MONITORING ON PLANT LEAF WATER POTENTIAL USING NIR SPECTROSCOPY FOR WATER STRESS MANAGEMENT

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ABSTRACT

The performance of the calibration model with temperature compensation for on-plant leaf water potential (LWP) determination in tomato plants was evaluated. During a cycle of water stress, the on-plant LWP measurement was conducted. The result showed that the LWP values under water stress and recovery from water stress could be monitored well. It showed that a real time monitoring of the LWP values using NIR spectroscopy could be possible.

Keywords: *water stress, real time monitoring of leaf water potential, NIR spectroscopy, plant response-based*

INTRODUCTIONS

In a protected cultivation, in order to increase the sugar content of tomato fruits, a water stress was applied. Several works have demonstrated that under the water stress condition, the tomato fruit was high in sugar and acid content. However, at the same time, the high blossom-end rot (BER) incidence and decreasing of yield was occurred. For this reason, an accurate irrigation control was highly desired to impose the proper water stress level.

In order to save labor and time, irrigation operations are often automated using timers, specialized controllers, or computer control (Bakker *et al*., 1995). Computer-controlled irrigation systems can utilize a range of data to achieve accurate delivery of water according to crop requirements. Automated control systems that use timers, supply-based measurements of water in the root zone (Hansen and Pasian, 1999), or demand-based model of expected water use do not attempt to measure the actual water status of the plants they serve (Prenger et al., 2002). A more accurate control system would use the plant’s status as a feedback for controlling the greenhouse environment and irrigation (Prenger et al., 2005).

Research in the area of greenhouse measurement and instrumentation has investigated ways to use the crop as a feedback for greenhouse control systems with the “speaking plant approach” (SPA) (Hashimoto et al., 1985). Infrared thermometry provides a non-contact, nondestructive method for measuring canopy temperature and has been used for canopy temperature measurement in the field and growth chamber conditions (Kacira et al., 2002).

Leaf water potential (LWP) could provide direct information of plant water stress. So far, it has been used as a good indicator of plant water stress. In previous study (Suhandy et al., 2006), it has been shown that a nondestructive measurement of LWP using NIR spectroscopy could be available. Using this method, a real time monitoring of the LWP values was possible.

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This bioinformation was very useful to be used as a feedback for routine control of the water stress level. However, an irrigation control system using LWP values feedback has not been established in a greenhouse cultivation system. In this study, a monitoring of LWP values in tomato plant under a cycle of water stress was demonstrated. This method could be useful to implement a plant response-based irrigation control system for the water stress management.

MATERIALS AND METHODS

Plant material

Tomato plants (*Lycopersicon esculentum* cv. Momotaro Fight) were used as sample. 45 days after seedling, a healthy plant was selected and the fifth leaf from the apex was used for monitoring. The plant was subjected to water stress for one hour by draining the nutrient solution from the roots. After one hour of the water stress, the plant was irrigated again to recover from the water stress by watering with the nutrient solution for one hour. The on-plant NIR measurement was performed at every 10 minutes. The NIR measurement was started from the beginning of water stress and stopped at the end of watering. Figure 1 shows the configuration of on-plant NIR measurement for monitoring the LWP values in tomato plants.

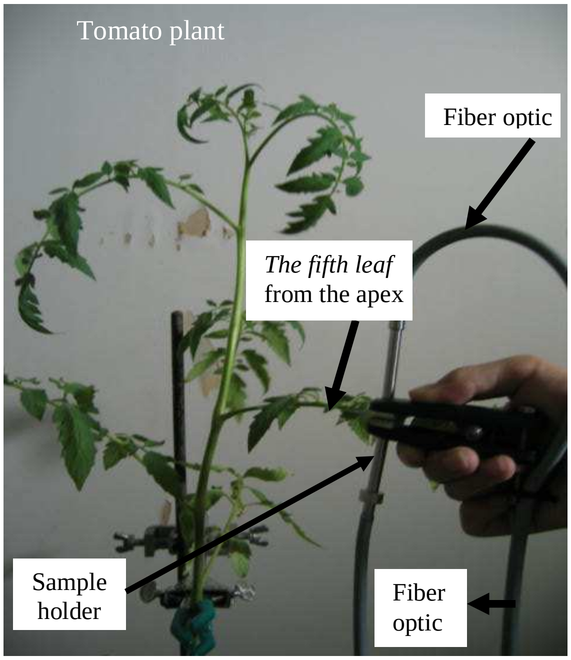

Figure 1. Monitoring of the LWP values using NIR spectroscopy.

Methods of leaf spectral acquisition

The on-plant NIR spectral acquisition was conducted. Using the NIR spectrometer (MMSI; Zeiss, Germany), the relative absorbance of the leaves to that of the ceramic plate was measured. At every 10 minutes, six spectra from six positions of the leaf were acquired. The spectra were recorded by placing the leaf between the light source and the detector. The adaxial leaf surface was facing with the light source. The spectra were stored in the computer for further analysis through the fiber optics.

The measuring condition for spectral acquisitions was 10 ms for scanning time and 50 scans for averaging. A ceramic plate with 1.0 mm thickness was used as a reference. The intensity of light transmitted through the ceramic plate was measured, and then NIR measurement was performed by using a leaf in place of the ceramic plate. The spectral acquisition of the ceramic plate was made every time prior to the spectral acquisition of the leaf.

Methods of LWP measurement

The LWP was measured using the pressure chamber method similar to that in the previous study (Suhandy *et al*., 2006). Immediately, at the end of monitoring, the leaf was cut and then the actual LWP value was measured using the pressure chamber method (PMS instrument model 600, USA).

Data analysis

The average spectra from six positions were calculated. Then using the calibration model with temperature compensation, the LWP was calculated for the average of original spectra. The calculation was processed using The Unscrambler® version 7.01 (CAMO AS, Norway). At the end of measurement, the leaf was cut and then the actual LWP value was measured by the pressure chamber method. Bias, the difference between the actual and the calculated of LWP values, was occurred. Then the bias was corrected.

RESULTS AND DISCUSSION

Figure 2 shows the behavior of the LWP values during a cycle of water stress. At first after water supply was cut by draining the nutrient solution from the roots, the plant started to become stressed. During the water stress, a fan was used to promote high evapotranspiration in the leaf surface. Since that water supply was cut, the unbalance between water supply and water demand was occurred. The excessive of water demand was occurred. This unbalance could be identified since that the LWP values decreased and after 60 minutes of the water stress, the LWP values decreased from –0.12 MPa to –0.80 MPa. At the end of the water stress, the tomato plant was wilt.

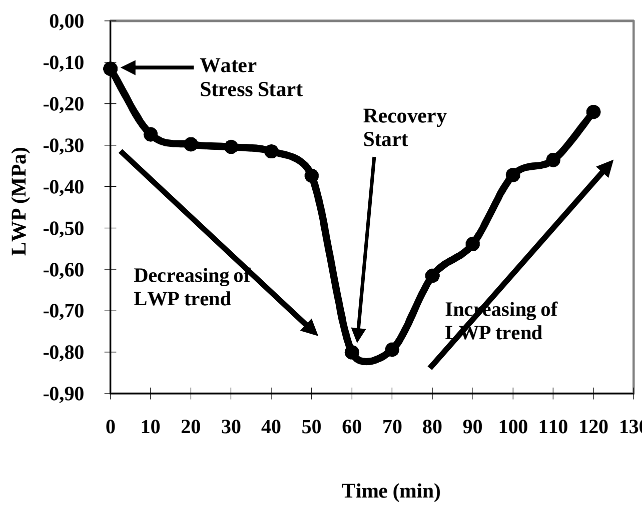

Figure 2.The LWP values during a cycle of water stress monitored by NIR spectroscopy.

Then a watering using the nutrient solution was applied for one hour. Water supply through the roots was started. At the same time the rate of evapotranspiration was decreased since that the use of the fan was stopped. It can be identified that the trend of the changes of the LWP values were shifted. The increasing trend of LWP values was identified and at the end of watering, the LWP was –0.22 MPa. The result showed that the LWP values under water stress and recovery from water stress could be monitored well. It showed that a real time monitoring of the LWP values using NIR spectroscopy could be possible.

CONCLUSIONS

The LWP values could be monitored continuously by using NIR spectroscopy. The result showed that the developed calibration model could be used for the water stress management. It has a potential to implement the irrigation control using the LWP values to produce tomatoes with high sugar content.

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