

# Development of Simple Techniques for Rapid Leaf Area Measurement in Cotton

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## Introduction

The ongoing development and adoption of decision support tools within the Australian cotton industry has led to the need for refinement of several crop data collection techniques. Present and future applications of the crop growth simulation model OZCOT (Hearn, 1994), whole farm water use efficiency calculator (Tennakoon and Milroy, 2000), and the crop water management tool HydroLOGIC will be greatly enhanced by updates of crop status and development entered throughout the season. One of those needed is crop leaf area, which will help to improve estimates of evapotranspiration of moisture from the soil and crop. Leaf area of the crop is often referred to as the leaf area index (LAI), which represents the leaf area of the crop above a known area of ground surface. This paper presents the results of initial studies comparing a range of simple methodologies that could be used by cotton managers to obtain estimates of LAI throughout the cotton season.

## Materials and Methods

The two experimental sites were established at the Australian Cotton Research Institute, Narrabri, NSW in October 2001. Each site was sown with a single variety that varied in leaf type (Sicot 289*i*, normal leaf; Siokra V-16*i*, okra leaf). The irrigated crops were grown and managed under normal cultural conditions.

From November, a range of different measurements were taken within three random 1 m<sup>2</sup> locations at each site. Measurements were taken on six occasions throughout the whole season. Within each 1 metre section the measurements were (Plate 1):

- Crop height (cm) – ground level to growing tip of main stem of all plants.
- Canopy width (cm) – the exact width of the canopy perpendicular to the ground (five measurements per m).
- Light interception by the crop was estimated using a 1 metre long checked ruler, with alternating black and white 1 cm squares (three measurements per m). Canopy interception percentage was estimated by counting the number of shaded 1cm squares compared to the total area of the ruler.
- Light interception was also measured with a ceptometer (light meter), providing an accurate estimate of canopy interception for comparison with other measures.
- A photo, using a digital camera placed at a fixed height overhead and along the plant row.

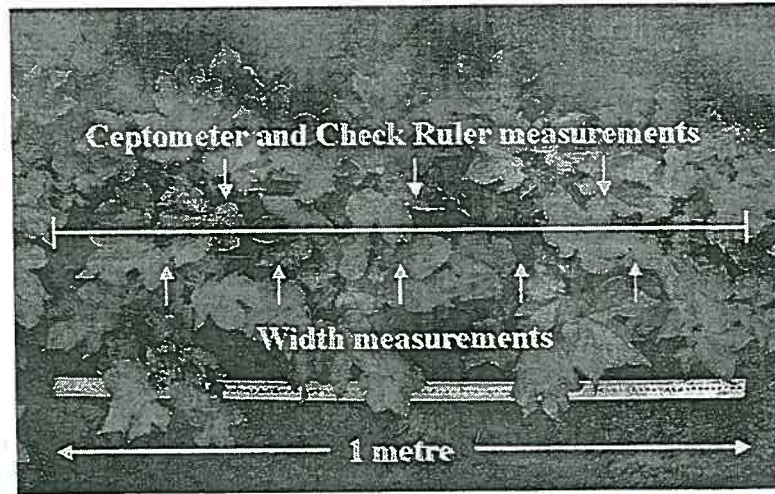


Plate 1. Measurement positions within the plant row during 2001-02 season.

Following these measurements each 1 metre section of row was harvested at ground level, and partitioned into leaf and stem (including fruit). Following partitioning, the leaf area ( $\text{cm}^2$ ) was measured accurately using a LICOR leaf area planimeter. The leaf area was then converted to LAI. Data for each type of methodology was related to the actual LAI measured to compare their ability to estimate LAI. The digital photos taken in this season will be collated to produce a photo guide with corresponding measured LAI. This guide will then be tested for LAI estimation in the 2002/2003 season.

## Results and Discussion

Both varieties exhibited similar leaf area development, although the normal leaf variety developed a higher leaf area faster due to greater individual leaf area. Leaf development during the season may have been reduced initially due to cold weather during the October-November period, but recovered well during December. Maximum recorded leaf area index was achieved in the normal leaf variety at 107 DAS (2.77) and 145 DAS (2.46) in the okra leaf variety. Ceptometer readings revealed differences in interception development between the normal and okra leaf varieties, although by 90 and 110 days after sowing (mid-January) at least 80% of the incident solar radiation was being intercepted by both varieties (Figure 1).

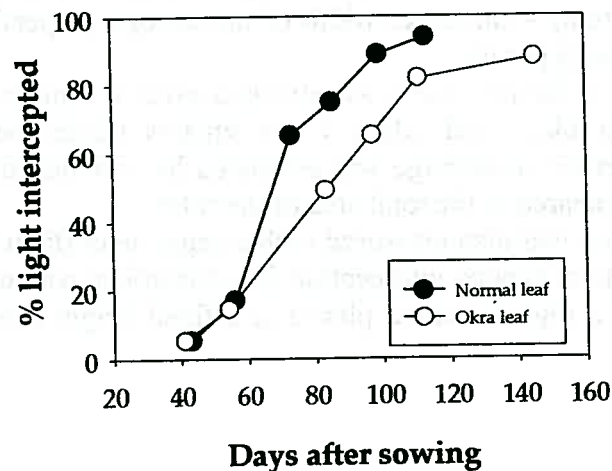


Figure 1. Light interception measured by ceptometer of the two varieties (Sicot 289*i*, normal; Siokra V-16*i*, okra) in 2001/2002 season.

Crop heights showed a steady increase to a maximum of 70-75cm in both trials, with canopy width growing to 80cm (normal) and 90cm (okra) (Figure 2). The patterns and relationship between plant height, canopy width and leaf area index were similar between the two varieties and generally linear in their response.

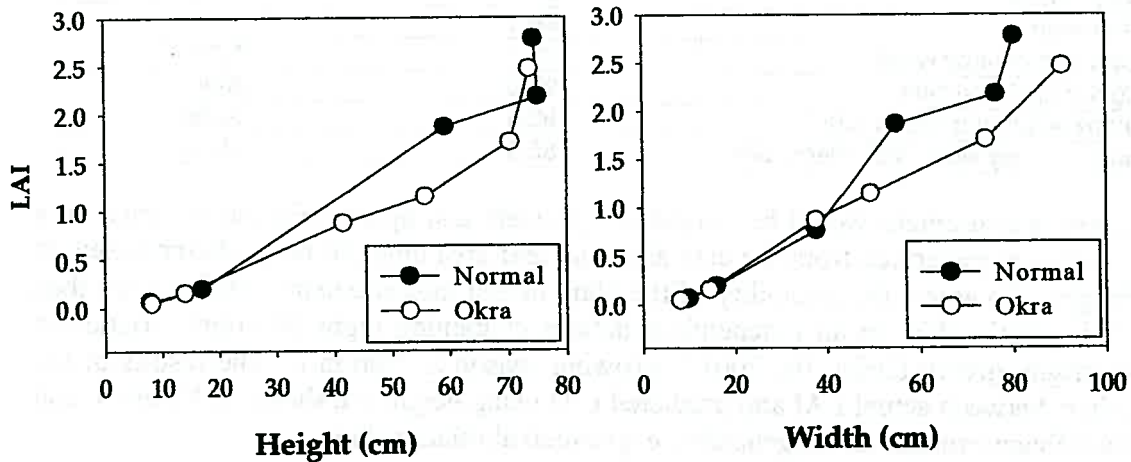


Figure 2. Crop height and canopy width development comparison with leaf area index.

Comparisons between the two light interception techniques revealed remarkable accuracy in the check ruler. However, in both varieties the checked ruler interception results were consistently below the more accurate ceptometer readings (Figure 3).

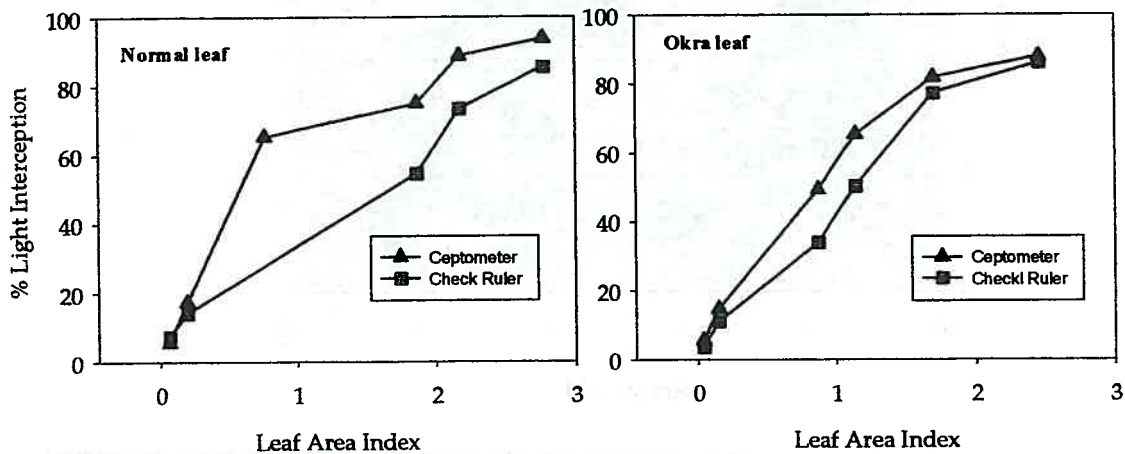


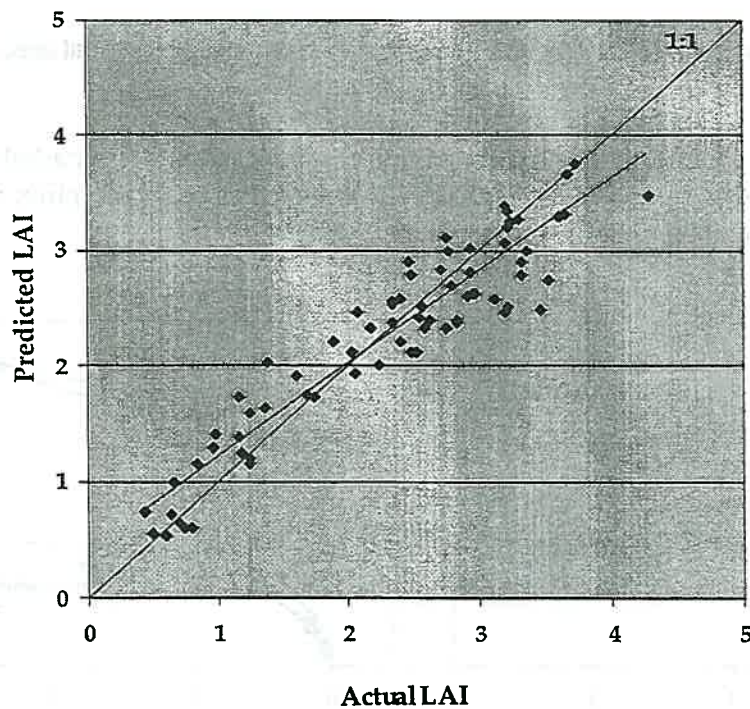
Figure 3. Comparison between light interception measured by ceptometer and checked ruler.

Statistical analysis on the correlation between measurement technique and LAI shows how closely related a particular parameter is to the measured LAI, where 100% indicates perfect correspondence. Analysis showed that the simple measurement of crop height was able to account for 91 percent (%) of the variation in measured leaf area (Table 1). Individually, the canopy width and checked ruler techniques were able to improve this percentage to 94 percent (%) of the variation. However, combining several techniques did not significantly improve the correlation with the measured leaf area index values.

**Table 1.** Statistical analysis results for each measurement technique, where the correlation coefficients ( $R^2$ ) are for the regression of each measurement (x) with LAI (y).

Measurement technique	Percentage of variation explained ( $R^2$ )	Statistical improvement ( $P < 0.05$ )
Height	91.4	
Canopy width	93.6	
Check ruler	94.1	
Height and canopy width	93.1	None
Height and check ruler	93.0	None
Canopy width and check ruler	92.6	None
Height, canopy width and check ruler	85.0	None

The height measurement would be simple for growers and agronomists to conduct, so a relationship was generated from the data allowing leaf area index to be predicted based on plant height. To assess the flexibility of the plant height measurement technique, we then tested this relationship on an independent dataset containing eight different varieties of diverse origin, grown during the 2001-2 growing season at Narrabri. The results of the comparison between actual LAI and predicted LAI using height are shown in Figure 4, and show significant promise in the generated experimental relationship.



**Figure 4.** Independent assessment of height relationship for predicting leaf area index, compared to actual leaf area index for 8 cultivars ( $LAI = 0.03470 \times \text{Height} - 0.0352$ ,  $R^2 = 0.914$ ,  $P < 0.001$ ).

### Conclusion

The results from the 2001-02 trial and the correlations using the height relationship, indicates that the measurement of plant height at several locations within a field could be used to estimate plant leaf area index. The ability to input LAI into crop simulation models, such as OZCOT and HydroLOGIC, will enable more accurate simulation of evapotranspiration and ultimately plant growth. Work is continuing to assess and evaluate these methods further.

**References:**

Hearn, A.B. (1994). OZCOT: A simulation model for cotton crop management. *Agricultural Systems*, 44: 257-299.

Tennakoon, S.B., and Milroy, S.P. (2000). *Managing water use efficiency on farms*. Proceedings of the 10<sup>th</sup> Australian Cotton Conference, Brisbane, Australia, August 2000.

The first of these is the 'Cultural Revolution' which began in 1966 and lasted until 1976. It was a period of intense political and social upheaval, during which the Chinese government sought to eliminate the influence of traditional Chinese culture and to create a new, 'revolutionary' culture. This led to the destruction of many ancient buildings and the persecution of intellectuals and artists.

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