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GC-MS Based Metabolomics Revealed Defense and Detoxification Mechanism of Cucumber Plants Under Nano-Cu Stress

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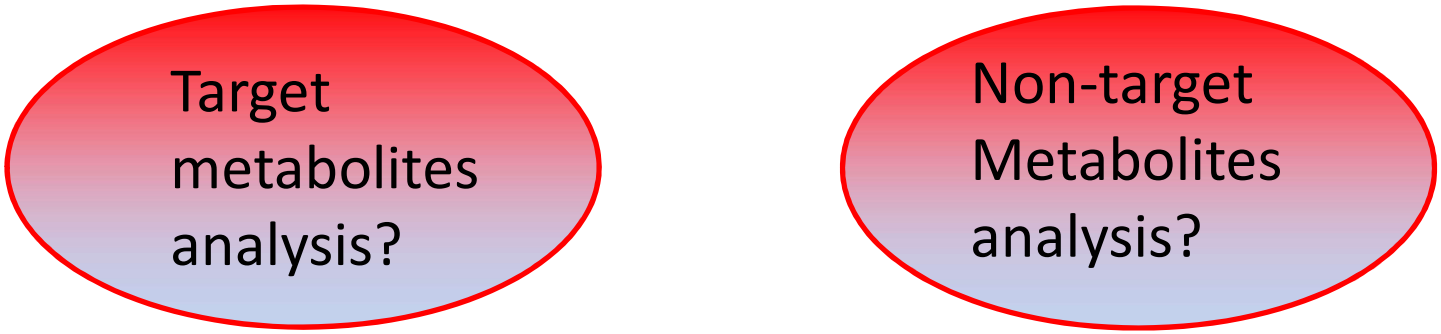
Background

Sources:
https://www.google.com/search?q=pesticide+spray&biw=1236&bih=636&source=lnms&tbm=isch&sa=X&ved=0CAYQ_AUoAWoVChMIhaSP0sT8yAIVRcljCh1joQ1F

Interaction between NPs and crop plant?



Analytical platforms for environmental metabolomics

	Sensitivity	**Sample preparation**	**Structural information**
NMR	Low	Non-destructive; easy sample preparation	Yes
GC-MS	High	Requires sample derivatization	No
LC-MS	High	No requires sample derivatization	No

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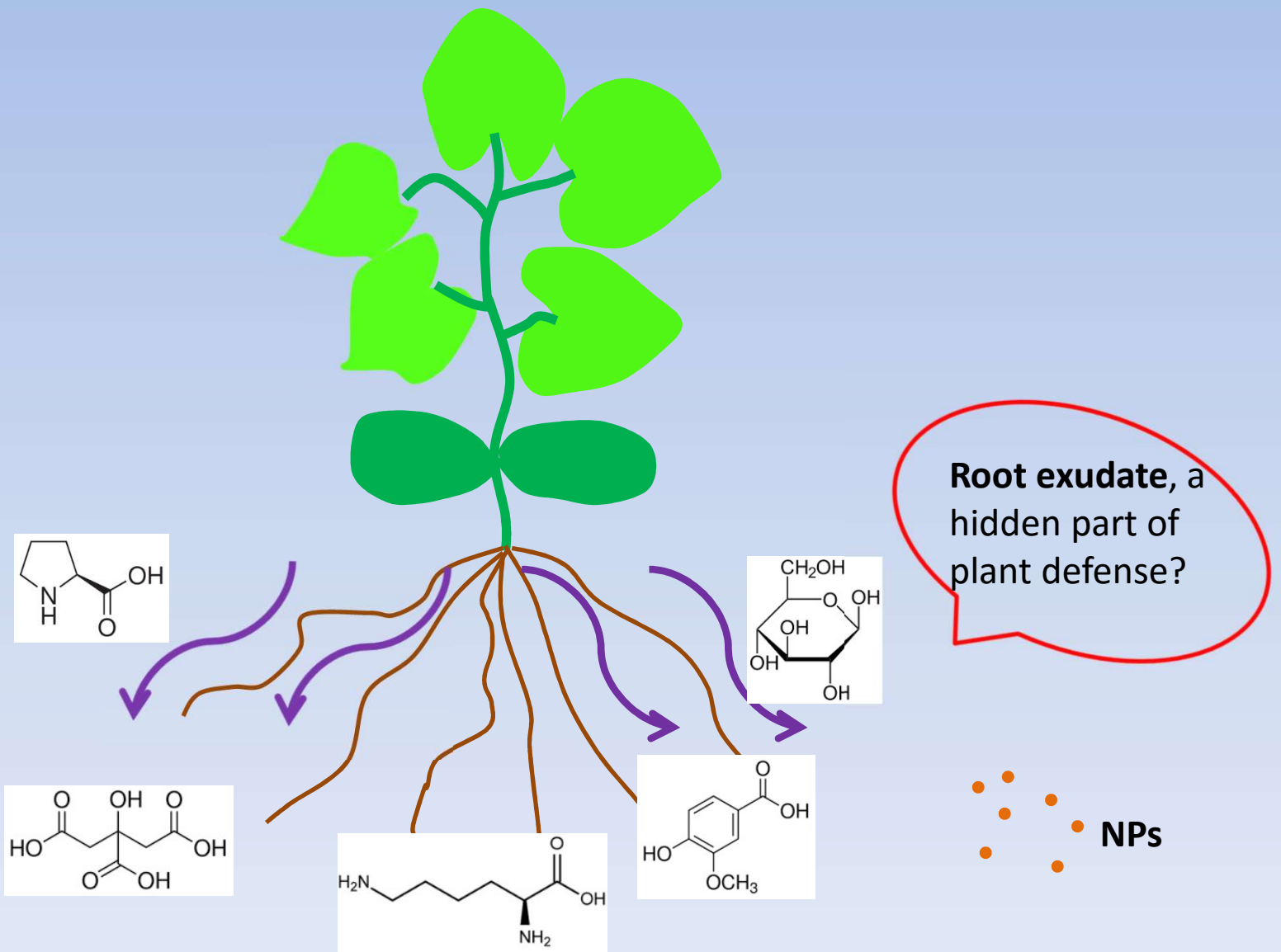
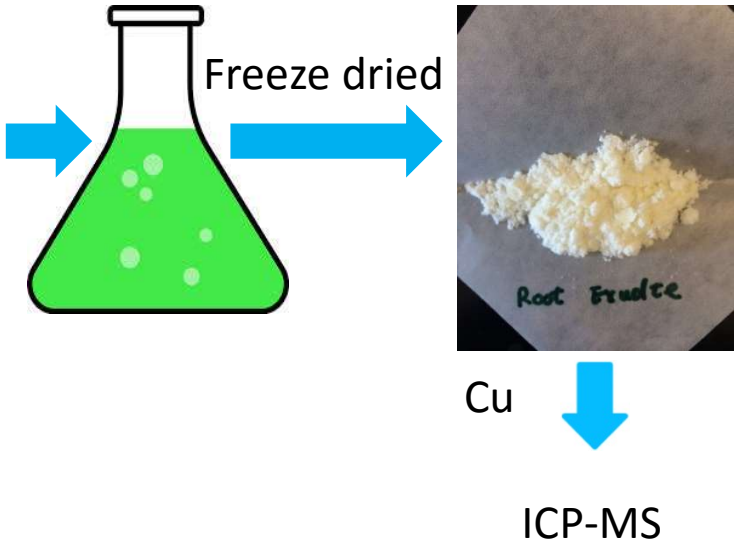
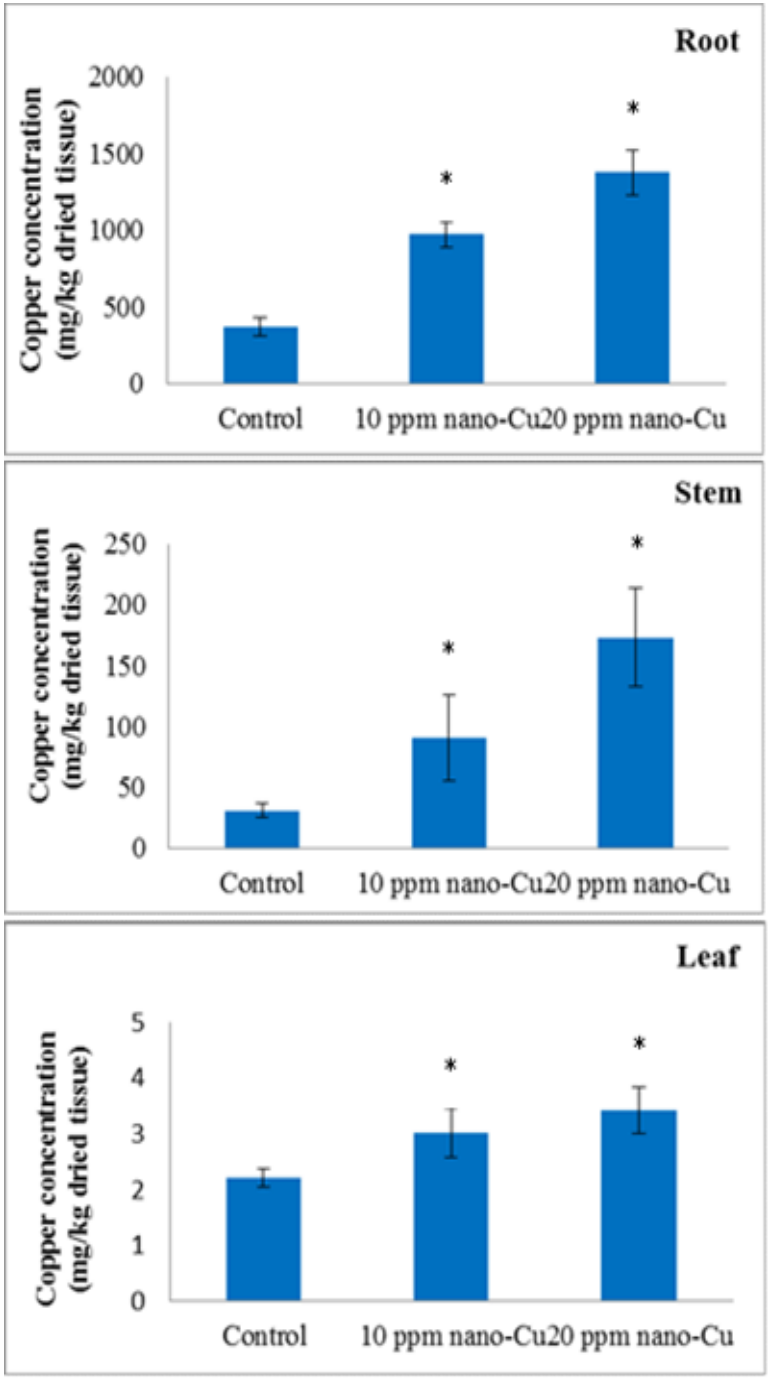


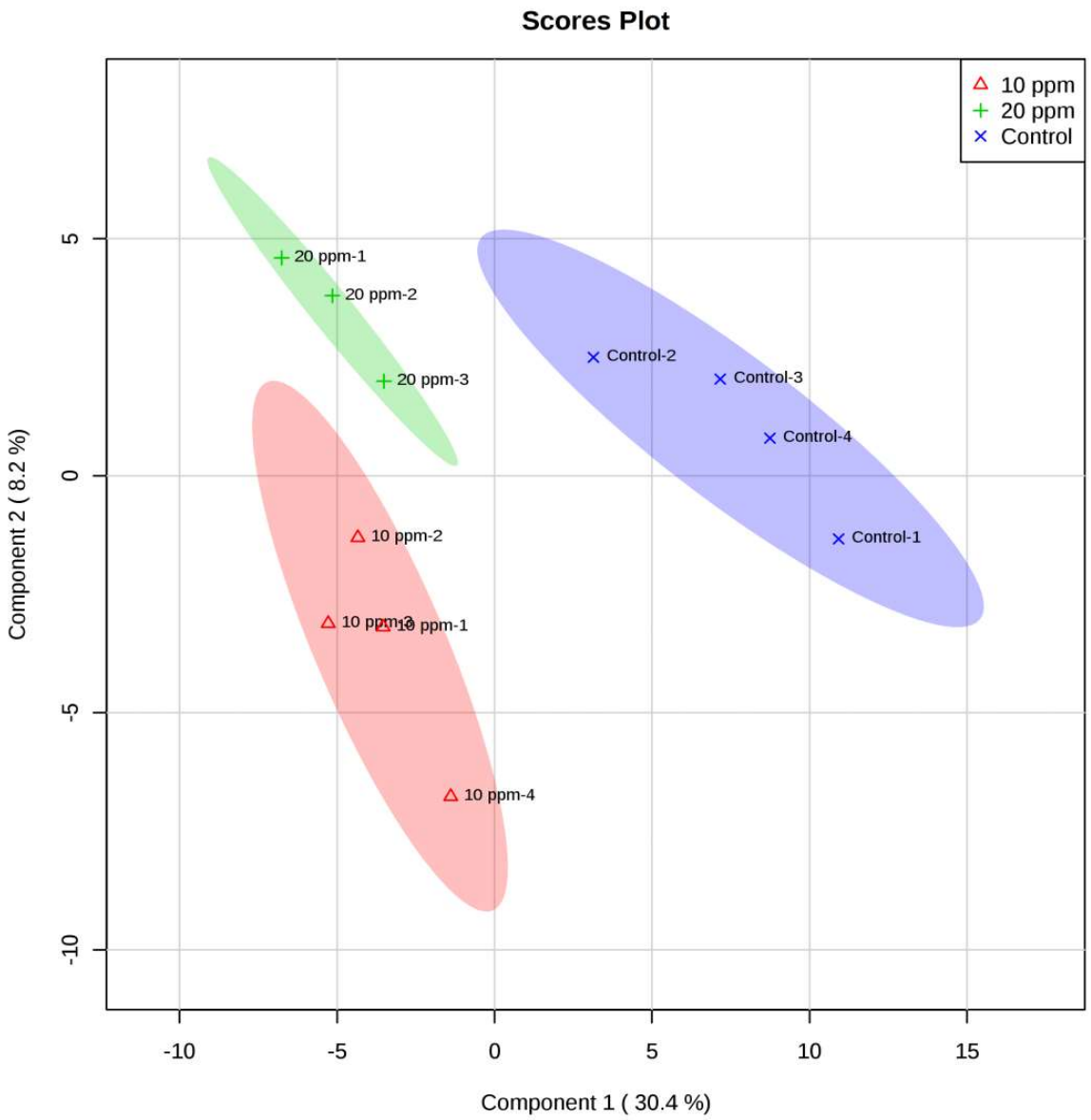
Method



Two-week-old cucumber plants were exposed to nano-Cu (0, 10 ppm, 20 ppm) for one week.

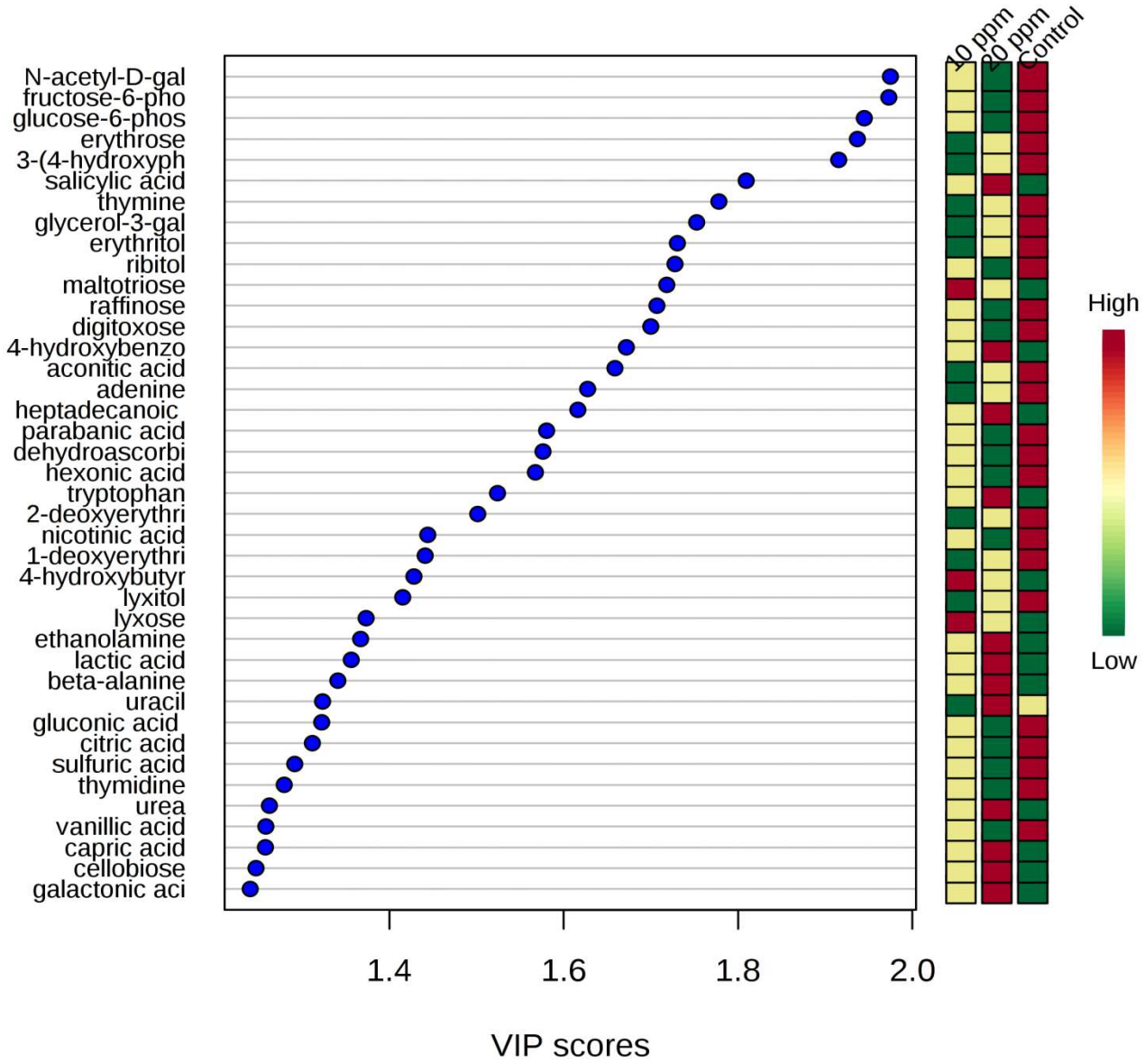


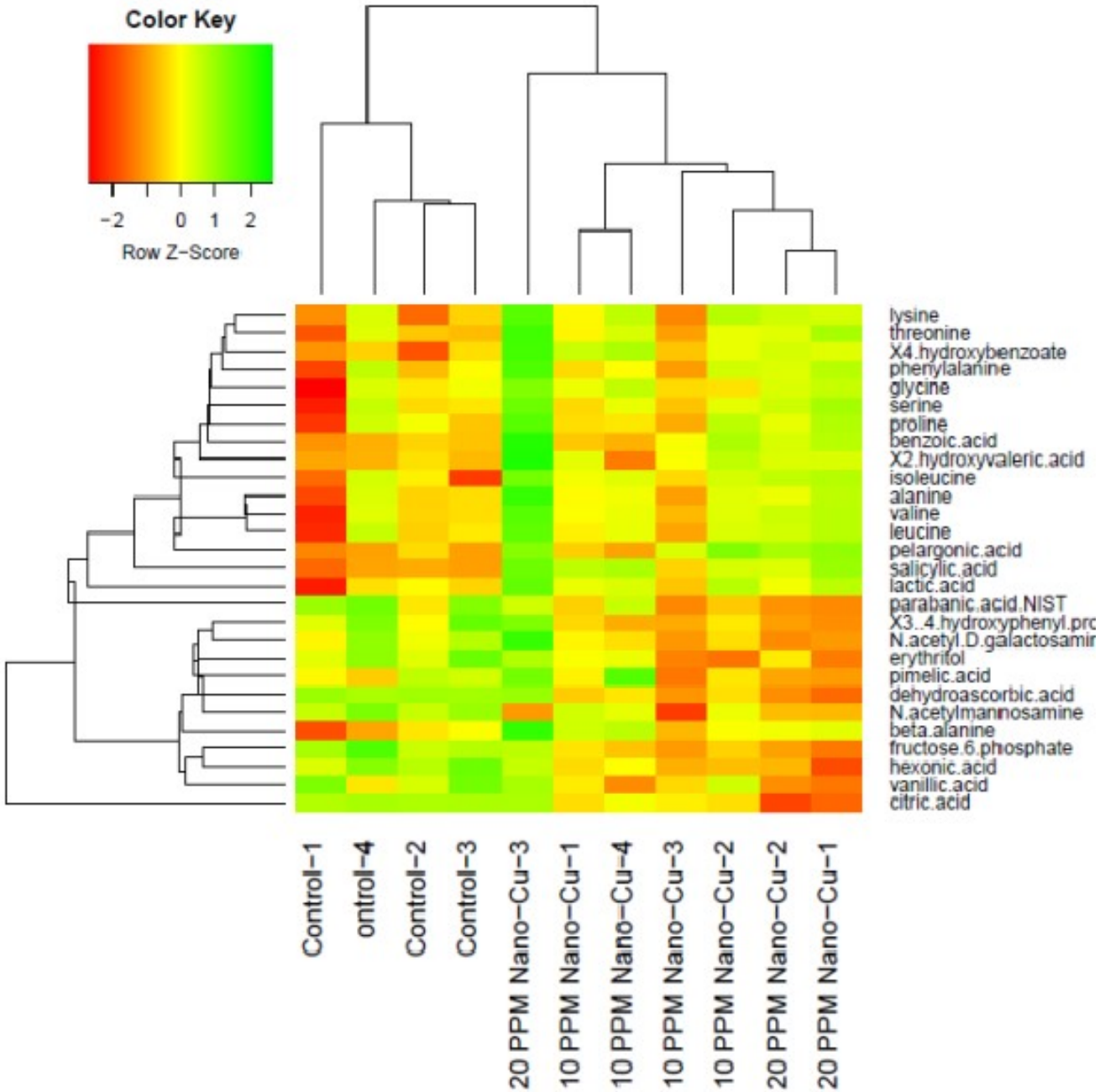
Cu concentrations in 3-week cucumber plants treated with 0, 10, and 20 mg/L nano-Cu.



Partial least squares-discriminant analysis (PLS-DA)of cucumber fruits extract metabolites as affected by different concentrations of nano-Cu.

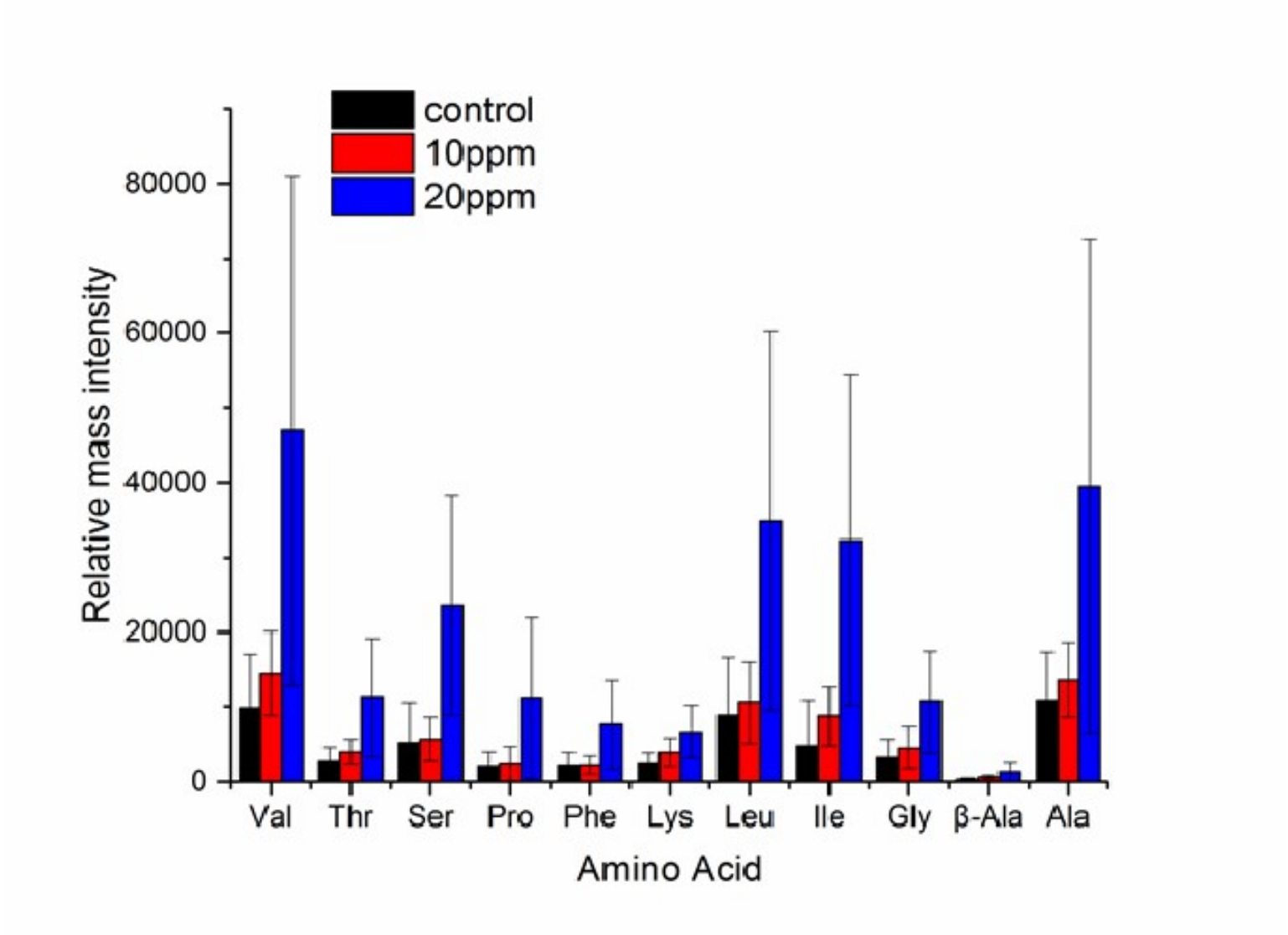
VIP scores from PLS-DA analysis showing the discriminating metabolites



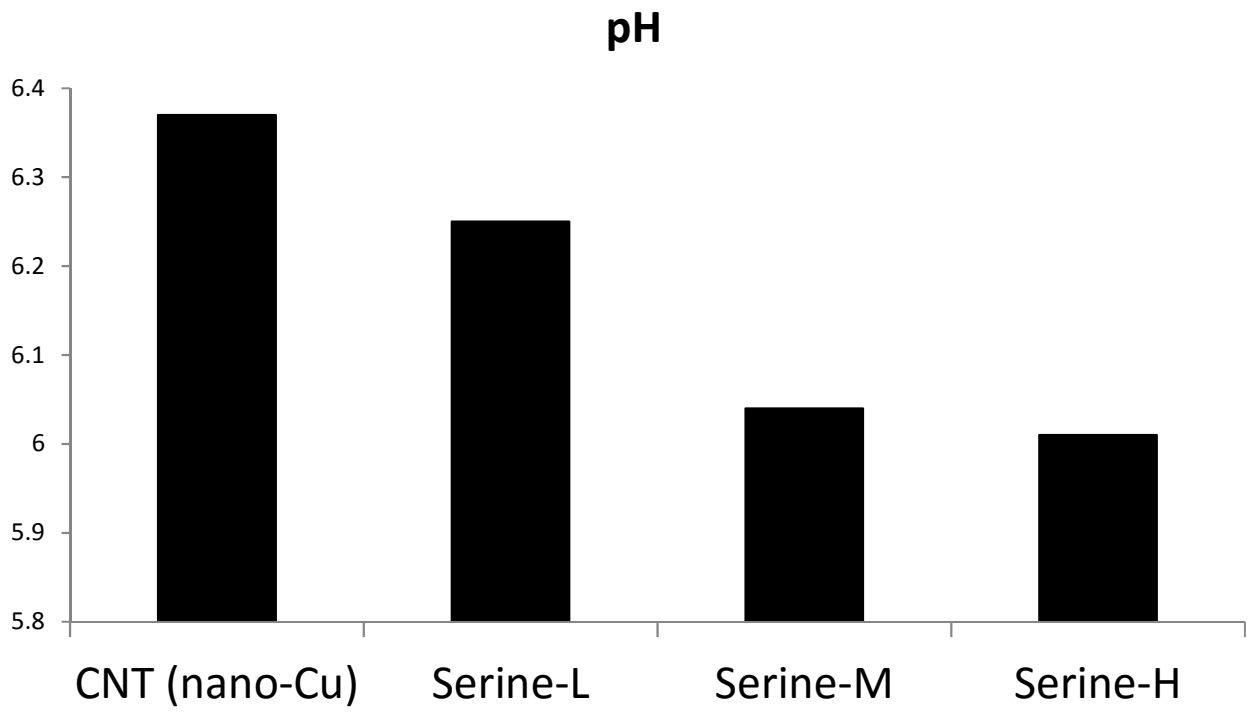


Heatmap generated by hierarchical cluster analysis of GC-MS data

GC-MS quantification data of up-regulated amino acids in root exudates

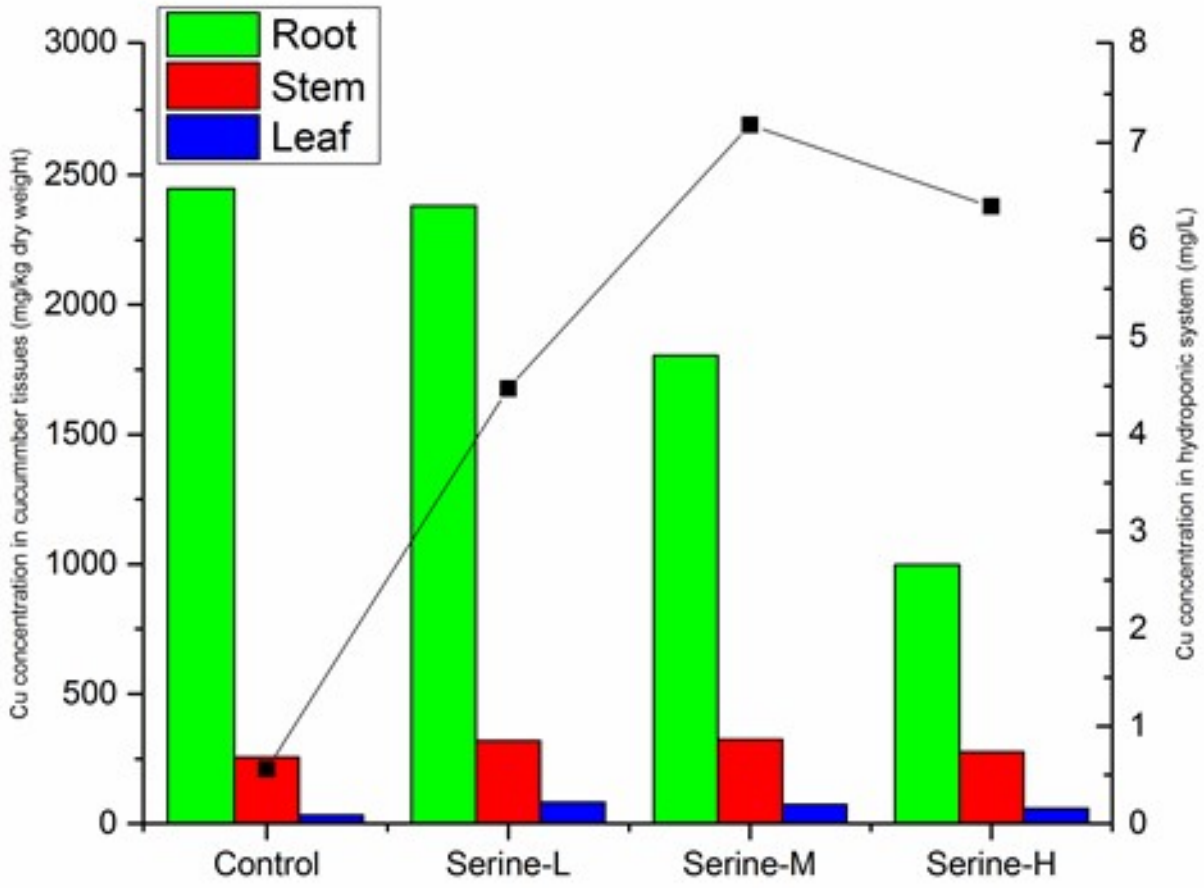


pH value in hydroponic solutions

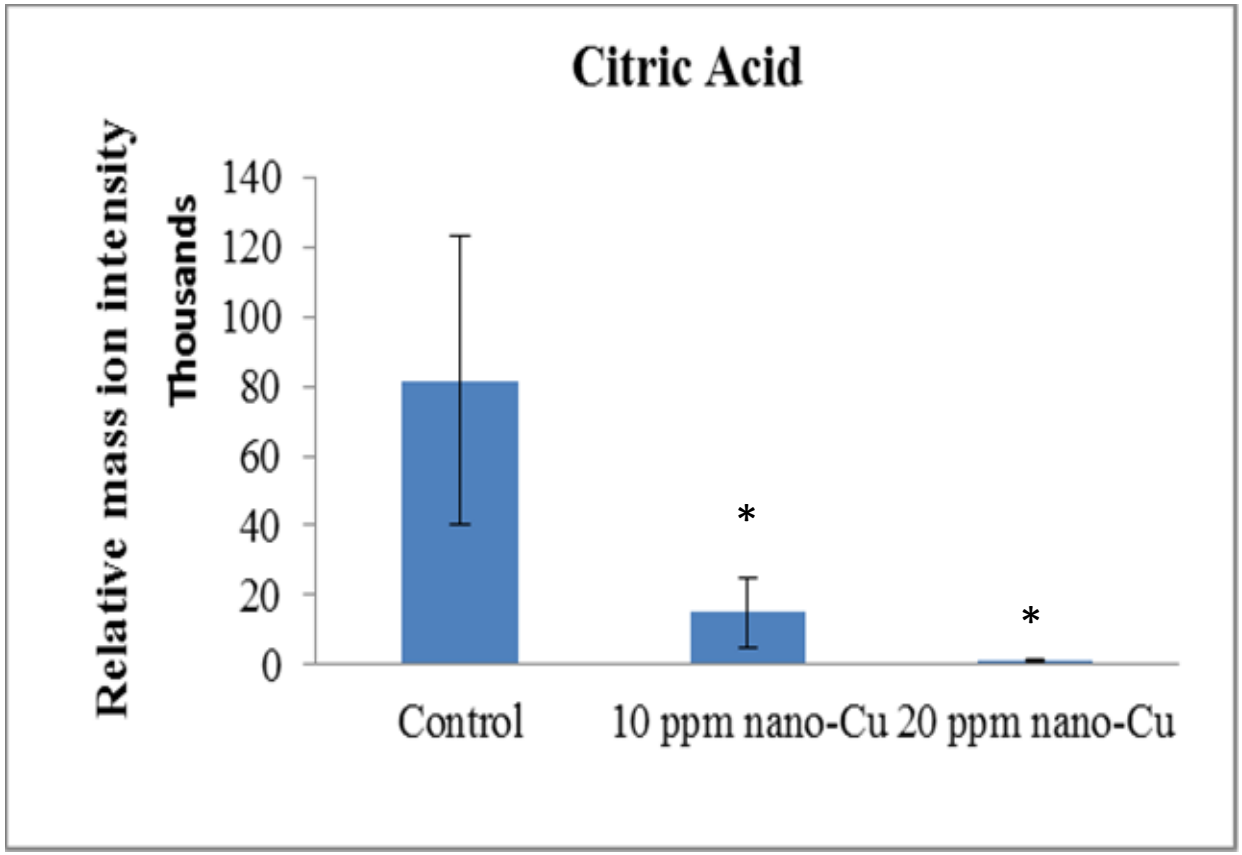


Two-week-old cucumber plants were exposured to 20 mg/L nano-Cu with different levels of serine (0, 6.25, 12.5, and 25 mM)

Cu uptake in cucumber tissues and nutrient solution

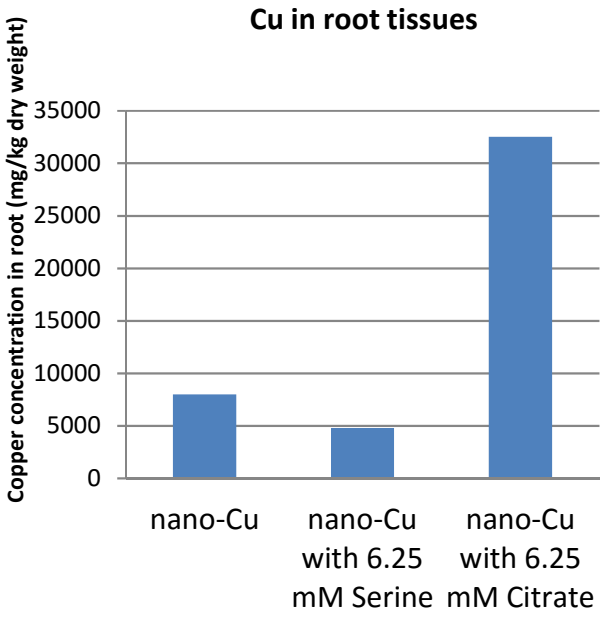


Two-week-old cucumber seedlings were cultivated in half strengh of Hogland nutrient solution containing 20 mg/L nano-Cu with different levels of serine (0, 6.25, 12.5, and 25 mM) for 48 hours.

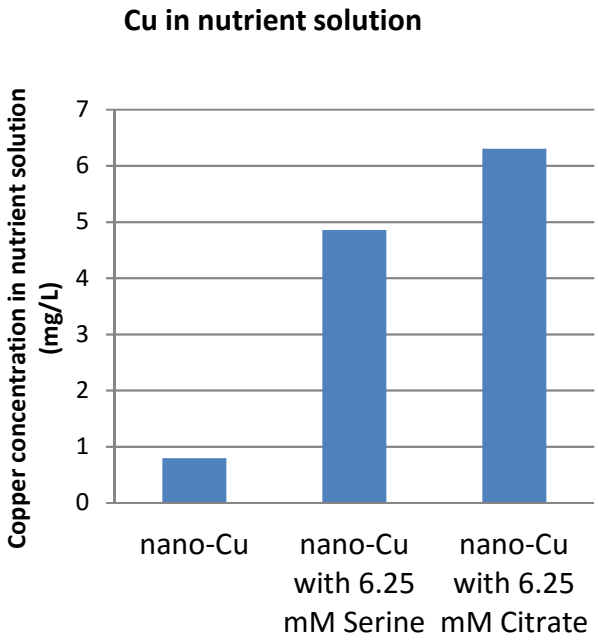


GC-MS quantification data citric acid in root exudates in response 10 mg/L and 20 mg/L nano-Cu.

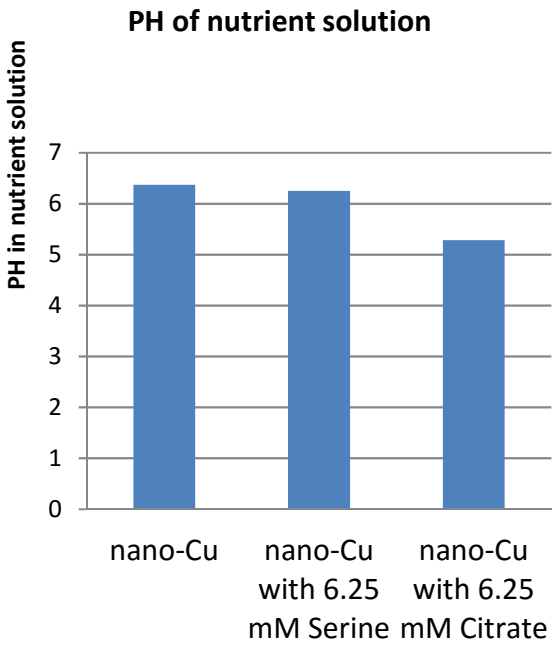
A

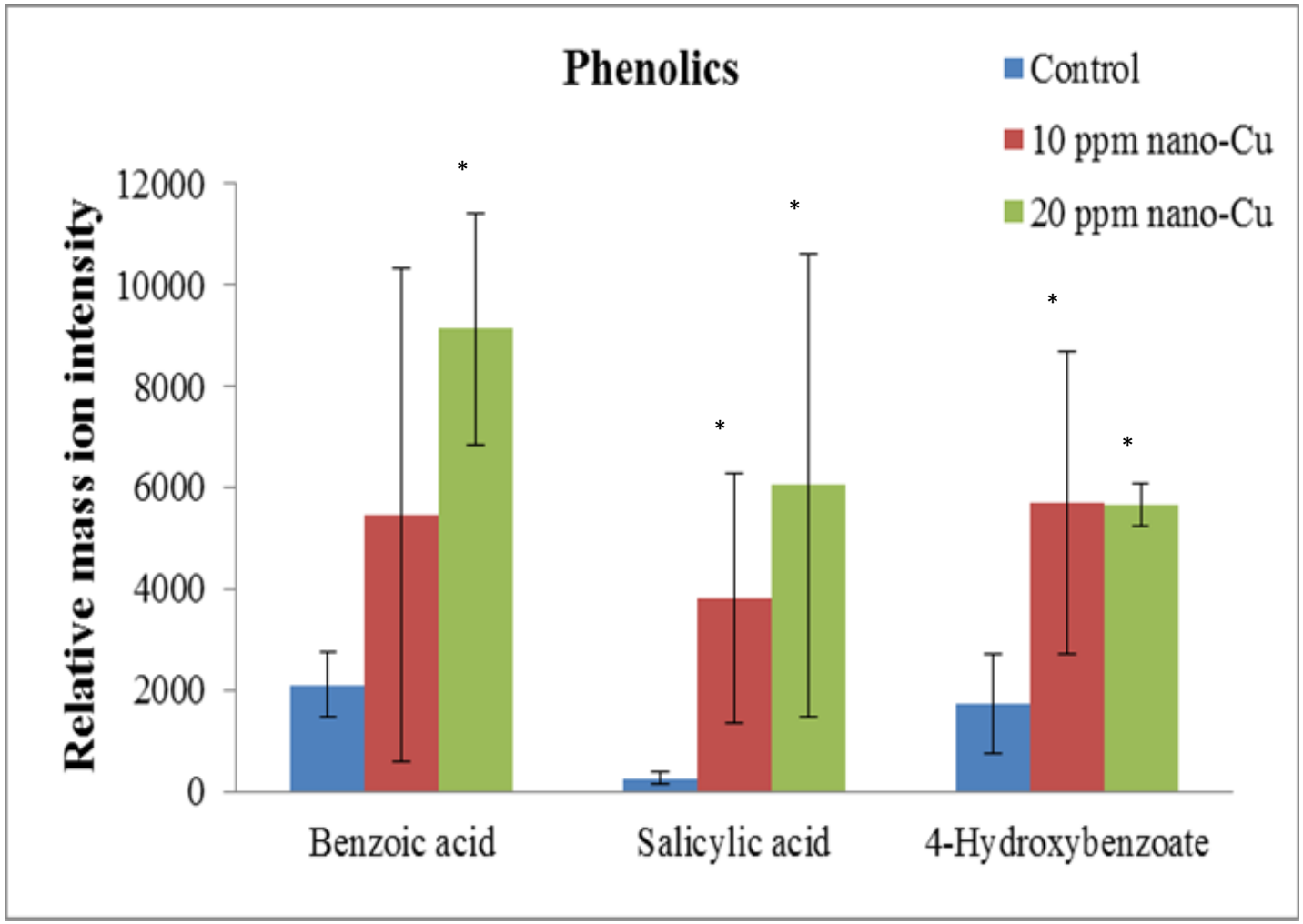

Cu in root tissues
Copper concentration in root (mg/kg dry weight)
35000
30000
25000
20000
15000
10000
5000
0
nano-Cu
nano-Cu with 6.25 mM Serine
nano-Cu with 6.25 mM Citrate

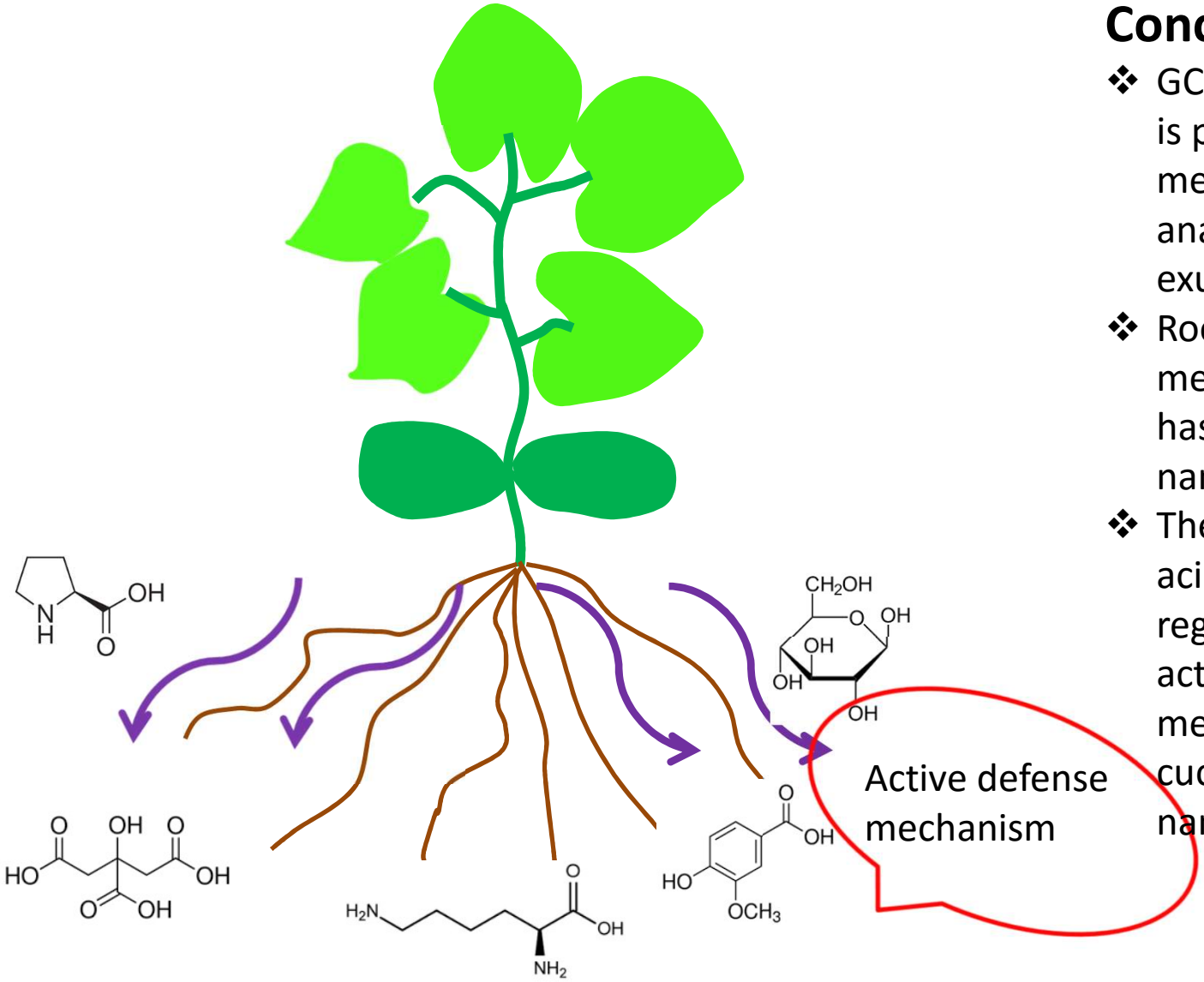
B


Cu in nutrient solution
Copper concentration in nutrient solution (mg/L)
7
6
5
4
3
2
1
0
nano-Cu
nano-Cu with 6.25 mM Serine
nano-Cu with 6.25 mM Citrate

C


PH of nutrient solution
PH in nutrient solution
7
6
5
4
3
2
1
0
nano-Cu
nano-Cu with 6.25 mM Serine
nano-Cu with 6.25 mM Citrate


Phenolics
Control
10 ppm nano-Cu
20 ppm nano-Cu
Relative mass ion intensity
12000
10000
8000
6000
4000
2000
0
*
*
*
*
*
Benzoic acid
Salicylic acid
4-Hydroxybenzoate



Conclusion:

- GC-MS based platform is powerful tool for metabolites profile analysis of root exudates
- Root exudates metabolites profiling has been altered by nano-Cu
- The up-regulated amino acids and down-regulated citric acids are active defense mechanism for cucumber plants to nano-Cu

Future perspectives and environmental applications

- We are testing more plants species, e.g. corn, soybean, alfalfa, spinach, and more copper-based NPs to thoroughly understand the detoxification mechanism of those plants

- The plant itself give us strategies to decrease the toxicity of naon-Cu in real soil.

Acknowledgments

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Thank you for your attention!