ILLINOIS

Field Monitoring of Crop Photosynthesis and Respiration

By Steven E. Hollinger

Plants use the sun's energy to fix C through photosynthesis, the process essential to the production of economic crop yield. At the same time plants are fixing C, they are transpiring and losing water through their open stomata. The water lost by transpiration results in drying of the soil. When the soil becomes too dry to maintain the transpiration required to meet evaporative demand of the atmosphere, the stomata close and the rate of photosynthesis decreases.

Recent advances in technology should allow simultaneous measurement of factors such as weather, carbon (C), water and energy fluxes which will aid the understanding of effects of various management practices on crop growth and yield.

Much effort has been put into research to determine when canopy photosynthesis begins to shut down due to a water shortage. Researchers in the past have placed shelters over several corn plants to measure the rate of photosynthesis during the day. However, these shelters could stay over the plants only a short period of time before the environment in the shelter would become unfavorable for photosynthesis and the plants would stop fixing C. High labor requirements limited the number of measurements that could be taken, and the experiments were limited to short time periods when canopies were fully developed.

Recent technology advances have provided the tools needed to continuously monitor carbon dioxide (CO_2), water vapor, and energy exchange in plant canopies. The new tools include a three-dimensional sonic anemometer and an open path infrared gas analyzer. The three-dimensional sonic anemometer measures the vertical and horizontal components of the wind, and the infrared gas analyzer measures the concentration of the C and water vapor in the air.

Infrared light from a regulated light source is detected by sensors that measure the light from the source after it has passed through a column of air with a known path length. If the vertical wind direction is away from the surface of the canopy and the CO_2 concentration is lower than when the vertical wind direction is toward the canopy, then CO_2 is moving toward the canopy from the atmosphere. This would indicate that the canopy is removing CO_2 from the air...photosynthesis is occurring. If the CO_2 concentrations in air parcels moving away from the canopy are higher than air parcels moving towards the canopy, then the canopy is releasing C to the air by respiration.

The advantage of these new instruments is that they are designed for continuous measurements of CO_2, water and energy fluxes in the field.

In addition to the sonic anemometer and the infrared gas analyzer, instruments are available which measure global radiation, net radiation, incoming and outgoing photosynthetic radiation, air temperature, humidity, soil temperature, soil moisture, and soil evaporation at the site. These instruments provide the additional weather data needed to analyze the response of CO_2 and water vapor fluxes to temperature and water stresses.

While the main purpose of the observations is to understand the effects of crops on the weather, we are able to use the same instruments to monitor the response of the crops to weather.

For example, daily total photosynthesis and respiration were measured for a no-till corn field in Illinois in 1997. The measurements showed that from June 20 to July 31, photosynthesis was closely coupled with net radiation (sunlight). Prior to this period, the canopy was not developed to the point of making leaves compete with one another for light. After this period, soil moisture appeared to be more limiting than net radiation, even though the crop showed no visible signs of moisture stress. These measurements can increase understanding of yield limiting factors and have exciting potential for guiding the development of higher yielding cropping systems.

Farming is the art and science of managing the soil and crops to optimize photosynthesis and conversion of sugars to produce an economic yield. While each individual plant contributes to yield, photosynthesis occurs in a community of plants. The new technology described here allows the simultaneous measurement of weather and C, water and energy fluxes which will aid in the understanding of how different management practices affect crop growth and yield.

Instruments installed in fields with different soil fertility levels or treatments will demonstrate how fertility contributes to photosynthesis and respiration, and ultimately final yield, in different weather environments. BC

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Satellite Imagery… *(continued from page 22)*

information system (GIS) or desktop mapping program that has a high graphical interface.

The frequency of satellite shots depends on the crop type and how intensely the crop needs to be monitored. For high value, sensitive crops such as potatoes, weekly monitoring may be required. Otherwise, once or twice a season may be adequate. The cost of satellite image maps can range from 10 to 60 cents per acre depending on the number of fields in the image. Township sized images (6 miles x 6 miles) are available from SPOT.

Satellites are capable of photographing the same area every 1 to 6 days. Turnaround time from the date the shot was taken to when it is in the crop scout's hands can be about three days. Without time constraints, it will be 7 to 10 days.

Satellite imagery at a glance:

- Map field boundaries
- Identify crop stress
- Merge with other geo-referenced data to create a spatial database
- Latitude and longitude provide in-field accuracy. BC

Mr. Nichols is with SPOT Image, Reston, Virginia, and Edwardsville, Illinois.