

PHYSIOLOGICAL AND MOLECULAR RESPONSES OF TEXTILE HEMP (*Cannabis sativa* Santhica 27) TO CADMIUM AND ZINC, WITH A PARTICULAR FOCUS ON THE ANALYSIS OF SILICON-INDUCED PROTECTION MECHANISM.

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Introduction

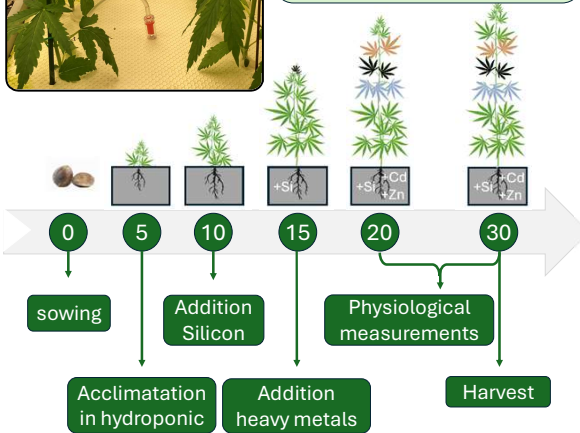
Hemp (*Cannabis sativa* L.) is a fast-growing, resilient crop with promising applications in **textile production**. In addition to its industrial value, hemp has attracted attention for its potential in **phytoremediation**. This study links **gene expression** (RNA-seq) with **physiological** and **biochemical** responses in plants under **cadmium** and **zinc** stress, and evaluates the potential protective role of **silicon**.

Protocol

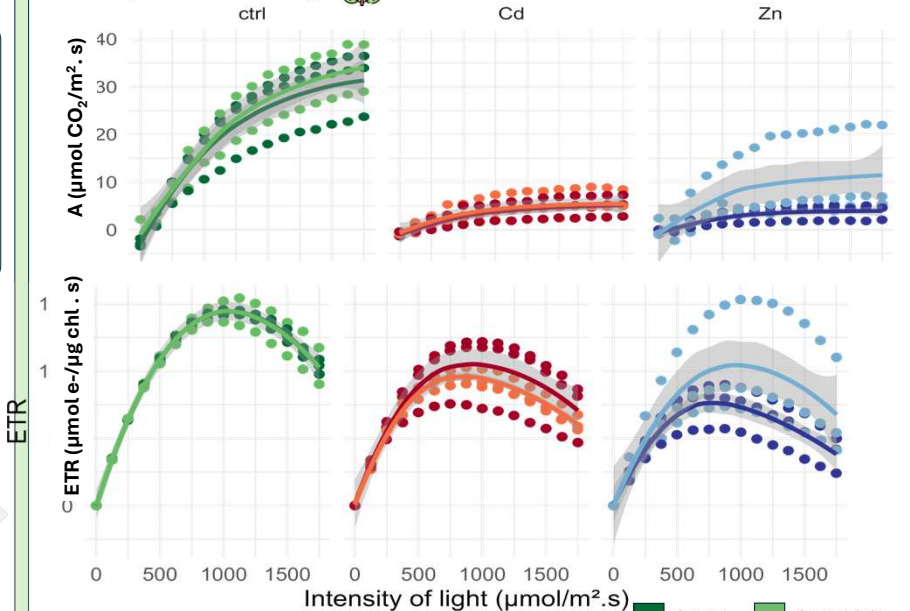


Materials :
Cadmium 20 μM & Zinc 100 μM
Metasilicic acid 2mM
Hoagland solution
Cannabis sativa Santhica 27

Analysis :
Response curve of light
Hormonal analysis
Pigments contents
RNAseq



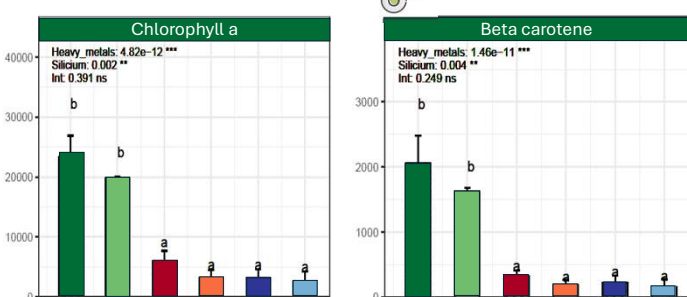
Photosynthetic activity



Cadmium and zinc significantly reduce photosynthetic rate (A) and effective electron transport rate (ETR). Silicon treatment shows no clear effect. Therefore, light use efficiency also decreases under metal stress, with no protective role observed for silicon.

Legend:
Control (green), Control & Si (light green), Cadmium (red), Cadmium & Si (orange), Zinc (blue), Zinc & Si (light blue).

Chlorophylls and carotenoids



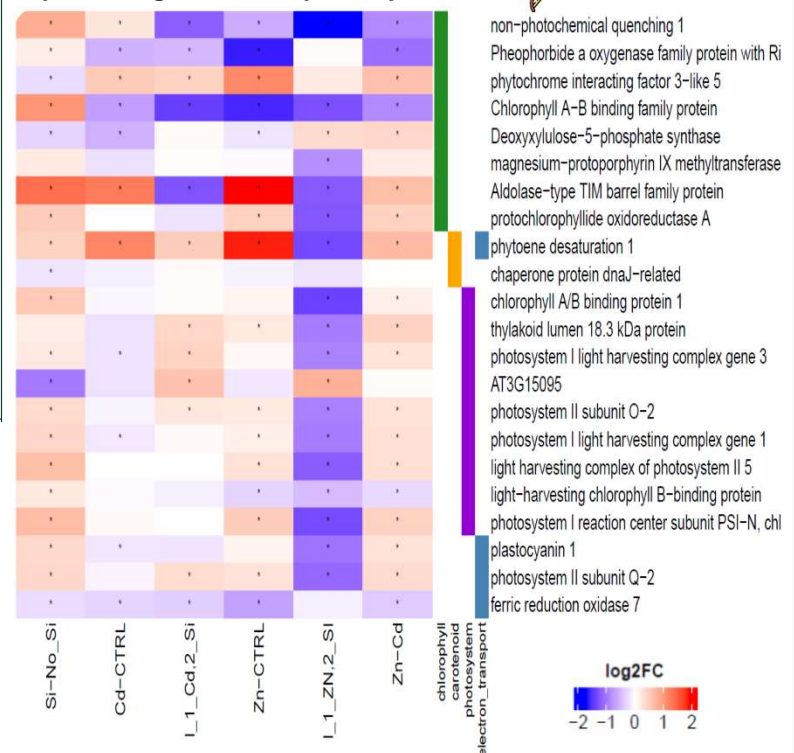
Cadmium and zinc systematically reduce chlorophyll a, chlorophyll b, and all detected carotenoids (β -carotene, violaxanthin, lutein, zeaxanthin, etc.). Silicon treatment tends to mitigate pigment content.

Cadmium and zinc treatments reduce the expression of key genes involved in chlorophyll and carotenoid synthesis, metabolism and degradation (e.g., PaO, Chl A-B binding proteins, DXS, ChIM, POR, PDS1). Genes related to photosystems I and II (e.g., LHCA1, LHCA3, LHCB3, LHCB5) and electron transport (e.g., plastocyanin) show variable regulation depending on the metal.

Silicon increases the expression of many photosynthesis-related genes under control conditions but shows a limited effect under cadmium or even negative effect under zinc stress.

Gene expression showed significant differences between the cadmium and zinc treatments compared with the biochemical and physiological analyses. The source of the stress caused by cadmium and zinc is therefore not identical, while their impact from a biochemical and physiological point of view seems to follow the same trend.

Expression genic link at photosynthesis



non-photochemical quenching 1
Pheophorbide a oxygenase family protein with R1
phytochrome interacting factor 3-like 5
Chlorophyll A-B binding family protein
Deoxyxylulose-5-phosphate synthase
magnesium-protoporphyrin IX methyltransferase
Aldolase-type TIM barrel family protein
protochlorophyllide oxidoreductase A
phytoene desaturase 1
chaperone protein dnaJ-related
chlorophyll A/B binding protein 1
thylakoid lumen 18.3 kDa protein
photosystem I light harvesting complex gene 3
AT3G15095
photosystem II subunit O-2
photosystem I light harvesting complex gene 1
light harvesting complex of photosystem II 5
light-harvesting chlorophyll B-binding protein
photosystem I reaction center subunit PSI-N, chl
plastocyanin 1
photosystem II subunit Q-2
ferric reduction oxidase 7

Conclusion & perspectives

Cadmium and zinc consistently reduce photosynthesis at physiological, biochemical, and transcriptomic levels. Interestingly, silicon shows limited or even negative effects physiologically and biochemically. Transcriptomic data, however, suggest that silicon may also downregulate key photosynthesis-related genes under stress. This apparent discrepancy could be due to hemp's low silicon uptake—about 10 times less than high-Si accumulators like rice—potentially limiting its effectiveness.