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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.

Nolan Regnier[1] and Stanley Lutts[1]

(1) Groupe de Recherche en Physiologie Végétale, Earth and Life Institute, Louvain-La-Neuve, Belgium

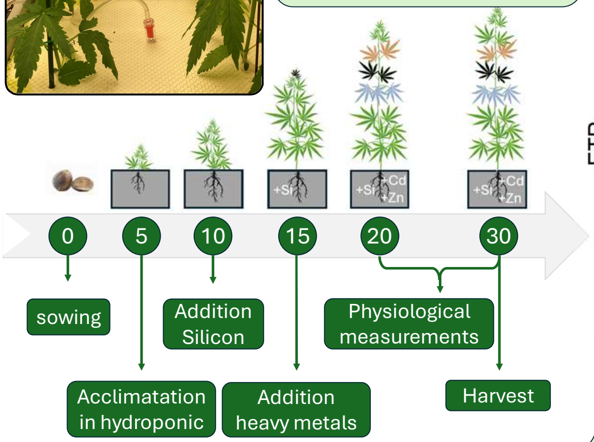
Introduction

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**.

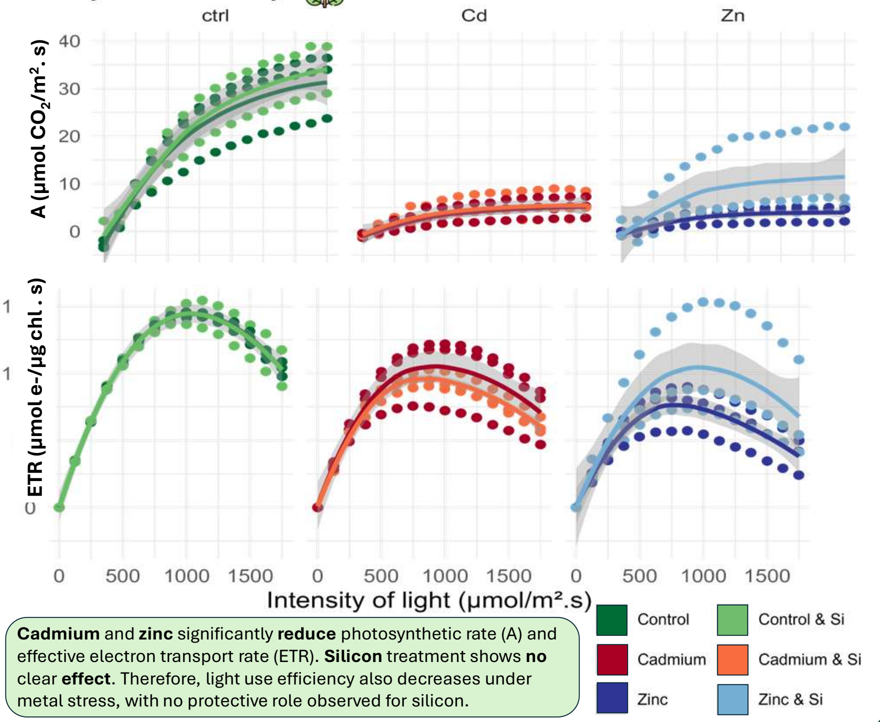
Protocol

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

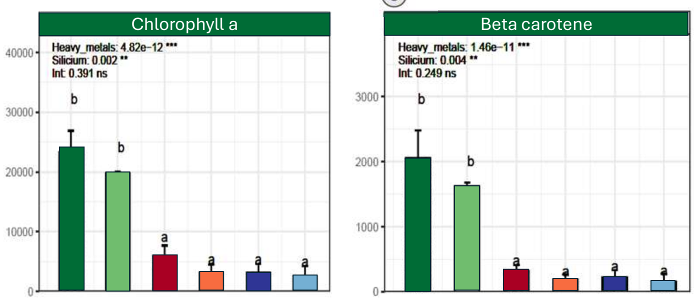


Photosynthetic activity



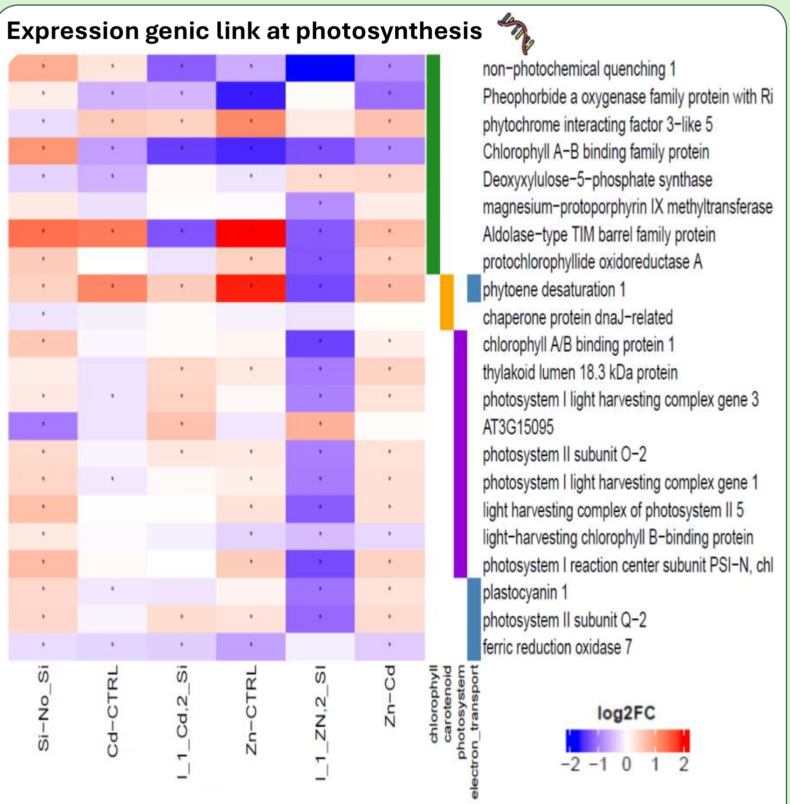
Cadmium and **zinc** significantly **reduce** photosynthetic rate (A) and effective electron transport rate (ETR). **Silicon** treatment shows **no** clear **effect.** Therefore, light use efficiency also decreases under metal stress, with no protective role observed for silicon.

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**.

Expression genic link at photosynthesis



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, ChlM, PORA, 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**.

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.

nolan.regnier@uclouvain.be & stanley.lutts@uclouvain.be