National Aeronautics and Space Administration


Environment

# Plant Chlorophyll Content Meter

## Detects plant stress earlier than visual methods

**NASA's John C. Stennis Space Center** has developed a hand-held plant stress detector that measures the amount of chlorophyll in foliage, based upon light reflected from the plant. When unfavorable growth conditions result in plant physiological stress, leaf chlorophyll content typically begins to decrease. The hand-held optoelectronic instrument provides a quantitative measure of chlorophyll loss—an indicator of plant physiological stress. The instrument exploits the known spectral-reflectance characteristics associated with the chlorophyll contents of both healthy and unhealthy plants. It collects light reflected from a target plant, separates it into two different wavelength bands (red and infrared), and analyzes the reflected light to determine plant physiological stress. Tests have demonstrated that this technology enables plant stress to be detected up to 16 days prior to any visual indicators (e.g. color change, integrity change) being present. Additionally, sensitivity analysis has shown that NASA's reflectance-based method provides immediate results that are consistent with other methods, without requiring extensive field measurements or laboratory analysis.

## BENEFITS

- **Compact and Lightweight:** Prototype weighs one pound, the case measures 1 x 4 x 2.5 inches; compact, lighter can be made
- **Easy to use:** To operate, a user simply points the unit at the light source for calibration, then at the plant for data collection; physical contact with the plant is not required
- **Range and field-of-view versatility:** The instrument can analyze a single leaf at 18 inches, an entire tree at 20 yards, and could modified for use in remote sensing from aircraft
- **Low cost:** The device can be inexpensively manufactured, uses commercially available components
- **Adaptable:** The device can analyze any type of broad needle leaf
- **Fast:** No adaptation period is required, a reading can be completed in a few seconds
- **Accurate:** Regression analysis of an instrument reading vs. extracted chlorophyll content results in excellent statistical correlation (R2 > 0.9)

technology solution

## THE TECHNOLOGY

The technology developed is a hand-held unit, which by determining the plant's chlorophyll content, detects plant stress. When plants are suffering from physiological stress, leaf chlorophyll content will decrease. Stennis' technology analyzes light reflected from plants, which can be correlated to chlorophyll content and, consequently, the level of plant stress. NASA's reflectance based plant stress detection technology differs significantly from existing transmittance-and fluorescence-based systems. Transmittance-based systems measure the percent of light transmitted through the leaf, and this requires physical contact with the plant and time for the plant to adjust to being covered by the instrument. Fluorescence-based systems measure how much far-red or near-infrared light is re-emitted by the plant-as chlorophyll decreases, fluorescence increases. This method, however, requires that the leaf be irradiated only with short wavelength light (e.g. blue or green light), which may not be practical in field tests.

This NASA-developed hand-held chlorophyll content meter, uses a unique algorithm to combine the radiance from a plant and reference radiance, to then compute a numeric indication of the stress level in the plant. Two optical filters in this hand-held device measure the reference radiance and radiance from the plant. The ratio indicates the level of stress in the plant sample. To acquire the measurements, incident light enters the instrument through a lens, is split into two beams-one passes through an infrared bandpass filter and the other through a red bandpass filter (the two optical filters), and then onto a photodetector. Photodiodes digitize the output and relay it to a microprocessor to compute the reading of plant stress. This reading is displayed on an LCD display for the user to interpret plant conditions. The instrument is operated in the following procedure: readings are first taken with the instrument aimed at a standard reflectance target; next, readings are taken with the instrument aimed at the plants of interest. The primary innovative aspects of this device are (1) the plant stress detection processing algorithm and (2) the hand-held size of the system.

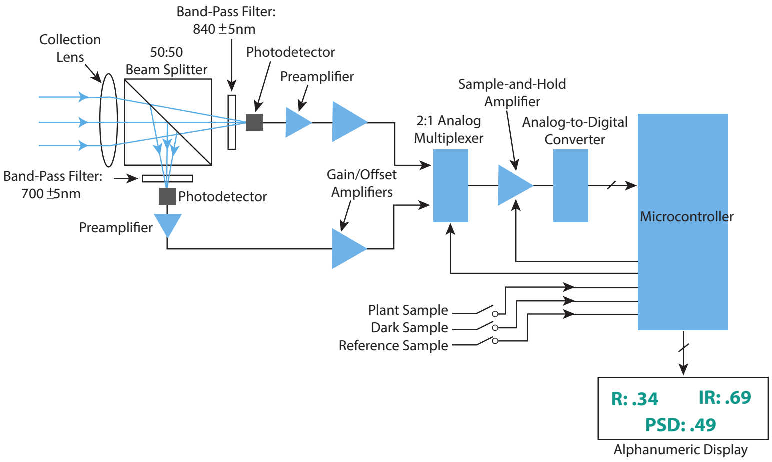


FIGURE – Schematic diagram of meter device, from original invention embodiment.

## APPLICATIONS

This technology could be used in Agriculture, Precision Farming, Horticulture, and Plant Research to accomplish a variety of objectives:

**Promote healthier and more productive plants:** Detecting pre-visual plant stress provides an opportunity to identify and reverse the effects of drought, chemicals, pests, or other negative influences, and encourages the cultivation of healthier plants, forests and farms

**Reduce chemical expenses and environmental concerns:** Monitoring plant stress can help prevent the excessive use of agricultural chemicals and reduce associated groundwater contamination

**Monitor the physiological effects of plant stress:** University, government, and industry laboratories could use the instrument to research how leaf chlorophyll content is affect by nutrient, biological influences, herbicides and other environmental impacts

## PUBLICATIONS

U.S. Patent No. 6,020,587

**More Information**

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