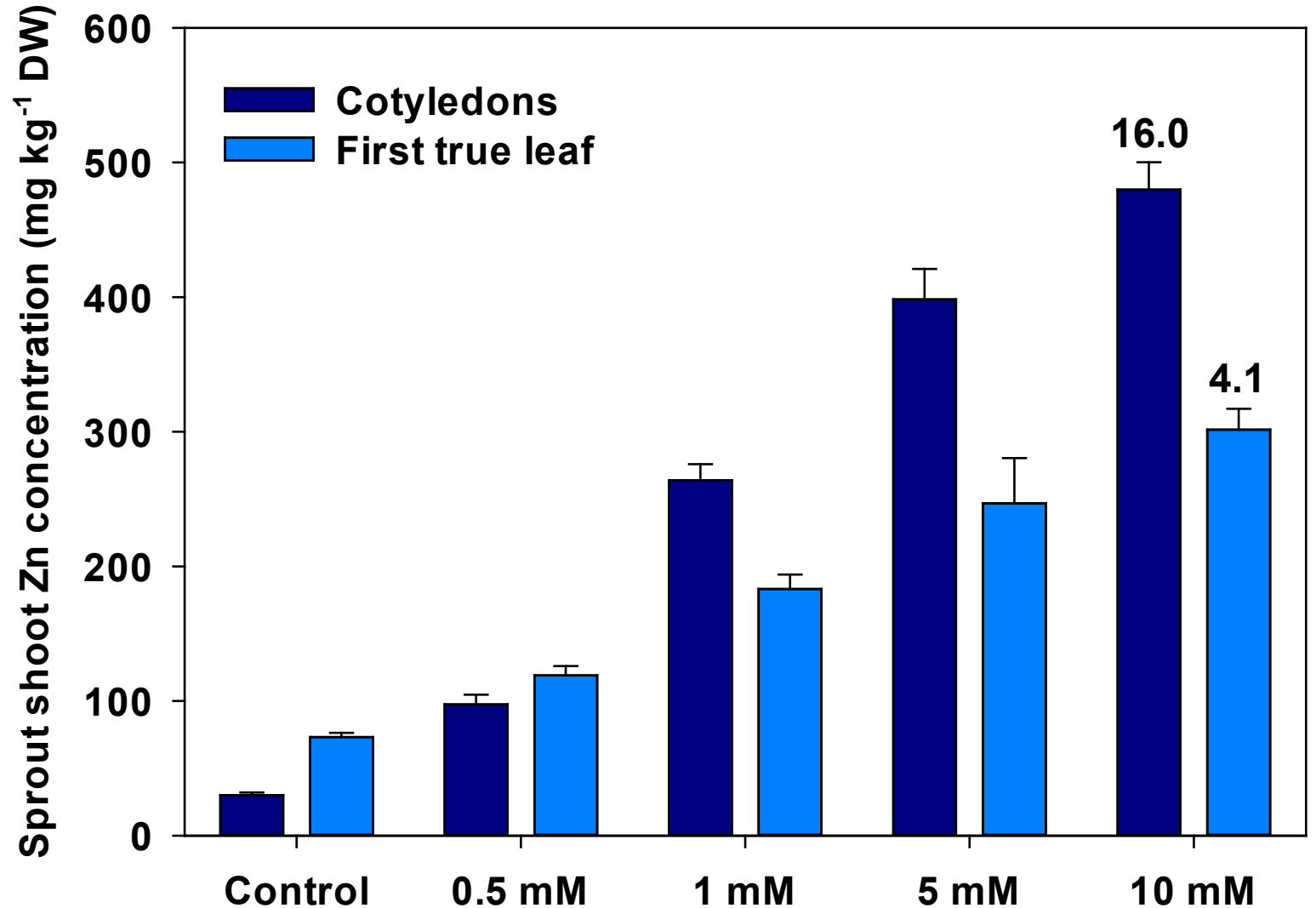
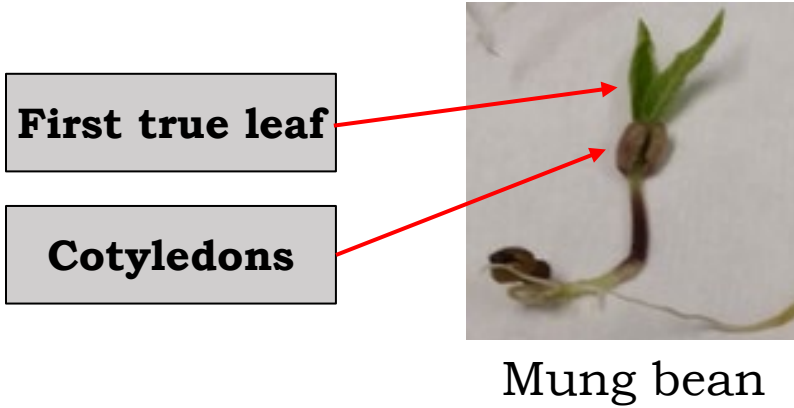
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Mung bean



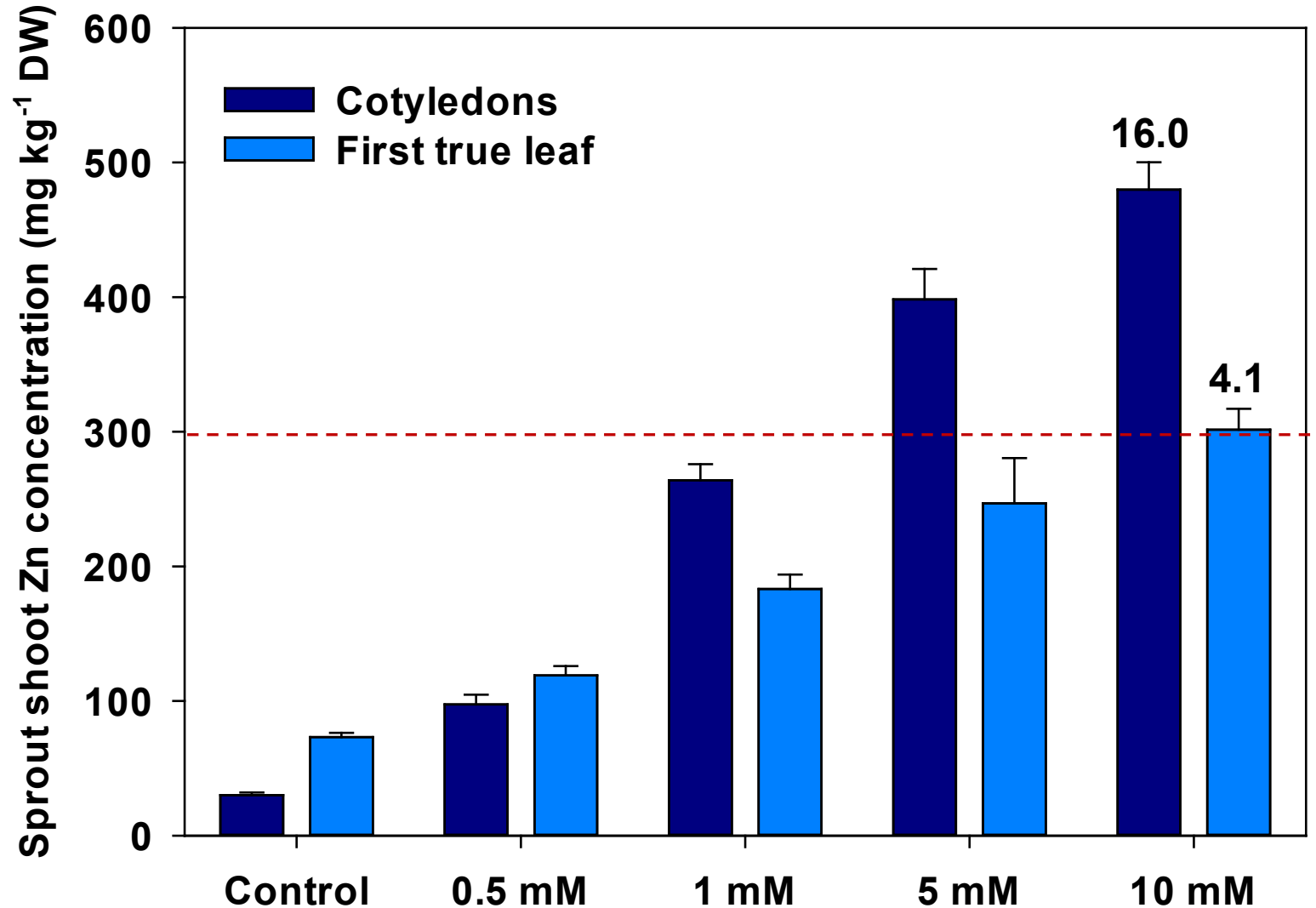
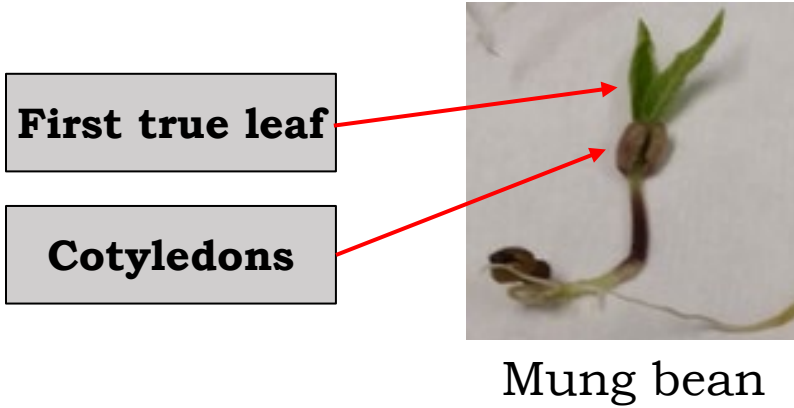
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# Results

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## **Experiment 3:**

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# Results

**Experiment 3:**  
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Soybean



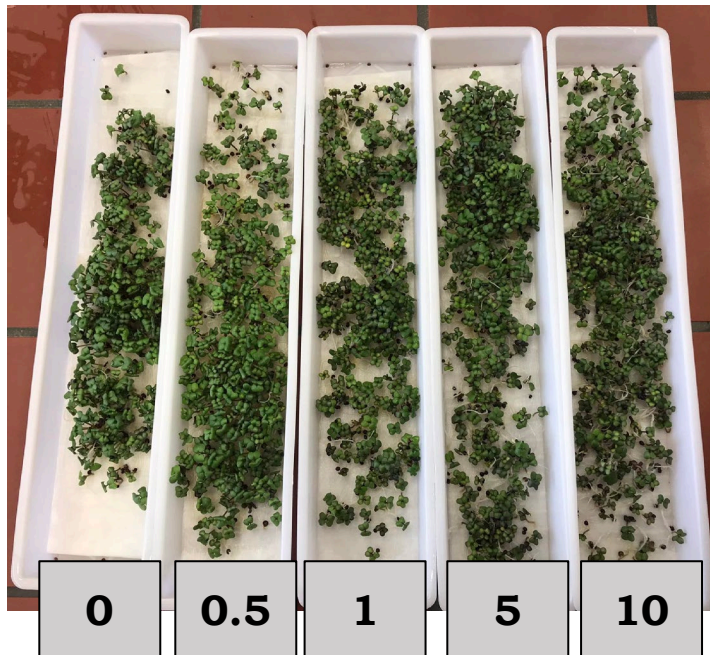
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Soybean



Rapeseed



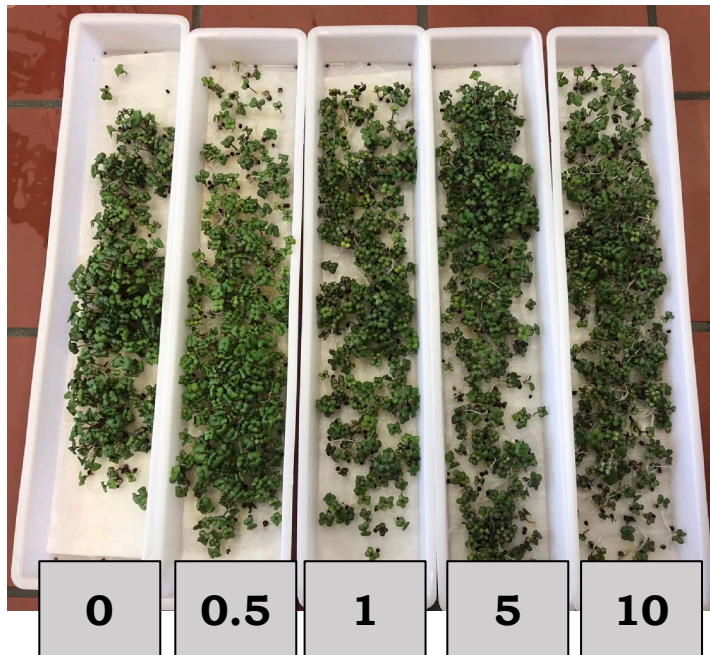
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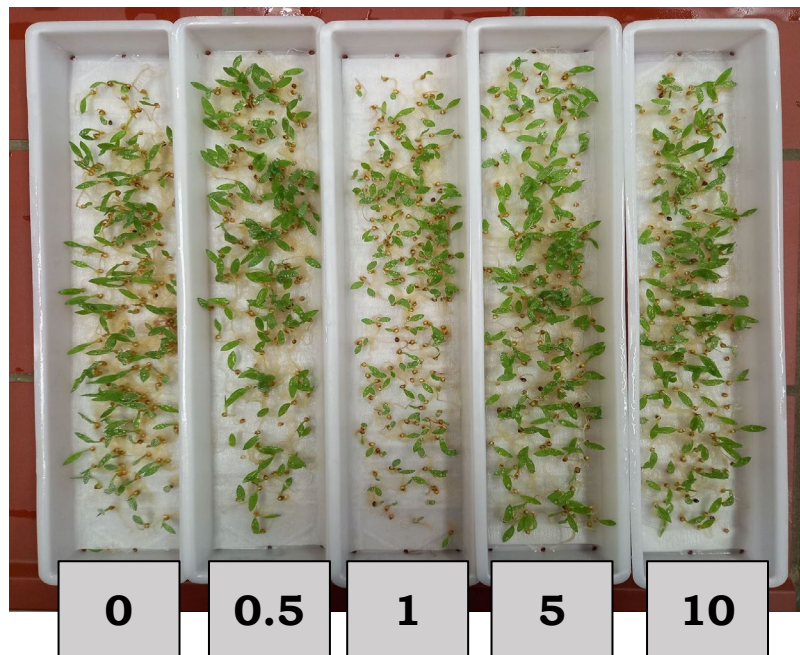
Soybean



Rapeseed



Proso millet





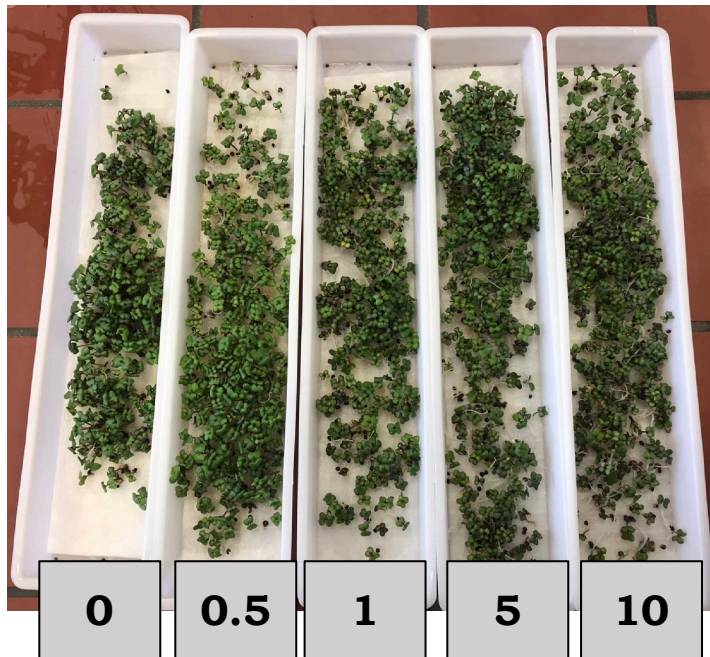
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**Experiment 3:**  
**0 (Control),**  
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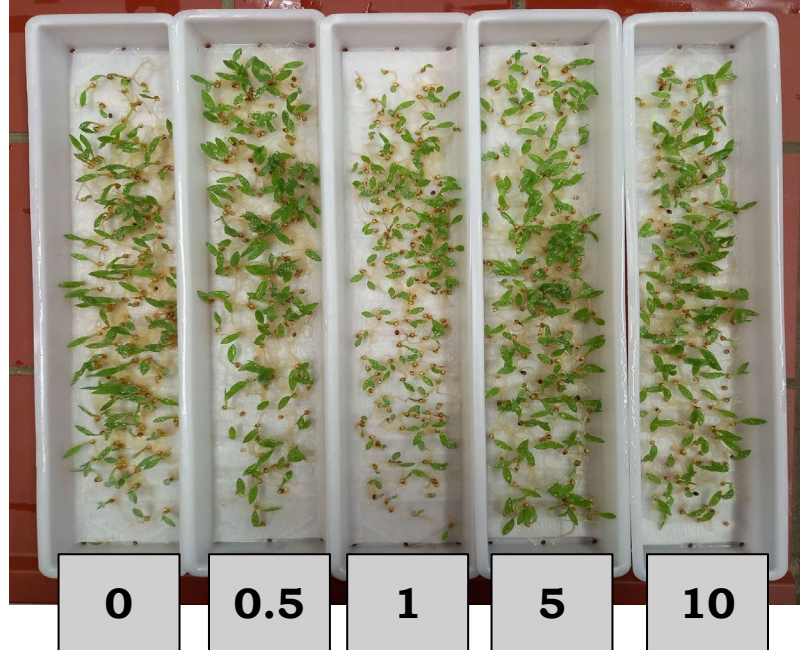
Soybean



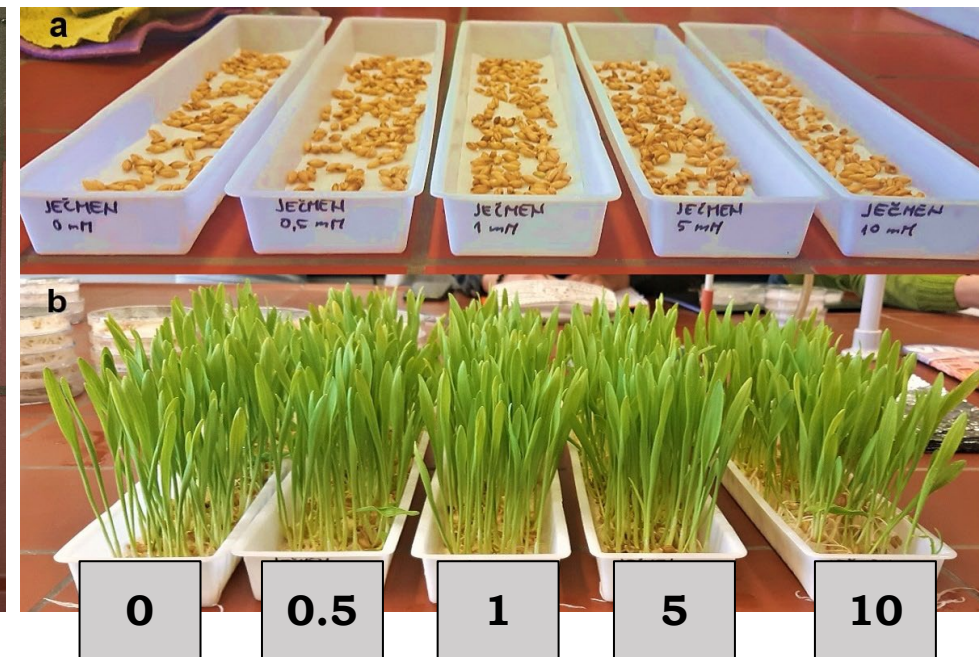
Rapeseed



Proso millet

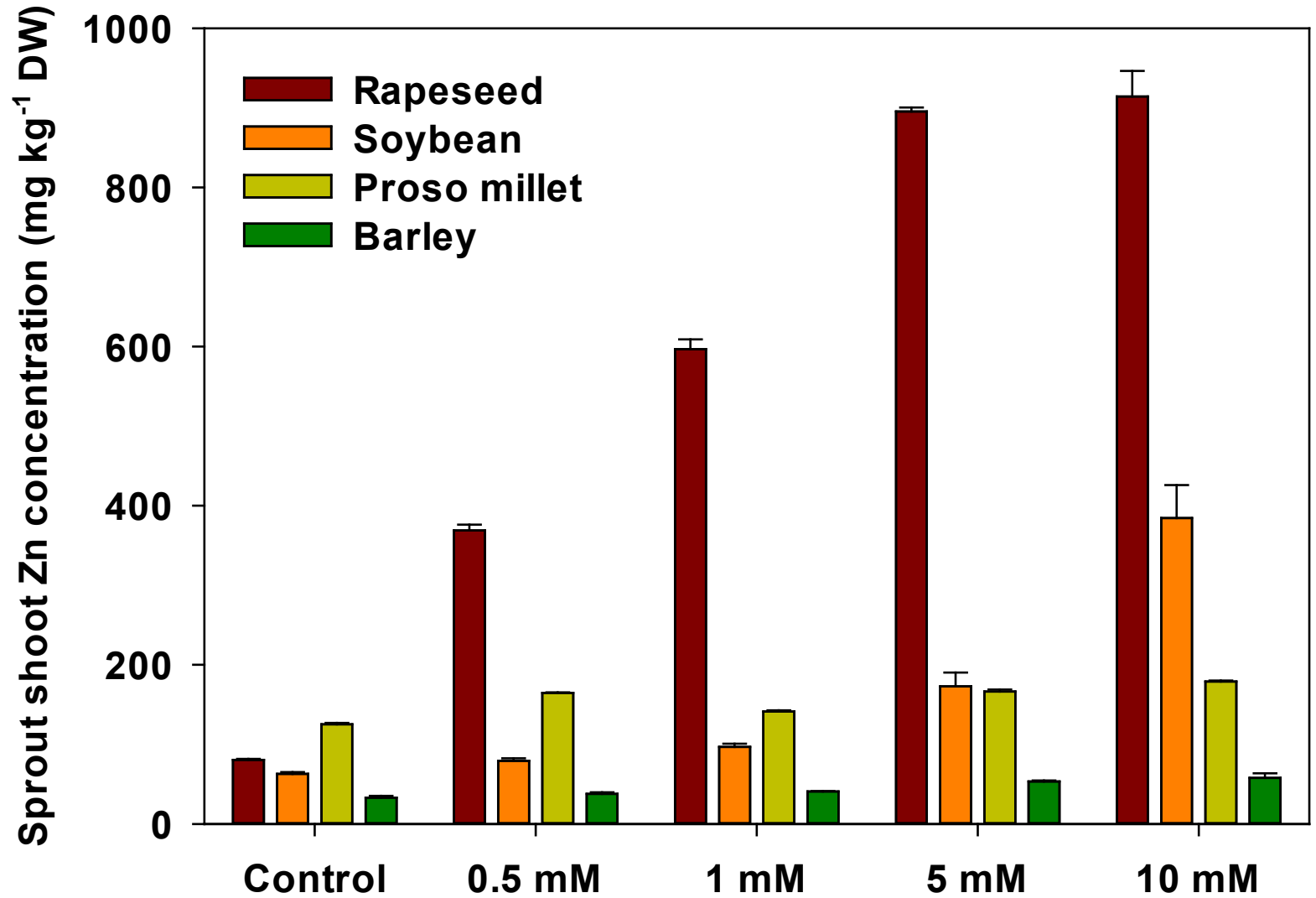


Barley



# Results

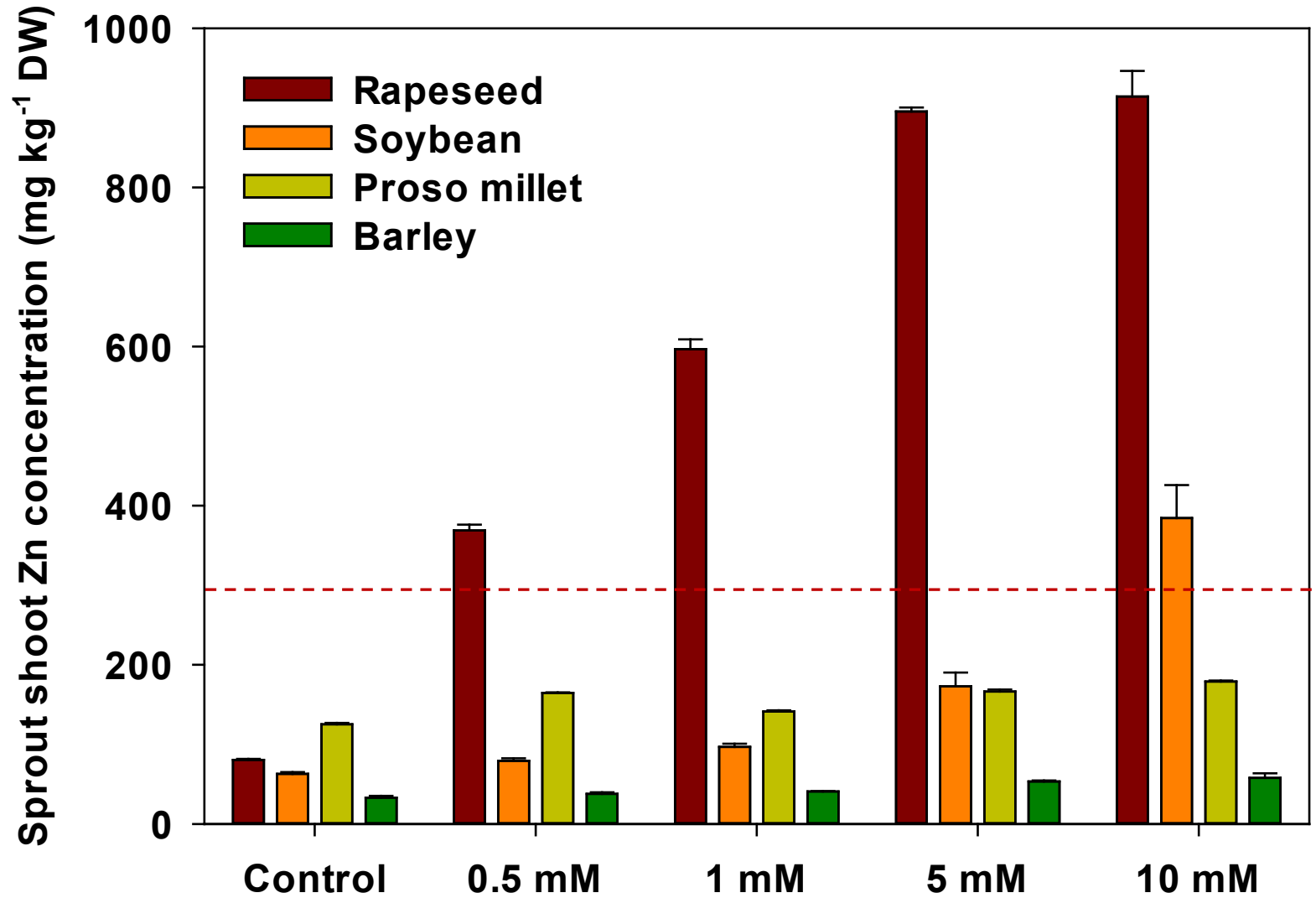
**Experiment 3: ZnCl<sub>2</sub>**  
**0 (Control),**  
**0.5, 1, 5, 10 mM ZnCl<sub>2</sub>**





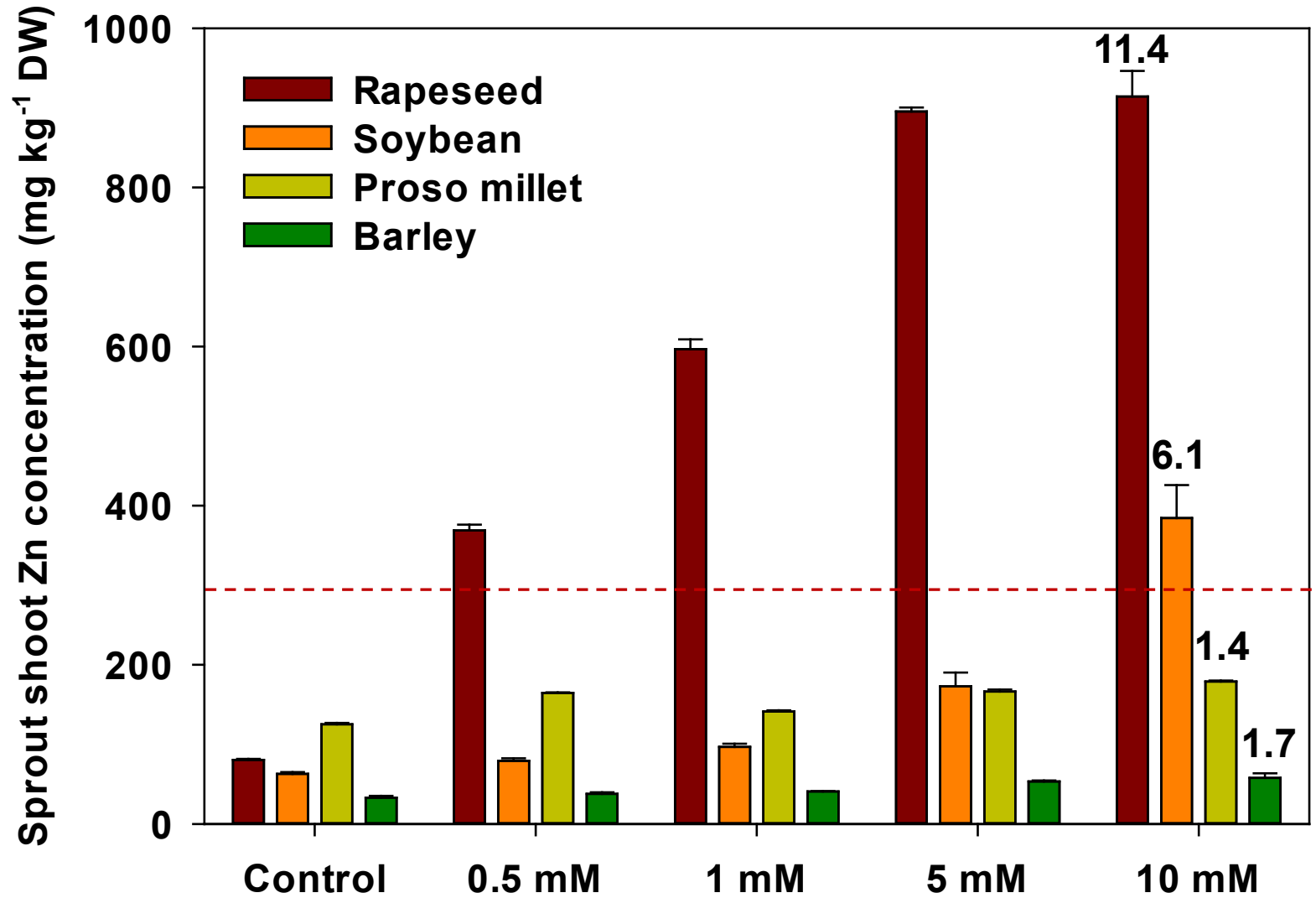
# Results

**Experiment 3: ZnCl<sub>2</sub>**  
**0 (Control),**  
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**Experiment 3: ZnCl<sub>2</sub>**  
**0 (Control),**  
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# Conclusions

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- There is a large variation in the level of increase in Zn concentration in different sprouts.
- The largest increase was observed in Mung bean cotyledons (16.00), followed by small-seeded garden cress (>11-fold) and rapeseed (>10-fold).
- The smallest increase was observed in cereals proso millet (1.5-fold), barley (1.7-fold) and wheat (3.5-fold).
- Occasionally, there was growth penalty observed, presumably (but not exclusively) linked with toxic Zn concentrations (>300 mg kg<sup>-1</sup> DW).
- ZnCl<sub>2</sub> concentrations and the time of soaking should be optimised for each species individually not to exceed toxicity threshold but still achieve desirable increase in Zn concentration.

# Acknowledgements

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**P1-0212**  
**J4-3091**

# Acknowledgements

## *Collectanea studentium physiologiae plantarum*



**P1-0212**  
**J4-3091**

2021 Vol. 12 Št. 2

C S P P

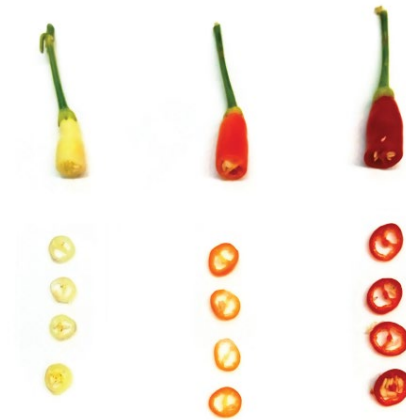
Collectanea Studentium Physiologiae Plantarum



2022 Vol. 13 Št. 1

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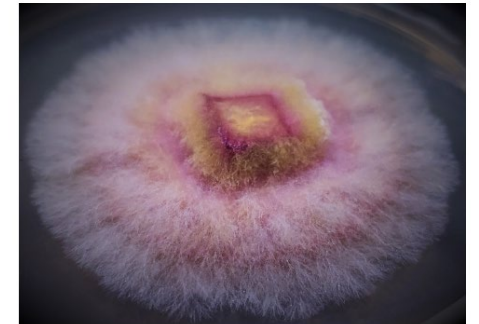
Collectanea Studentium Physiologiae Plantarum



2022 Vol. 13 Št. 2

C S P P

Collectanea Studentium Physiologiae Plantarum



<https://www.bf.uni-lj.si/sl/o-fakulteti/knjiznice-bf/publikacije-in-revije/2021011412353830/collectanea-studentium-physiologiae-plantarum>



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**P1-0212**  
**J4-3091**

2021 Vol. 12 Št. 2

C S P P

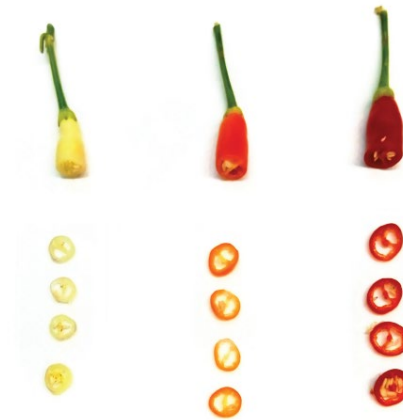
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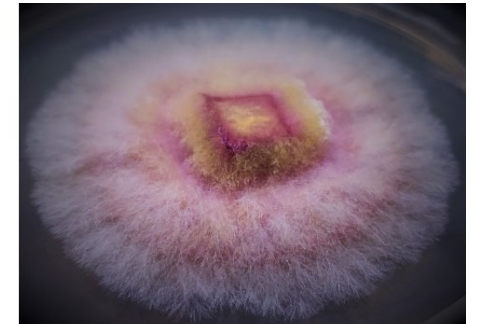
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**Thank you for your attention!**