Plantation of sunflowers in elevated carbon dioxide concentration by the addition of biochar

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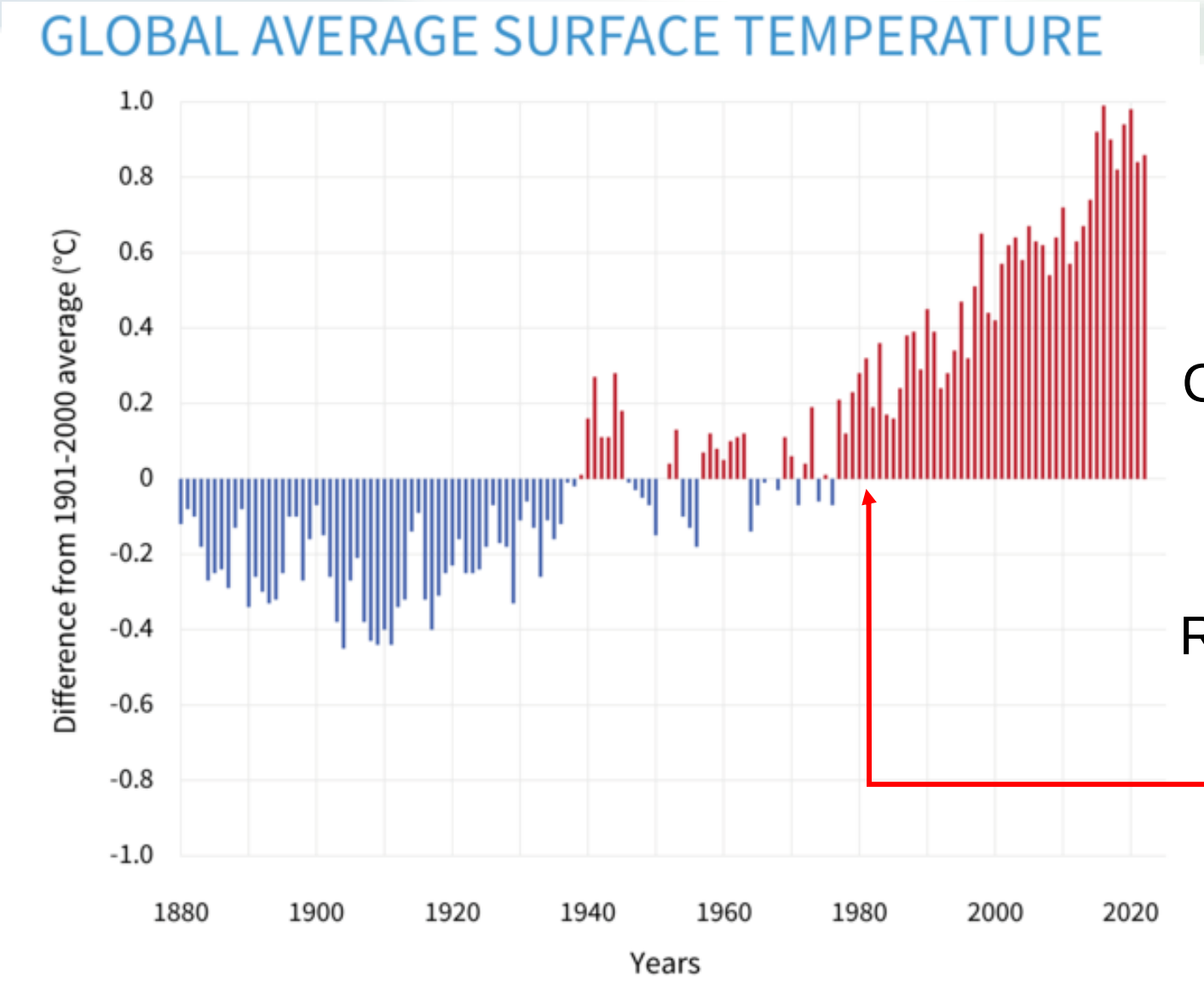
Wang, Yiying, et al. "Meeting the heavy-metal safety requirements for food crops by using biochar: An investigation using sunflower as a representative plant under different atmospheric CO_2 concentrations." *Science of The Total Environment* 867 (2023): 161452.

Contents

Introduction

- **Global warming**



CO_2

Greenhouse gas (GHG)

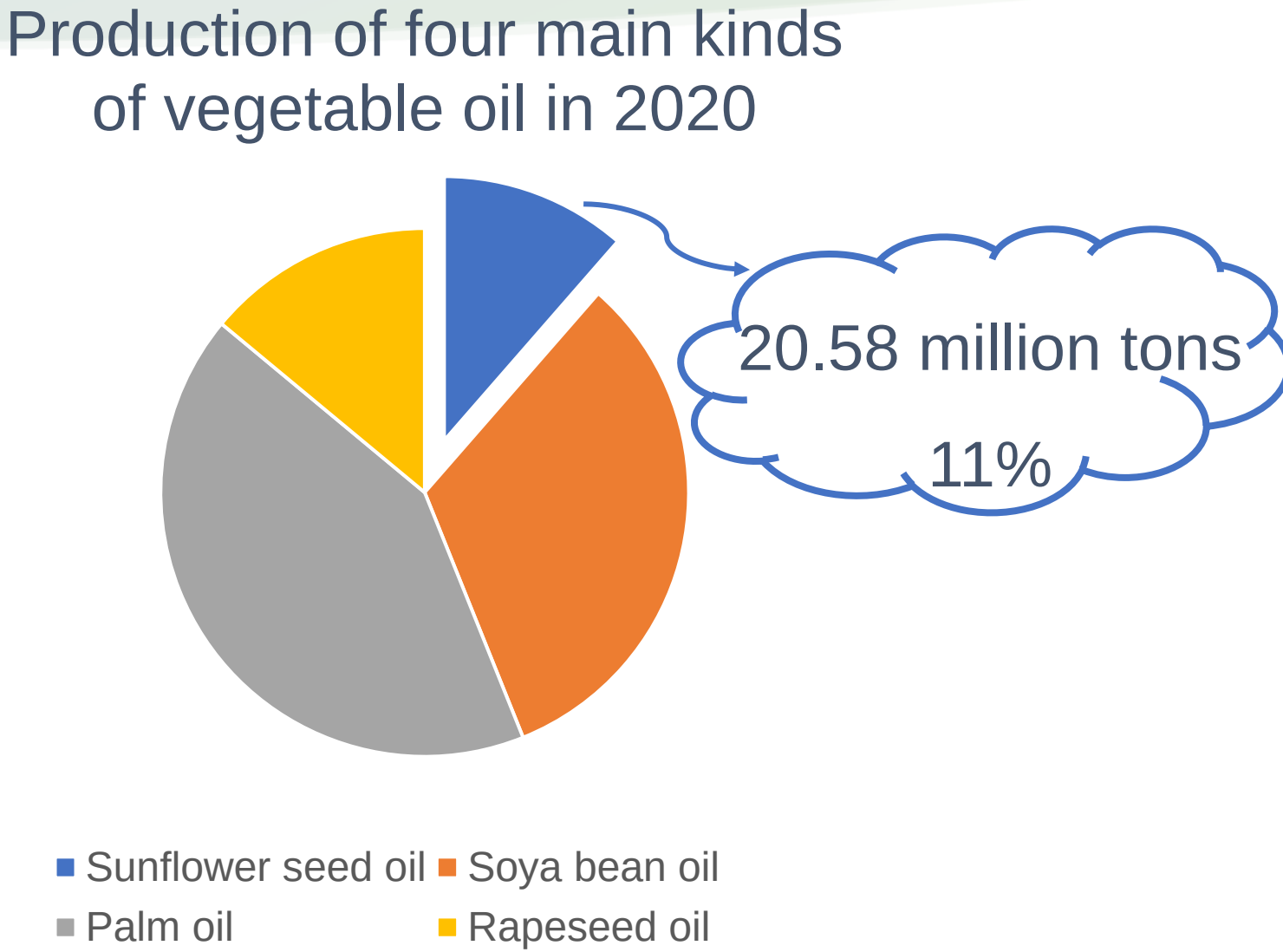
Risen by 0.18 °C per decade

Stimulate the plant‘s photosynthesis and water use efficiency

Affect yield

Lindsey, R., Dahlman, L., 2022. Climate change: global temperature. National Oceanic and Atmospheric Administration (NOAA). https://www.climate.gov/news-features/ understanding-climate/climate-change-global-temperature.

- **Sunflower**


Production of four main kinds of vegetable oil in 2020
20.58 million tons
11%
Sunflower seed oil
Soya bean oil
Palm oil
Rapeseed oil

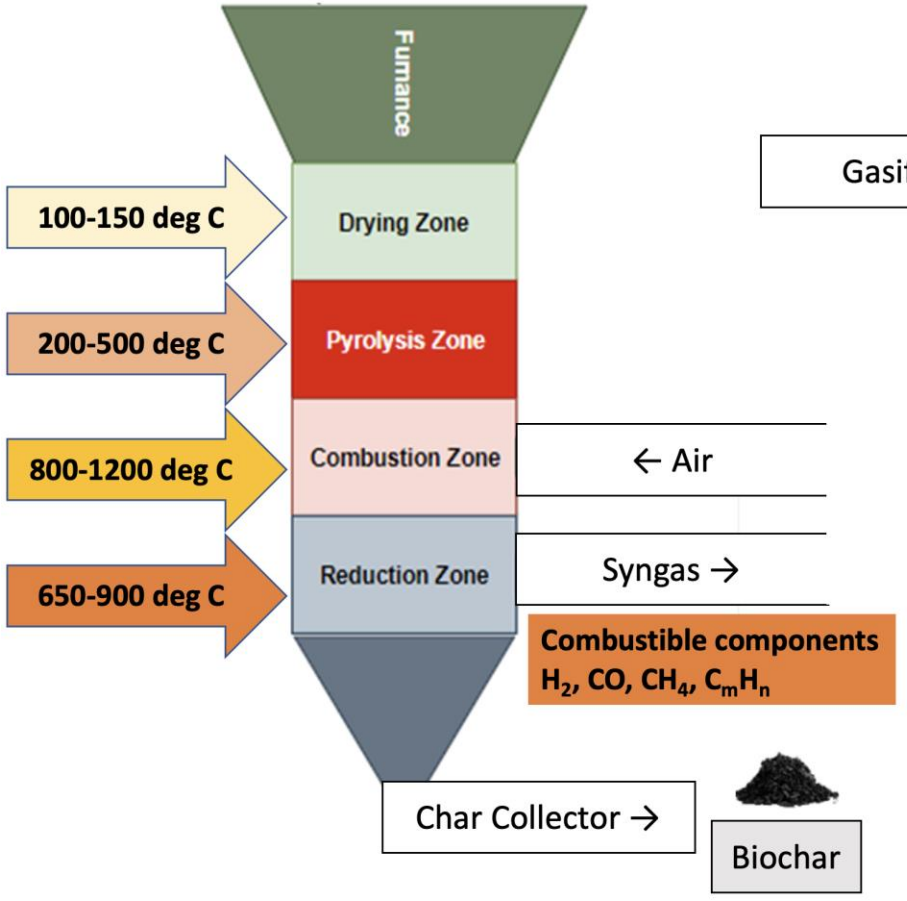
- **Biochar**

- Sequester carbon
- Mitigate atmospheric GHG
- Trap heavy metals in the soil
- Enhance water use efficiency
- Adjust pH

Methodology

• Biochar production

Trimming landscaping plants



Proposed Singapore biochar standard → Safe to use for agricultural purpose?

- **Growing substrate**

Biochar

Compost

Biochar-compost mixture (500 g)

Soil (2500 g)

Growing substrate

Biochar ratios:
0%, 15%, 30%, 45%

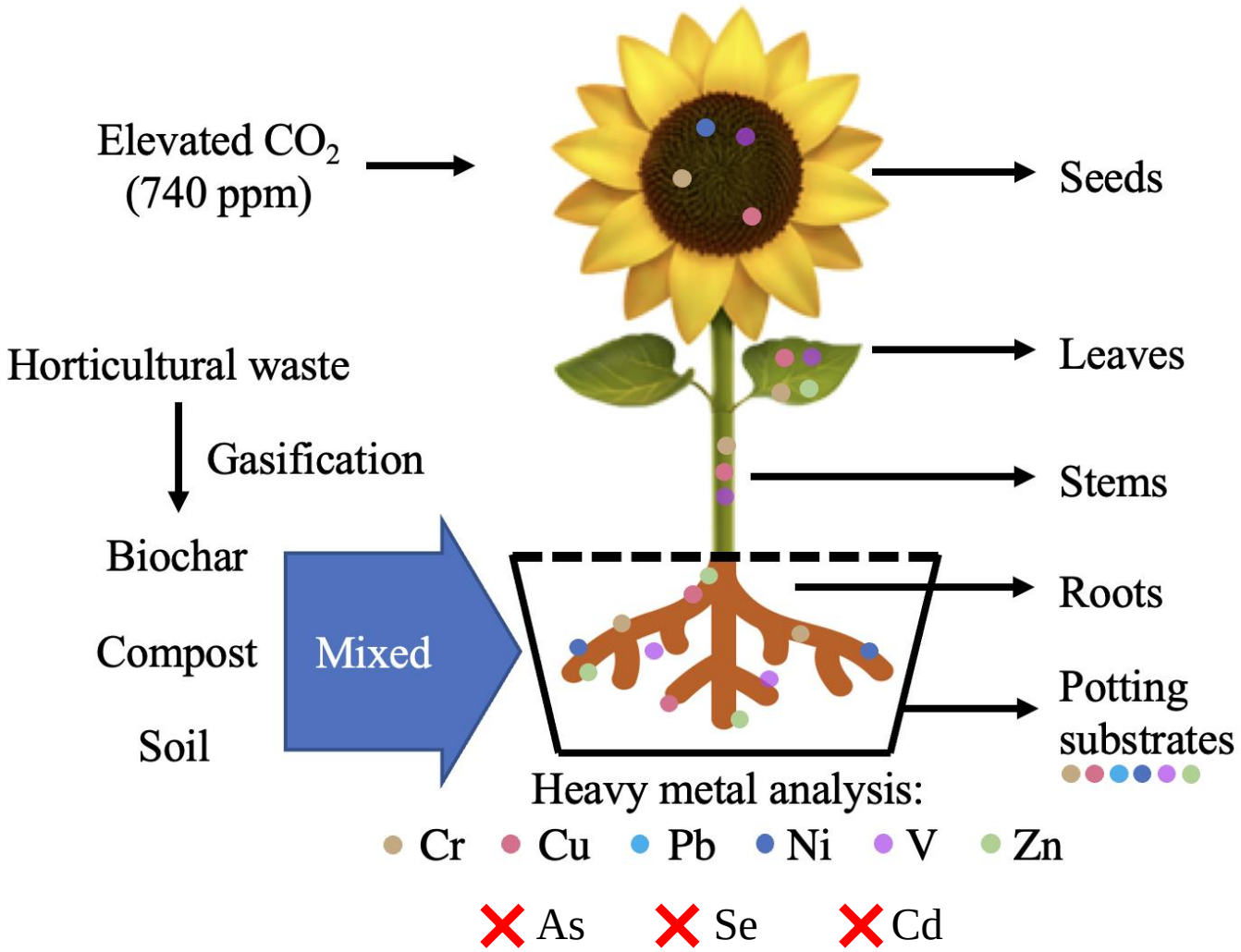
Open area (OA)

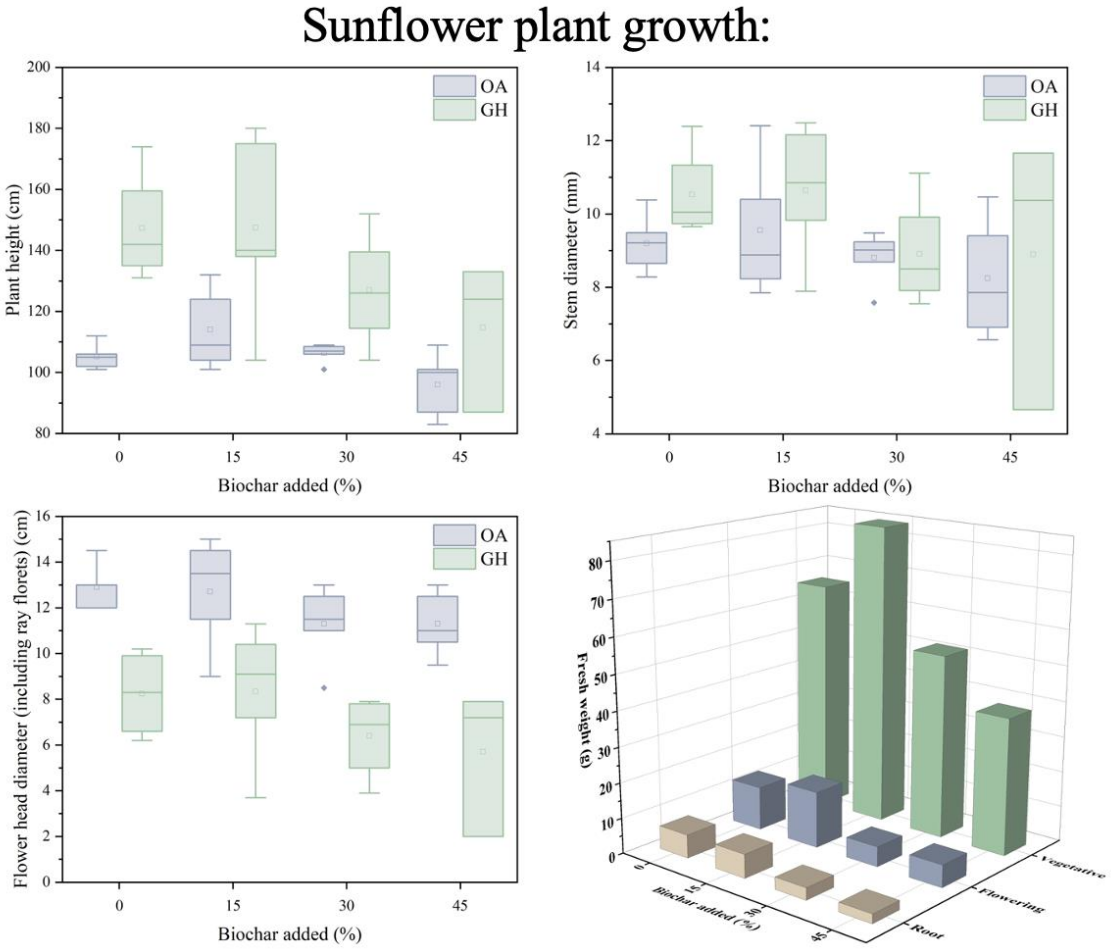
Ambient CO_2: ~420 ppm

Greenhouse (GH)

Elevated CO_2: ~740 ppm

• Heavy metals analysis





Results and discussion

Effect of elevated CO_2 on sunflower growth

• Effect of elevated CO_2 on sunflower growth

Increasing ratio of sunflower characteristics from OA to GH.

Sunflower characteristics	Biochar 0%	Biochar 15%	Biochar 30%	Biochar 45%
Plant height	40.02%	29.30%	19.47%	19.45%
Stem diameter	14.49%	11.41%	1.26%	0.66%
Flower head diameter (with ray florets)	–36.05%	–34.33%	–43.36%	–49.56%
*Contents in each cell stands for: Average value				

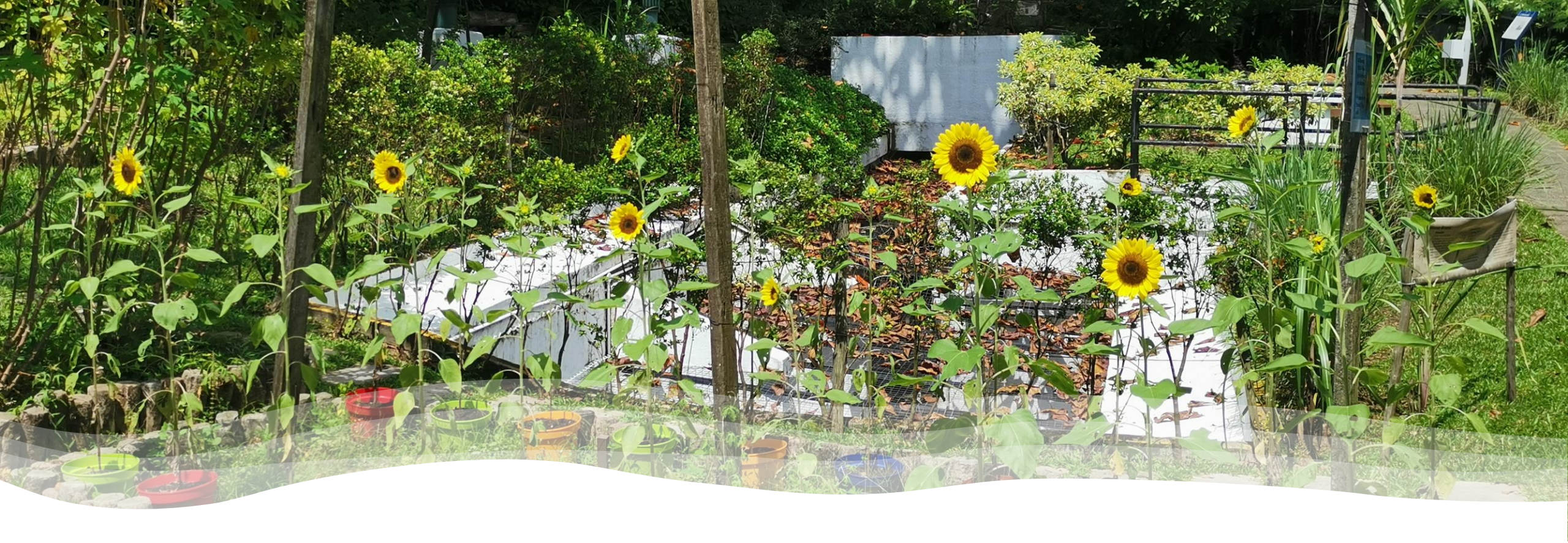
$$\text{Increasing ratio} = \frac{\text{Characteristic of sunflower in GH} - \text{Characteristic of sunflower in OA}}{\text{Characteristic of sunflower in OA}}$$

• Effect of elevated CO_2 on sunflower growth – Seed

- Lower seed mass (0% to 25%) which their maternal plant matured at elevated CO_2 (Poorter and Navas, 2003)

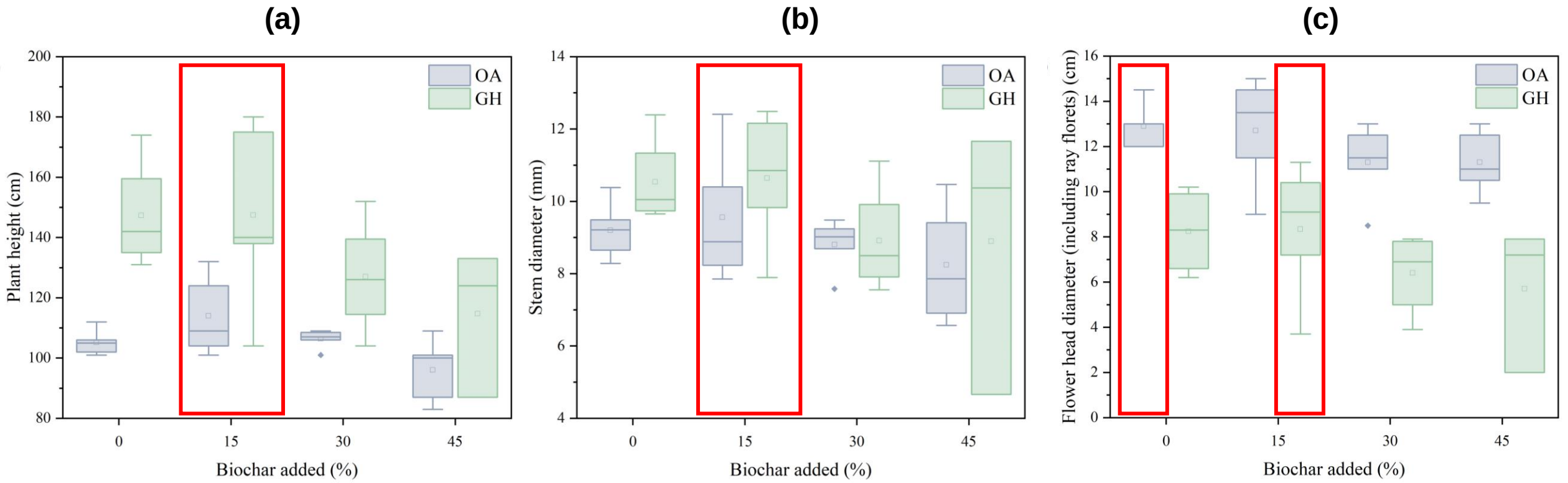
- **Seed crops was not suitable to planted in elevated CO_2 concentration**

Immature seeds in GH



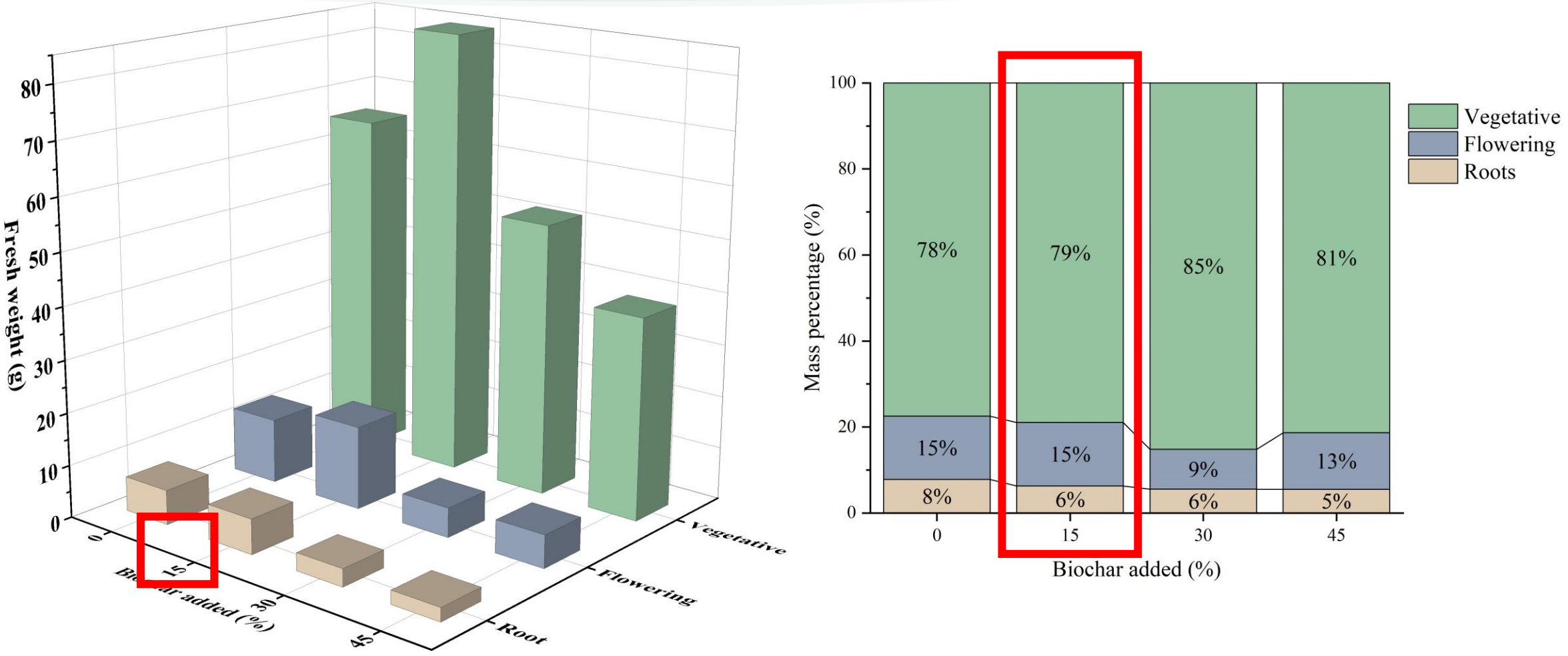
Effect of biochar on sunflower growth

- **Effect of biochar on sunflower growth –**
  (a) Plant height; (b) Stem diameter; (c) Flower head diameter

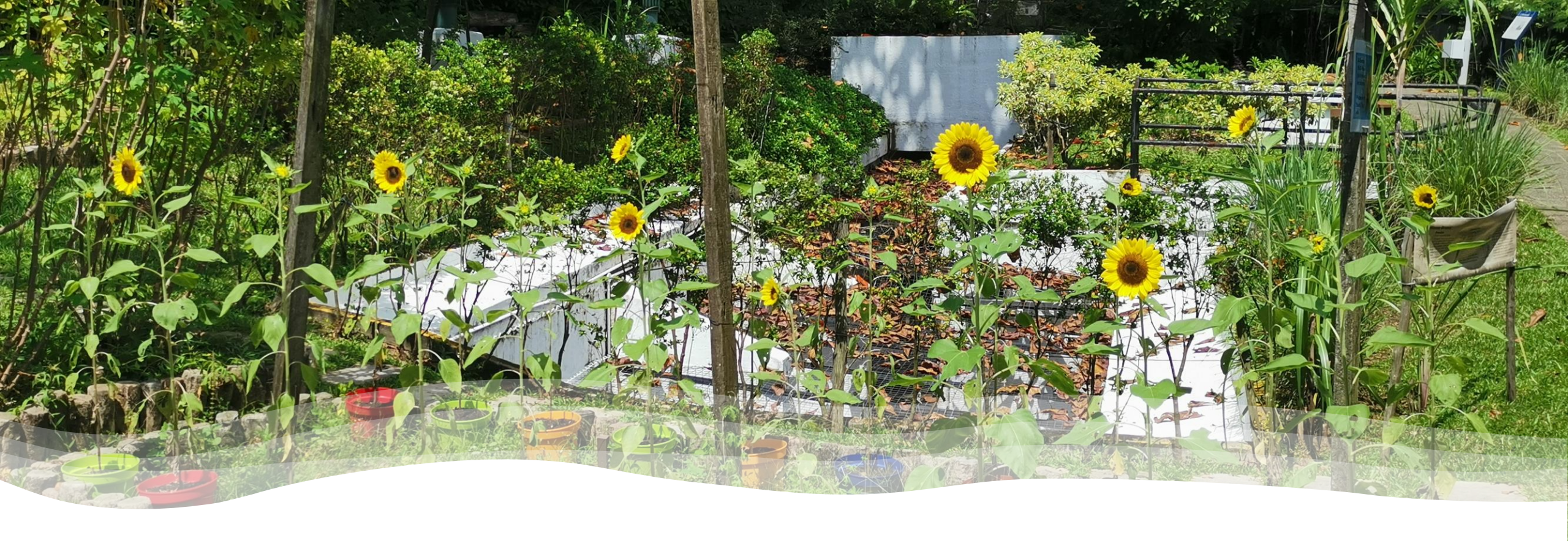


*The horizontal lines in the boxes represent the median; the square hollow points represent the mean; the individual dot represents outliers.

- **Effect of biochar on sunflower growth – Fresh weight**

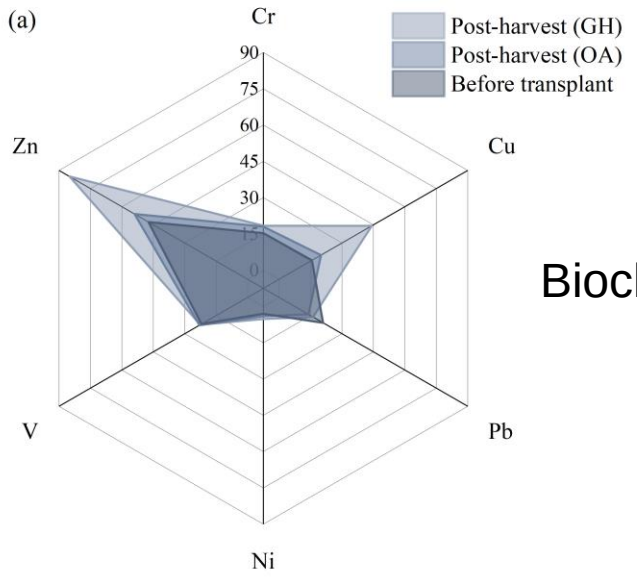


(a) Fresh weights of the vegetative, reproductive and root portions of the sunflower plant, and (b) their proportions in the GH-grown plants (n = 5).

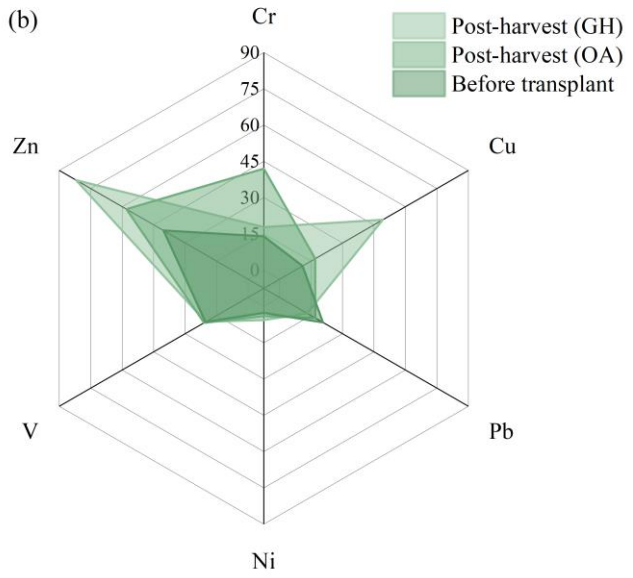


Heavy metals in the growing substrates

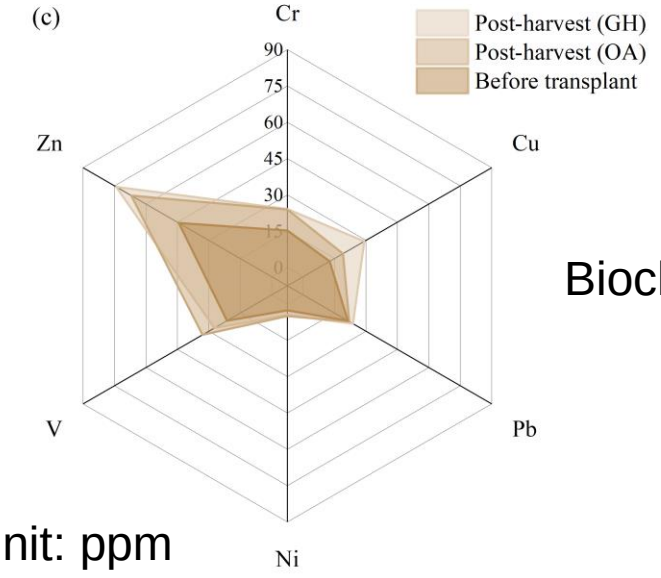
- **Heavy metals in the growing substrates – Before and post-harvest**



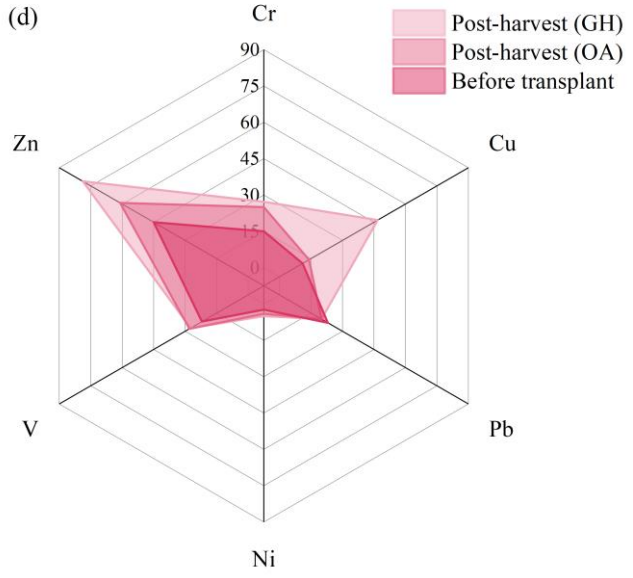
Biochar 0%



Biochar 15%



Biochar 30%

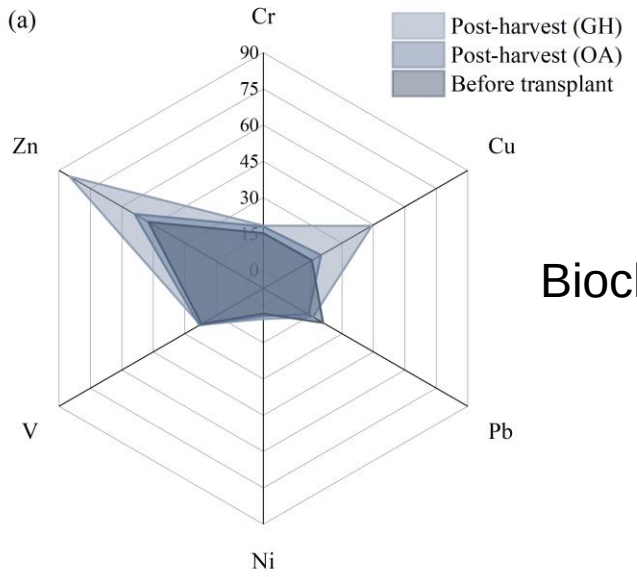


Biochar 45%

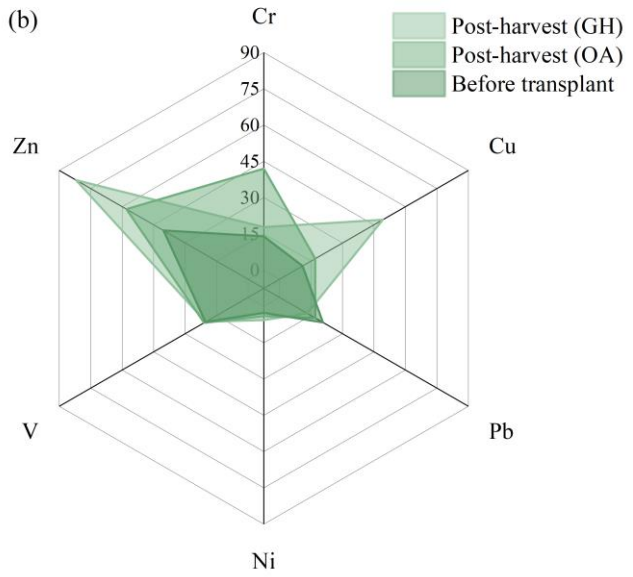
- **Higher heavy metal increasing ratio manifests the lower take-up rate of heavy metals by plants compared with other substances**

*Unit: ppm

- **Heavy metals in the growing substrates – OA and GH**

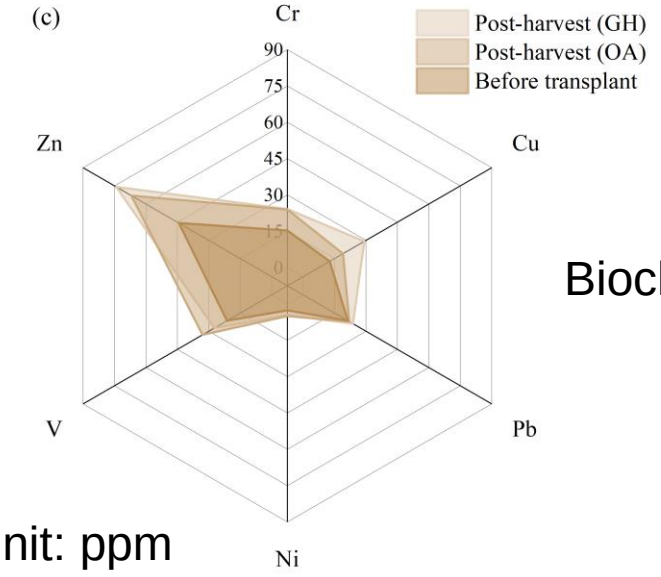


Biochar 0%

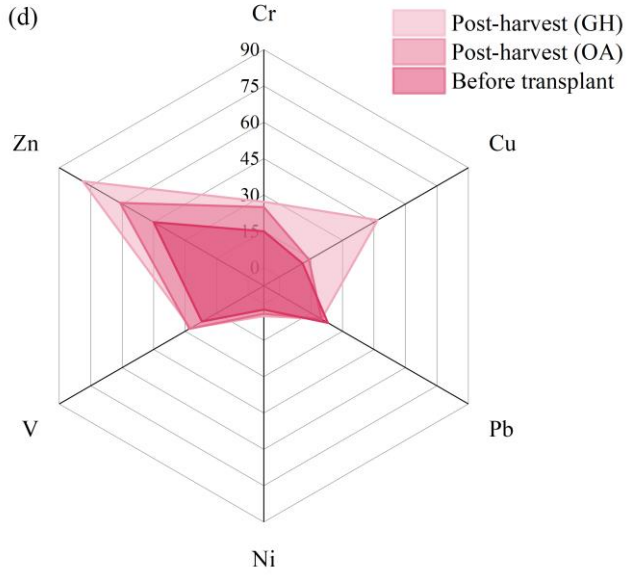


Biochar 15%

- **Vital plant activity in elevated CO_2**
- **Properties of growing substrates changed in elevated CO_2**



Biochar 30%

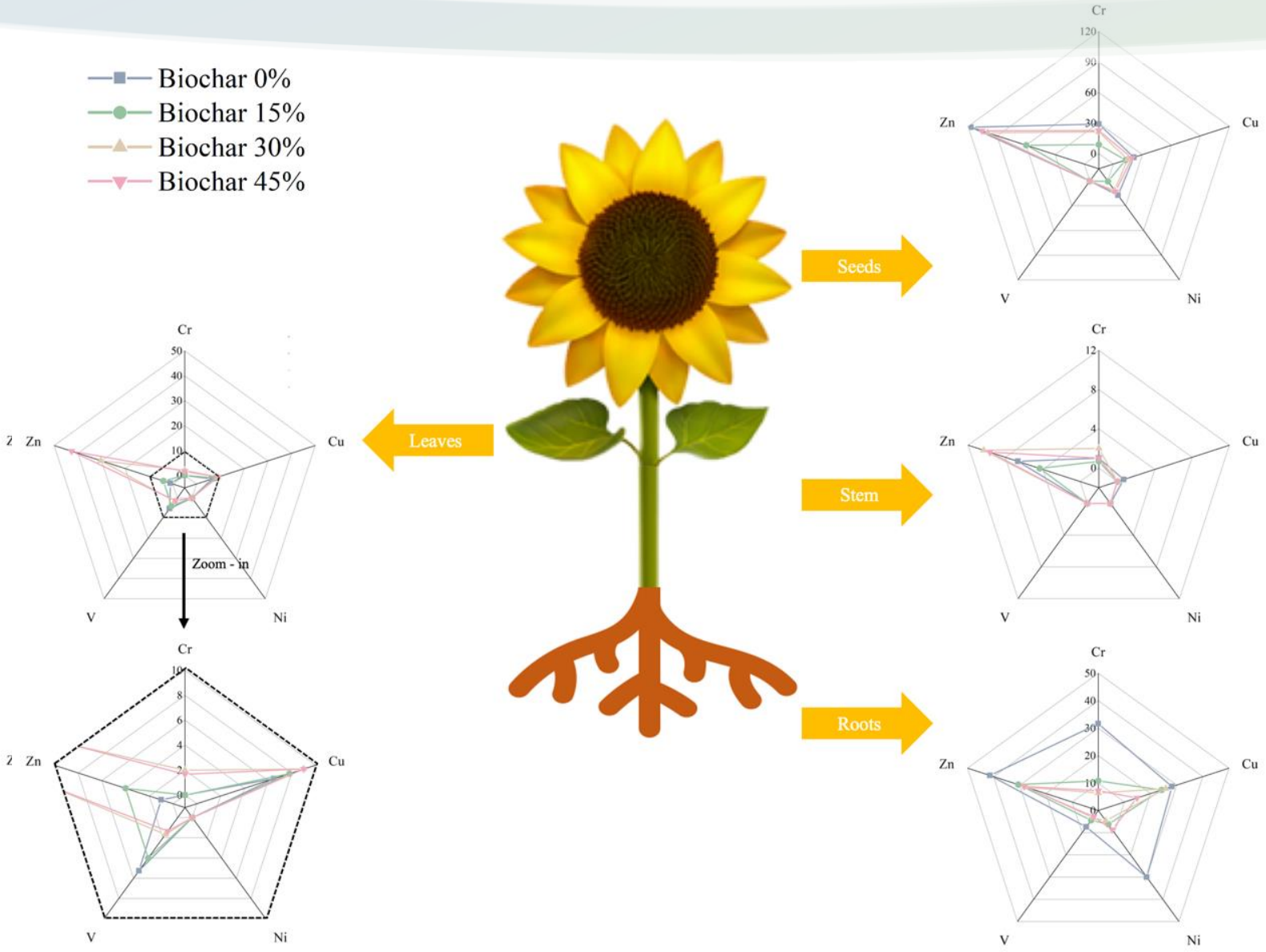


Biochar 45%

*Unit: ppm

Heavy metals in sunflower plants

• Heavy metals in sunflower plants



- Most heavy metals would retain in sunflower roots and seeds

• Heavy metals in sunflower plants – Food safety for seeds

As, Se, Cd, V, Pb | **Cr, Cu, Ni and Zn**

Not detected

- Fulfill Singapore food regulations (Sale of food act, chapter 283, section 56(1)) in terms of As and Cd.
- Safe to eat within a certain amount (referenced Dietary Reference by IOM)

Heavy metal	Tolerable upper intake level* (mg/day)	Safe consumption of sunflower seeds** (g/day)
Cr	Not determined***	N/A
Cu	10	787
Ni	1	3333
Zn	40	667

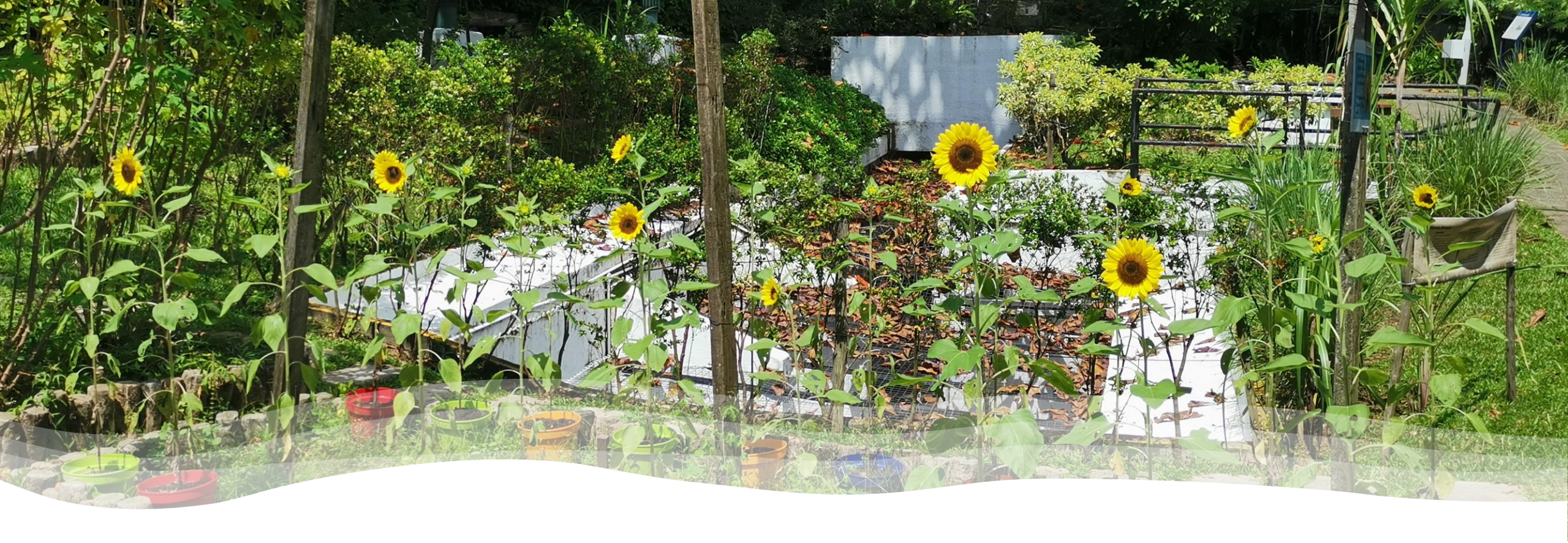
*Determined by Institute of Medicine in the United States (IOM).

**Sunflower seeds refer to the seeds produced in this study which their maternal plant matured at elevated CO_2 with addition of 15% biochar in the growing substrates.

***Cr overdose from food hasn't been linked to significant adverse effects (not including hexavalent chromium)

Conclusions

- **Conclusions**
  - 740 ppm atmospheric CO_2 promoted the growth of the plant's vegetative parts (stem and leaves) but hindered the growth of its reproductive parts
  - At both 420 ppm and 740 ppm atmospheric CO_2, plant growth was best using the 15% biochar growing substrate, but the positive effect of biochar to sunflower plants was muted at 740 ppm atmospheric CO_2
  - Studied heavy metals percentage (except for Pb) in the growing substrates rose after harvesting the plants
  - Seeds in the 15% biochar grown plants have the lowest concentration of heavy metals



Thank you for your attention ☺

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