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### Title

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### **Spatial Imaging of Zinc and Other Elements in Huanglongbing-affected Grapefruit by Microscopically Focused Synchrotron X-Ray Investigation**

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Huanglongbing (HLB) is a highly destructive, fast spreading disease of citrus that causes substantial economic losses to the citrus industry worldwide. Nutrient levels and their cellular distribution patterns in HLB-affected grapefruit were analyzed after graft-inoculation with infected lemon scions containing '*Candidatus Liberibacter asiaticus*', the heat-tolerant Asian type of HLB bacterium. After 12 months, infected plants showed typical HLB symptoms including leaf curling and blotchy mottle on leaves. Zinc (Zn) concentrations in young, mature, and old leaves of grapefruit significantly decreased by HLB infection. Micro-XRF imaging of Zn and other elements showed that preferential distribution of Zn was observed in the phloem tissues of leaves and stems collected from healthy grapefruit plants but was absent from HLB-affected samples. Quantitative analysis of Zn intensity in the cross-sections of leaves using standard samples revealed that Zn concentration in phloem tissues of healthy grapefruit leaves was more than 10 times higher than that in the HLB-affected leaves. No significant variation was observed in the distribution patterns of other elements such as K and Ca in stems and leaves of grapefruit plants before or after graft-inoculation with HLB infected lemon scions. These results suggest that reduced phloem transport of Zn is one of the most important constraints that contribute to HLB-induced Zn deficiency in citrus such as grapefruit. Our report provides the first *in situ* visualization of elements' variation within the tissues of HLB-infected citrus at cellular level.