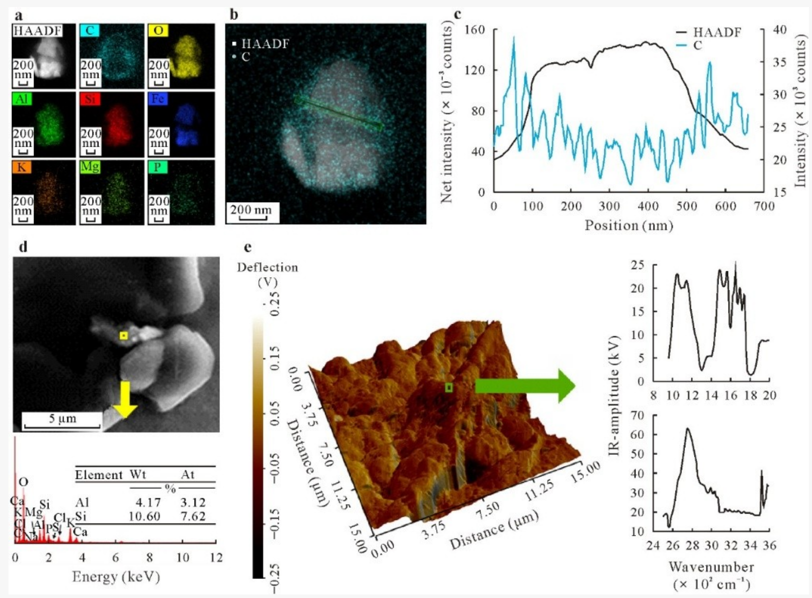
Cracks in the root: how wheat absorbs clay minerals

GA, UNITED STATES, May 25, 2026 /EINPresswire.com/ -- Clay minerals have long been thought too large for plant absorption, but new research turns that assumption on its head. Scientists have discovered that wheat (Triticum aestivum) can absorb micrometer-sized montmorillonite particles—a common soil clay mineral—through tiny cracks formed at sites of lateral root emergence. Once inside, these particles travel through the plant's vascular system to stems and leaves, collecting nutrients and becoming coated with biomolecular coronas along the way. This unexpected uptake mechanism offers a new perspective on how plants interact with soil minerals and opens exciting possibilities for nutrient delivery and sustainable agriculture.



Transmission electron microscopy (TEM) images of the montmorillonite in xylem sap detected with high-angle annular dark field mode (HAADF) and elemental mapping (including C, O, Al, Si, Fe, K, Mg, and P) using energy dispersive spectrometry (a and b), lin

Clay minerals play vital roles in terrestrial ecosystems, from retaining soil nutrients to regulating plant growth. Among them, montmorillonite is especially significant due to its high ion exchange capacity and wide availability in agricultural soils. Traditionally, however, scientists believed these particles were too large to penetrate plant roots because of structural barriers like the Casparian strip. Yet recent findings suggest that cracks at the junctions of lateral roots may provide a backdoor for foreign particles. Due to these challenges and unknowns, further research is urgently needed to explore how clay minerals interact with plant root systems and influence nutrient dynamics.

In a study led by the Chinese Academy of Sciences and Qingdao University, researchers tracked the journey of fluorescently labeled montmorillonite particles in wheat and found that they can bypass traditional root barriers. Published in Pedosphere in March 2025, the research employed advanced imaging technologies to reveal how these clay particles enter through natural fissures at lateral root junctions and travel throughout the plant. The findings redefine our understanding of mineral uptake and highlight a novel, previously overlooked pathway in plant-soil interactions.

By tagging montmorillonite with a stable fluorescent dye, researchers followed the particles' journey in hydroponic and soil-based systems. Fluorescence signals began appearing in root vascular tissues after 24 hours, intensifying over time—especially at the sites where new lateral roots emerged. These findings were confirmed through confocal microscopy and scanning electron microscopy (SEM) imaging. Further tests in quartz sand and soil matrices demonstrated that uptake persisted, albeit at lower levels due to interactions with negatively charged soil particles.

Using SEM-EDS and high-resolution transmission electron microscopy (TEM), the team detected montmorillonite in the stems and leaves, indicating that the particles were translocated via the xylem. These transported particles carried essential nutrients like potassium, calcium, and iron, and were coated in biomolecular coronas—organic layers made of proteins, lipids, and carbohydrates. AFM-IR spectroscopy confirmed that these coronas formed unique chemical signatures, distinct from other silica-based particles, thereby affirming the identity and transformation of montmorillonite within the plant.

"This study fundamentally shifts our view of how plants interact with their soil environment," said Dr. Yongming Luo, senior author of the study. "The discovery that micrometer-sized clay particles can be absorbed through natural root openings and transported internally reveals a hidden route for nutrient delivery. It provides an exciting foundation for future research into soil–plant dynamics and sustainable nutrient management."

The findings suggest that crops like wheat and rice—known to require high silicon inputs—could directly utilize clay particles as alternative nutrient sources, especially in nutrient-depleted soils. The biomolecular coronas formed during transport may influence nutrient availability, plant metabolism, and even particle mobility within tissues. These insights could revolutionize the design of nano-enabled fertilizers or soil amendments that mimic natural mineral uptake pathways. As agriculture faces mounting pressure to increase productivity sustainably, understanding how plants internalize and utilize soil minerals could be a key part of the solution.

References

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