# A Minimally-Invasive 3D-Printed Microneedle Array Applicator System (MU-NAAS) for Delivery of Therapeutics to Citrus Leaf Tissue

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This work reports the design, fabrication, and testing of a novel minimally-invasive mechanical delivery system that can potentially transport therapeutics to Huanglongbing (HLB) affected trees. HLB has devastated Florida's 9-billion-dollar citrus industry. Since HLB is caused by phloem-restricted bacteria, treatment must reach phloem tissue to be effective. Direct delivery to phloem is extremely challenging, demanding innovation. It is hypothesized that a microneedle-based applicator will be suitable for creating punctured channels on leaves through which treatment can reach phloem. A microneedle array was designed (using CAD), 3D printed and fixed onto a mechanical applicator to fabricate the μNAAS device. As a proof-of-concept, a treatment containing cadmium (not present in leaves naturally), was delivered to citrus leaves by this applicator. Treated leaves were subsequently washed thoroughly and characterized using scanning electron microscopy-energy dispersive spectroscopy (SEM-EDS) for cadmium uptake, which confirmed treatment delivery qualitatively and the creation of punctured channels. X-Ray fluorescence spectroscopy quantified concentrations of cadmium in plant tissue. A 45% increase was observed in microneedle treated plants compared to control (statistically significant). This study successfully demonstrated the potential for microneedle applicators to directly deliver therapeutics and other useful substances (such as genetic materials) to citrus phloem. Future steps include designing and fabricating an efficient biodegradable microneedle-embedded staple carrying therapeutic cargoes that will be applied onto trees with a staple gun, creating minimally-invasive, cost-effective rapid therapeutic application suitable for testing in greenhouse/field condition.

**Awards Won:**
Fourth Award of $500