（学位第３号様式）

学 位 論 文 要 旨

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題　目	Studies of leaf photosynthesis with the measurements of internal and external CO_2 concentrations (葉内外 CO_2 濃度測定による光合成研究)

Because assimilation rate (A) at a given internal CO_2 concentration (C_i) in leaves represents the biochemical capacity in photosynthesis, the relationship has been widely investigated in plant physiology. The C_i is routinely calculated from the behavior of water vapor diffusing outward, assuming the departing vapor behaved like the entering CO_2. Nevertheless, the A-C_i analysis has been restricted since the calculation for the leaves with closed stomata was doubted. In this study, a system to measure C_i directly was developed, and its applicability to the A-C_i curve measurement as well as problems in the calculation and possibilities of the direct measurement were explored. In addition, filed application of the system was discussed based on some measurements of diurnal change in photosynthesis and CO_2 concentration in crop canopies.

1. A system development

   The system to measure C_i was incorporated into an LI-6400XT open gas exchange system (Li-Cor). The C_i was directly measured with a cup attached to the abaxial surface of leaves while normal gas exchange through the same section of adaxial surface was simultaneously detected. The C_i was measured in a circulated closed loop without pressure pulses, and smoothly reached equiriblium. The system was expected to trace reliable A-C_i curves.

2. A-C_i curves for leaves with closed stomata

   The A-C_i curves in leaves with stomata closed by feeding 10 μM abscisic acid were traced with directly measured C_i. The calculated C_i departed from the measured one, tracing an artifactual non-stomatal limitation of photosynthesis, whereas the direct measurement did not and followed the curve for leaves with open stomata. Water transfer across cuticle, estimated from the difference between the calculated C_i and measured C_i, was consistent with the water permiablility of the cuticle. Therefore, the gas exhcange model is doubted as it assumes stomata are the only pathway across the leaf surface. In addition, simultaneous measurement of gas exchange and chlorophyll fluorescence indicates the overestimated C_i potentially underestimates the CO_2 diffusion in mesophyll cells.

3. Diurnal change of photosynthesis under drought

   The measurements were conducted in a drought-resistant crop in semi-arid. Decline in A and down-regulation of photochemistry in leaves were coordinated with the midday stomatal closure. The C_i increased accordingly, but not when the diurnal stomatal closure was mitigated by a water treatment. Thus, the diurnal change in C_i is indicative of drought stress in plants.

4. Diurnal change of ambient CO_2 in the canopy

   In crop canopies, the CO_2 concentration was diurnally depleted by photosynthesis. The depletion was pronounced in the higher layer of the canopy with more actively photosynthesizing leaves. Therefore, it should be considered that photosynthesis is potentially limited by the external CO_2 concentration in the field condition.

In conclusion, the system presented here is promissing tool for A-C_i analysis in plant physiology. The meghod can be applied to a management of crop productions as the indicater of stress in field grown platns with real-time monitoring of C_i. Especially, the simplicity of the system would be great advantage in the field applicaitons.