Measuring Plant Health with Sensors

An important aspect of plant breeding is to carefully evaluate the health and vigor of lines within the program. Plant breeders have always taken careful notes about the behavior and performance of lines in various conditions. Most of these observations have been subjective observations that tend to improve with experience, but sometimes difficult to communicate within or between programs. In the last decade there has been a technological revolution in plant breeding in which more plant breeders are using sensors to describe plant temperatures, greenness, leaf area, plant height, and many other traits. These sensors can be hand-held, mounted on ground controlled vehicles and now most frequently attached to drones which fly over fields collecting mega-bytes of data related to plant health and development.

Canopy temperature: infrared thermometers can detect differences among plants for leaf temperature. Elevated leaf temperature can indicate that a plant is suffering from moisture deficit stress; is infected by a disease, particularly vascular diseases or nematodes; infested with insect pests; or maturing at different rate than other plants.

Red-Green-Blue (RGB): these types of sensors can be used to detect differences in leaf area and greenness, identification of fruiting forms; and detection of plant stress. These sensors have been particularly helpful in differentiating lines with higher levels of drought and salt tolerance, estimating yield, and classification of lines according to seedling vigor.

Normalized Differential Vegetative Index (NDVI): this device measures the greenness within a specified area. This allows plant breeders to have an objective number associated with seedling vigor, stress tolerance, and overall plant health. One of the earliest and most valuable uses of NDVI developed at Oklahoma State University was the ability to determine nitrogen fertilizer needs of winter wheat. If the wheat had a low NDVI measure, it was recommended that additional fertilizer applications be made on the crop. This has resulted in substantial improvements in nitrogen management in wheat.

Chlorophyll meters: these devices do not directly measure the number of chlorophyll organelles within a plant cell, rather they derive an estimate of chlorophyll content based on the degree of green color within a leaf sample. The darker green color indicates a higher saturation of chlorophyll. High chlorophyll numbers allow the plant to convert a large amount of solar energy into energy for plant growth and development, which usually translates into high yielding crops. Plant breeders want to identify plants within their breeding programs that have a high likelihood of having high amounts of chlorophyll.

Exercise:

1. Depending upon which type of sensor is available, scan plants that have obvious differences in stress either from lack of soil moisture, nutrient deficiency, or some other type of stressor.
2. If more than one sensor is available compare the differences in values among the plants and plot them in a regression plot. If only one sensor is available, have students develop a visual rating system and create a regression between the sensor data and the visual rating for each plant.

Discussion:

1. Why do plant breeders use sensors to evaluate plant health?
2. What type of information can sensors tell plant breeders about their plants?
3. How can sensors be carried across a field in order to scan plants?