

# Biofortifying sprouts with zinc by seed priming

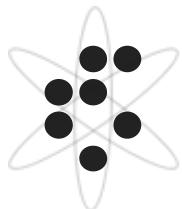
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**Paula Pongrac<sup>1,2</sup>, Pia Starič<sup>1</sup>, Katarina Vogel-Mikuš<sup>1,2</sup>**

[paula.pongrac@ijs.si](mailto:paula.pongrac@ijs.si); [paula.pongrac@bf.uni-lj.si](mailto:paula.pongrac@bf.uni-lj.si)

<sup>1</sup>*Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia*

<sup>2</sup>*University of Ljubljana, Biotechnical Faculty, Jamnikarjeva 101, 1000 Ljubljana, Slovenia*



Jožef Stefan Institute

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

Univerza v Ljubljani  
*Biotehniška* fakulteta



Slovenian  
Research  
Agency

## **Insufficient dietary intake of nutrients leads to malnutrition**

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## **Macronutrients**

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## **Macronutrients**

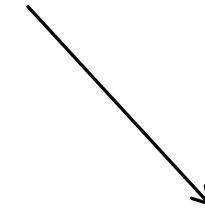
## **Micronutrients**

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**Macronutrients**

**Micronutrients**



**Vitamin malnutrition**

**Vitamin A**

**Vitamin B12**

**Vitamin B1**

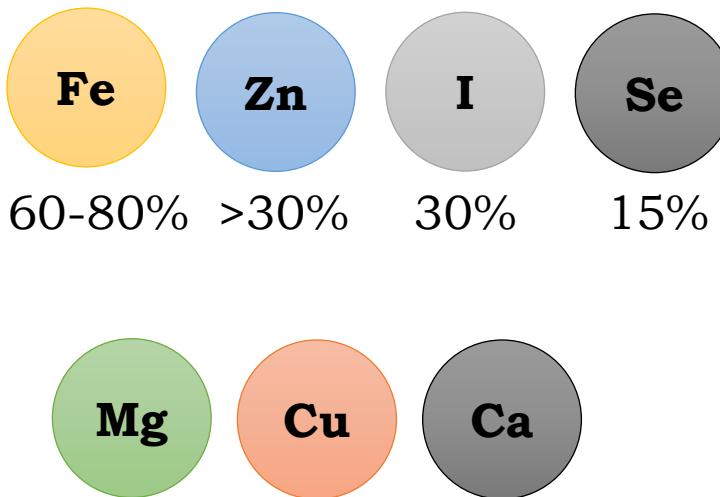
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## Macronutrients

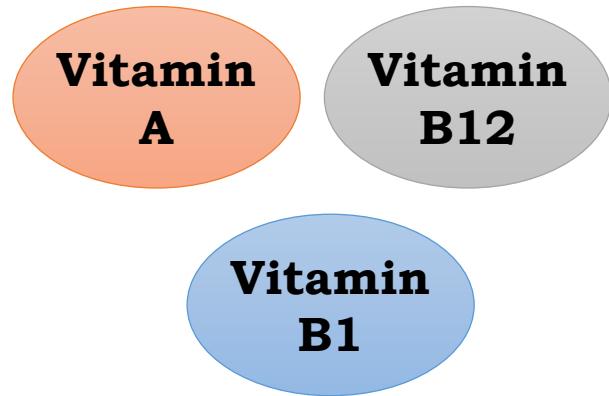
## Micronutrients



### Mineral malnutrition



### Vitamin malnutrition

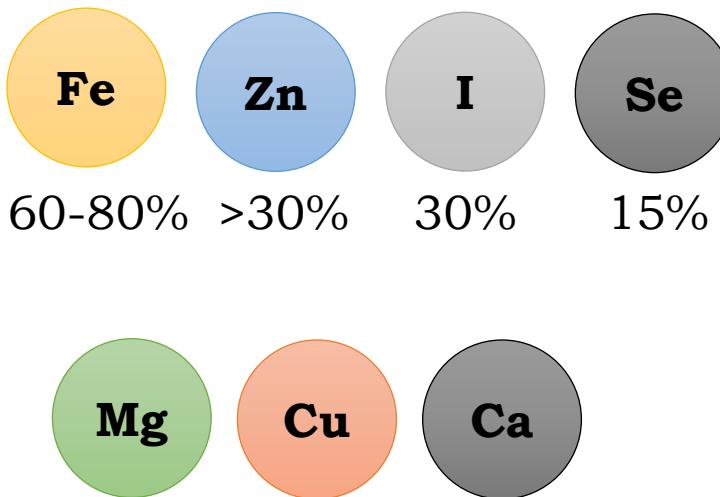


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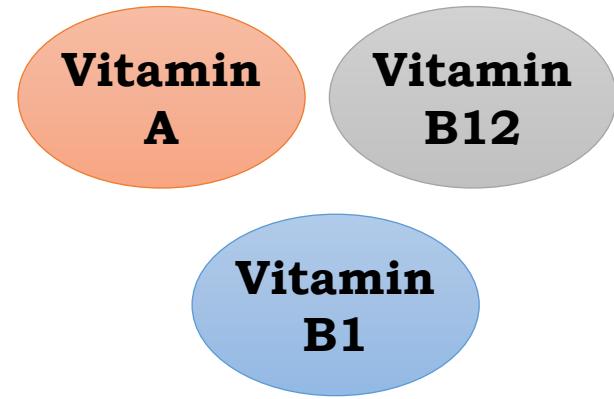
## Macronutrients

## Micronutrients

### Mineral malnutrition

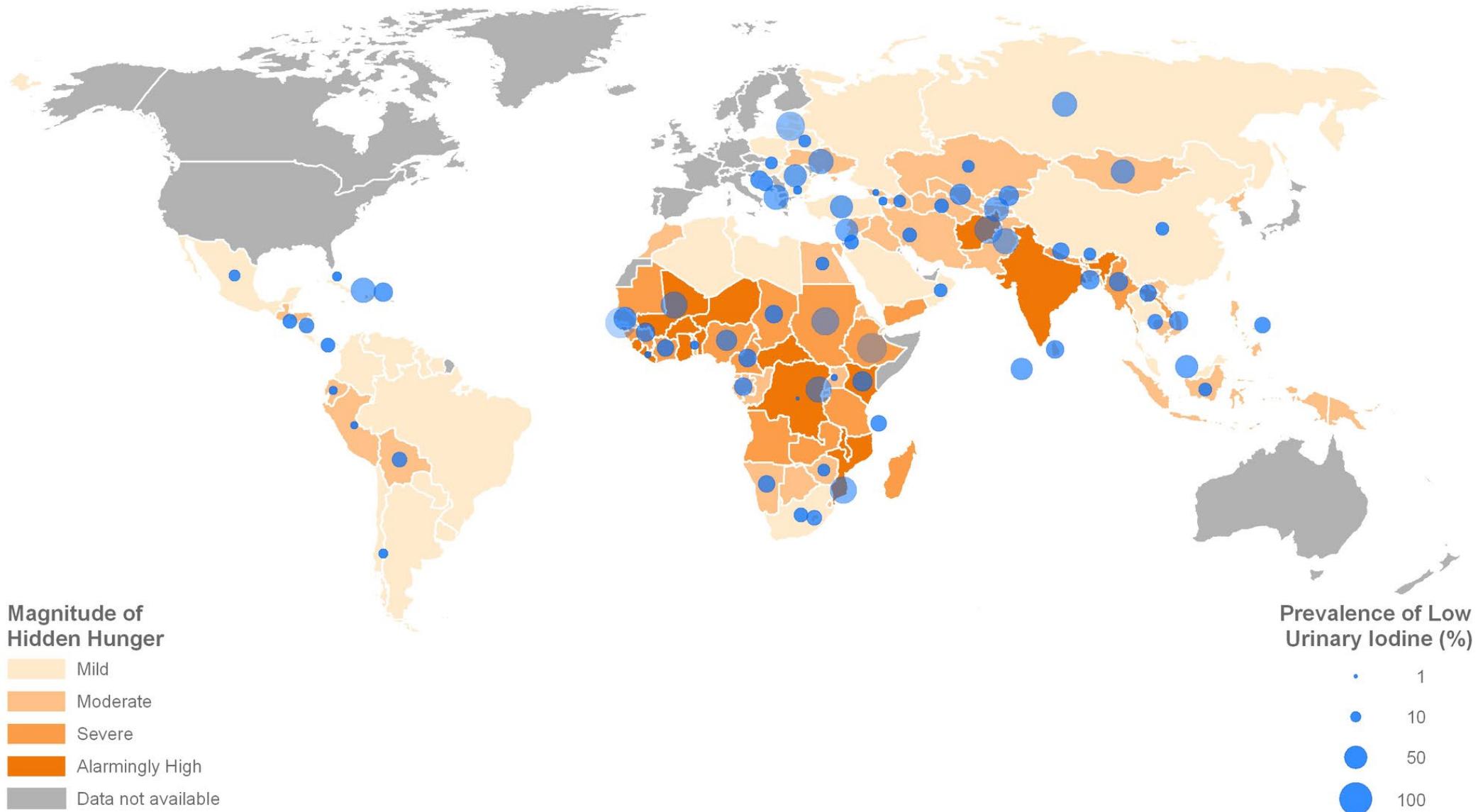


### Vitamin malnutrition

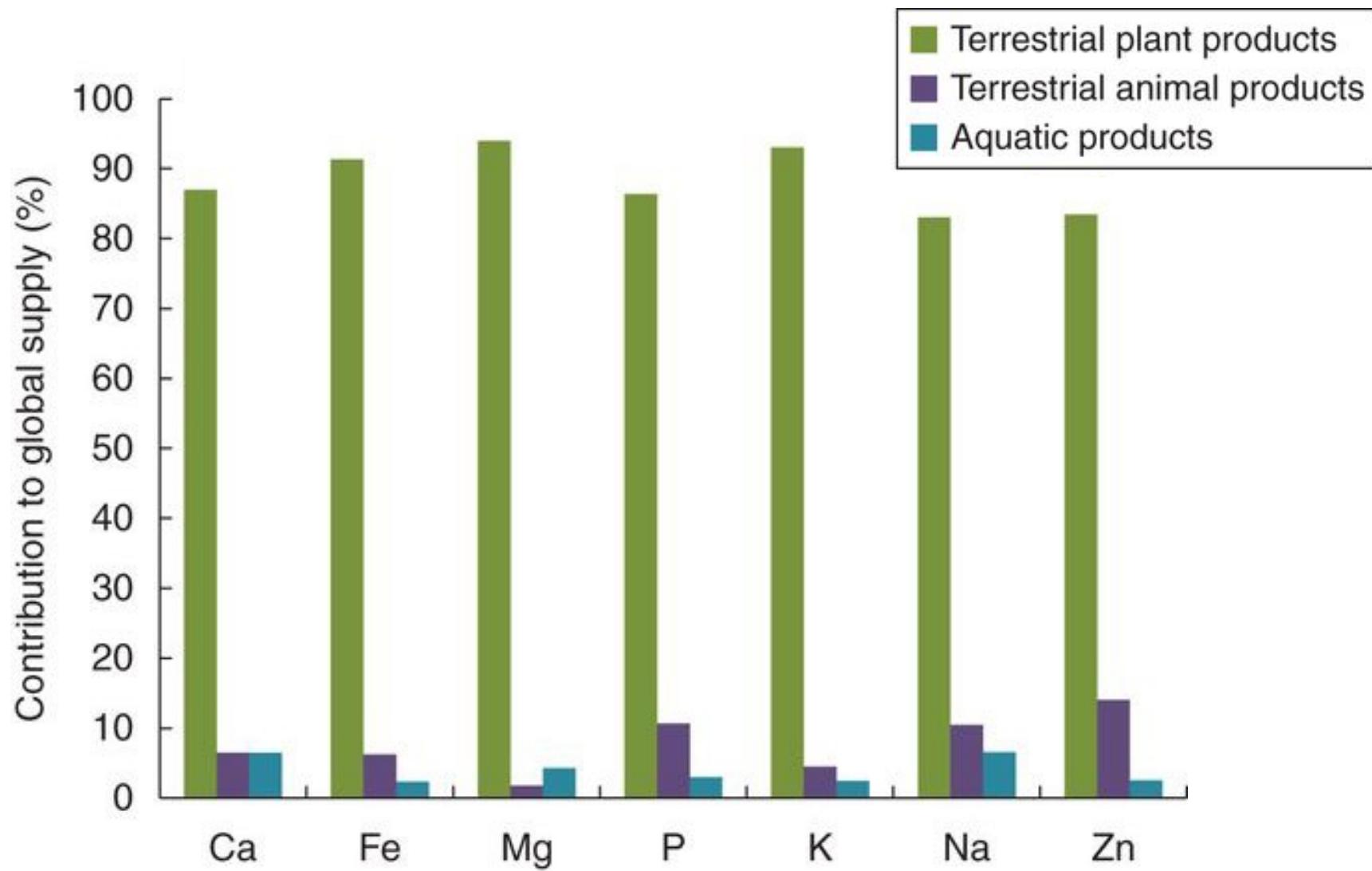


“Hidden hunger”

# Global map presenting hidden hunger distribution



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



## **Strategies to combat hidden hunger**

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# Strategies to combat hidden hunger

## 1. Diversification



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

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## 1. Diversification



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

## 2. Dietary mineral supplements

A Google search results page for "zinc supplements". The top navigation bar shows "zinc supplements" and includes "All", "Images", "Videos", "News", "Books", "More", "Tools", and a search icon. Below the search bar are several filters: acne, skin, benefits, natural, nature made, hair, hormonal acne, chewable, zinc picolinate, amway, and b. The main search results display various zinc supplement bottles from brands like Jameson, OZiva, Nature Made, Puritan's Pride, NOW Foods, Nature's Bounty, Country Life Vitamins, Walmart, and Swisse. A central box highlights "THE BEST ZINC SUPPLEMENTS" with images of different supplement bottles. To the right, there are "Related searches" including "acne zinc supplement", "zinc supplements benefits", "before and after zinc supplementation", and "Inside Tracker blog Zinc Supplementation on Trial: W...". Below the main results, there are additional images of zinc pills and capsules.

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](https://www.cheerios.com/products/multi-grain-cheerios)

# Strategies to combat hidden hunger

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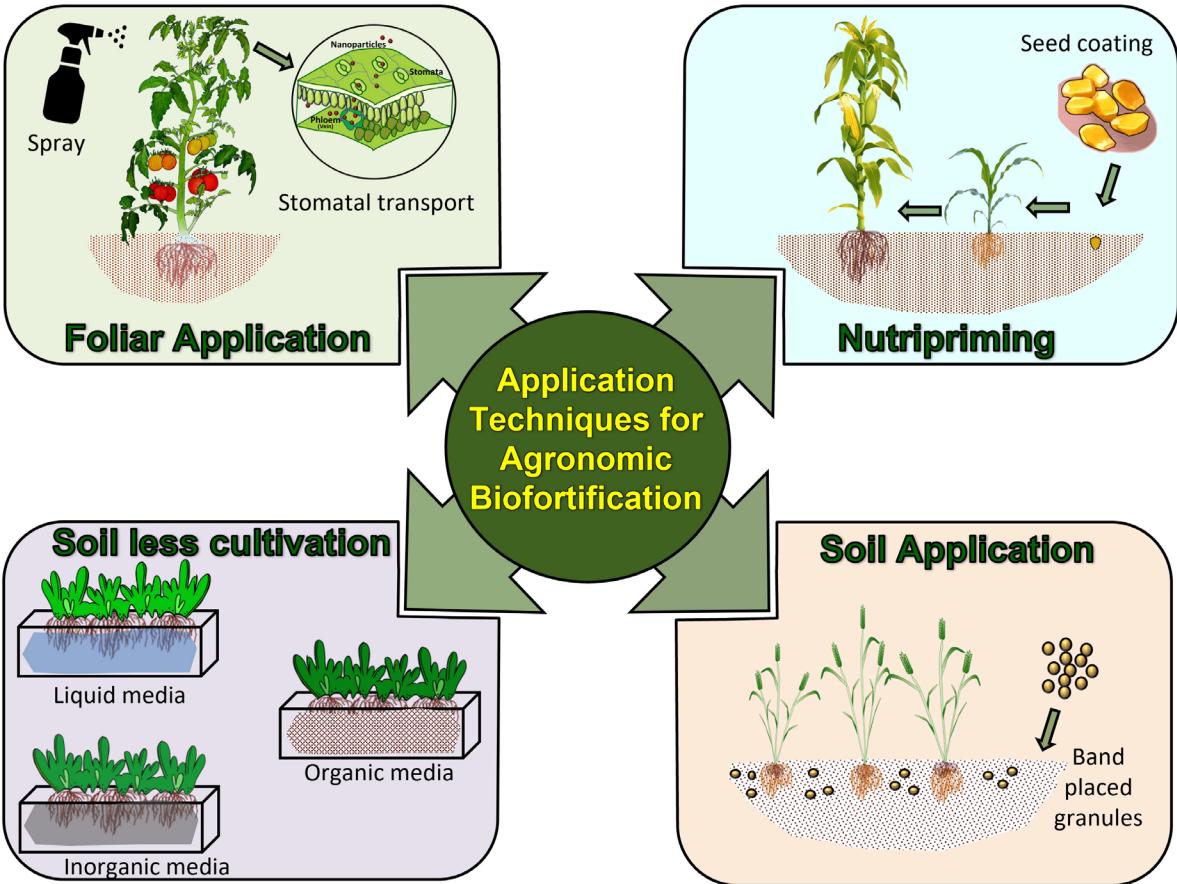


<https://www.soline.si/>



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## 4. Biofortification: agronomic and genetic



# Strategies to combat hidden hunger

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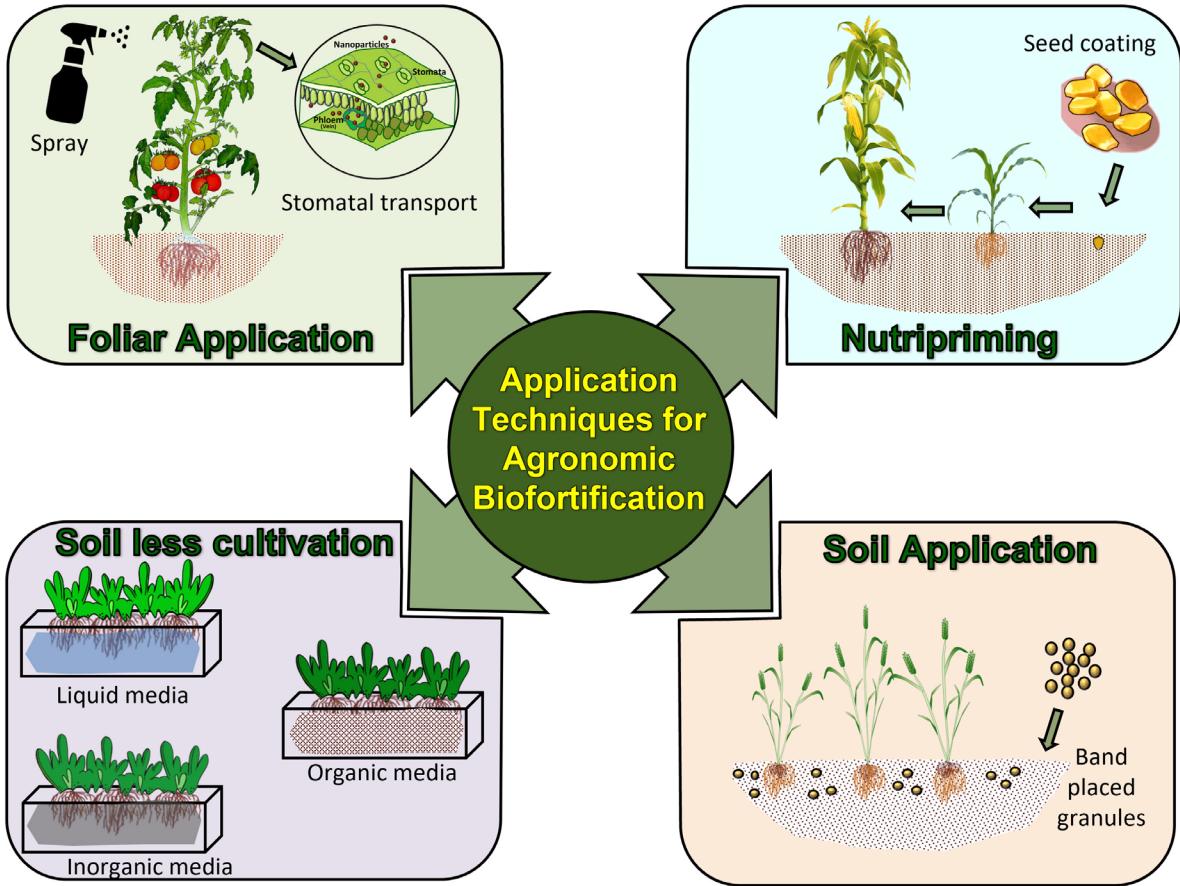


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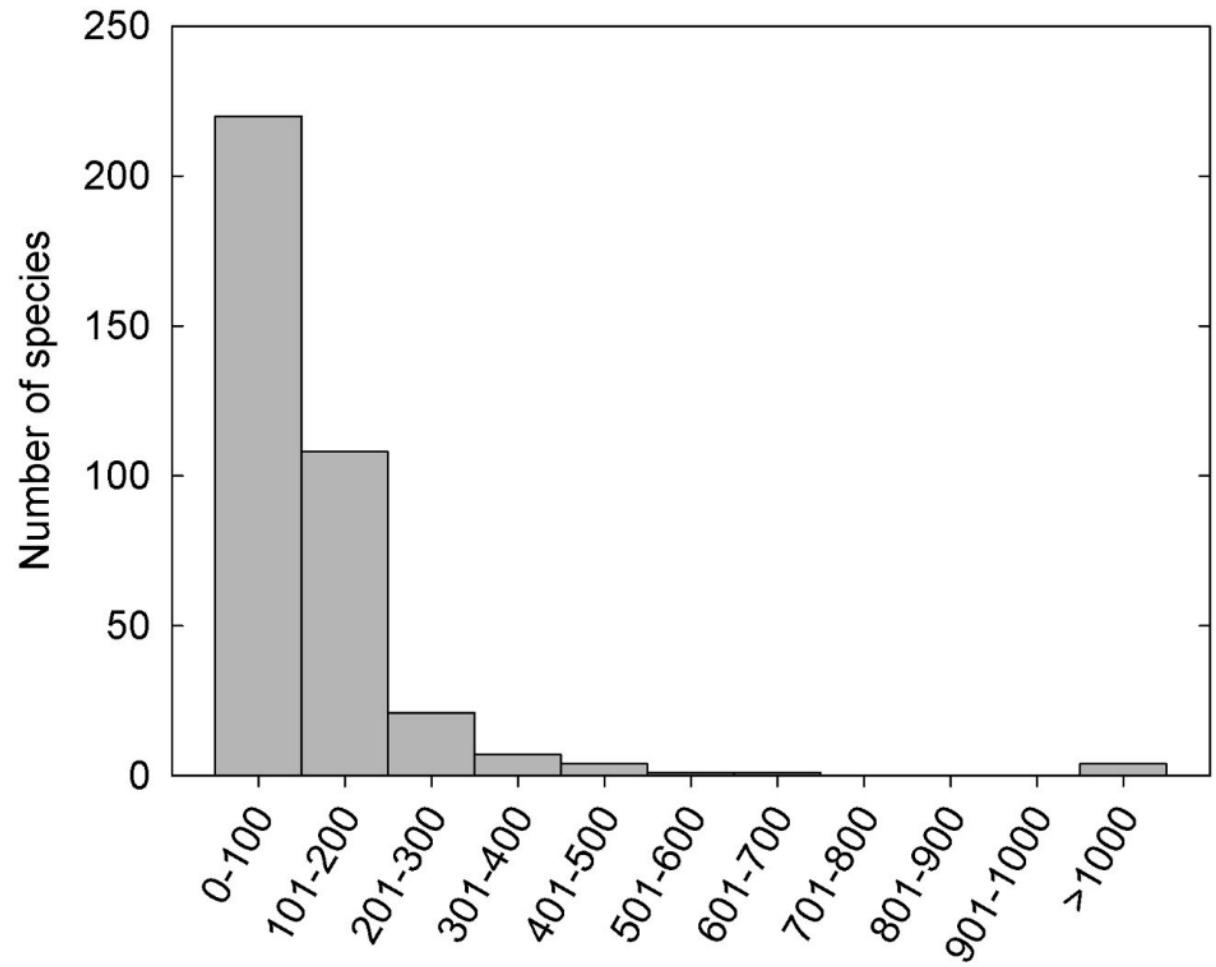
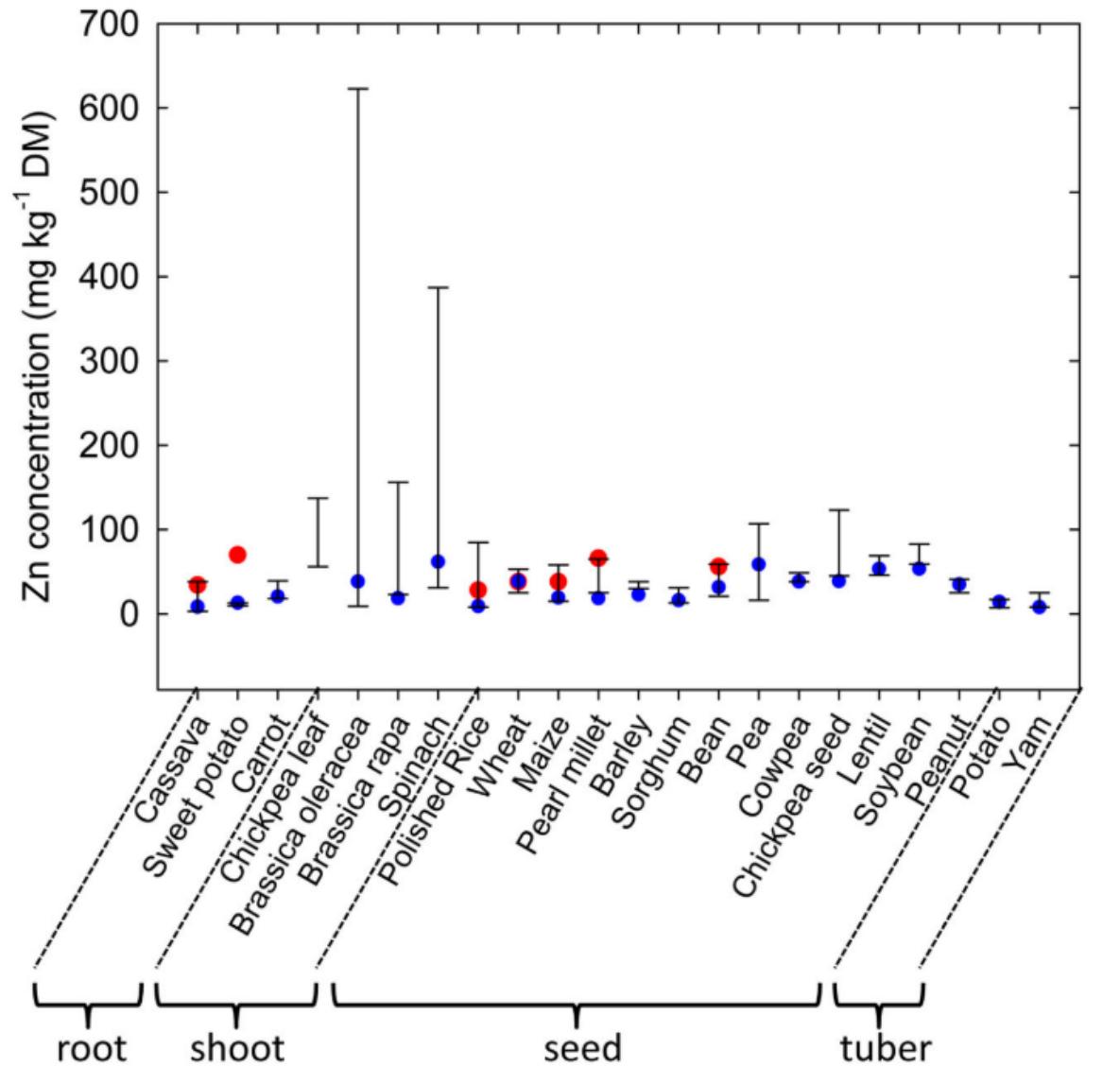
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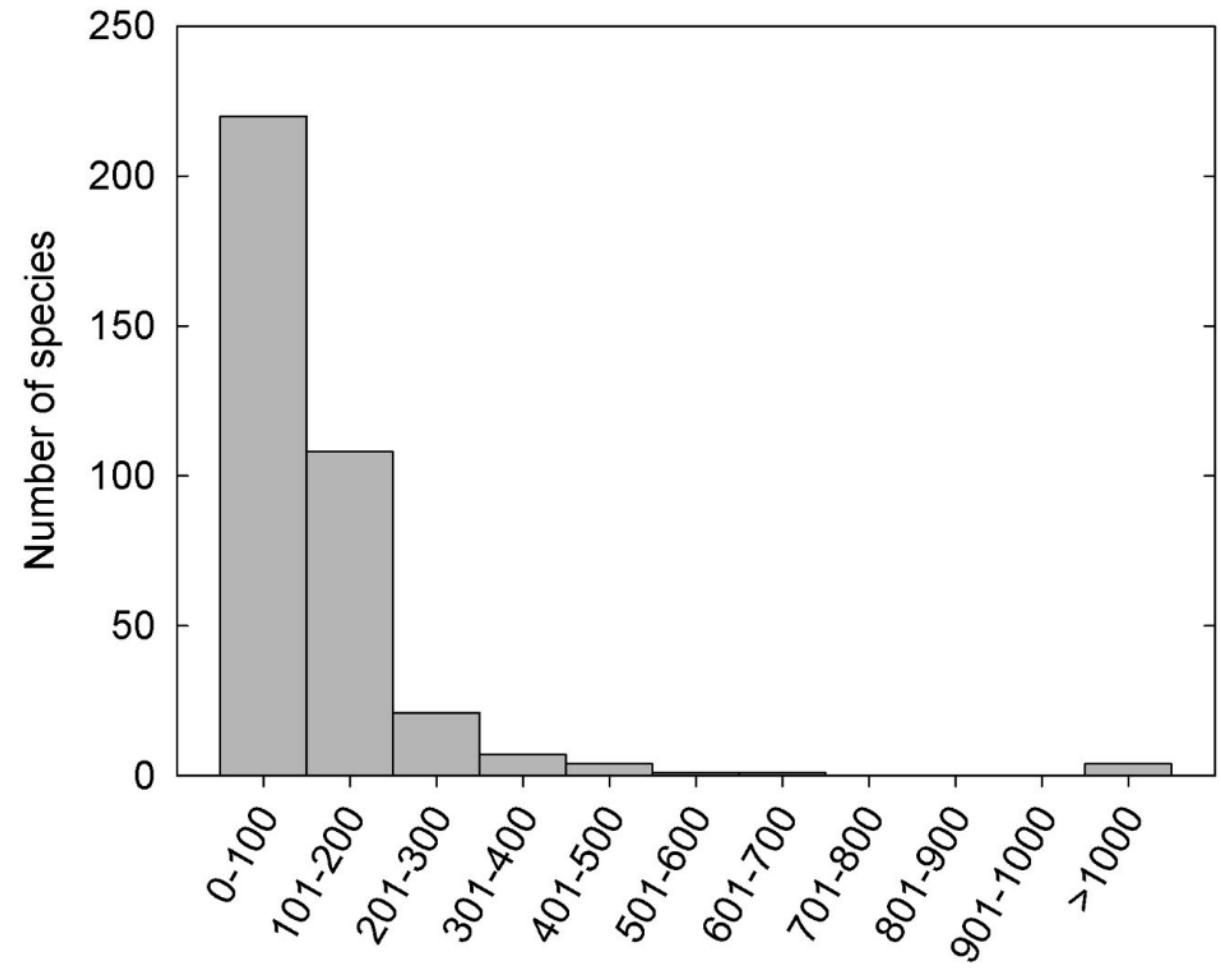
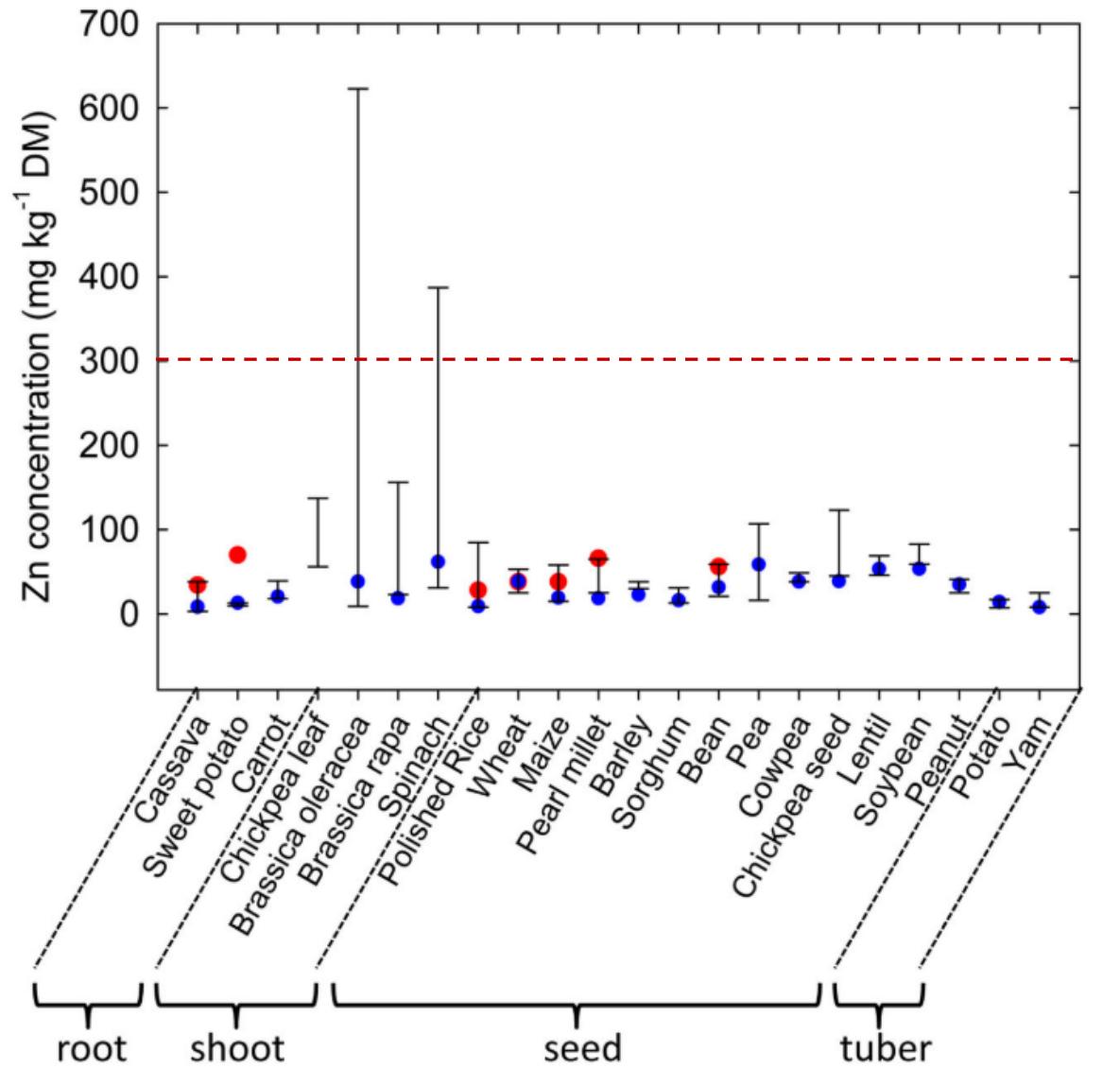


<https://www.harvestplus.org/>

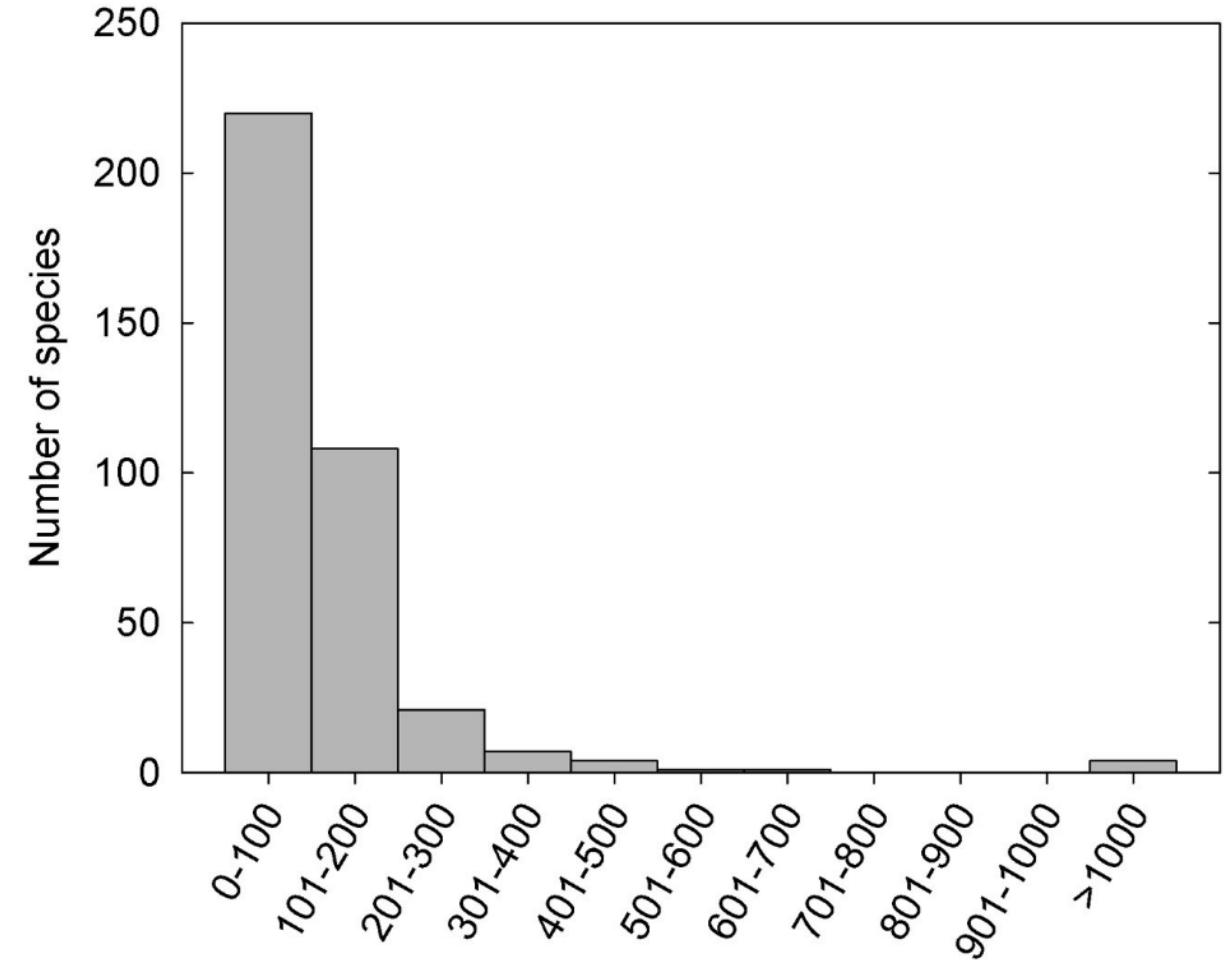
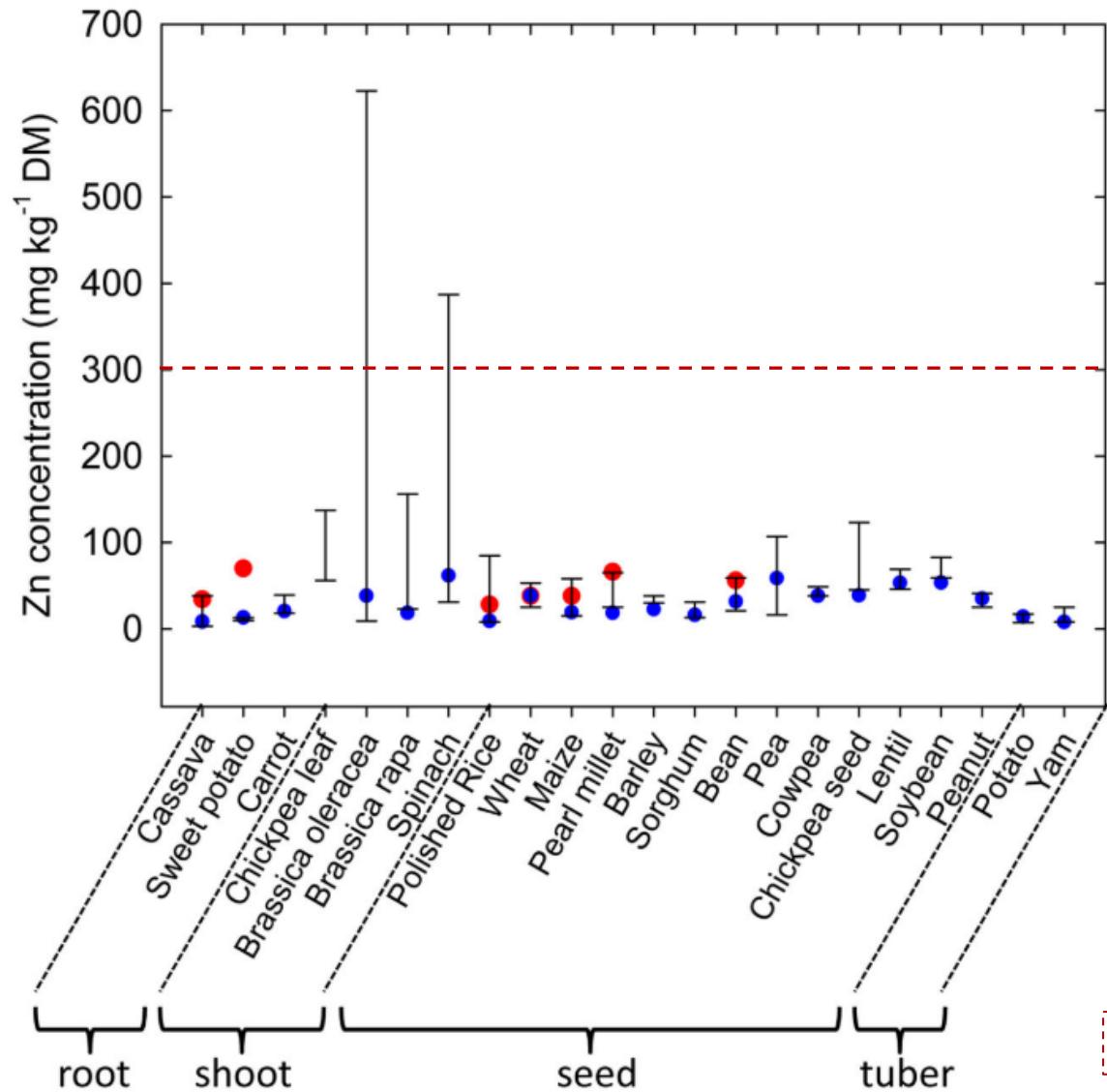
# Variability in Zn concentration in crops



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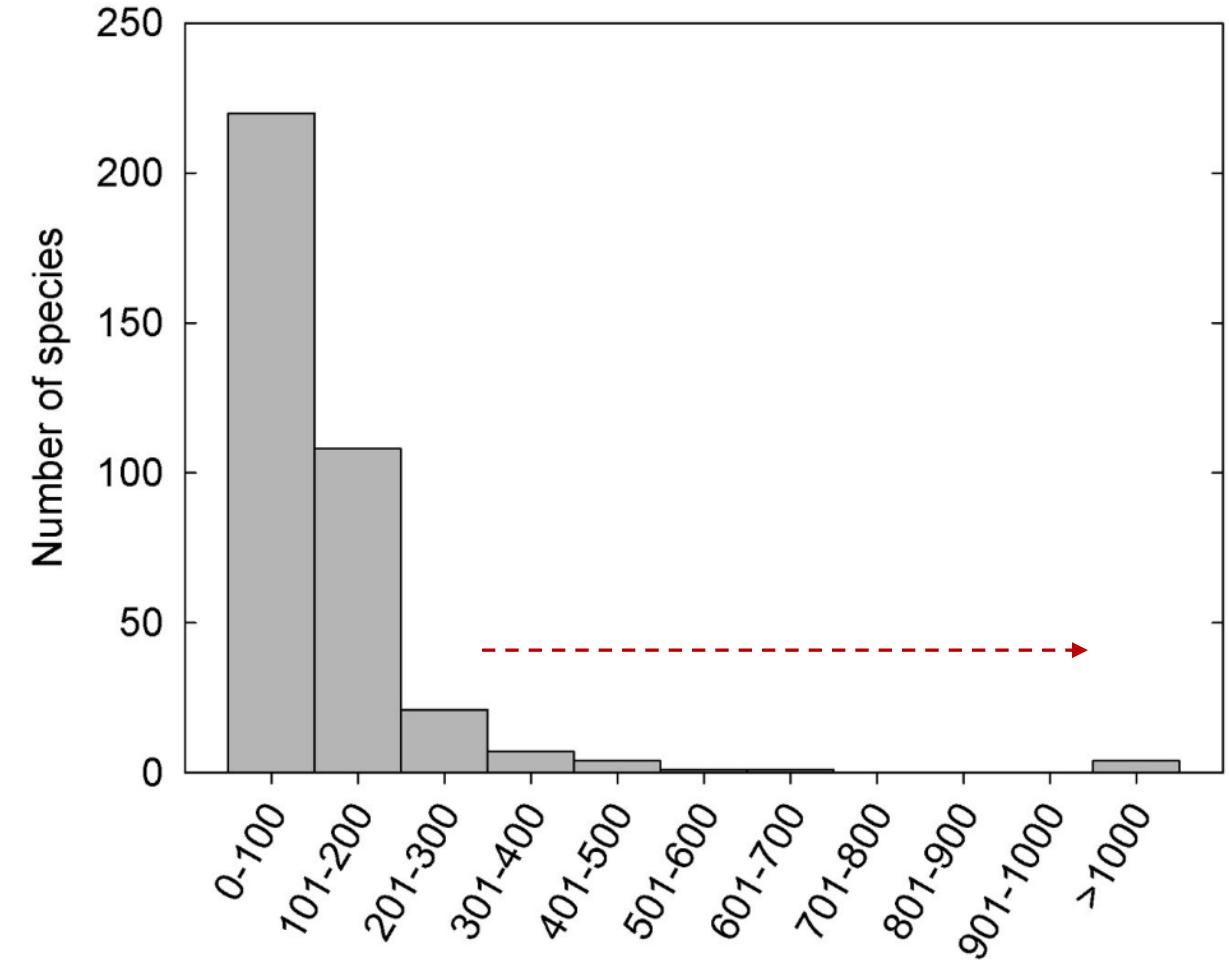
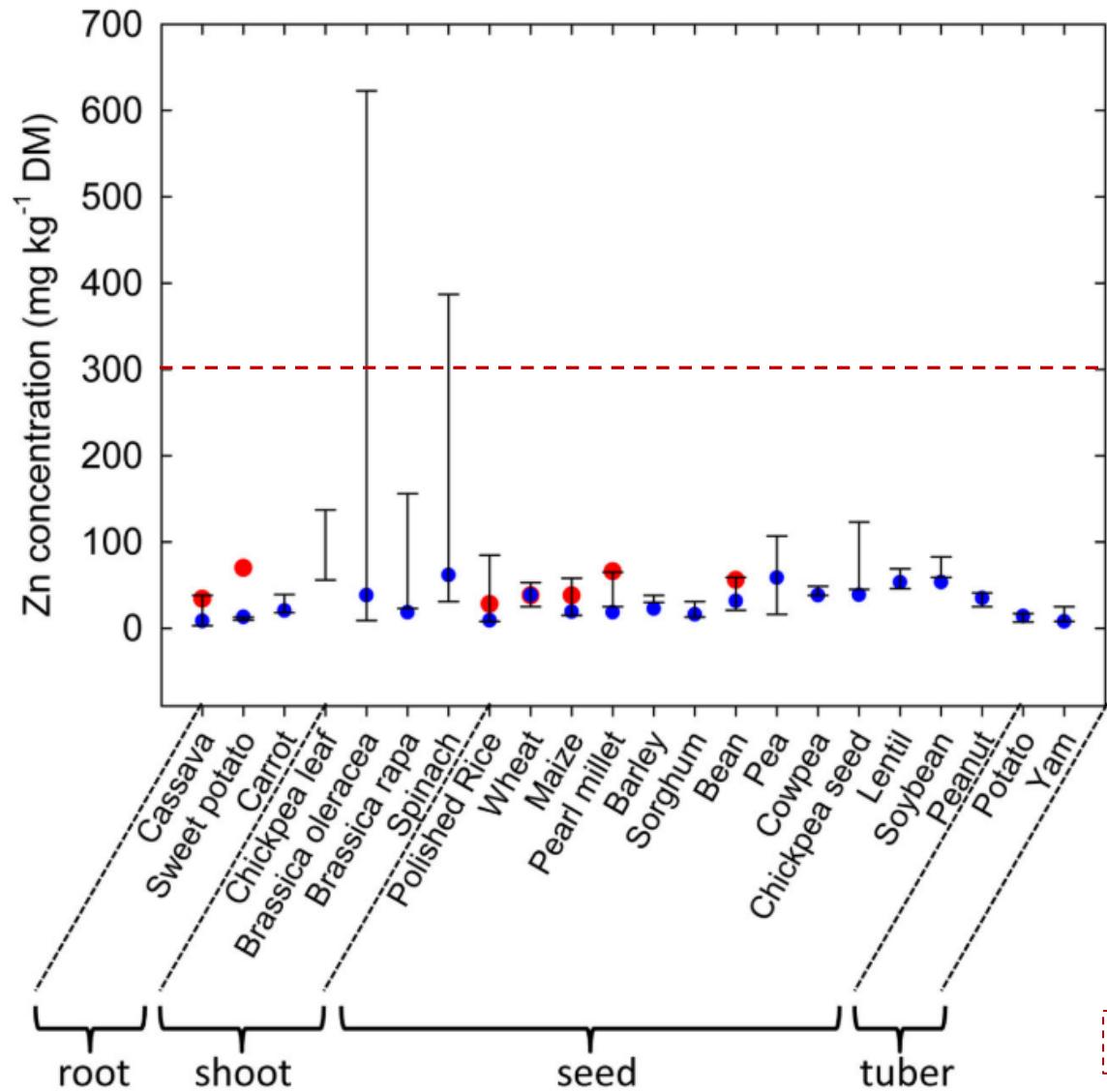


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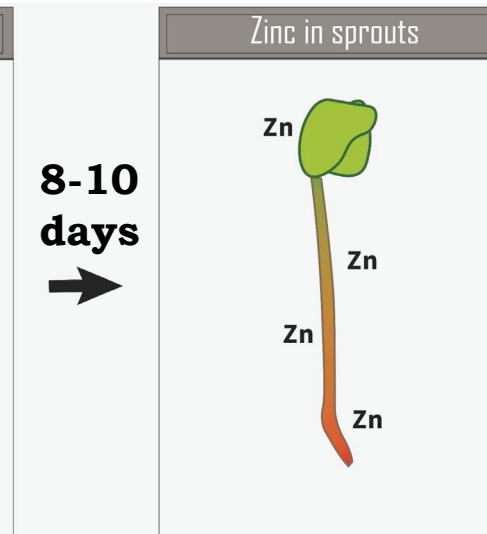
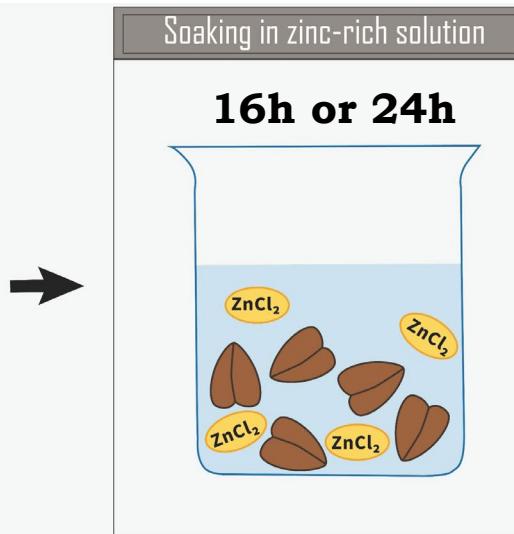
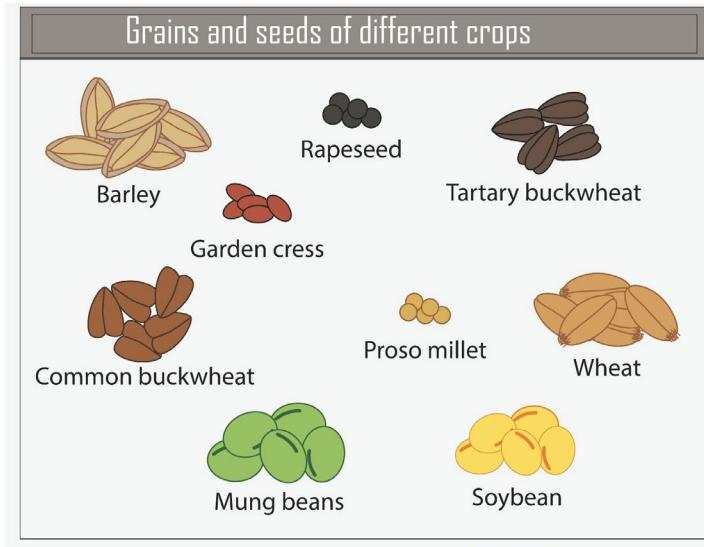
Dashed line > Zn concentration above which toxicity occurs in crops

# Variability in Zn concentration in crops



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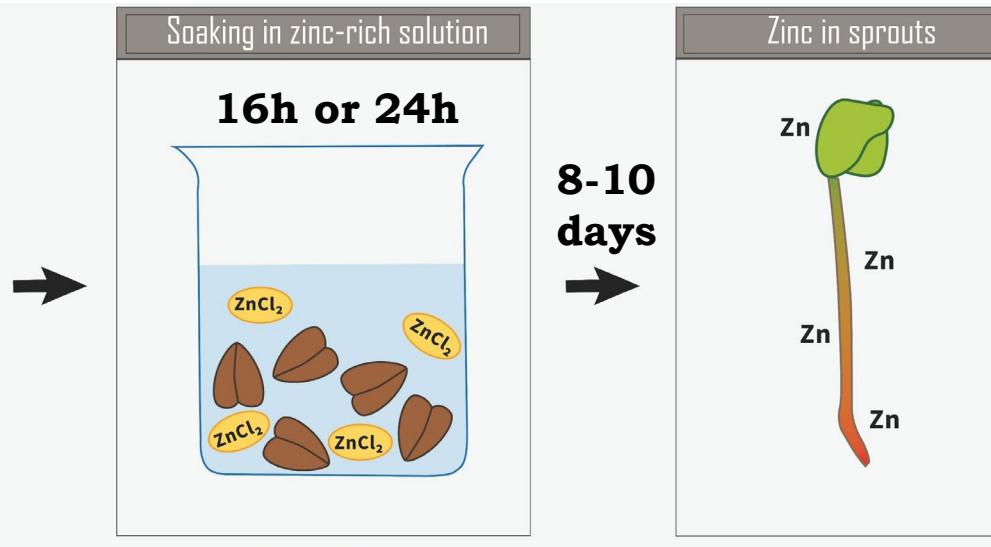
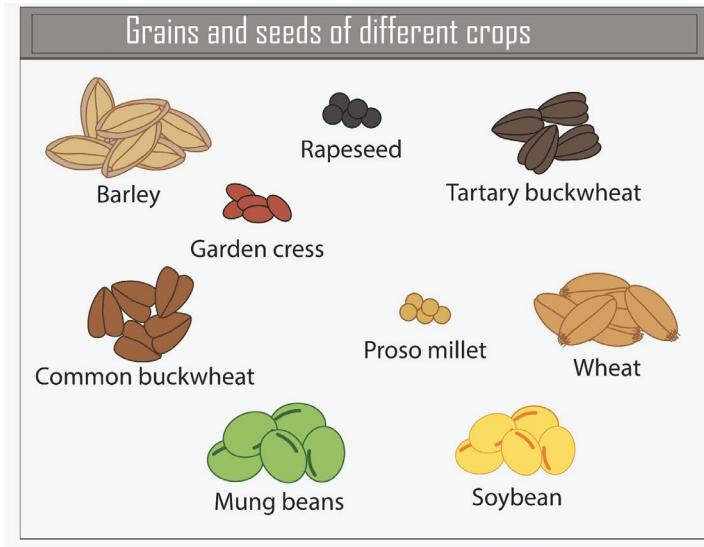
# Materials and methods



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



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## Experiment 1: $\text{ZnSO}_4$ and $\text{ZnCl}_2$

Common buckwheat (*Fagopyrum esculentum*)

Tartary buckwheat (*Fagopyrum tataricum*)

## Experiment 2: $\text{ZnCl}_2$

Common buckwheat

Wheat (*Triticum aestivum*)

Garden cress (*Lepidium sativum*)

Mung bean (*Vigna radiata*)

## Experiment 3: $\text{ZnCl}_2$

Soybean (*Glycine max*)

Barley (*Hordeum vulgare*)

Proso millet (*Panicum miliaceum*)

Oilseed rape (*Brassica napus*)



## Results

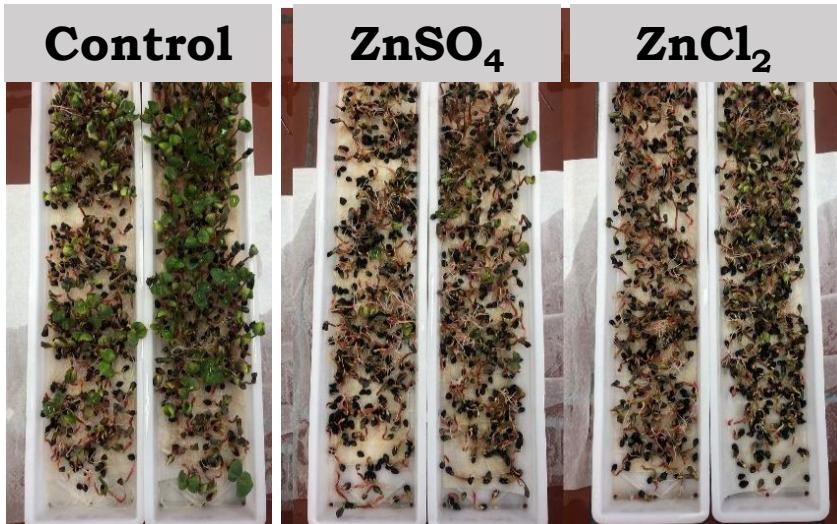
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**Experiment 1: 0 (Control), 500 mM ZnSO<sub>4</sub> or 100 mM ZnCl<sub>2</sub>**

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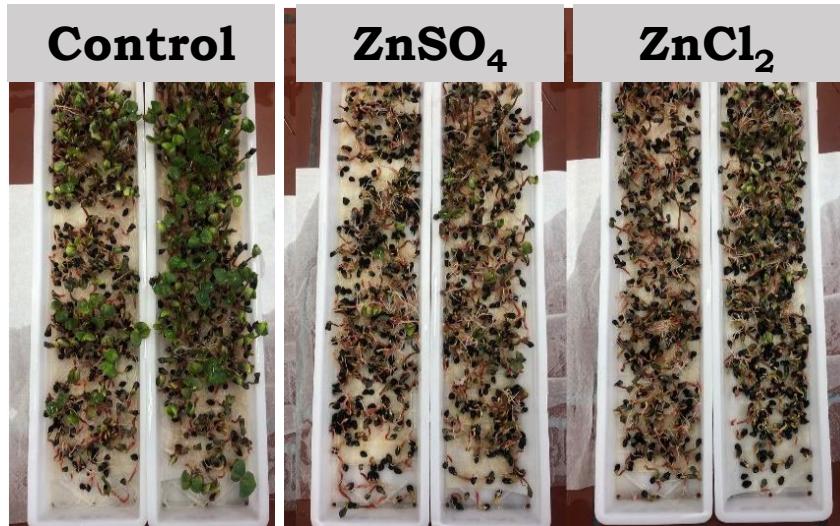
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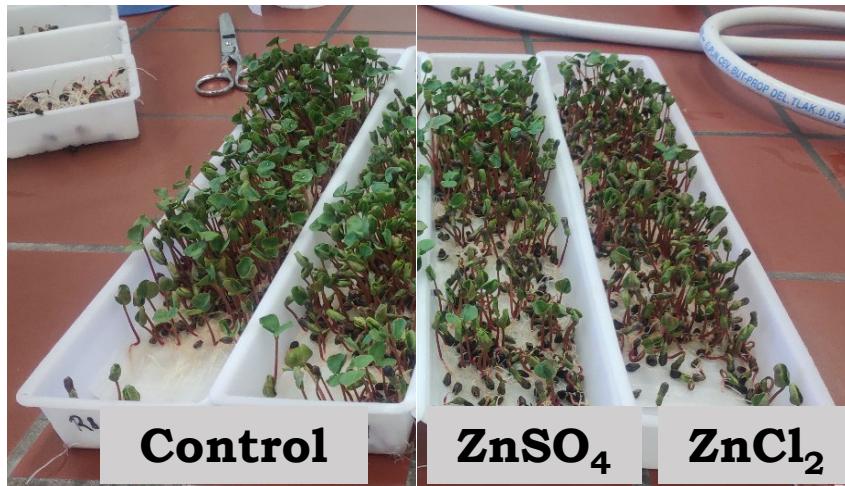
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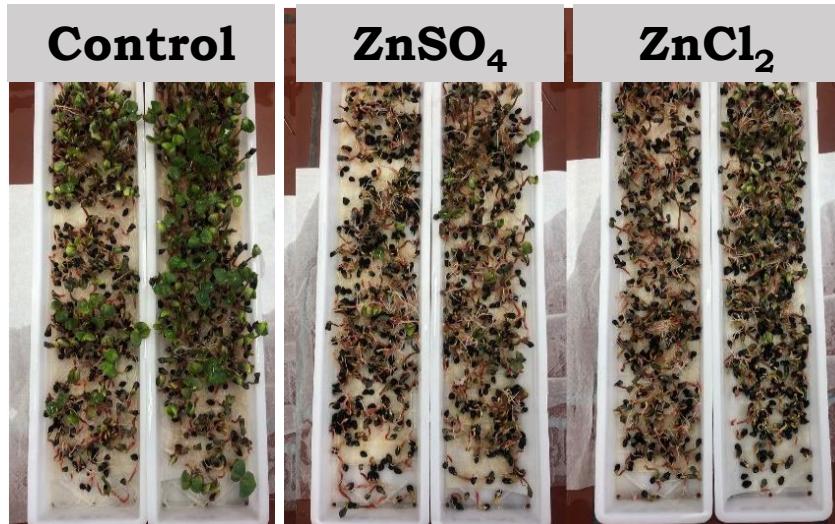
Tartary buckwheat



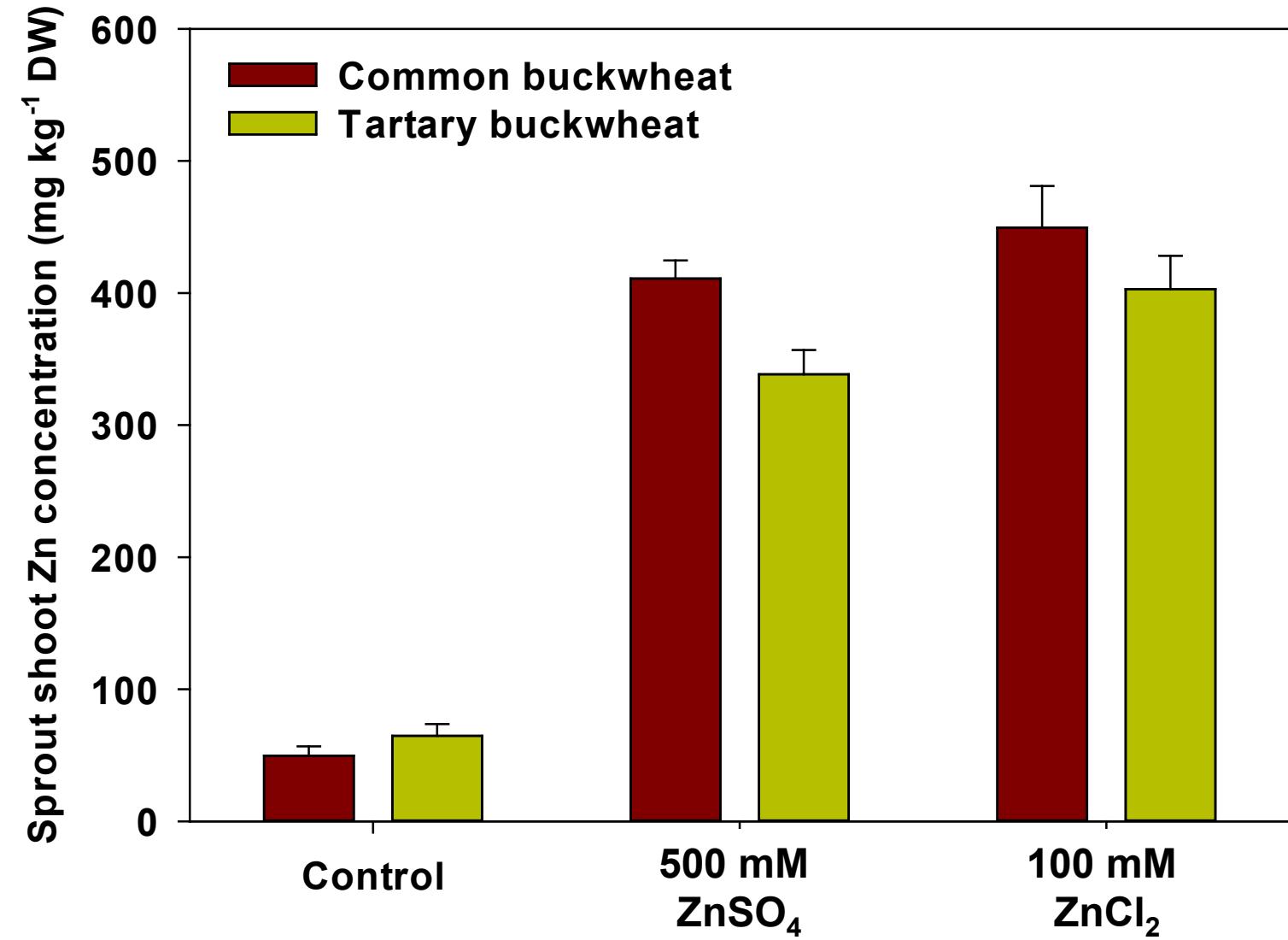
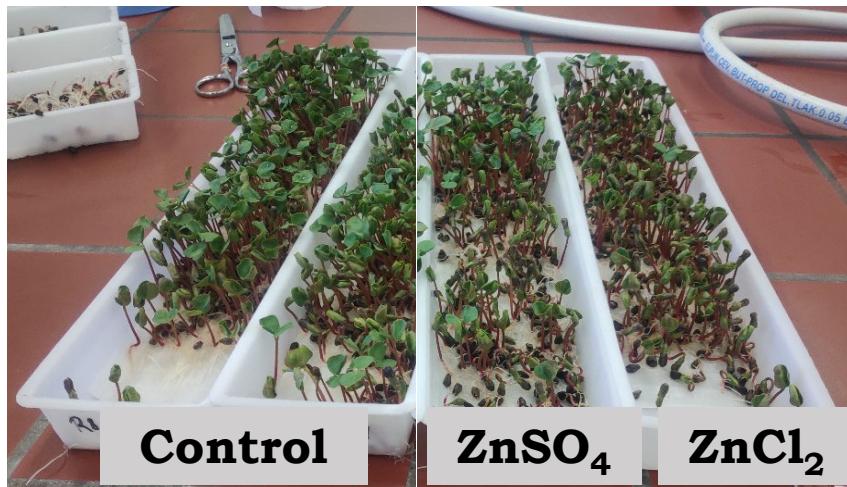
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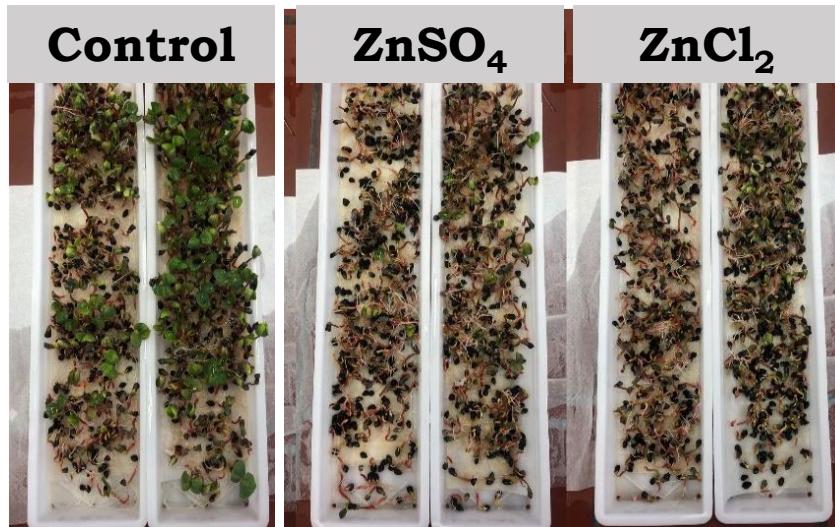
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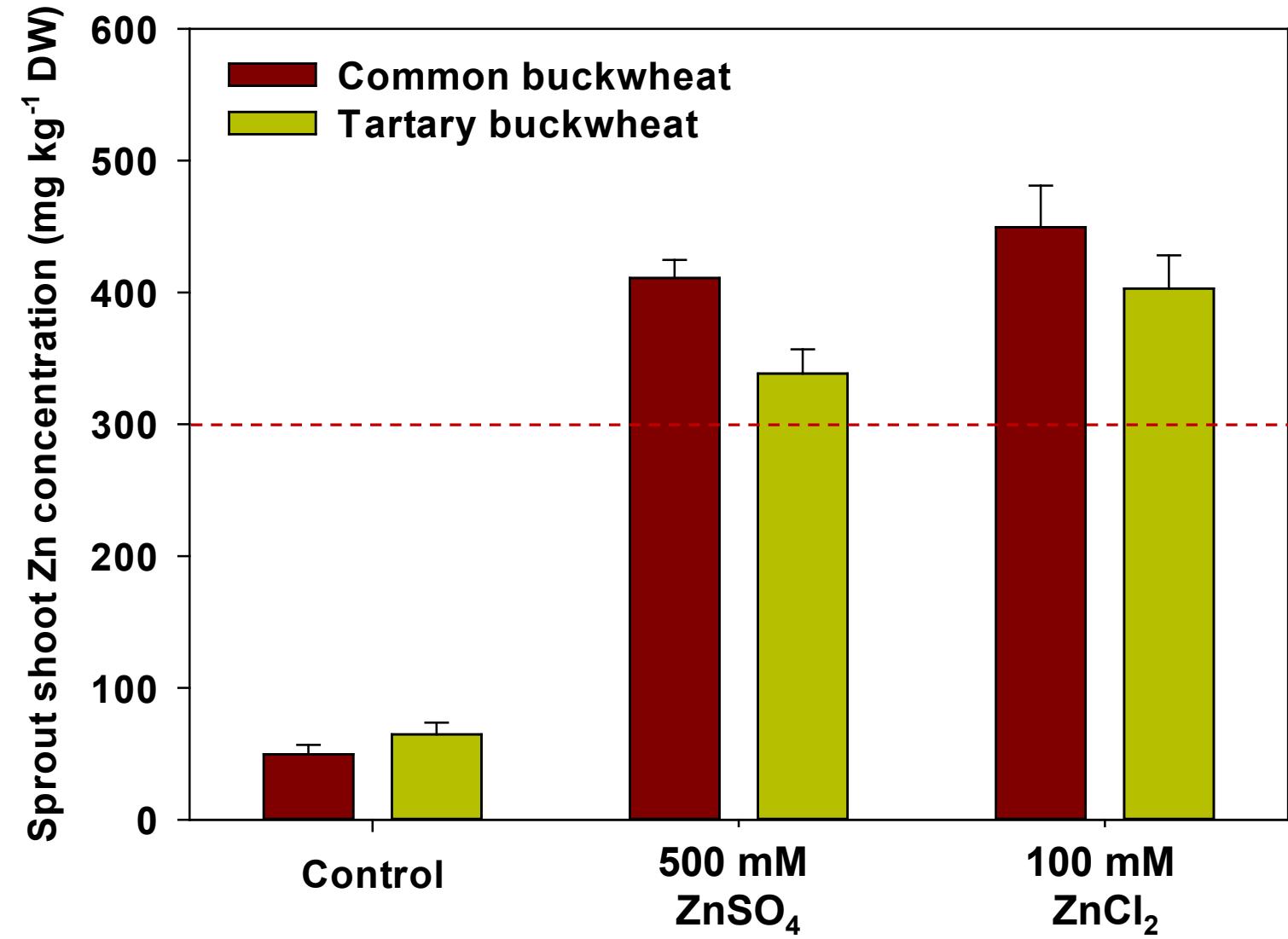
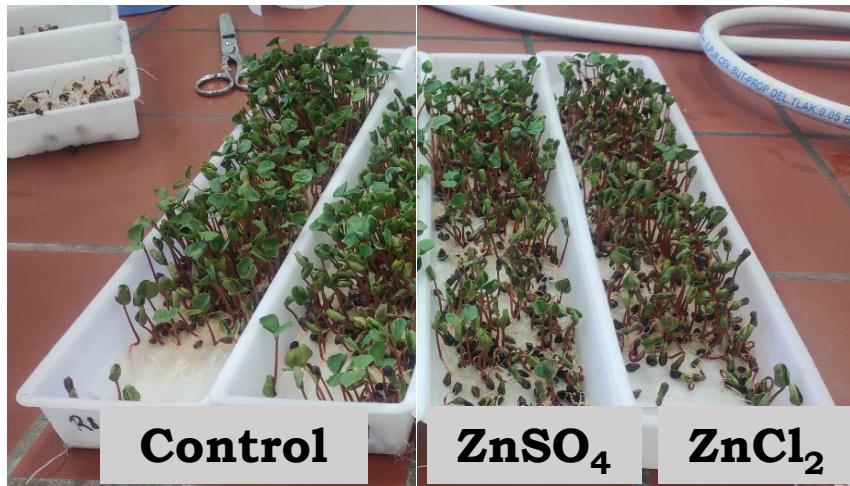
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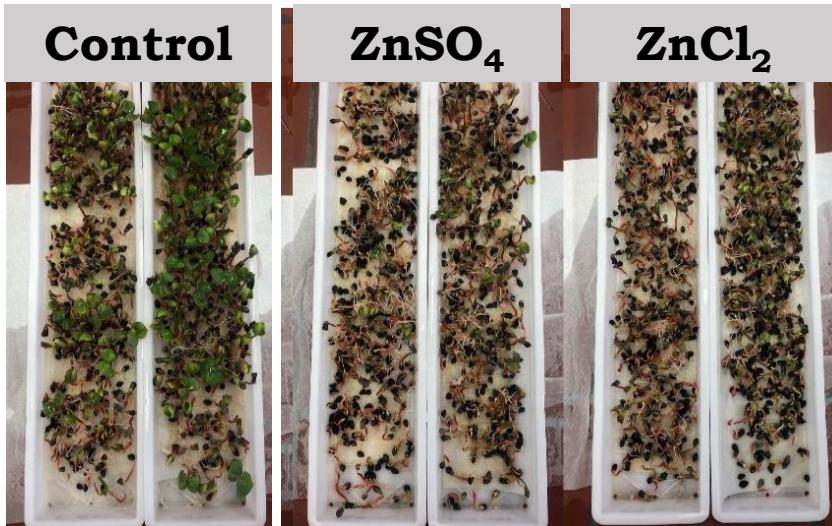
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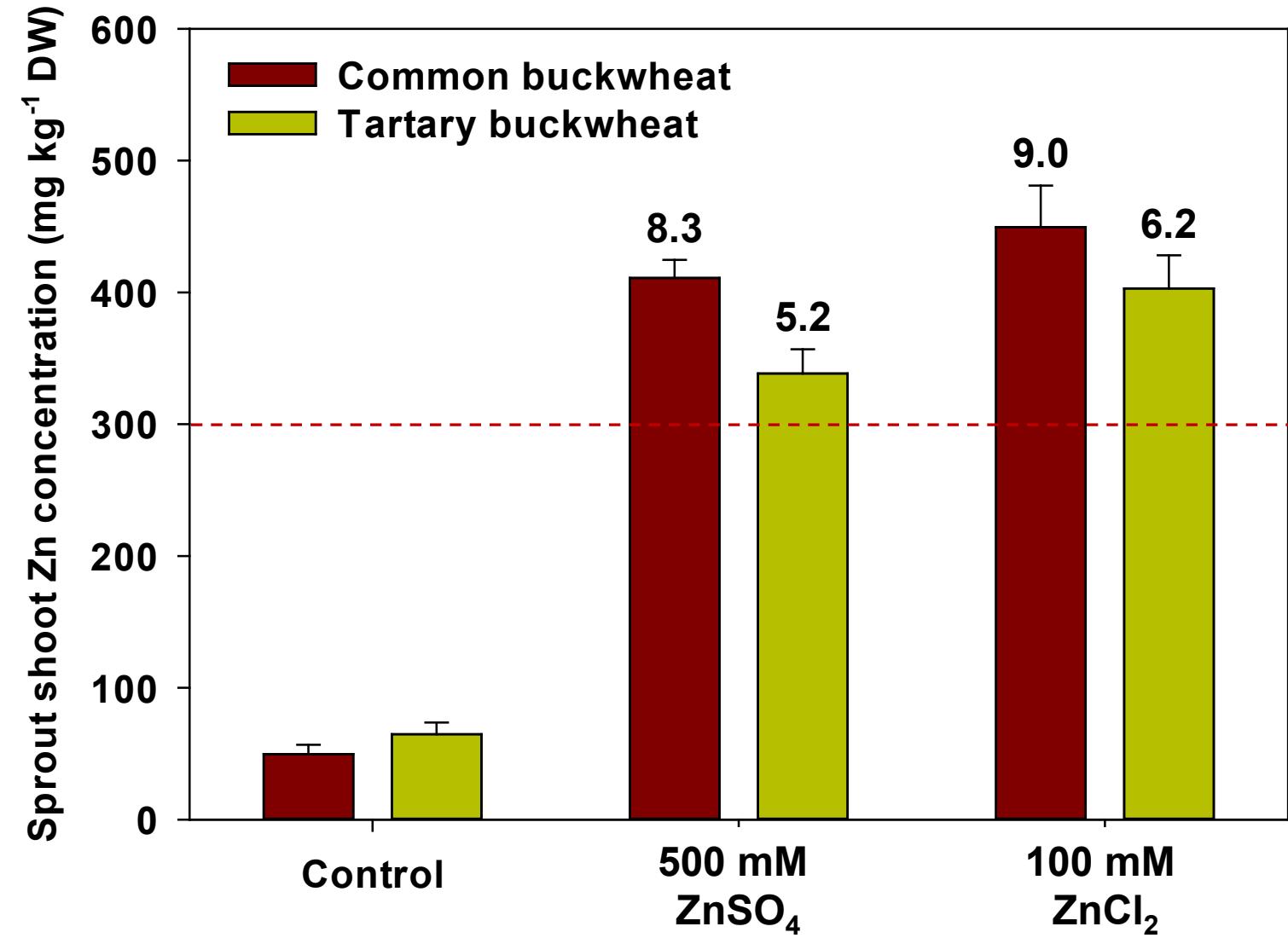
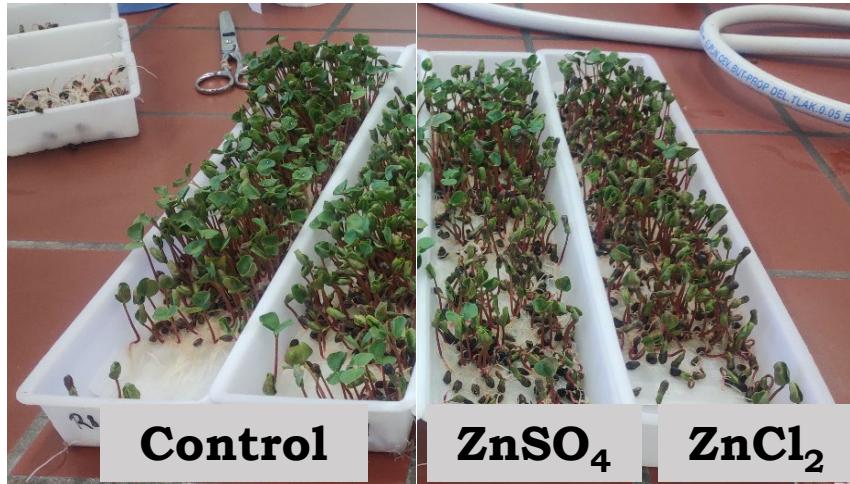
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Common buckwheat



Tartary buckwheat



## Results

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**Experiment 2:**

**0 (Control),**

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

## Results

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Wheat



# Results

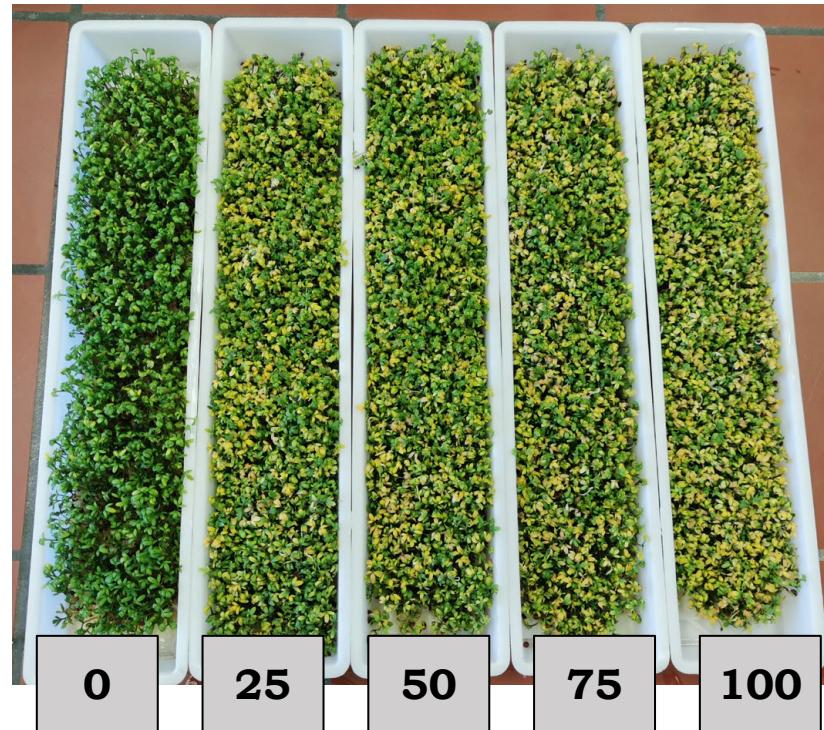
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Garden cress



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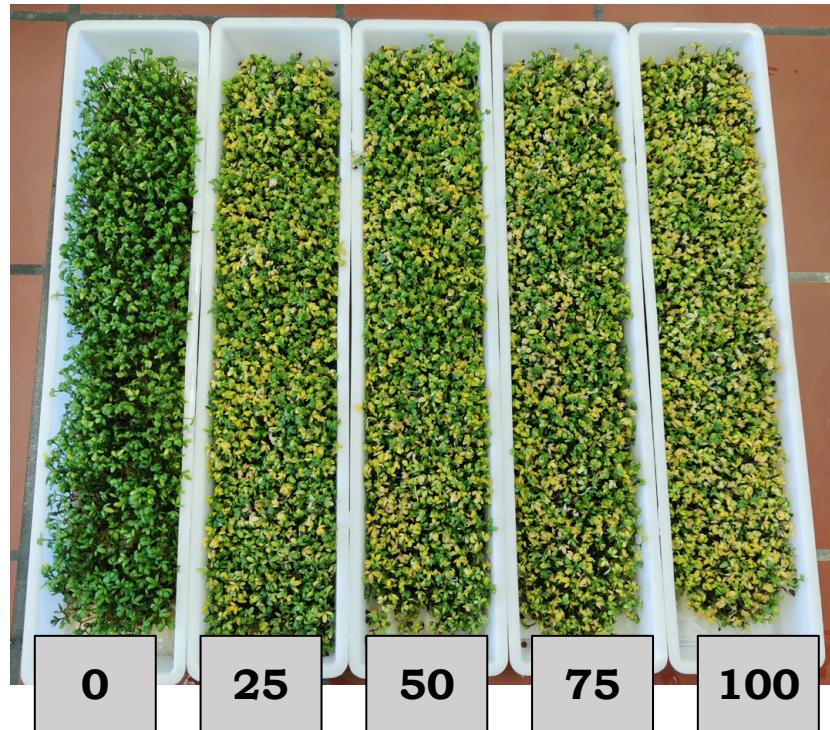
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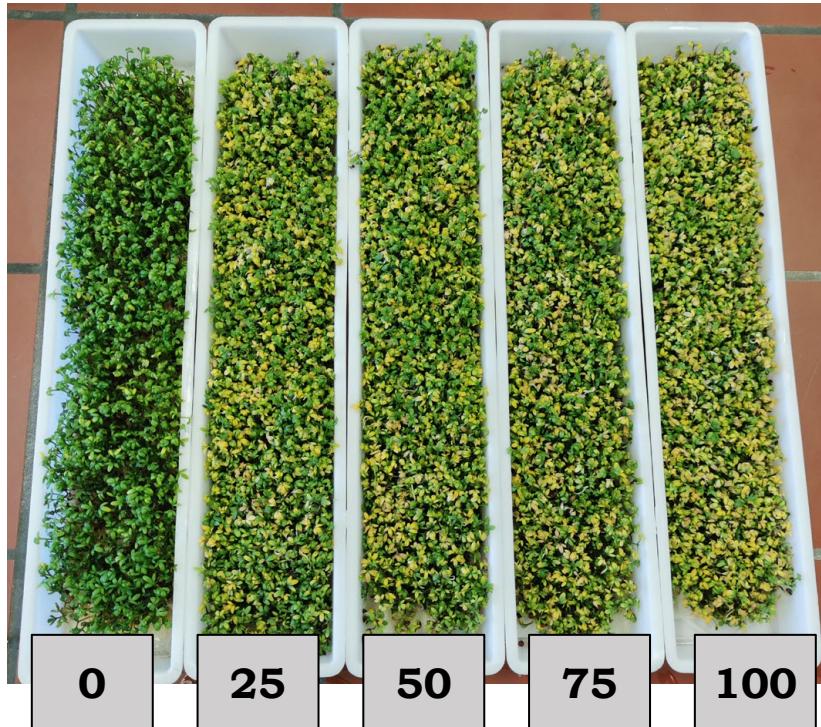
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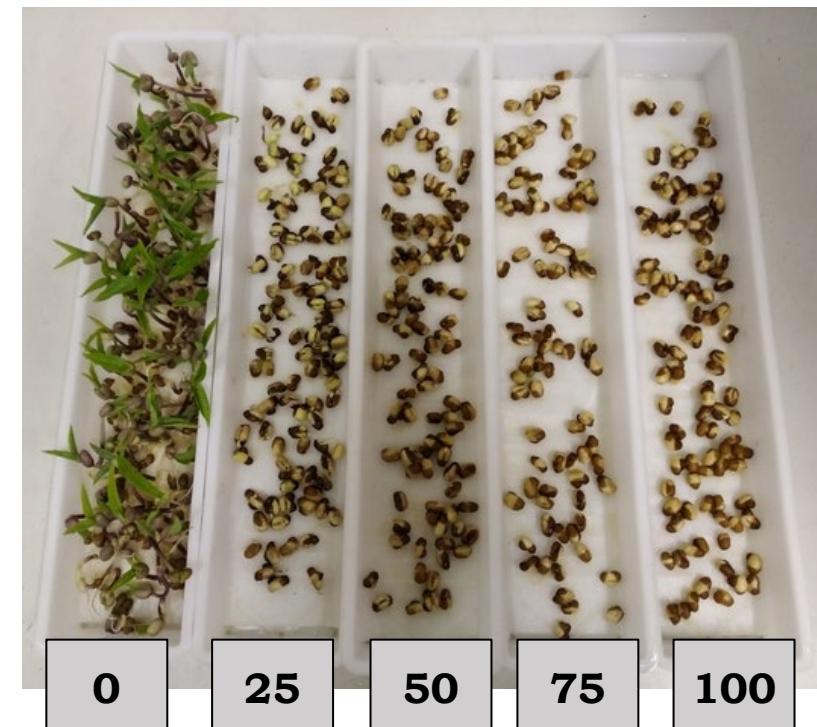
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Common buckwheat

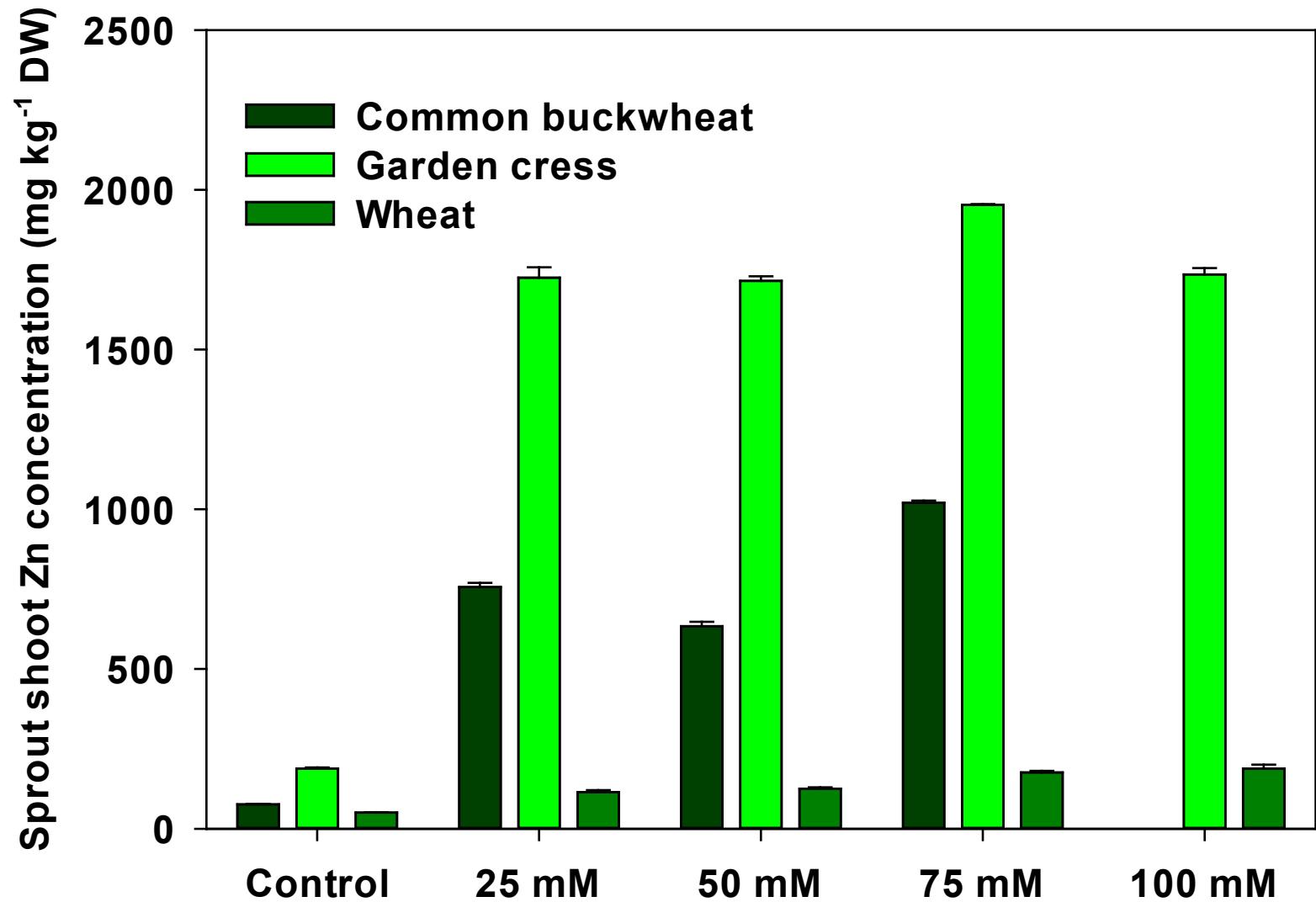


Mung bean



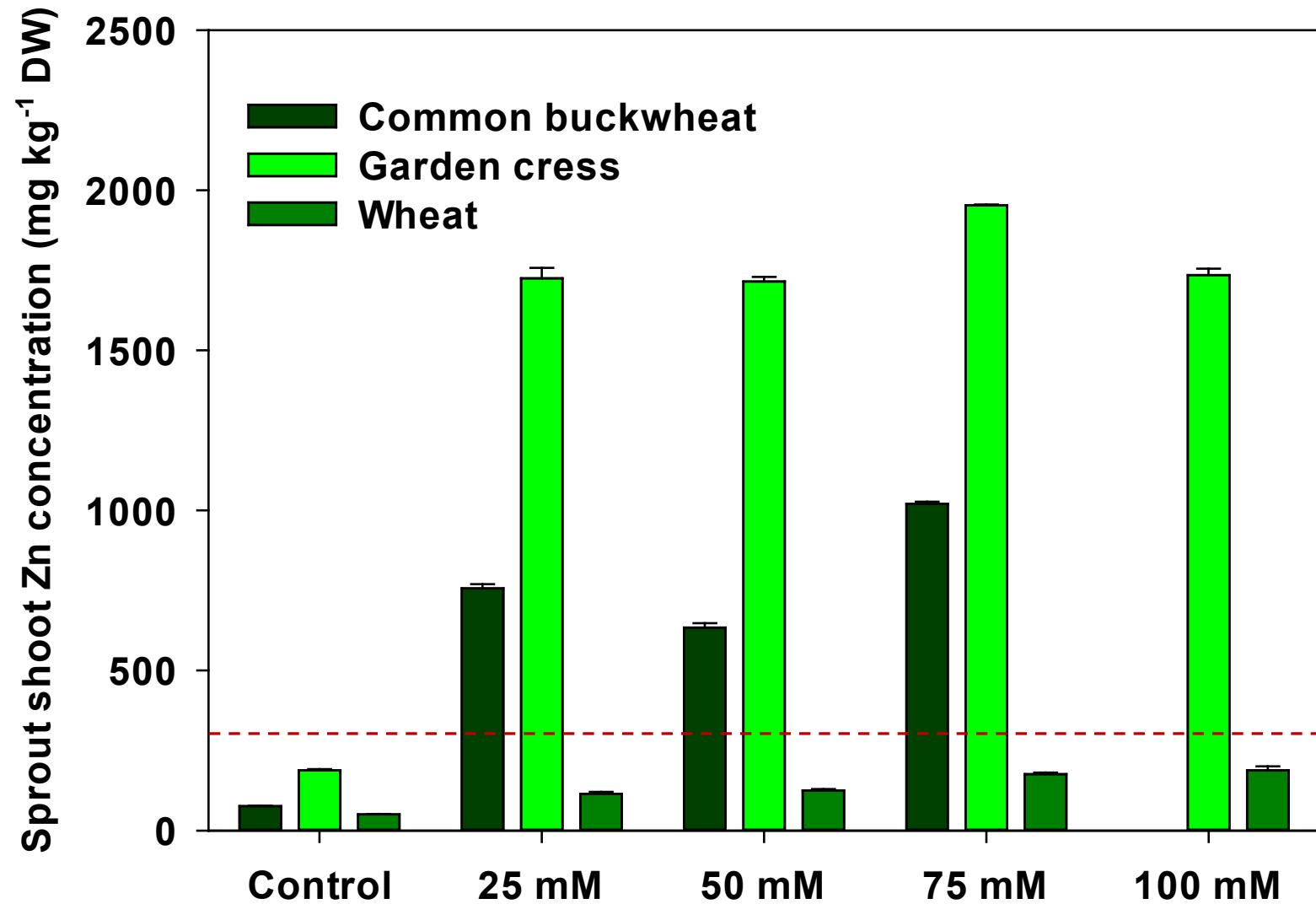
## Results

**Experiment 2 - continuation:**  
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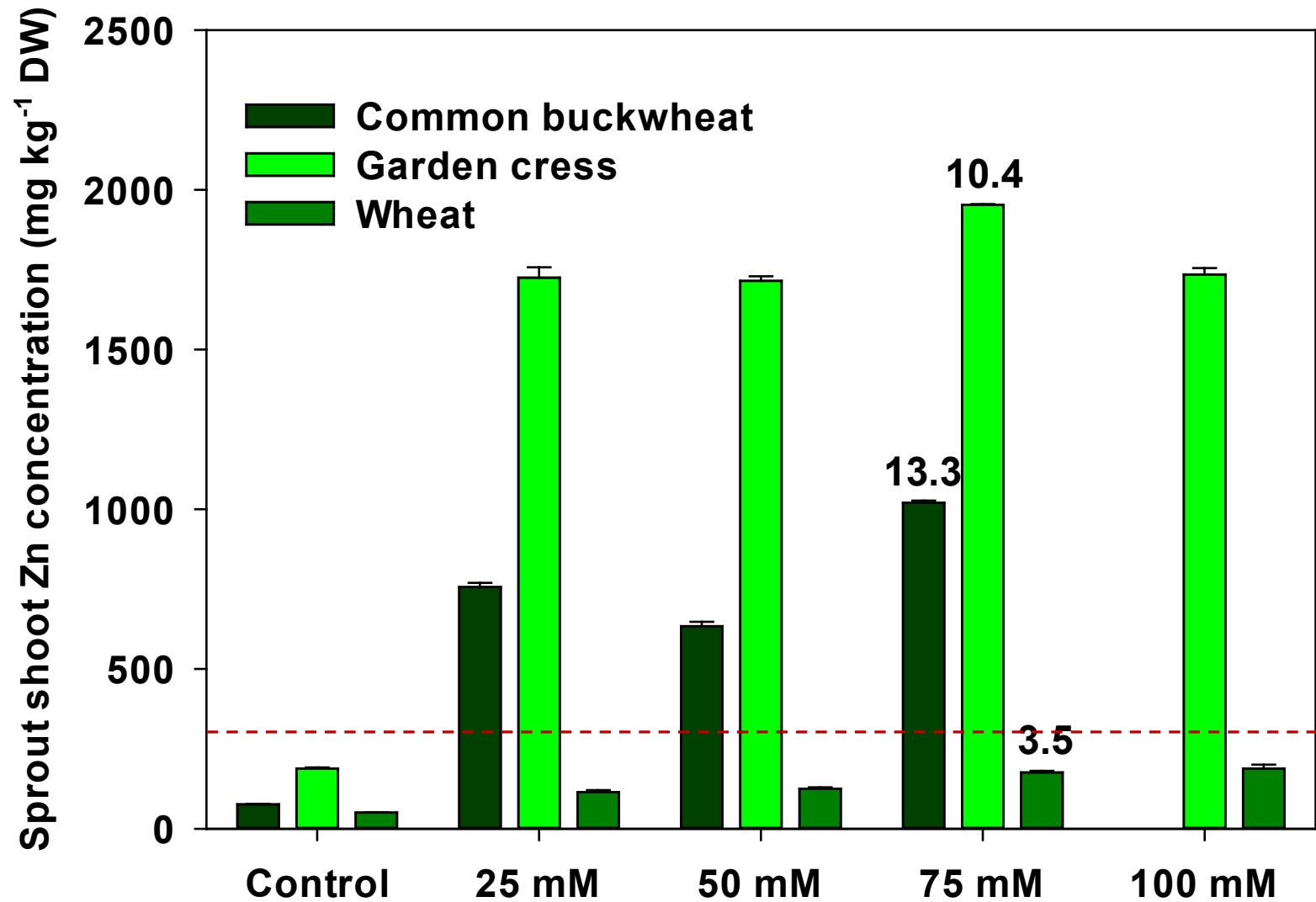
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**Experiment 2 - continuation:**  
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## Results

Experiment 2 - continuation:  
0 (Control),  
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# Results

## Experiment 2:

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

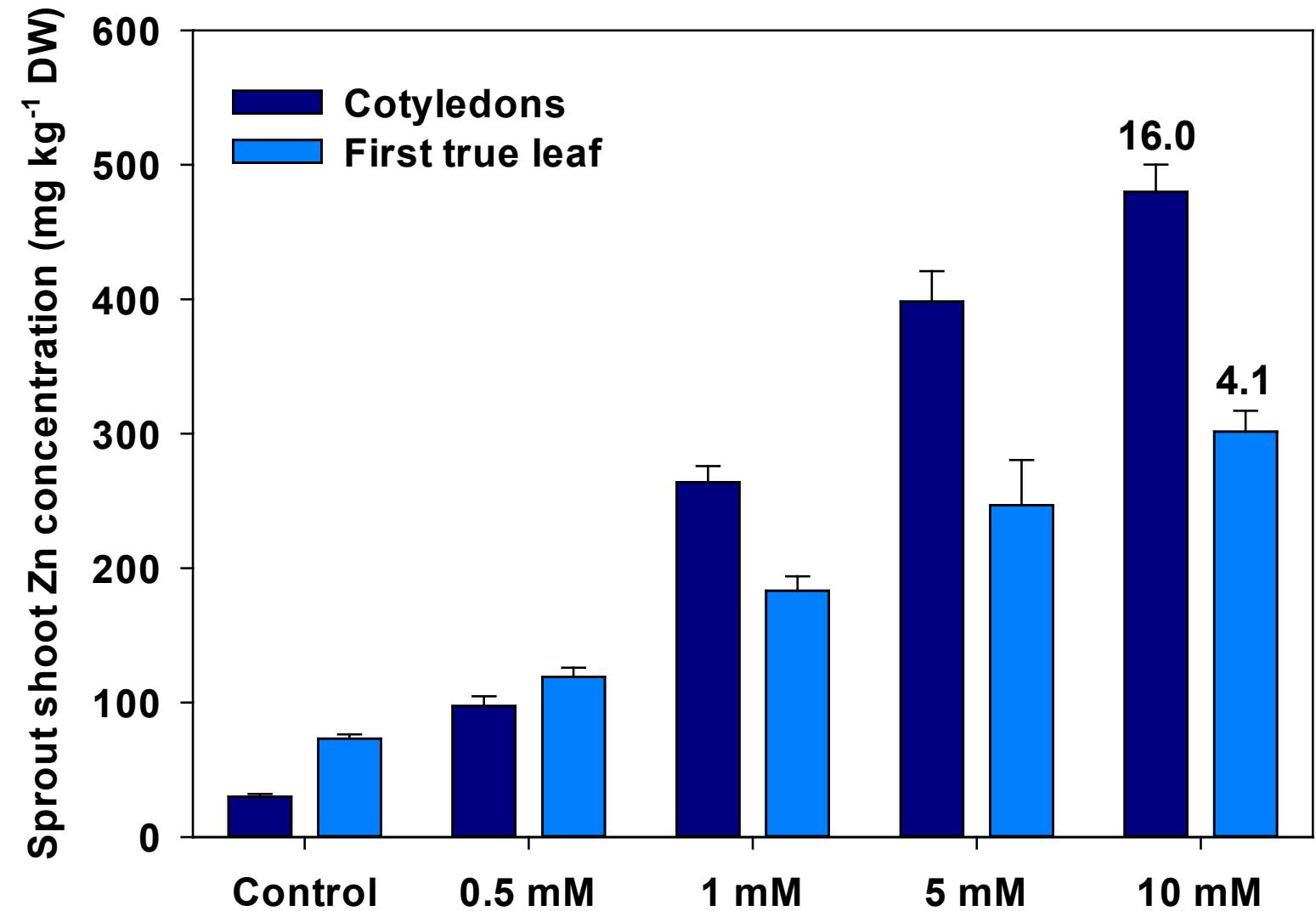
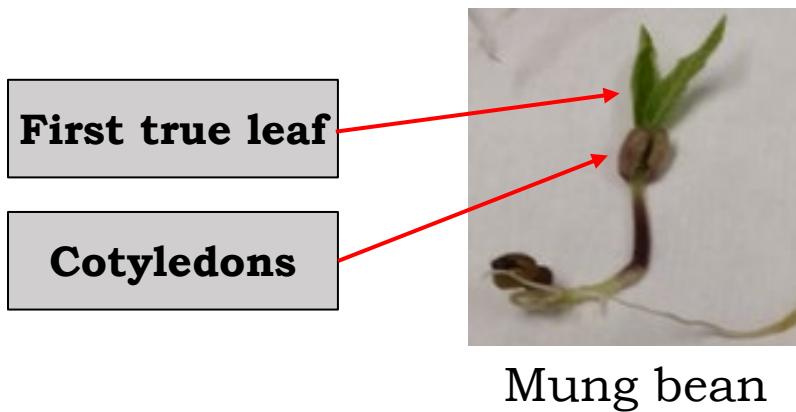
Mung bean



## Results

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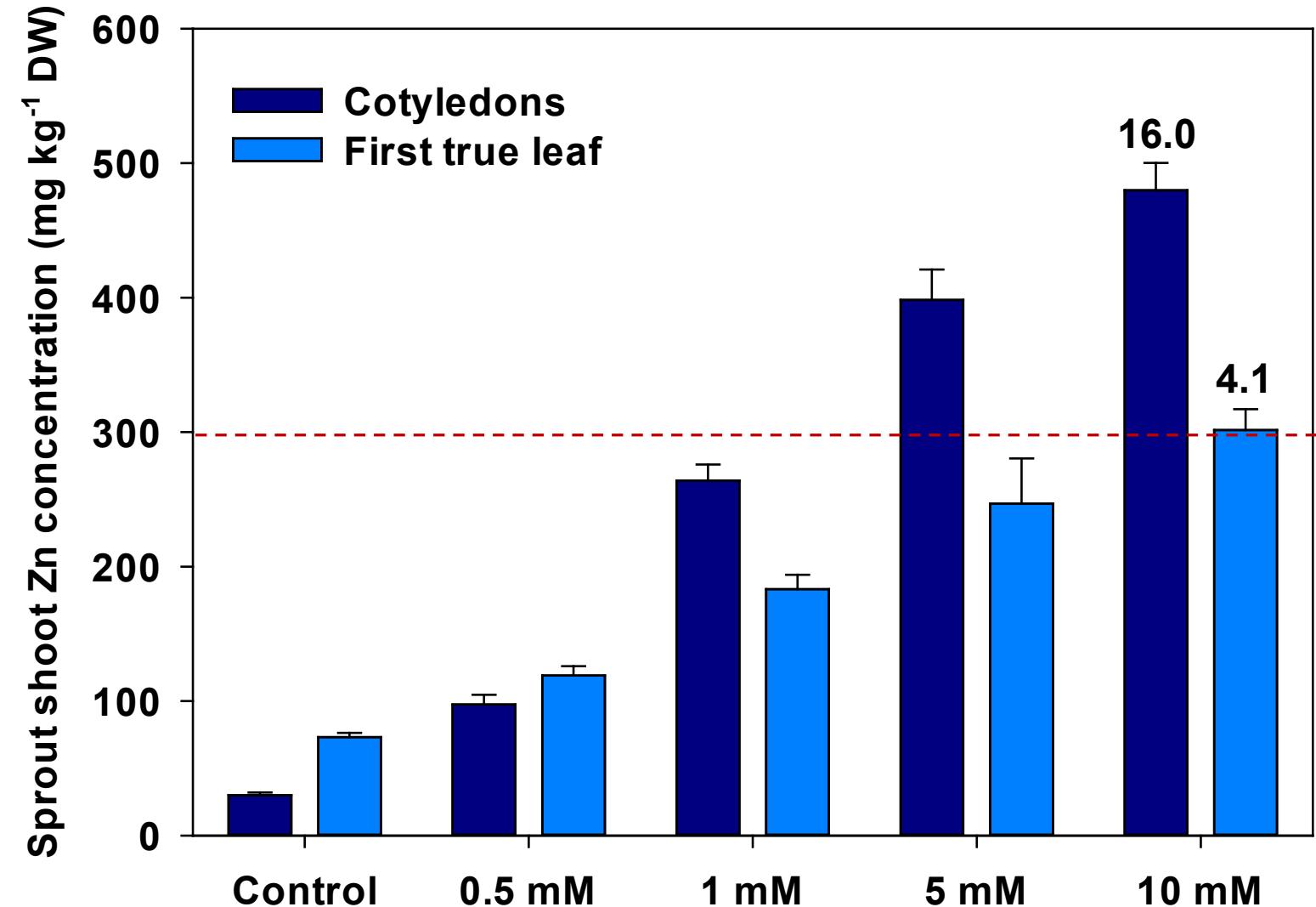
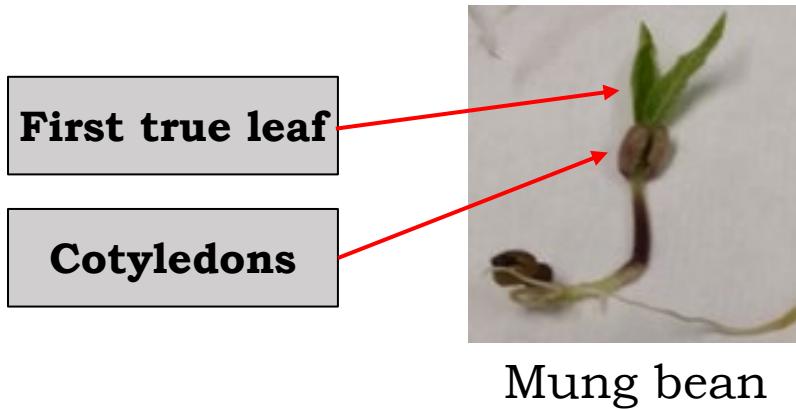
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## Results

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## Results

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Soybean



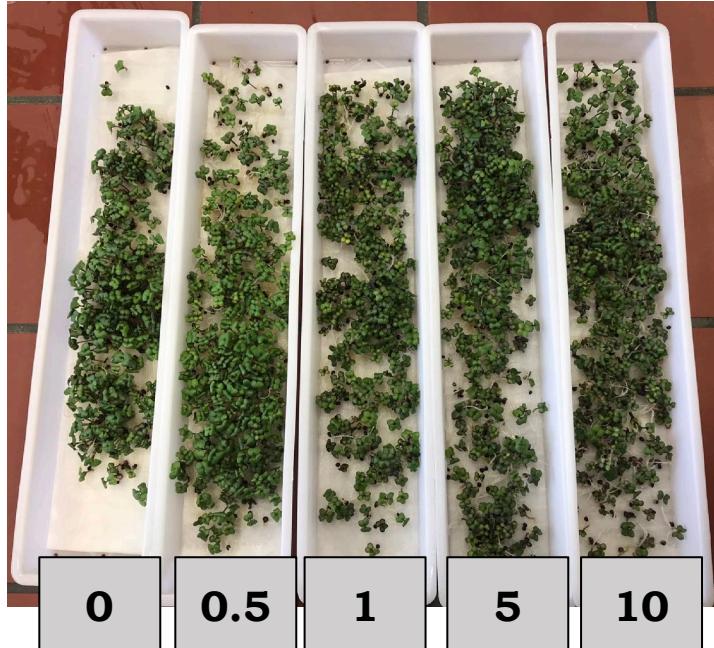
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# Results

Soybean



Rapeseed



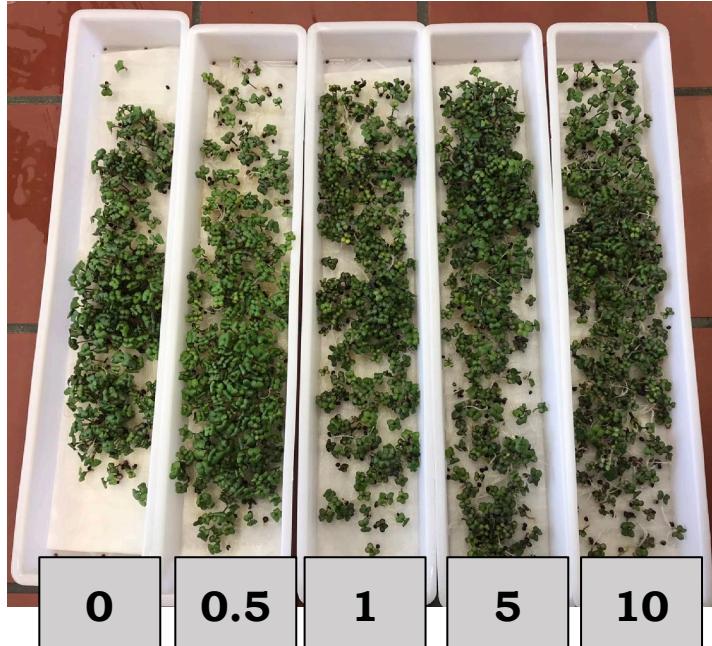
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Soybean

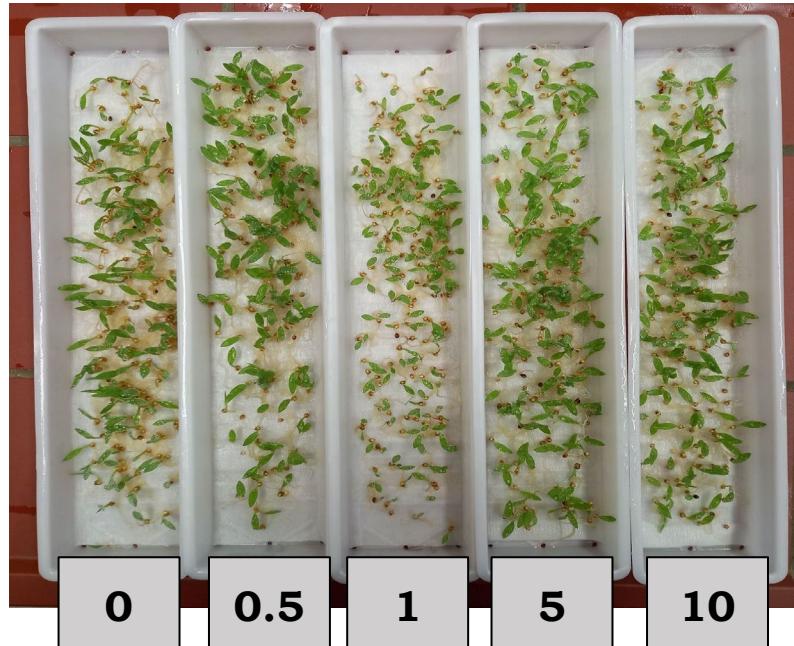


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Rapeseed



Proso millet



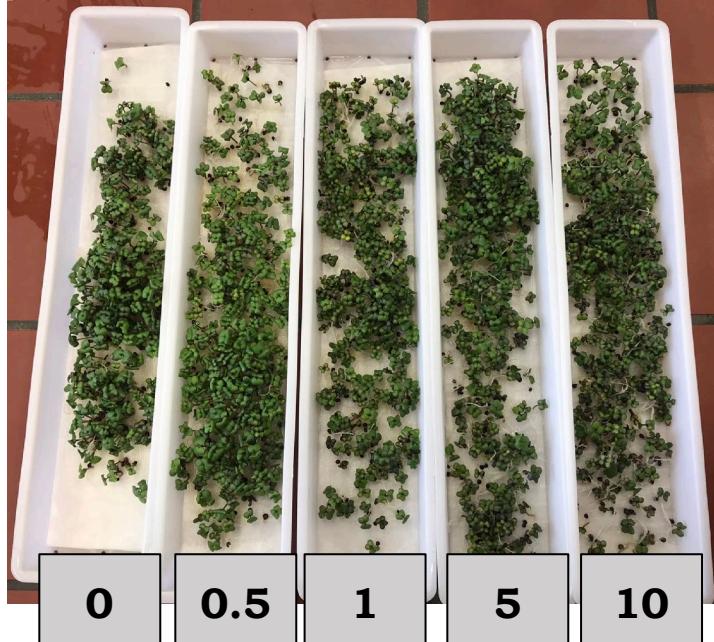
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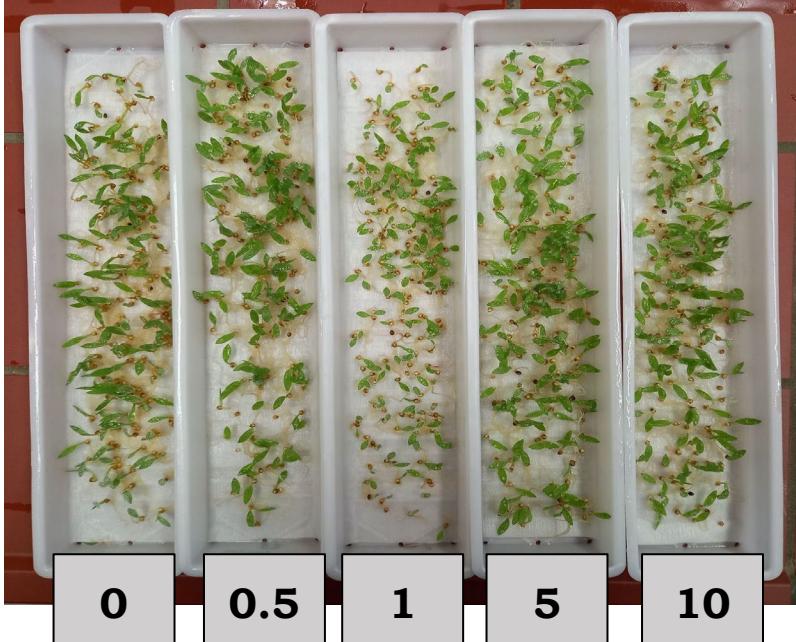
Soybean



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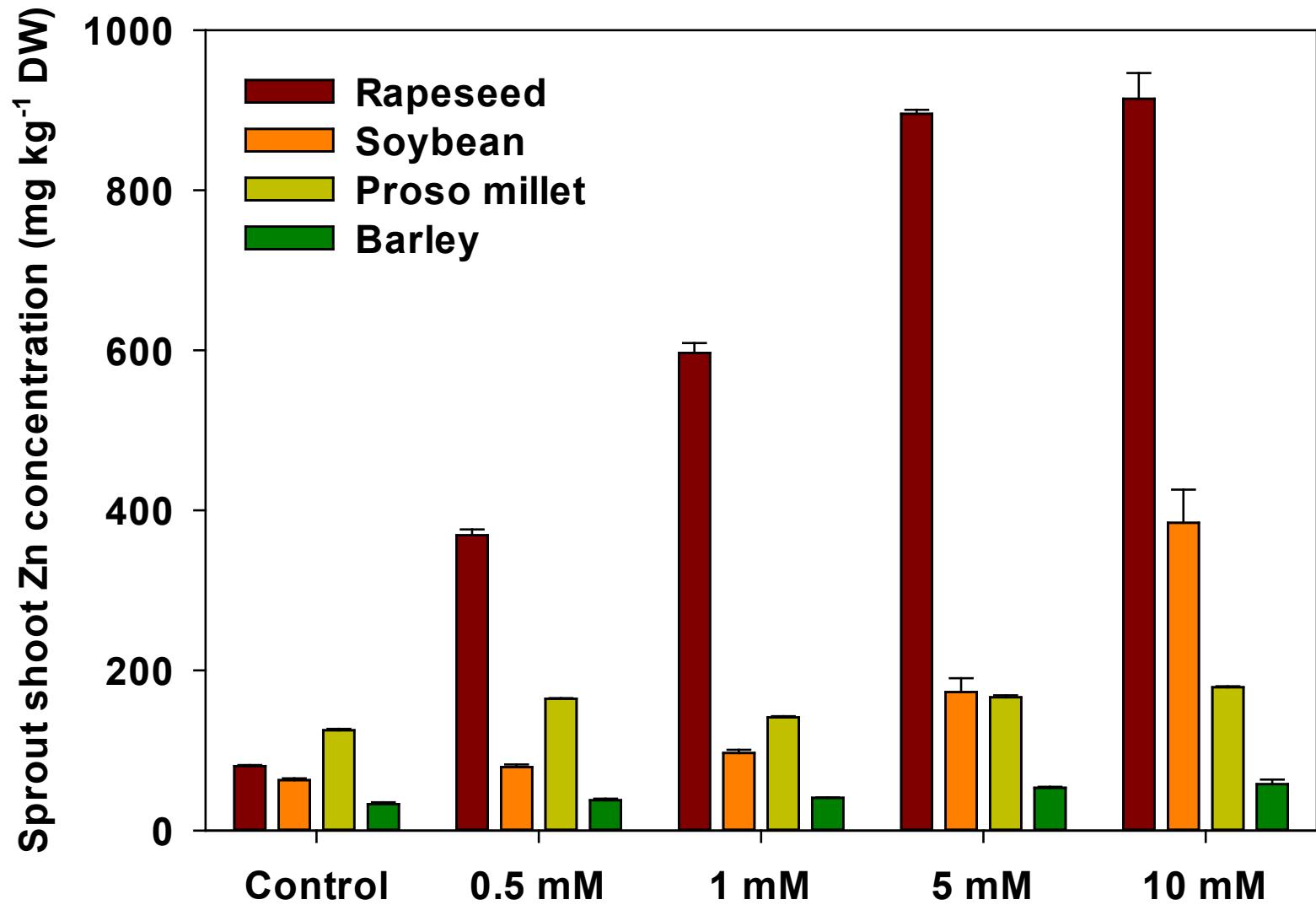


Barley



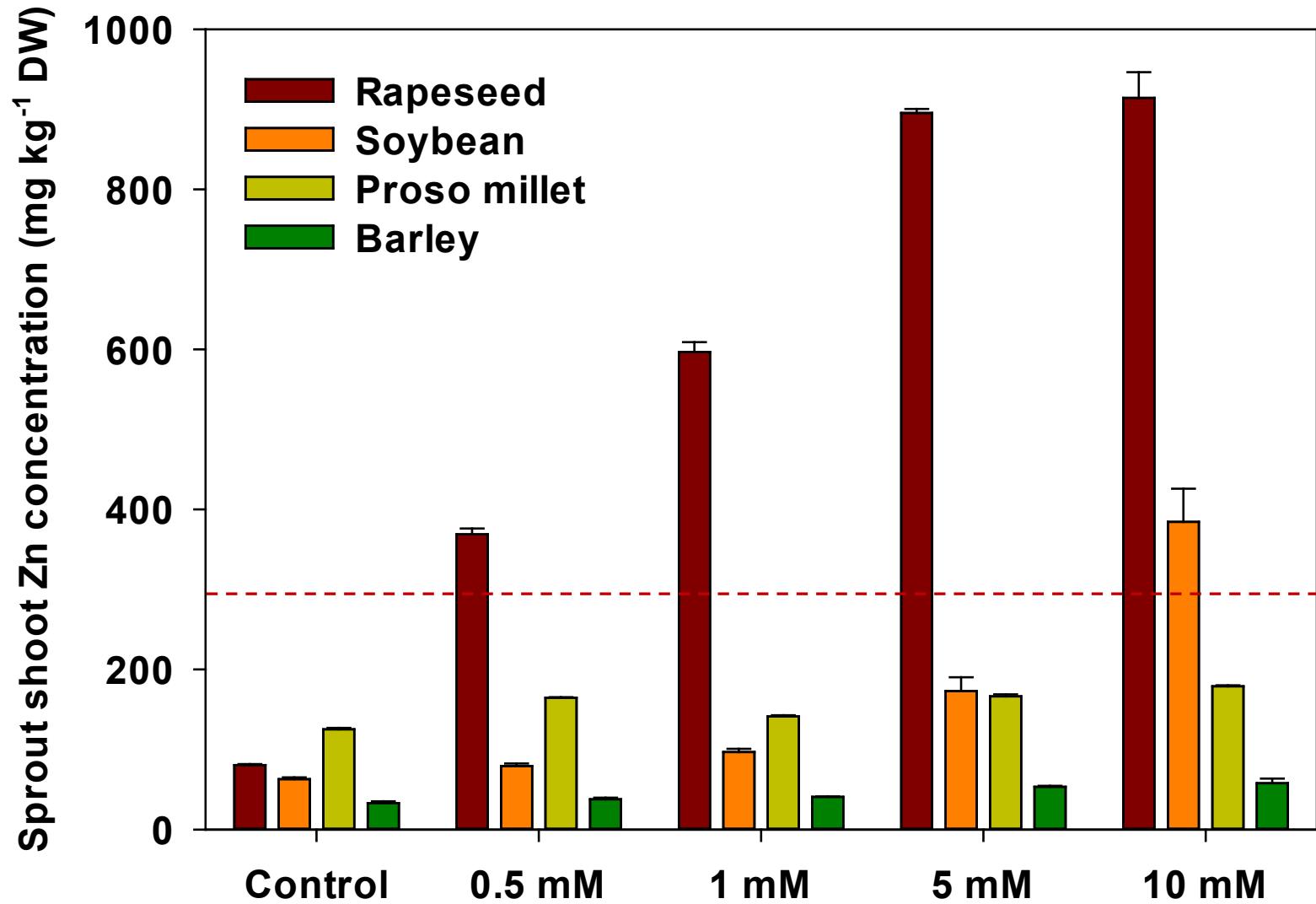
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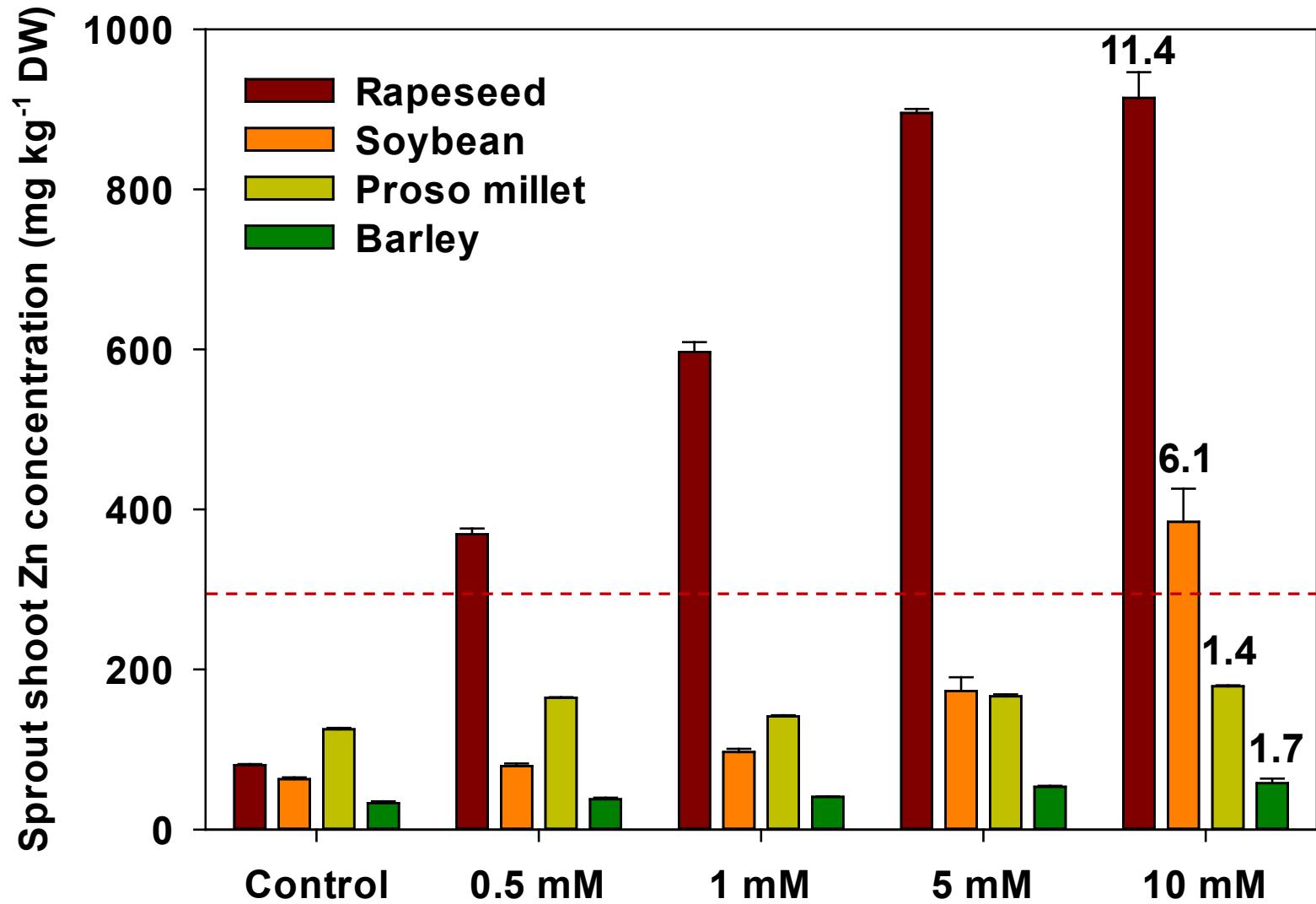
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## Results

**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 ( $>300 \text{ mg kg}^{-1}$  DW).
- $\text{ZnCl}_2$  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**

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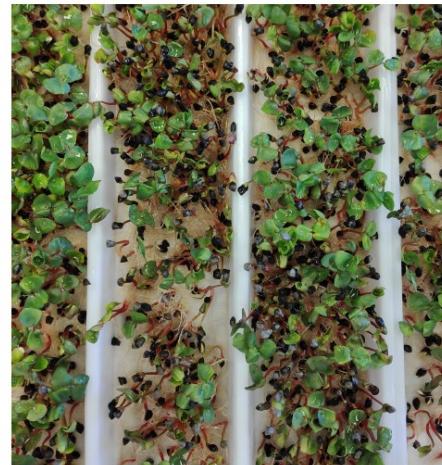
*Collectanea studentium physiologiae plantarum*



**P1-0212  
J4-3091**

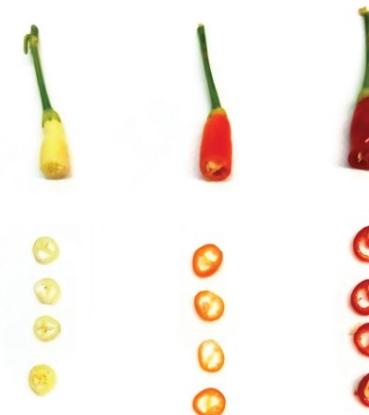
2021 Vol. 12 Št. 2

**C S P P**  
Collectanea Studentium Physiologiae Plantarum



2022 Vol. 13 Št. 1

**C S P P**  
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2022 Vol. 13 Št. 2

**C S P P**  
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# Acknowledgements

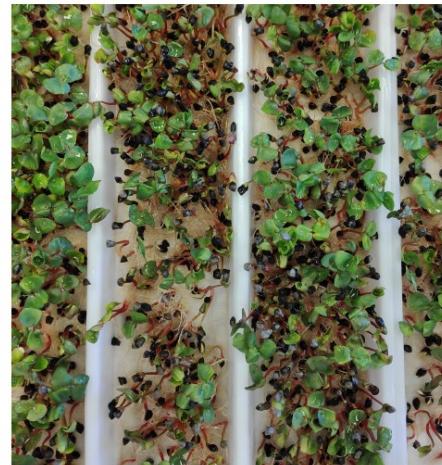
*Collectanea studentium physiologiae plantarum*



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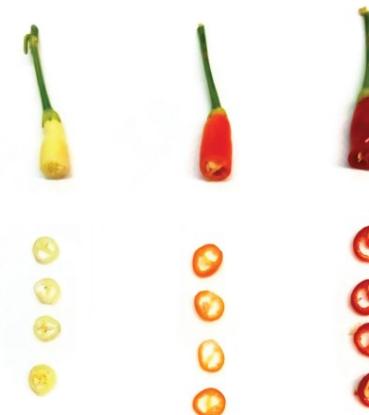
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**Thank you for your attention!**