[BT]

Startup Pitch

Fall 2023

Meet the Founders

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Background

44.36% of the United States is farmland, with the average land size consisting of → **90%** of U.S. food

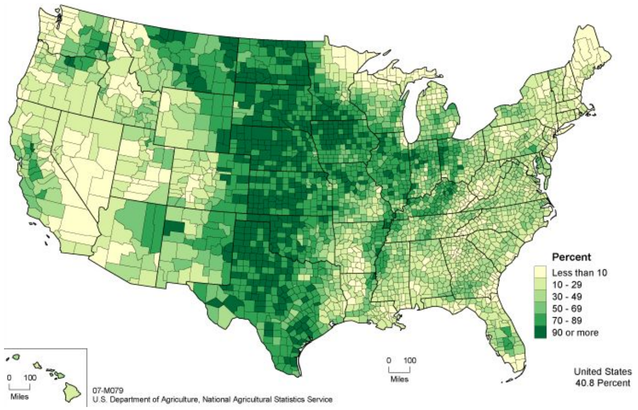
Climate change and **diseases** lead to significant yield losses, with fungal organisms accounting for **85%** of plant diseases

Agricultural soil testing is necessary every **3 to 5 years** for **disease and overall nutrient testing** in various crop sectors

Soil units require **extensive laboratory examinations** and can be very costly — around $14 for 15-20 acres

Around **$365 per farm** for complete soil testing for **over 2 million** farms throughout the US

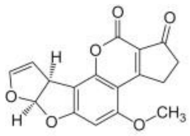
US Farmland Percentage



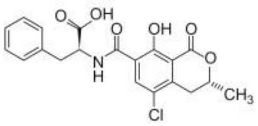
Soil testing is crucial for disease detection but are often **time consuming** and **expensive** for large farmlands

EcoSense

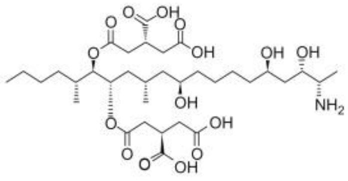
Genetically engineered plants for continuous crop disease warnings



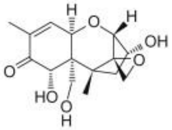
Aflatoxin B1



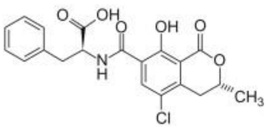
Ochratoxin A



Fumonisin B1



Deoxynivalenol



Zearalenone

Detection of Mycotoxins

1. Carbon nanotubes (CNTS) can be functionalized with **mycotoxins** which are naturally produced by fungi and are related to crop disease
2. These nanosensors are then embedded into the leaf of our plant where they emit a **fluorescent signal** when mycotoxins are present
3. Within **10 minutes** of a mycotoxin entering the root system the plant can draw up the molecule where they encounter the detector

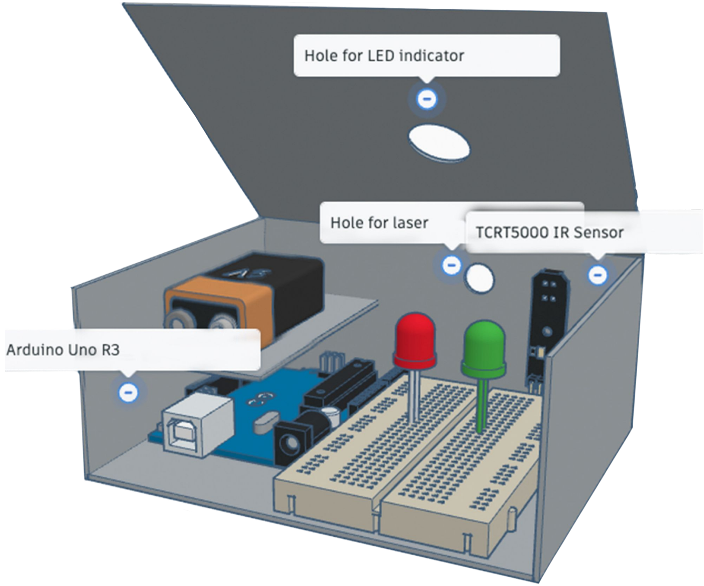
Due to the versatility of this technique **any living plant** can be embedded with these nanosensors

EcoSense Detector

Hand-held infrared signal and sensor to indicate mycotoxin presence

Detection of Fluorescent Signal

1. Our complimentary device uses a laser to excite the nanosensor fluorescence, prompting the nanotubes to emit a near-infrared signal
2. The built in infrared sensor can detect whether an infrared signal is present or not and convey this data to an Arduino.
3. The device then shows a green light if no mycotoxins are present (no infrared signal) and a red light if mycotoxins are detected (infrared signal)



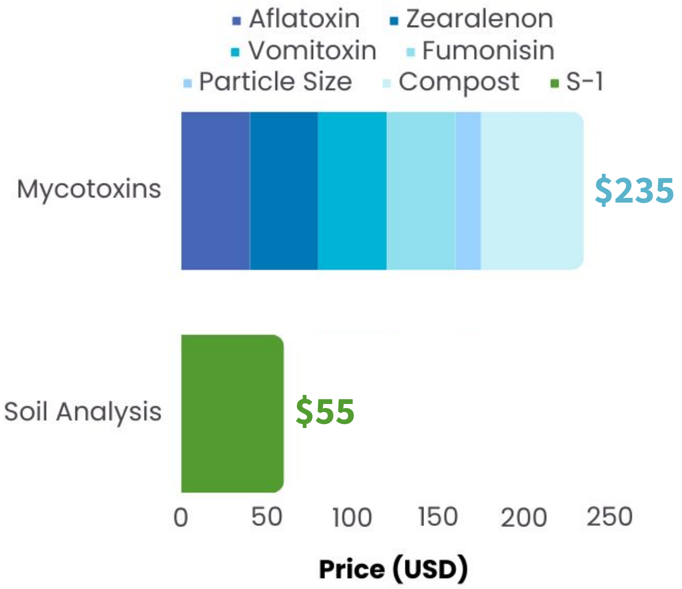
This **9 volt** powered device is simple for users and clearly indicates the presence of crop disease

Market Analysis

Soil Testing Competitor Facilities

INTERNATIONAL AG LABS
A BIOLOGICAL APPROACH TO AGRICULTURE

CSI, INC.
Soil Testing, Recommendations & Quality Products



USA Agriculture Growth

An annual growth rate of **5.66%** is expected for **export value** (CAGR 2023-2028)

Production value in the agriculture market is projected to reach **$298.30 billion** in 2023 and **$342.70 billion** in 2028

Marketing Strategy

Agriculture & Farming Shows

Demonstrate **ease of use** and advanced modern technology

Opportunity to **network** with industry leaders and generate a **larger user base**

Directly promotes brand to all farmers

Major Retail Stores

Lowes, Home Depot, and local supply business can host EcoSense

Widely available for **commercial** farmers and also **small scale** farming/lawn care

Agricultural Organizations

Partnering with USDA's Farm Service Agency to allow the use of EcoSense to farmers at a **discounted** rate

Government agency provides a sense of **credibility** to the product

Location-Based Social Media

46% of U.S. farmers use Facebook for both **personal** and **professional** business reasons

Facebook ad recommendation algorithm allows a **streamlined** approach for farmers to view EcoSense

Risks and Mitigations

Risk	Mitigation
False positive results may arise due to the CNTs incorrectly detecting mycotoxins or detecting different biomolecules	CNTS have a high surface area and reactivity so they can be covalently or noncovalently **functionalized** specifically to mycotoxins.
If CNTs-modified plants are newly introduced to the ecosystem, there is a risk of them becoming **invasive**	There is **variability** between the plants that can be engineered with CNTs, allowing **safe usage** for all lands and crop fields
Farmers **may be hesitant** to adopt genetically engineered plants due to concerns about efficacy and long term effects	Conduct thorough **field trials** to showcase the performance, benefits, and safety of genetically modified plants

Q&A Session

Appendix – Fungal Plant Diseases

Most plant diseases – **around 85%** – are **caused by fungal or fungal-like organisms**. However, other serious diseases of food and feed crops are caused by viral and bacterial organisms. Certain nematodes also cause plant disease. Some plant diseases are classified as “abiotic,” or diseases that are non-infectious and include damage from air pollution, nutritional deficiencies or toxicities, and grow under less than optimal conditions. For now, we’ll look at diseases caused by the three main pathogenic microbes: fungus, bacteria and virus. If plant disease is suspected, careful attention to plant appearance can give a good clue regarding the type of pathogen involved.

Appendix - Crop Disease in the US

Crop diseases can have a large impact on agricultural productivity. Invasive plant pathogens, including fungi, cause an estimated $21 billion in crop losses each year in the United States (Rossman, 2009). Verticillium dahliae is a soil borne fungus that is introduced to the soil via infested spinach seeds and that causes subsequent lettuce crops to be acted with Verticillium wilt (V. wilt). Lettuce is an important crop in California, and the majority of the lettuce production in the United States occurs in California. The value of California's lettuce crop was $1.7 billion in 2013 (National Agricultural Statistics Service, 2015).

Appendix - Mycotoxin and Soil Relation

Soil phytopathogenic fungi are principally associated with crop diseases; however, the effects of fungal infection may extend beyond the field to human and animal consumers putting their health at risk. Mycotoxigenic fungi can produce secondary metabolites known as **mycotoxins**, which are considered to be **toxic when present in human food and animal feed**. Mycotoxins are characterized as odourless and tasteless compounds, thus their identification in food is difficult. Furthermore, mycotoxins are heat resistant and tolerate a wide range of pH, making them hard to breakdown. In this review we follow the fates of mycotoxins from the ecology of their producers in the soil to pre-harvest occurrence in host plants, postharvest in storage and their effect on human well-being, focusing on aflatoxin as a case study.

Appendix - MIT Bomb-Detecting Spinach

In the new study, the researchers **embedded sensors for nitroaromatic compounds** into the leaves of spinach plants. Using a technique called **vascular infusion**, which involves **applying a solution of nanoparticles to the underside of the leaf,** they placed the sensors into a leaf layer known as the mesophyll, which is where most photosynthesis takes place.

They also embedded **carbon nanotubes** that emit a **constant fluorescent signal** that serves as a reference. This allows the researchers to compare the two fluorescent signals, making it easier to determine if the explosive sensor has detected anything. If there are any explosive molecules in the groundwater, it takes about 10 minutes for the plant to draw them up into the leaves, where they encounter the detector.

To read the signal, the researchers shine a laser onto the leaf, prompting the nanotubes in the leaf to emit near-infrared fluorescent light. This can be detected with a small infrared camera connected to a Raspberry Pi, a $35 credit-card-sized computer similar to the computer inside a smartphone. The signal could also be detected with a smartphone by removing the infrared filter that most camera phones have, the researchers say.

In the 2014 plant nanobionics study, Strano's lab worked with a common laboratory plant known as Arabidopsis thaliana. However, the researchers wanted to use common spinach plants for the latest study, to demonstrate the versatility of this technique. "You can apply these techniques with any living plant," Strano says.

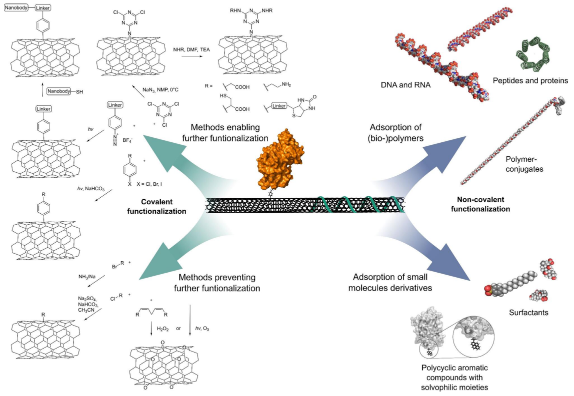
So far, the researchers have also engineered spinach plants that can detect dopamine, which influences plant root growth, and they are now working on additional sensors, including some that track the chemicals plants use to convey information within their own tissues.

Appendix – Biosensing with Carbon Nanosensors

Both covalent or noncovalent functionalization approaches play an essential role in tailoring molecular interactions close to the SWCNT surface. By using such concepts, SWCNT-based biosensors for many highly important biomolecules have been developed.

More recently, this allowed chemical signaling to be mapped in a completely new manner, for example, release patterns of neurotransmitters from cells with high spatial and temporal resolution, which provides unique insights into fundamental biological questions. Moreover, recent advances have been made in remote in vivo biosensing applications by the multimodal optical detection of several analytes. By combining multiple nanosensor elements and integrating them into functional arrays, analytes can be identified and distinguished on the basis of their characteristic image signatures. Such a combination of optical nanosensors could pave the way for the next generation of fast and reliable in situ diagnostics. In addition, these approaches provide completely new opportunities for standoff process controlling, for example, fabrication of antibodies or monitoring in food and agriculture industries (smart plant sensors).

The extended π-system makes SWCNTs hydrophobic and consequently they easily aggregate in solvents like water. Therefore, an important step in the preparation of SWCNT-based sensors is their functionalization to isolate, solubilize and colloidally stabilize single SWCNTs. The functionalization also serves the purpose to a) interact (specifically) with other molecules and b) translate this interaction into a fluorescence change.



Appendix – Functionalization of Mycotoxin

The MWCNTs have emerged as a promising carbon nanomaterial especially in the fabrication of biosensors. Specifically, the carboxylic acid-functionalized MWCNTs (cMWCNTs) are extensively used as they enable rapid and direct electron transfer in electrochemically active materials. However, the aggregation problem in aqueous medium limits their application. To overcome this issue the fabrication of nanocomposites of cMWCNTs with a polymer such as chitosan (CH) and PEI or amino acid cysteine (CY) was shown to effectively enhance the water-solubility, film-forming tendency and electrochemical signals for highly sensitive detection of AFB1 and PAT.

The use of multi-walled carbon nanotubes (MWCNTs) in biosensor fabrication, particularly carboxylic acid-functionalized MWCNTs (cMWCNTs), has shown promise for the sensitive detection of mycotoxins. Despite challenges such as aggregation in aqueous media, nanocomposites of cMWCNTs with polymers like chitosan (CH), polyethyleneimine (PEI), or cysteine (CY) have been employed to enhance water solubility, film-forming tendencies, and electrochemical signals. Notably, these nanocomposites have demonstrated efficacy in detecting mycotoxins such as aflatoxin B1 (AFB1), patulin (PAT), and zearalenone (ZEA).

Immunoassays with Nanocomposites:
Nanocomposites of cMWCNTs and chitosan (cMWCNTs/CH) have been used for electrochemical immunoassays, showing high sensitivity and selectivity for ZEA detection at low working voltages. Similar approaches have been employed for AFB1 detection with high recovery rates.

Appendix – Cost Breakdown

Detector

$35.00	Arduino Uno R3
$1.80	TCRT5000 IR Sensor
$15.80	785 nm Laser Diode
$15.00	Electric Components

$67.60 per device

Plant Type

$5.99	Spinach Sapling
$5.48	Lettuce Seedling
$2-5.00	Herb Seedlings

$4.62 on average

Total

$72.22 on average

Appendix - Social Media for Farmers

In general, younger farmers tended to use social media more than average. About 46% of U.S. farmers use Facebook for personal reasons, according to the survey. Of those, 56% were age 35 and under. About 9% use Facebook for farm business reasons, while 21% of those age 35 and under did. Just less than 10% use Facebook to advocate for agriculture; that number jumps to 21% for the 35 and under crowd.

Appendix - When to Soil Test

How Often Should I Soil Test?

Generally, you should soil test every 3–5 years or more often if manure is applied or you are trying to make large nutrient or pH changes in the soil.

When to Soil Test?

Sample fields the same time each year to achieve more accurate trends in the soil fertility.

For cropland and vegetable production, it is best to sample in the fall of the year.

For pastures and perennial crops, it is best to sample during the late summer period.

Appendix – What Soil Testing Provides

Soil testing involves collecting soil samples from different parts of a field or garden, which are then sent to a laboratory for analysis. The laboratory tests the samples for key parameters such as microbial activity, disease risks, pH, nutrient levels, organic matter content, and more. Soil testing can provide growers and farmers with valuable insights into the unique characteristics of their soil, enabling them to make data-driven decisions about soil management practices that ultimately improve crop yields and overall soil health.

Soil testing can identify nutrient deficiencies or imbalances that may be limiting plant growth and yield, enabling growers to adjust their fertilization practices and optimize crop yields.

Soil testing can also help growers avoid over-application of fertilizers, which can be costly and have negative environmental impacts.

Soil testing can provide valuable insights into soil health, including organic matter content, pH, and texture. By managing soil health appropriately, growers can improve soil structure, nutrient cycling, and water retention.

Appendix - Mycotoxin Price (AgLabs)

MYCOTOXINS	
Aflatoxin	$40.00
Zearalenone	$40.00
Vomitoxin (DON)	$40.00
Fumonisin	$40.00
Particle Size	$15.00
Compost Analysis	$60.00

Appendix – Soil Analysis Price (CSI)

Soil Chemistry Testing and Packages

Complete Soil (Recommended for most growers/gardeners)

This package is recommended for most growers and gardeners as it includes three separate tests into one Complete package. Included are: **1) Standard CEC**– Mehlich III extractable (S, P, Ca, Mg, K, Na, B, Fe, Cu, Mn, Zn, Al), Cation Exchange Capacity (CEC), Base Saturation, pH and Organic Matter. **2) Saturated Paste**– Water soluble nutrient analysis (pH, Soluble Salts, Bicarbonates, (S, P, Ca, Mg, K, Na, B, Fe, Cu, Mn, Fe, Al), and **3) Nitrates and Ammonium**. The Complete Soil test provides the ideal framework to make educated and calculated decisions for improving soil and plant health and productivity.

$55.00

Complete Soil + Extras

This package is recommended for those growers that are looking for the "Extras"! In addition to the Complete Soil test from above, the extras included are Cobalt, Molybdenum, Selenium, Silica, Electrical Conductivity, and Estimated Nitrogen Release. This package is for those in livestock production, or just feel they want the best of the best!

$60.00