SHORT COMMUNICATION

AN INVESTIGATION ON THE UTILITY OF THE SUNSCAN CEPTOMETER IN ESTIMATING THE LEAF AREA INDEX OF A SUGARCANE CANOPY

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Abstract

The usefulness of the SunScan ceptometer in estimating the leaf area index (LAI) of a sugarcane crop canopy was investigated. This was determined by making LAI measurements with the instrument at selected points in the field, followed by destructive sampling at the same points. The two sets of data were then compared. Measurements of LAI were also taken at one point of the field at various times of day in order to determine the effect of time of sampling on the results. The SunScan ceptometer gave LAI estimates which were 95%±2% of the value that was obtained by destructive sampling. It thus appears to be useful in measuring LAI in a sugarcane crop. Measurements of LAI at different times of day showed that the best results are obtained around solar noon.

Key words: leaf area index, sugarcane, SunScan ceptometer

Introduction

Background

Leaf area index (LAI) is an important biophysical parameter of crops (Steduto and Hsiao, 1998). It is defined as the area of leaves per unit area of ground taking one side of each leaf into account (Monteith and Unsworth, 1990). A number of methods for measuring leaf area index have been developed, and can be classified as destructive and non-destructive methods (Kopec *et al*, 1987; Warren-Wilson and Reeve, 1959). Destructive methods involve physical disturbance of the canopy, while non-destructive methods do not. Thus, non-destructive methods can be used to monitor the growth of plants, as measurements of LAI can be made a number of times throughout the season. They enable comparisons to be made between different canopies of similar architecture (for example, trial plots of different cultivars of the same species or irrigation trial plots).

In this research the focus was on one non-destructive method, the use of the SunScan ceptometer.

Objectives

The objective of this research was to establish the suitability and accuracy of the SunScan ceptometer in measuring the leaf area index of a sugarcane canopy.

The SunScan ceptometer

Indirect methods for LAI measurement based on the transmittance of radiation through the vegetation have been developed. Lang *et al.* (1991) used the transmittance of the direct beam of the sun to determine the surface area index of *Pinus radiata* L. Lang and McMurtrie (1992) applied a similar procedure to determine total leaf area of single trees of *Eucalyptus grandis* L. An alternative method, which uses a fisheye light sensor that measures diffuse radiation simultaneously in five distinct angular bands, has been used in different agricultural crops (Welles and Norman, 1991) and is commercially available. Hemispherical photographs have been used to calculate LAI (e.g. Bonhomme and Chartier, 1972). The SunScan ceptometer, which simultaneously measures the photosynthetically active radiation incident at the top of a crop canopy and at the bottom, has also been used to measure LAI (e.g. Lambert *et al,* 1999). These methods have shown good performance for homogeneous canopies, but important errors are common when there are large gaps within the vegetation (e.g. developing row crops, tree plantations) or when the leaves are not arranged randomly (Lang *et al,* 1991). For instance, Grantz *et al*. (1993) have reported an underestimation of LAI of cotton (*Gossypium barbadense* L.) when using the Plant Canopy Analyzer (PCA).

Canopy type and LAI estimates

Some types of canopy do not conform well to the assumptions about canopy structure used by the SunScan in calculating LAI (Potter *et al,* 1996). Canopies for which the use of the SunScan gives the best results are those which are low and uniform (e.g. cereal crops) (Potter *et al,* 1996). In principle, high, uniform canopies which are not clumped are good for LAI measurements, but give practical problems for the above-canopy reference to be measured with the beam fraction sensor. If long cables to connect the beam fraction sensor to the data collection terminal are available, the beam fraction sensor can be placed outside the crop whose leaf area index is to be determined. With low, regular crops which are not uniform (e.g. row crops) absolute LAI values are dubious although the values obtained may show valid trends (Potter *et al,* 1996). Any other types of canopy do not give good results when a SunScan is used.

Materials and Methods

In pursuance of the objectives stated earlier, two field campaigns were launched. These experiments were done in two sugarcane plots at the Zimbabwe Sugar Association Experiment Station. The first plot was called Z4 while the second was called D1. A brief description of each plot is given below, as this has a bearing on the interpretation of results.

The sugarcane variety on the Z4 plot was NCo376 and when the experiment was done the height of the crop was about 2.5 m high. The crop had been well fertilised and was supplied with adequate water. The spacing between rows of sugarcane plants was 1.5 m, with ridges between the rows of plants. The plants were grown in furrows, as furrow irrigation was used.

The D1 plot also had an NCo376 sugarcane crop. This was a ratoon, and the height of the crop when the experiment was done was about 1.0 m. The inter-row spacing was 1.5 m and the crop was furrow irrigated. A visual assessment suggested that there was greater variability in LAI in this plot than in the Z4 plot.

Measurements to determine the accuracy of the SunScan ceptometer were taken. This was done by first measuring LAI at a number of points and heights using the SunScan ceptometer, followed by destructive sampling at the same points and heights to determine LAI. Details of these measurements are given below.

LAI measurements with the SunScan ceptometer

In order to measure LAI at a given point and at a certain height, a wooden support of the height at which LAI was to be determined was stuck into the ridge. Leaf area index measurements were then made on either side of the ridge with the SunScan probe resting on the wooden support. Figure 1 illustrates how the measurements were made. This was done so as to obtain a good spatially averaged LAI. Care was taken to ensure that whenever readings were taken the SunScan probe was level. Following this procedure, measurements of LAI were made at heights of 12 and 50 cm in the D1 plot, and in the Z4 plot measurements were done at heights of 12, 50 and 150 cm. After making LAI measurements at a number of points in the plots with the SunScan ceptometer, LAIs were determined at the same points by destructive sampling.

Variation of LAI with time

Measurements were taken to establish the effect of time of sampling on the accuracy of the values of LAI given by the SunScan ceptometer. This was done by making measurements of LAI at a given point at hourly intervals from 10h00 to 17h00. Destructive sampling was then done at the same point the following day in order to determine the actual LAI. The above procedure was done at two points on the same plot, but at different heights. The measurements on the two points were made on different days.

Results and Discussion

Variation of LAI with time

The results obtained show that LAI readings are lowest around solar noon and higher readings are obtained when measurements are made either late in the afternoon or early in the morning. This observation is in agreement with advice from the manufacturers of the instrument, who recommend that measurements be made within three hours of solar noon and preferably at zenith angles not more than 60° (Wood, 1996).

Accuracy of SunScan LAI estimates

Figure 1 shows the relationship between measurements of LAI made by the SunScan ceptometer and those obtained by the destructive sampling method. There is a high correlation between the readings. Regression statistics (see Figure 1) show that, on average, the SunScan ceptometer gave readings which were 95%±2% of the value that was obtained by the destructive method.

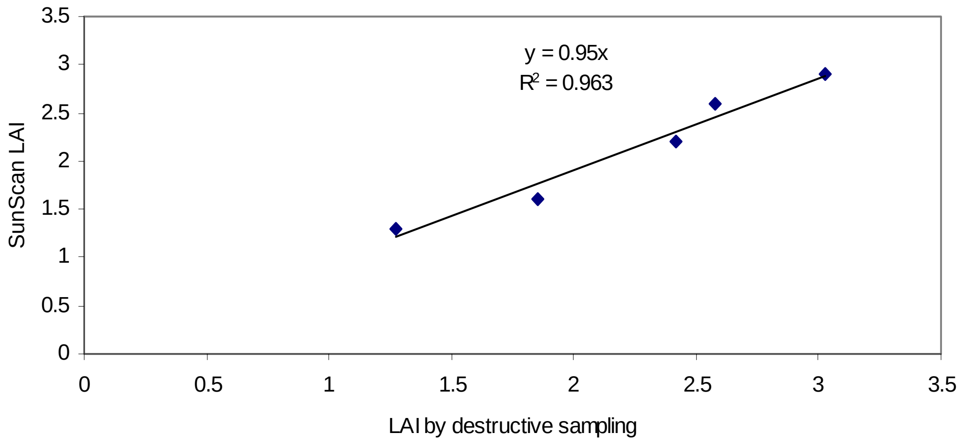

Figure 1. Relationship between Sunscan LAI values and values obtained by destructive sampling.

Conclusion

Results obtained in the experiment show that the SunScan ceptometer can give LAI estimates that are within 90-100% (with a mean of 95%±2%) of the value that would be obtained by destructive sampling. For most practical purposes, this level of accuracy should be adequate. The best results in terms of accuracy and consistency when using the SunScan ceptometer are obtained when measurements are made around solar noon. At any given point in a row, it is important to take two sets of readings, one in each half of the inter-row space, so as to get a good spatial average. About 5-10 readings for each set should be adequate. The average of the two sets (assuming there are equal numbers in each set) gives the LAI at that point.

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