Monitoring the Transport of Minerals and Nutrients in a Plant

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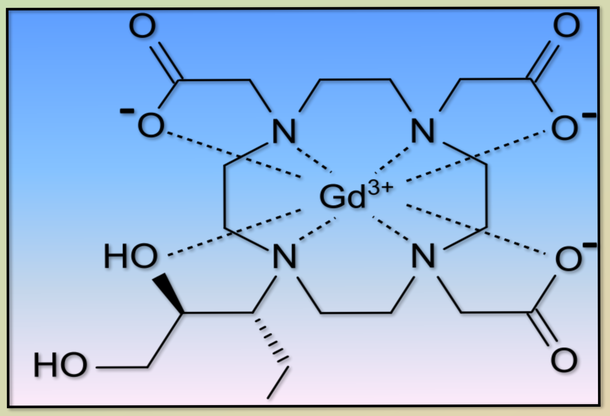
Abstract

This work analyzes various experimental results of nanoparticle (NP) transport in the matrix of a complex nutrient bed of various plant systems that seem to be measurable by x-ray imaging and near infra-red spectroscopy. Nanoparticles like metal oxide-induced phyto-toxicity is very important and is widely studied to understand the interactions between plants and environmental NPs, however lanthanide NP complexes are not yet been studied in such systems. Hence we are working to understand the uptake and translocation as well as abiotic transformation and redox conversions.

Background

Nanoparticle (NP), like metal oxide induced phyto-toxicity is very important and is widely studied to understand the interactions between plants and environmental NPs. However NP uptake and translocation is poorly understood as well as abiotic transformation and redox conversions.

MRI contrast Gadavist (shown below) was used with Gd+3 atom loosely bound to other negative structures as well as CT contrast Isoview was used. Such complex structures supply or absorb electrons and has preferential wash out patterns suggestive of charge transfer with the nutrient biomolecules.



Methods

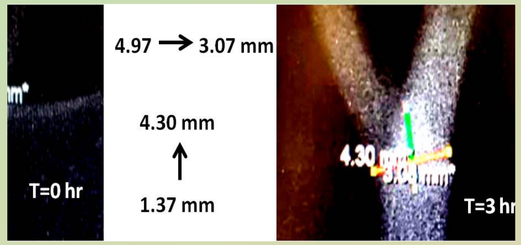
X-ray opaque solution (Metapex) was directly injected at the stems of a model plant (cucumber) to study possible intermix or disruption of normal translocation systems and subsequent reaction mechanisms and compared with standard growth measures of undisturbed plants over two weeks. NOMAD Pro2 dental machine and a digital plate Sirona were used for X-ray imaging. Metapex paste (with 40:30:20 mix of Ca(OH)2, Iodoform and Silicone Oil) was diluted 10:1 in water to minimize the rejection reaction in plant tissue. Direct injection was applied at two spots in a cucumber plant and x-rays were taken at T=0, 3 hr and 24 hr intervals.

X-rays were done at 50-60kVp at 5-10mAs while 1-2 mm slice CT was done at 100 kV.

Results

Altered Nutrient Transport in the Presence of "toxic" Nanoparticles in Plant Stem

Fig 1. demonstrates the diffusion of solution upward and horizontally as a result of concentration difference .



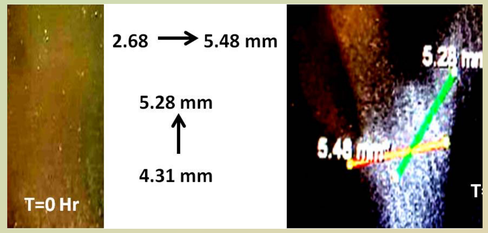
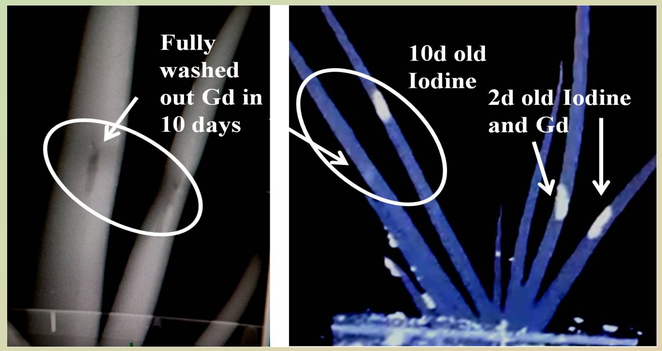


Fig 2. demonstrates that cucumber and eggplants require sunny and well-drained soil with plenty of organic matter. After rainy days, we observed healthy growth of the plants indicative of weather dependent nutrient transportation volume in soft plants..

Fig 3. (Left) residual Gd and Iodine contrasts by planer X ray at 65 kV/7 mAs 2 and 10 days post infusion, and (Right) CT reformats from 1.2 mm CT slices(80kV) of Aloe Vera plant. Note CT detects the residual Gd well but does not distinguish between 2d and 10d old Iodine; CT also misses the edema from metal ion toxicity in surrounding areas presumably due to scatter from high kV.



Discussion

Note CT detects minute amounts of residual Gd well but does not distinguish between 2d and 10d old Iodine; CT also misses the edema from metal ion toxicity in surrounding areas presumably due to scatter from high kV compared to low kV X-rays, suitable for plants.

Conclusion

- X-ray imaging can directly show presence and diffusion of metallic or electron rich ions. It is a suitable probe for nanoparticle transport in plants that could model physiologic behavior in biomedical applications in human tissues.
- CT can map NP distribution and wash out in much greater detail, to a minute quantity and in 3D fashion although tissue contrast for low attenuating fluids is limited in CT.

Acknowledgment

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References

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