Short Report

Portable Equipment for Measuring Three Dimensional Information of Crop Canopy Using a Magnetic Field Sensor*

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作物群落構造の簡易計測装置*：芝山道郎・佐藤恵一**・岡本勝男・秋山 侃

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Crop canopy structures, such as leaf position and orientation have been considered to be important in relation to their light-intercepting efficiency. Udagawa et al.⁶⁾ utilized the silhouette method that determined corn leaf distribution by measuring the heights and positions of 3 points on the leaf. Kawashima^{2,3)} measured the angle of soybean leaf inclination using a tool consisting of a protractor and a weight attached to the former by a thread, and developed a method to draw a figure showing the direction and the altitude of the normal on the leaf surface. However, an adequate method instead of taking measurements with a rule or a protractor is needed to shorten measurement time and increase the number of plants to be measured.

A 3-dimensional digitizer system for detecting position and orientation of plant parts was devised by the authors using an easily obtainable magnetic field sensor^{1,5)} and microcomputer which were mounted on a small handcart for portable usage outdoors.

Materials and Methods

1. Equipment

The magnetic field sensor, source and electronics unit are the products of McDonnell Douglas Electronics Company, Colchester, Vermont, U.S.A. (type : 3SPACE ISOTRAK) and imported by Nisshoh Electronics Corp., Tokyo. As the data logger, a lap top type

microcomputer, PC98-LT (NEC) is connected to the electronics unit through the medium of an interface and remote control unit made by Kokusai Gijutsu Kaihatsu Corp., in Tokyo. A two-wheel handcart was reformed to load the units on, and to mount a power cable of 20 m long that was wound by a drum. The photograph of the system is presented in Fig. 1.

The magnetic field sensor utilizes low-frequency magnetic field technology to deter-

Fig. 1. The portable 3-dimensional digitizer for field use.

A, Microcomputer ; B, Electronics unit ;
C, Remote controller ; D, Sensor ; E,
Interface unit ; F, Source.

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mine the position and orientation of the sensor in relation to the source, providing a full six degree-of-freedom measurement⁴⁾. The static accuracy is 3 mm r.m.s. in position, and 0.85° r.m.s. in angle. Operation with source to sensor separations up to 1.5 m is possible⁴⁾.

The digitizer is operated by the hand-held remote controller, and the information is transmitted to the microcomputer and logged into a three and a half inch floppy disk.

2. Method of measurement and the computer program

It is rather timeconsuming to detect complete 3-dimensional information for whole plants in the fields even if one can utilize this digitizer. For a practical simplification, the authors detected only the position and orientation of each leaf. The operator touches on the leaf surface with the sensor that should be held parallel to the midrib, then push the trigger button on the remote controller (Fig. 2). The position (x, y, z.), azimuth (yaw), elevation (pitch) and inclination (roll) of the leaf are simultaneously transmitted to the computer in an instant. The computer program is written in BASIC under MS-DOS.

3. Plant materials and sample measurements

Soybean plants (*Glycine max* Merr.) were used for the tests because their round-shaped dicotyledonous leaflets are suitable for our method and detecting leaf orientation-

Fig. 2. Field measurement using the portable 3-dimensional digitizer.
A, Remote controller ; B, Sensor.

Fig. 3. Diurnal changes of leaflet pitch angles of three soybean cultivars (top) and solar radiation ($\text{Jm}^{-2}\text{s}^{-1}$) (bottom).

adjusting movement²⁾ would be a good demonstration of the equipment.

Measurement was undertaken from 0500JST to 1900JST at one hour intervals on 1 Sep., 1988, for 3 plants each of cultivars Tachinagaha, Enrei and Horei in their blooming stages. They were grown in an experimental field of National Agriculture Research Center (NARC), Tsukuba.

Near by the bottom of each plant, a wooden mount was settled on the ground to set the source horizontally and the y-axis being in parallel to the meridian. One compound leaf each was selected from upper, middle and lower leaf layers and marked with paint. It took one minute to measure the 3 compound leaves of a plant with 5 repetitions.

Results and Discussion

Diurnal patterns of pitch angles (°) of upper layer leaflets are shown in Fig. 4. Positive angle indicates the tip of the leaflet being higher than the petiole. Roll, yaw and x-y-z position data are not shown in this figure. The amount of solar radiation accumulated hourly ($\text{Jm}^{-2}\text{s}^{-1}$) is also plotted at the bottom of the figure. The pitch angles decreased before dawn, then increased from the daybreak to the midday and decreased in the late afternoon. The solar radiation fell off during 1200 through 1300JST due to cloud cover. The pitch angles of the leaflets of cultivars Enrei and Horei dipped at 1300JST, but Tachinagaha's did not. The test measurements data

indicate that the digitizer system is useful for field comparative studies of crops or cultivars in their leaf orientation-adjusting movement as well as in canopy structures, in relation to environmental and physiological conditions.

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