TECHNIQUE FOR DETERMINING WATER USE EFFICIENCY (WUE) IN OIL PALM

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Water use efficiency (WUE) in plants is a key determinant of productivity and survival of plants under water limiting or drought conditions since water plays an important role in crop growth (Mohd Roslan and Mohd Haniff, 2004a,b; Henson and Chang, 1989). Crop water requirement depends on many factors such as the climate, crop species and stage of growth. Genotypes originating from different climates vary in their requirements for temperature and water (Clifton-Brown and Lewandowski, 2000). Thus, it is important to identify the genotypes that optimize the use of water in different climatic regions and are tolerant to water stress. Water deficits affect carbon assimilation and plants have various adaptations when facing these conditions (Boyer, 1980; Chaves, 1991).

There are various strategies that plants use in response to water deficit, they include: (1) avoidance of damaging water deficits; (2) stress-tolerance adaptations that enable the plant to continue functioning in spite of plant water deficits; and (3) mechanisms that enable the plant to optimize the use of water for dry matter production (Clifton-Brown and Lewandowski, 2000). WUE is the amount of water required to produce a unit crop yield or dry matter. Physiologically, this can also be defined as the amount of carbohydrate produced through photosynthesis per unit water loss. Usually, there is a direct correlation between crop productivity and water use. When there is a reduction in the potential evaporation rate due to climatic conditions, there will also be a reduction in the CO_2 uptake.

OBJECTIVE

The main objective of this study was to use a non-destructive technique for determining WUE in oil palm by using a portable photosynthesis system.

MATERIALS AND METHODS

Leaf gas exchange measurements were taken on DxP and Progeny A one-year-old seedlings grown under a rain shelter using the CIRAS-1 portable photosynthesis system (PP-System, UK) from 8.00 am to 12.00 noon. Readings were taken at about 70% relative humidity, 350 ppm CO_2 and 1000 μmol m^{-2} s^{-1} photosynthetic active radiation (PAR). Leaflets from frond number 1 were used (*Figure 1*). Three readings per seedling were taken with a total of 10 palms per progeny.

For the field experiment, gas exchange measurements were taken on two different sites of six-year-old oil palms at Sintok, Kedah. Six measurements per palm for each treatment were taken using leaflets from frond 17 (*Figure 2*). A total of 10 palms were measured from each site using the portable photosynthesis system.

The instantaneous WUE was calculated by the ratio of the net assimilated CO_2 and evapotranspiration rates.

Figure 1. Gas exchange measurement on oil palm seedling.

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Figure 2. Gas exchange measurement on six-year-old palm.

RESULTS AND DISCUSSION

DxP seedlings had about 19% higher WUE than Progeny A (*Table 1*). A higher WUE would indicate a lower evapotranspiration rate and better water utilization by the palms. Although the carbon assimilation by Progeny A was about 12% higher than by DxP, its 34% higher evapotranspiration rate caused it to have a lower WUE. Thus, Progeny A needs more water than DxP, *i.e.* it is less tolerant to drought than DxP.

In the field, the site B palms had about 12% higher WUE than site A (*Table 2*). This was attributed to the lower evapotranspiration caused by the lower stomatal conductance. A lower rate of evapotranspiration in site B palms may also indicate water saving mechanisms by them.

TABLE 1. GAS EXCHANGE MEASUREMENTS FOR DXP AND PROGENY A IN NURSERY EXPERIMENT

Planting material	Photosynthetic rate (μmol m^{-2} s^{-1})	Stomatal conductance (mmol m^{-2} s^{-1})	Evapo-transpiration rate (mmol m^{-2} s^{-1})	Inter cellular CO_2 (ppm)	Instantaneous WUE (mmol CO_2 assimilate/mol of water loss)
DxP	8.24 ± 0.29b	202.83 ± 2.29b	2.41± 0.11b	226.17± 3.64a	3.52± 0.12a
Progeny A	9.21± 0.29a	243.47±11.84a	3.24± 0.11a	229.47± 2.01a	2.86± 0.05b
% Difference from DxP	+11.77	+20.04	+34.44	+1.46	-18.75

Note: Means in the same column followed by same letter are not significant at $p<0.05$.

TABLE 2. GAS EXCHANGE DURING A DRY SEASON IN KEDAH ON SIX-YEAR-OLD DxP PALMS

Treatment	Photosynthetic rate (μmol m^{-2} s^{-1})	Stomatal conductance (mmol m^{-2} s^{-1})	Evapo-transpiration rate (mmol m^{-2} s^{-1})	Inter cellular CO_2 (ppm)	Instantaneous WUE (mmol CO_2 assimilate/mol of water loss)
Site A	19.59± 0.55a	195.20± 7.39a	5.21± 0.22a	185.04±8.36a	3.95± 0.20a
Site B	17.53± 0.78b	150.20 ± 7.32b	4.14± 0.23b	163.30±0.23a	4.42± 0.21a
% Difference from Site A	-10.52	-23.05	-20.54	-11.75	+11.90

Note: Means in the same column followed by same letter are not significant at $p<0.05$.

BENEFITS

Using WUE in oil palm selection has numerous benefits as follows:

- identify planting materials that need less water for productivity; and
- WUE determination using gas exchange is rapid and non-destructive compared to other techniques.

CONCLUSION

WUE in oil palm offers extra information for screening better planting materials. Higher WUE plants require less water than lower WUE plants and thus can be planted in drier areas. WUE determination through leaf gas exchange measurements is rapid and non-destructive.

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