CANOPY TEMPERATURE DIFFERENCE (CTD) FOR DETECTING STRESS IN OIL PALM

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The plant canopy temperature provides a measure of the plant response to its environment and has been recognized as a sensitive indicator of plant water status (Jackson *et al*., 1981; Idso, 1982). The relationships between canopy temperature, air temperature and transpiration depend on atmospheric conditions (vapour pressure deficit, air temperature and wind velocity), the soil (mainly available soil moisture) and the plant (canopy size, canopy architecture and leaf adjustments to water deficit).

Plants regulate their leaf temperatures by varying stomatal aperture to adjust the amount of water that is transpired. The evaporation of water cools the leaf. This natural system works well if there is adequate water for evaporation, and if the plant has roots to draw sufficient water into its vascular network. Plant water deficit develops when the demand exceeds the supply of water. The demand for water is set by atmospheric conditions, mainly radiation, atmospheric vapour pressure deficit and wind.

Although leaf temperatures of well-watered plants are generally below air temperatures due to transpirational cooling, in oil palm, leaf temperatures during the day often exceed air temperature. Hong and Corley (1976) found that leaf temperatures of oil palm seedlings could be as much as 10°C above ambient. While the difference between air and leaf temperature (ΔT) in oil palm is highly dependent on radiation load and other atmospheric conditions, it can still serve as an indicator of soil water status (Henson, 1991) or of water uptake, making it a potentially powerful diagnostic tool for water stress as confirmed recently by continuous ΔT monitoring at a drought-prone site (Henson *et al*., 2005). Additionally, ΔT could also be used to detect infection by diseases, such as *Ganoderma*, that results in restrictions in stomatal conductance (Haniff *et al*., 2005).

OBJECTIVES

The main objective of this study was to develop a suitable CTD technique for measuring water stress in oil palm using a portable non-contact infrared thermometer. The detailed objectives were as follow:

- to study the relationships between oil palm CTD and stress conditions caused, *e.g.* by diseases or soil water deficits.
- to develop a suitable technique for rapidly evaluating CTD of individual palms.

MATERIALS AND METHODS

Study Sites

The work was conducted at two sites. The first was at a coastal site in Selangor, with 14-year-old healthy and *Ganoderma*-infected DxP palms. An area with about 200 palms was mapped and leaf temperature measurements taken from each palm. The second site, with 6-year-old DxP palms, was an inland site that was free from *Ganoderma* infection near Bangi, Selangor. About 35 palms were mapped and leaf temperatures taken from each palm. Both studies were done during a wet period to avoid soil water deficit.

Canopy Temperature Measurements

Leaf temperatures were measured with a non-contact infra-red thermometer (Raytek, USA). Air temperature was measured using a screened mercury bulb thermometer. All measurements were taken near noon and under clear-sky conditions. The difference between air and palm canopy temperatures (ΔT) was then calculated

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and used to plot thematic maps using the SurGe mapping software (Czech Republic) to show the distribution of stressed palms in the field.

Gas Exchange Measurements

Leaf gas exchange measurements were done on selected palms using a portable infra-red gas analyser (LI-6400, Licor, USA) at ambient conditions.

RESULTS AND DISCUSSION

Oil palm leaf temperatures were easily measured using the non-contact infra-red thermometer from the ground, regardless of the palm canopy height of more than 10 m. Stressed palms had higher ΔT values as compared to healthy palms since their transpiration rate was reduced. This was substantiated by the gas exchange measurements that show the relationships between ΔT, stomatal conductance and transpiration (*Figures 1* and *2*). The reduction in transpiration rate through regulation of stomata aperture subsequently led to an increase in ΔT value. ΔT was significantly increased ($p<0.05$) with severity of *Ganoderma*-infection that was determined visually such as by the production of multiple spears, frond skirting or *Ganoderma* fruiting bodies on the trunk (*Figure 3*).

A thematic map of the ΔT values for the coastal site clearly shows the distribution of diseased stressed palms (*Figure 4*). Although there was no soil water deficit, the *Ganoderma*-infected palms experienced a diminishing supply of water and

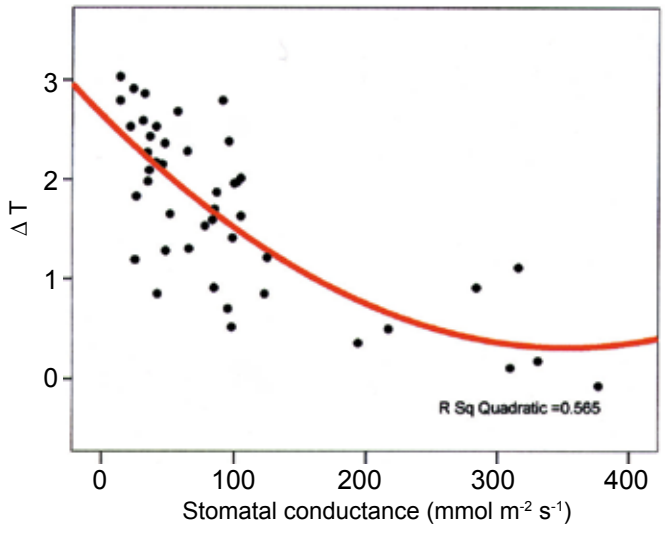

Figure 1. Relationship between ΔT and stomatal conductance in oil palm.

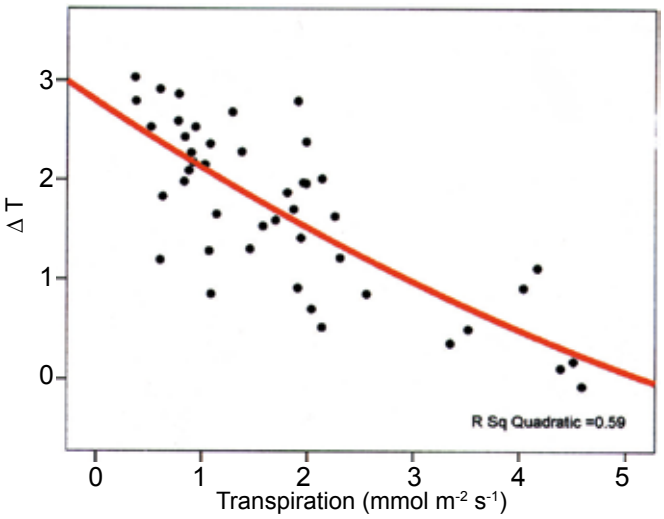

Figure 2. Relationship between ΔT and transpiration rate in oil palm.

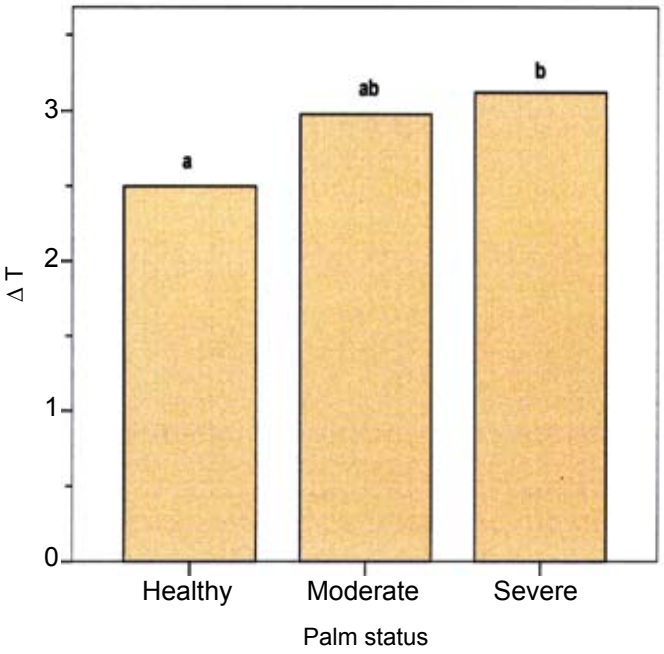

Figure 3. Significant difference in ΔT in healthy and Ganoderma-infected 14-year-old oil palm.

nutrients to the leaves due to tissue necrosis at the base of the stem that affected the vascular transport system. Therefore, the infected palms were under water stress and could be expected to have higher ΔT values than healthy palms. More data need to be gathered to ascertain whether this method can be used for the early detection of the disease.

The thematic map of the ΔT values for the inland site may indicate the distribution of stressed palms (*Figure 5*). Although the 6-year-old palms

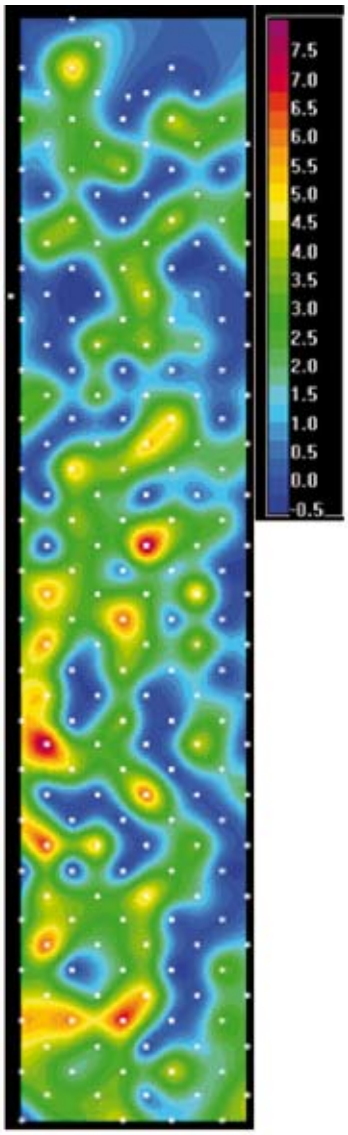

Figure 4. Thematic map of ΔT from a Ganoderma*-infected coastal site with 14-year-old DxP oil palms. The high ΔT values correspond with symptoms of multiple spears, lower frond skirting or* Ganoderma *fruiting bodies on the trunk.*

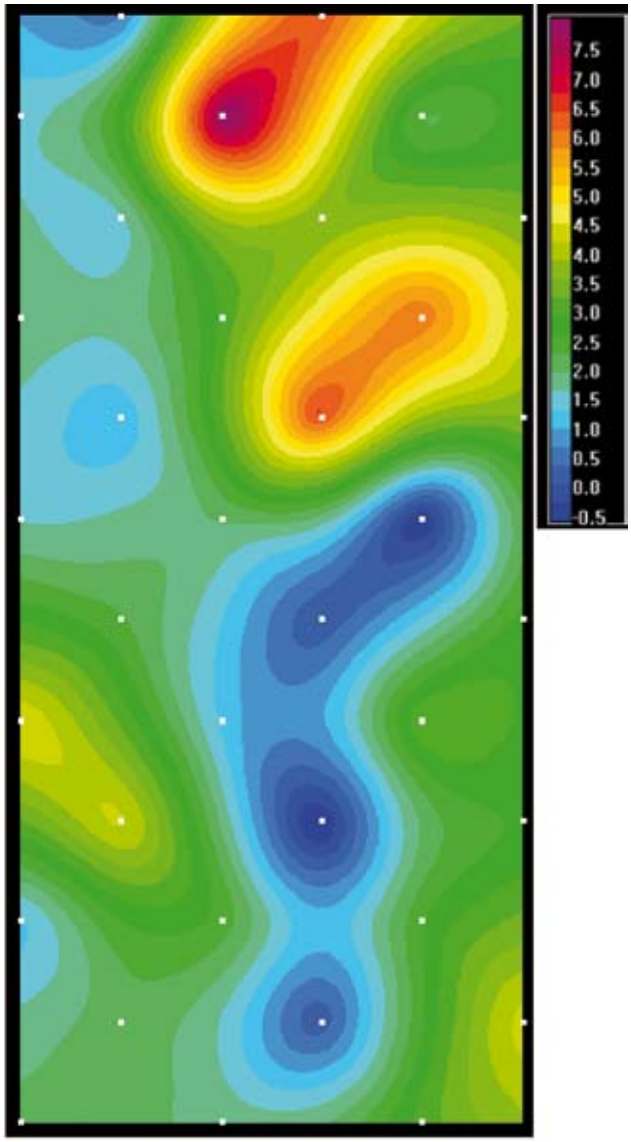

Figure 5. Thematic map of ΔT from an inland site with 6-year-old DxP oil palm. Palms under stress are indicated by the high ΔT values.

had uniform vegetative growth, the thematic map of ΔT values show that some palms experienced stress. This could have arisen from localized soil water deficits or other physiological factors that influenced transpiration.

The CTD method is a relative indicator, since solar radiation has a large effect on ΔT which also changes with location and time of day even under clear-sky conditions. It was assumed that the solar radiation at the time of measurement was constant.

CONCLUSION

The CTD technique can be used to identify stressed palms in the field. The stress can either be related to *Ganoderma* infection, localized soil water deficits or other physiological factors that affect transpiration. The CTD technique has the advantage of being simple and low cost. Thematic mapping of the ΔT values allows better evaluation of individual palm performance in a plantation so that appropriate remedial actions can be taken where possible.

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