Penetration of foliar-applied Zn and its impact on apple plant nutrition status

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INTRODUCTION

The absorption of foliar fertilizer is a complex process and currently remains poorly understood. The ability to visualize and quantify the pathway that elements take following application to leaf surfaces is critical for the science and practical application of foliar fertilizer. Apple (*Malus domestica* Borkh.) was selected as an experimental species because it is highly sensitive to Zn deficiency. Most apple orchards in areas with calcareous and salt-affected soils suffer from Zn deficiency every year, which results in high loss of yield and severe deterioration of fruit quality

MATERIALS & METHODS

By using micro X-ray florescence, we are able to analyze the impact of surface physicochemical properties of apple plant leaves on their Zn absorption and further translocation. Then, higher resolution imaging was applied to assess the penetration process by in vivo mapping of Zn at subcellular level. We also investigate the interaction of Zn and other elements to examine how do nutritional status in apple leaves respond to foliar Zn application. The ability to visualize and quantify the pathway that elements take following application to leaf surfaces is critical for our understanding of the utility of foliar fertilizers and allows for the direct contrast of relative efficacy of different formulations and chemistries.

RESULTS & CONCLUSIONS

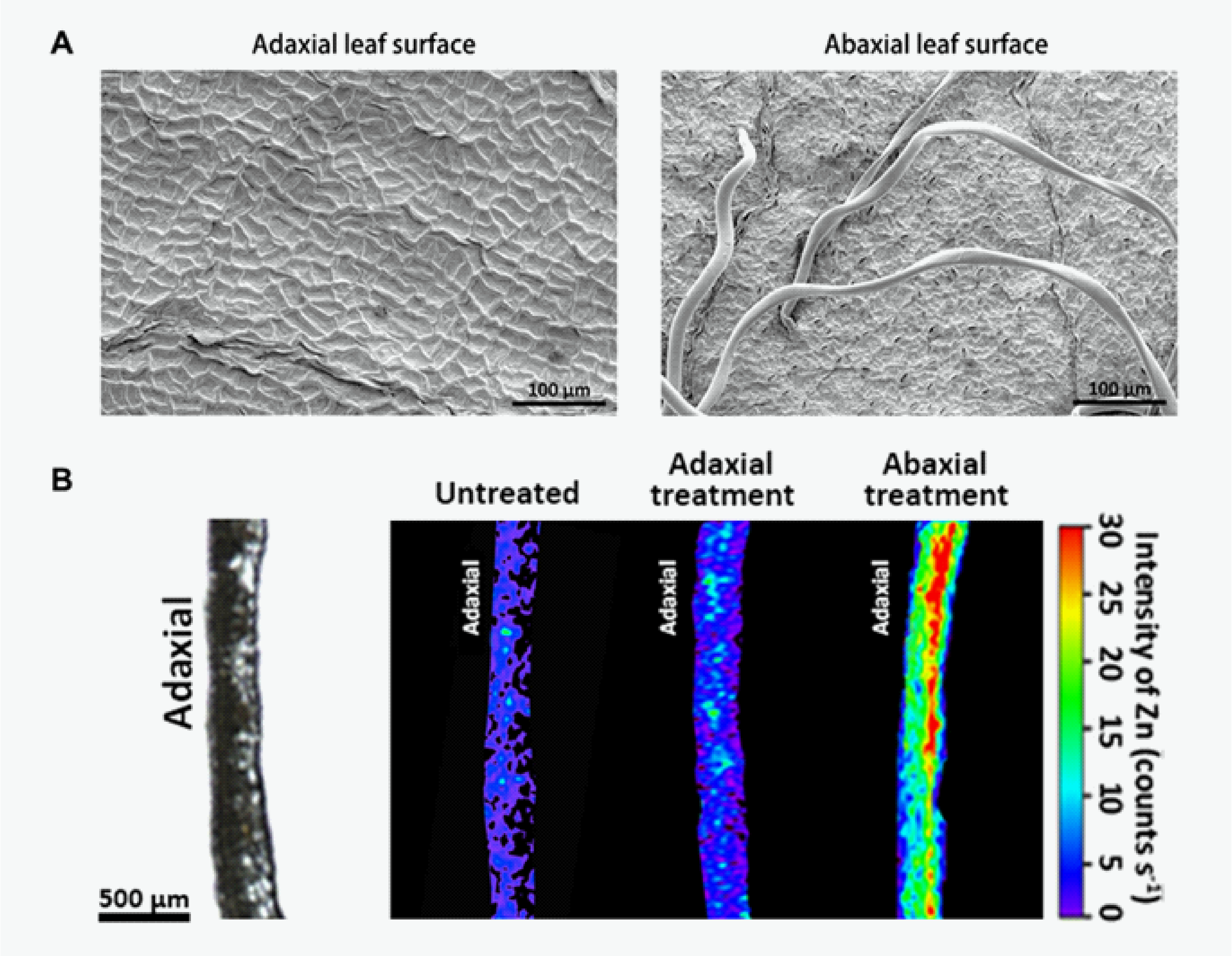


Figure 1 SEM micrographs of leaf surfaces of apple mature leaves (A) and Micro-XRF mapping of Zn in the cross sections of leaves after foliar Zn application (B)

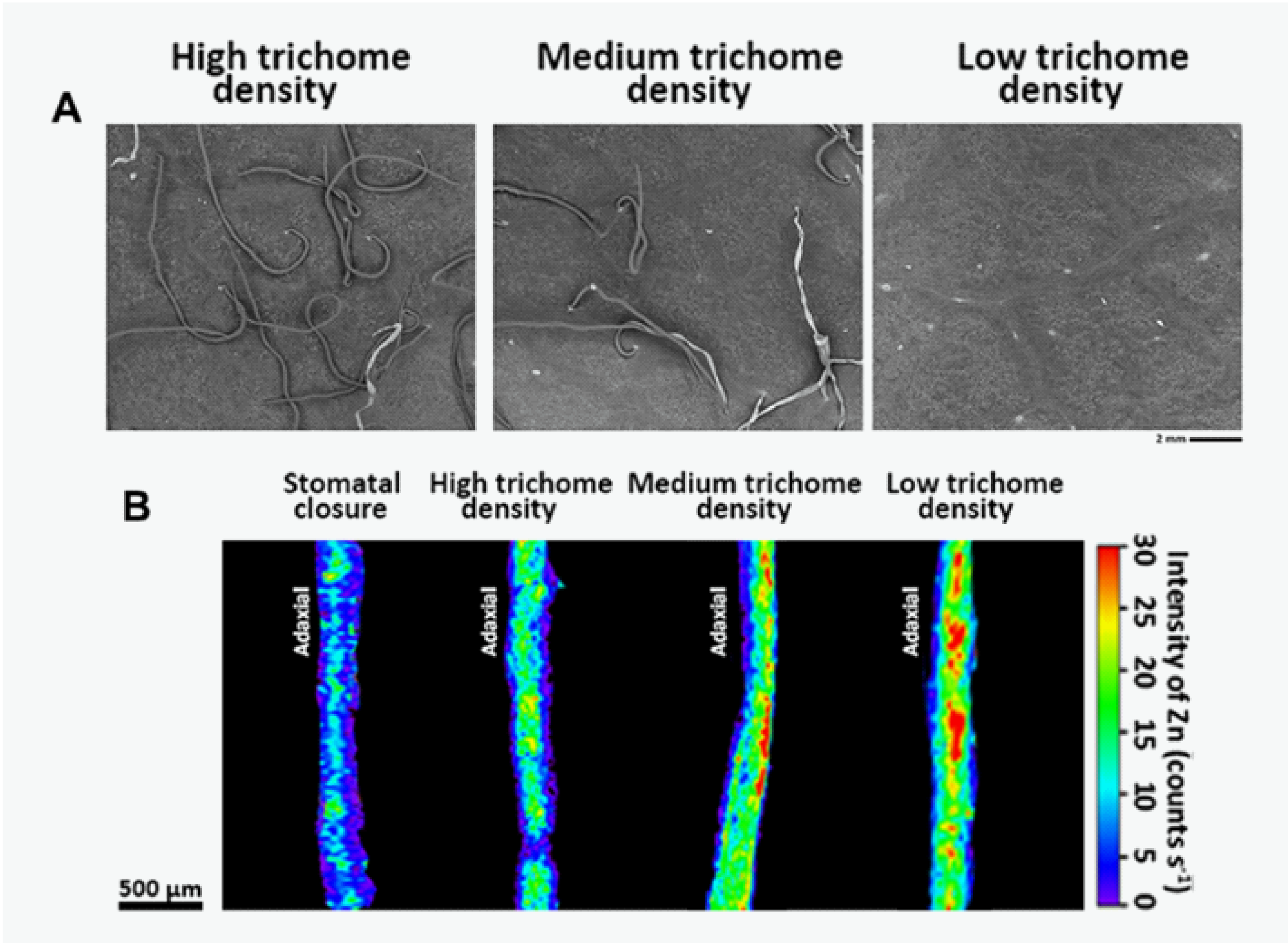


Figure 2 SEM micrographs of abaxial apple leaves with high, medium and low trichome densities (A) and Micro-XRF mapping of Zn in cross-sections of leaves after foliar Zn application (B)

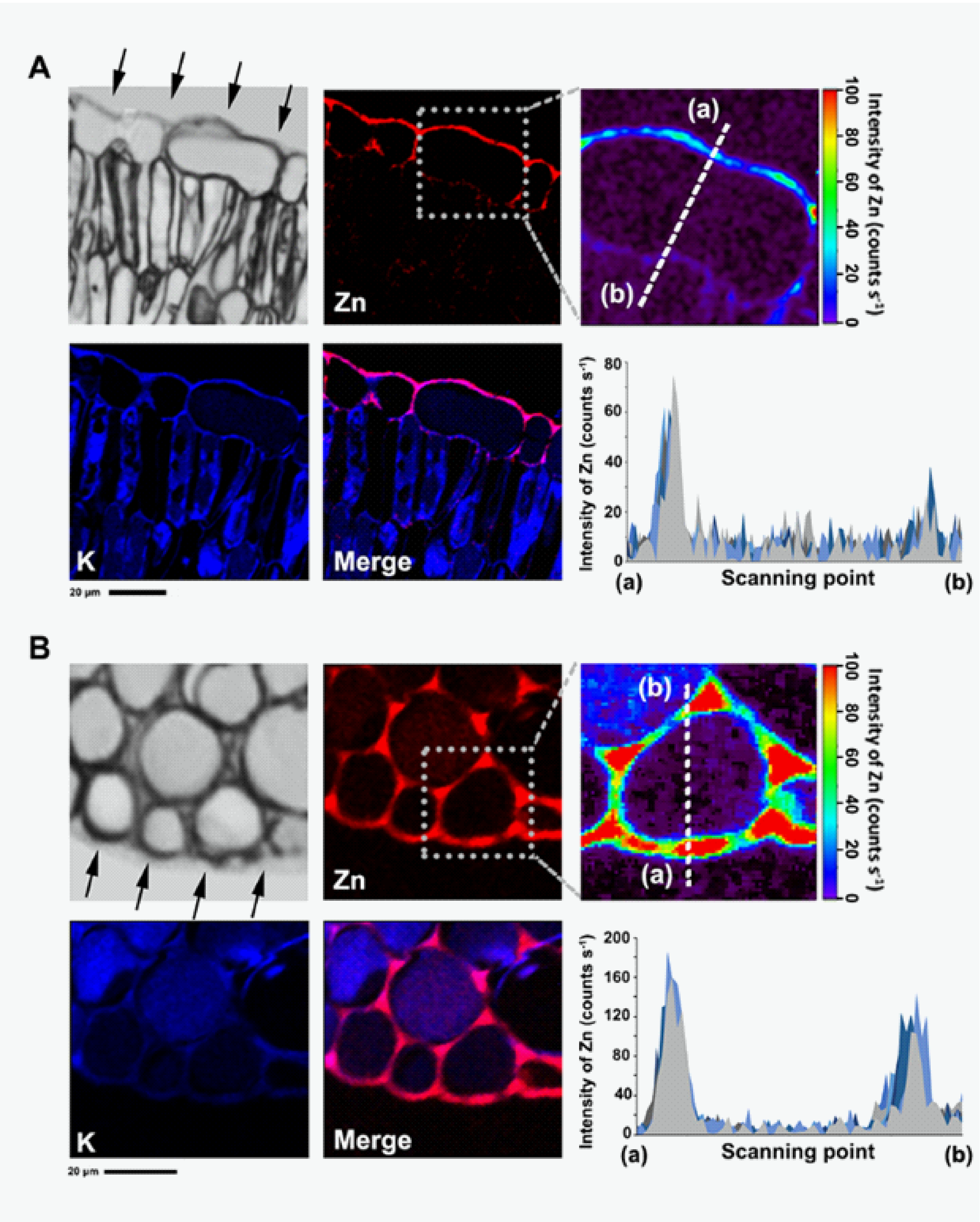
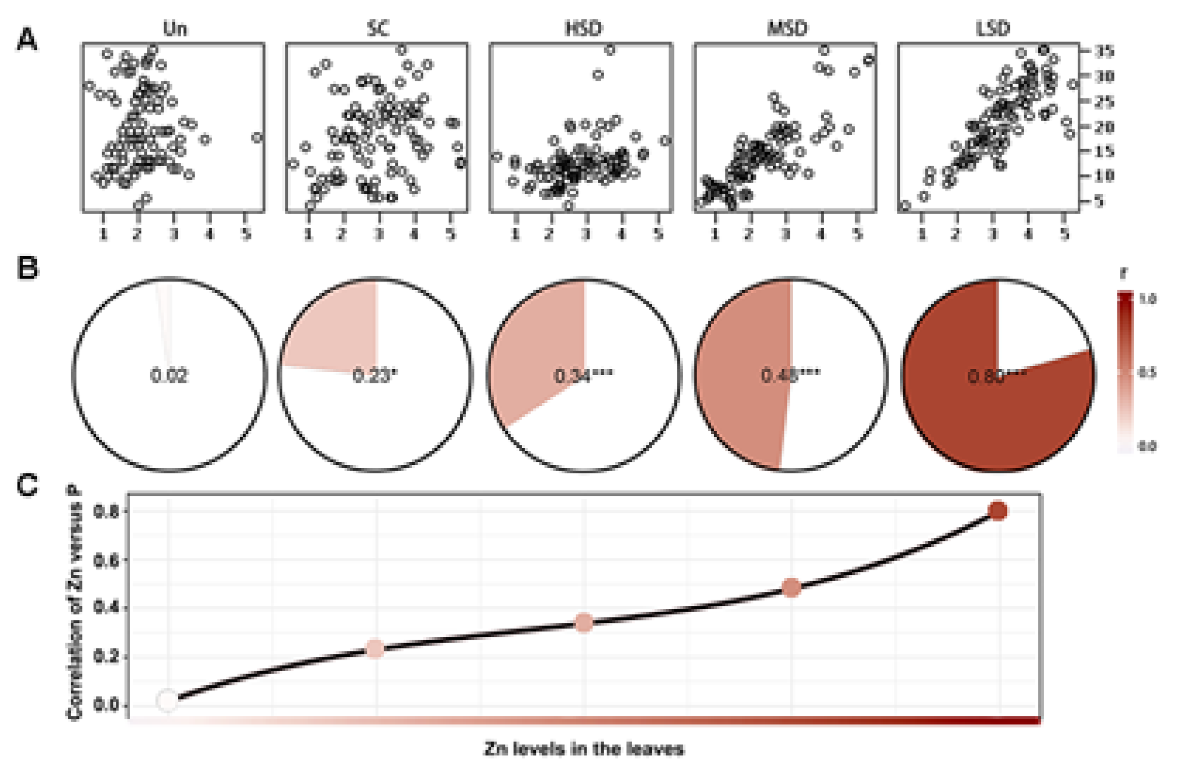


Figure 3 Subcellular distribution of Zn in apple leaves after foliar Zn application. Nano-XRF images were obtained from cross sections of apple leaf tissue after foliar Zn treatment of adaxial (A) and abaxial (B) leaf surfaces.



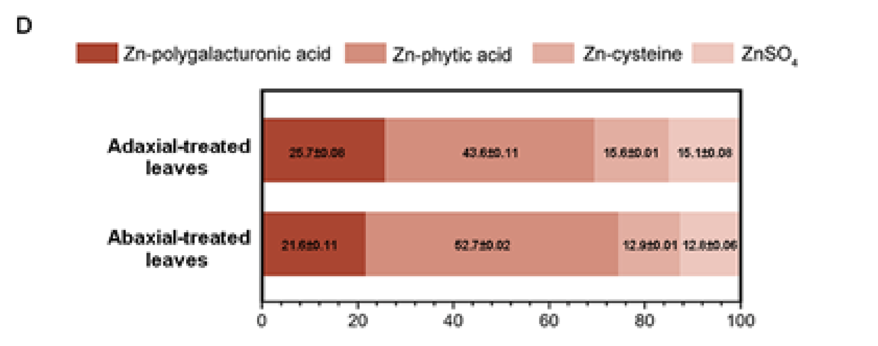


Figure 4 The spatial correlation between micro-XRF intensity of Zn versus P and the proportion of Zn species in leaves.

Conclusion

The results indicate that the absorption of foliar applied Zn was largely dependent on plant leaf surface characteristics. Higher-resolution elemental maps revealed that high-binding capacity of cell wall for Zn contribute to the observed limitation of Zn penetration across epidermal cells. Trichome density and stomatal aperture had opposite effects on Zn fertilizer penetration; a higher density of trichomes increased the hydrophobicity of leaves, whereas the presence of stomata facilitated foliar Zn penetration. Low levels of Zn promoted the accumulation of other mineral elements in treated leaves, the complexation of Zn with phytic acid occurred potentially owing to the exposure to high Zn conditions. The present study provides the direct visual evidence for Zn penetration process across the leaf surface which is important for the development of strategies for Zn biofortification in crop species.

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