Name(s)

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Project Number

S1103

Project Title

Measuring Chlorophyll Fluorescence and Spectral Reflectance for the Remote Sensing of Agriculture

Abstract

Objectives

The intent of this project is to create a device that will monitor the health of plants in order to maximize plant production using less water. Given that there is no standard for remote sensing of agricultural crops, we want to compare the sensitivity of the two leading methods: fluorescence and spectral reflectance. We believed that chlorophyll fluorescence will be a more sensitive method of detecting stress in agricultural crops.

Methods

We decided to test our hypothesis by creating two custom sensors: a reflectometer and a fluorimeter. The reflectometer was configured with LEDs a photodiode and a condenser lens to collect the light. The chlorophyll fluorimeter was configured with a blue LED, a long pass filter of 650nm, and a monochrome camera. For five days, we measured the reflectance spectrum and chlorophyll fluorescence of 18 dehydrated (Experimental) and 18 healthy (Control) plants. At night, we measured the reflectance of each plant with blue, red, and green LEDs; and immediately after we measured the chlorophyll fluorescence of the plant. We analyzed the fluorescence data, normalizing by the illumination, using Matlab to find the average fluorescent yield of the leaves.

Results

The chlorophyll fluorescence data showed a consistent decrease in fluorescence over time as the plants were not watered. A T-Test of the chlorophyll fluorescence data comparing the control and experimental groups showed that after only three days the T-test showed that there was a probability of less than 0.04 that the variation in the two groups was due to random behavior. However, the reflectance data did not show a relationship between the population of the control and the population of the experiment.

Conclusions

The spectral reflectance data was identical for both the experimental and control groups, while the fluorescence data could distinguish between the two groups after water was withheld from the plants for three days. This proved that chlorophyll fluorescence is a more sensitive way of detecting plant health than spectral reflectance. The control and experiment plants were nearly visually identical for all five days. The fluorimeter can detect the decline of plant health before it is visible to the human eye. This proves our hypothesis that a fluorimeter can detect a decrease in plant health, correlated with a decrease in chlorophyll fluorescence, better than a reflectometer.

Summary Statement

We created a device that monitors the health of plants in order to maximize plant production by measuring the plant's chlorophyll fluorescence.

Help Received

None. We designed, built, and performed the experiments ourselves.