ESTIMATING LEAF WETNESS DURATION ON A COTTON CROP FROM METEOROLOGICAL DATA

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Introduction

Leaf wetness duration (LWD), promoted by dew, rainfall, fog, or irrigation, is one of the most important factors influencing plant diseases, both their outbreak and severity (HUBER & GILLESPIE, 1992; KIM et al., 2002). Free water over the plant tissue has an important role during many epidemiological processes, mainly affecting infection and sporulation (HUBER & GILLESPIE, 1992). In the cotton crop, LWD and temperature are responsible for the occurrence of several important diseases in the Southeast and Central-West Regions of Brazil (MONTEIRO, 2002).

Measurement of leaf wetness is often difficult (GILLESPIE & KIDD, 1978), even with the automatic sensors which were developed over the last 35 years. According to KIM et al. (2002) the use of LWD automatic sensors and data-loggers is unattractive to many growers because of the difficulties to install, maintain, and manipulate them, as also described by MONTEIRO el al. (2002). In addition to this fact, the majority of official weather stations networks do not have LWD sensors available. So this variable must be estimated when the purpose is to use a weather-based plant-disease management scheme.

The development of methods to estimate LWD has been the subject of several papers. Many of them are discussed by HUBER & GILLESPIE (1992). They range from the simple empirical methods, based on one variable like relative humidity, to the most complex, based on the physical aspects of the dew deposition and evaporation as presented by PEDRO JR. & GILLESPIE (1982) and RAO et al. (1998), which used respectively the energy balance and aerodynamic resistance approaches.

The objectives of the present study were to use and compare four different models to estimate wetness duration on cotton leaves, using 15 min data from an automatic weather station installed inside the crop area, and also to show the differences between the LWD measured at 1.7m in the weather station, and close to the plants.

Material and methods

The field experiment was carried out during the summer of 2001/02, from December to March, in an area cultivated with two cultivars of cotton crop (IAC23 and Coodetec) in Piracicaba, State of São Paulo, Brazil (Lat.: 22°42'S, Long.: 47°30'W, Alt.: 546masl).

An automatic weather station was installed inside the crop area, where the following meteorological variables were measured at 1.7m: air temperature and relative humidity, net radiation, wind, rainfall, and LWD (Model 237 – Campbell Sci., painted with two coats of white latex and angled at 20°). Six micro-stations were installed close to the crop, 3 for each cultivar, having sensors of air temperature, relative humidity, and painted LWD.

The weather station and the micro-stations were programmed to measure the variables each second and average them each 15 min using two automatic data acquisition systems (Campbell Scientific, Models CR10 and CR23X).

These meteorological data were used to estimate LWD according to the following methods:

a) Number of Hours with Relative Humidity above 90% (**NHRH>90%**);
b) Dew point depression (**DPD**) as suggested by GILLESPIE et al. (1993), using 2°C for onset and 3.8°C for drying;
c) Classification and Regression Tree (**CART**) model (GLEASON et al., 1994);
d) Aerodynamic Resistance (**RES**) model as presented by RAO et al. (1998).

The estimated and observed LWD data were compared by regression analysis (determination – R^2, and agreement – D coefficients) and by the evaluation of errors (mean error – ME, mean absolute error – MAE, and maximum error – MAX E).

Results and discussion

The relationships among the LWD data measured in the weather station and estimated by the four methods are presented in Figures 1 and 2. In general, all methods of LWD estimation performed quite well. For the DPD, CART and RES models an overestimation of around 2%, 6%, and 7% respectively was observed, whereas the NHRH>90% method showed an underestimation of 6%. This analysis resulted in high values of agreement index (D), indicating the accuracy of these methods (Table 1). However the precision (R^2) of the estimations was not as high, remaining between 0.75 and 0.90, and resulting in mean absolute errors between 1.27 and 2 hours. The method that showed the highest precision, NHRH>90%, presented the greatest maximum error, 4.75 hours, followed by DPD, RES and CART methods.

The first two methods, NHRH>90% and DPD, being empirical and of simple use, are a practical tool for estimation of LWD in the cotton crop where data of solar or net radiation are generally not available. These two simple methods based on temperature and relative humidity were as good as estimates from the other two complex methods, which require net radiation and/or wind speed data. This behavior was also observed by RAO et al. (1998) for the estimation of wetness duration on maize ears.

Comparing the LWD data obtained in the weather station with those observed close to the crop canopy, it was verified that a large difference existed between them, mainly for periods with less than 15 to 17h of dew (Figure 3). This shows that

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LWD must be measured or estimated site-specifically, or adjusted by empirical coefficients, as those given by the linear regression in Figure 4. For long wetness periods (LWD > 17h), normally promoted by rain, the differences are smaller both between the LWD measured in the crop and in the weather station, and among the sensors.

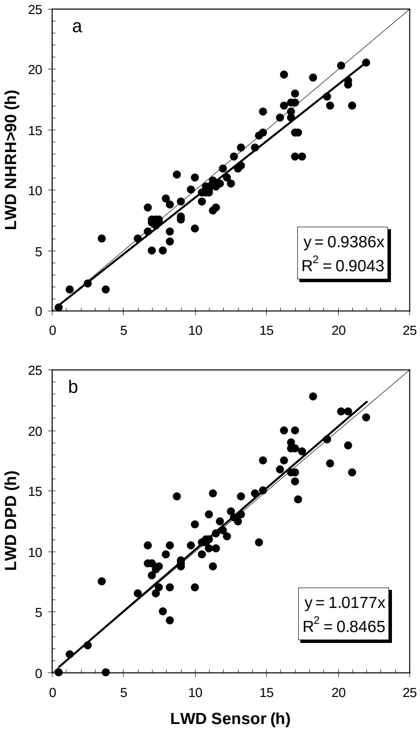

Figure 1. Relationship between LWD measured and estimated by the NHRH>90% (a), and DPD (b) methods, for meteorological data measured above a cotton crop.

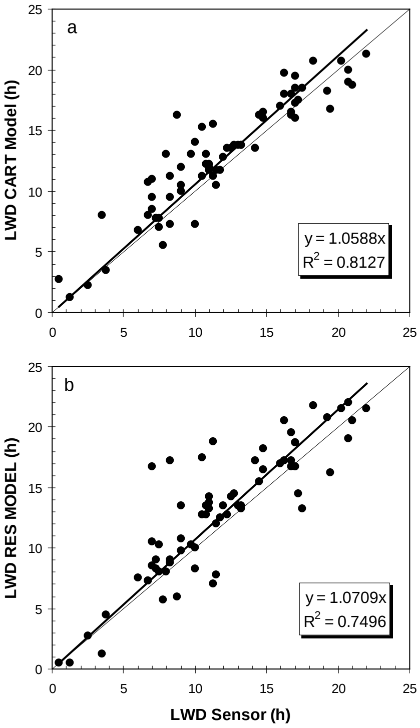

Figure 2. Relationship between LWD measured and estimated by the CART (a), and RES (b) methods, for meteorological data measured above a cotton crop.

Table 1. Regression analysis and errors related to the estimation of LWD by different methods from meteorological data.

Method	b	R^2	D	ME	MAE	MAX E
					(Hours)	
NHRH>90%	0.94	0.90	0.97	-0.70	1.27	4.75
DPD	1.02	0.85	0.96	0.32	1.54	4.50
CART	1.06	0.81	0.95	1.07	1.63	2.75
RES	1.07	0.75	0.92	1,11	2.00	4.25

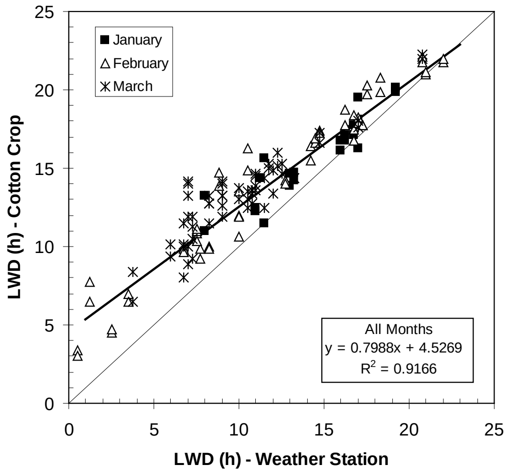

Figure 3. Relationship between LWD measured in the weather station and in the micro-stations, for the cotton crop. Each point for micro-stations is the average of 3 measurements points in each cultivar.

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