Physiological regulations and the evaluation technologies of the crop photosynthesis

Yu Tanaka (Graduate School of Agriculture, Kyoto University)
tanaka.yu.2s@kyoto-u.ac.jp

Single leaf photosynthesis is one of the most important traits affecting the crop dry matter productivity. Until now, however, limited information is available for the enhancement of crop productivity through increased photosynthetic capacity. This is due to the complexed process of the environmental responses of leaf photosynthesis and biomass production under the field conditions, with lower throughput of the measurement of leaf photosynthesis. The present study aimed to elucidate the physiological mechanisms underlying the genetic variations of leaf photosynthesis and their environmental responses in soybean and rice, and to develop the technologies enabling the high-throughput measurement of the leaf photosynthesis.

The significant genetic variation of the single leaf photosynthetic capacity was observed between the high yielding US varieties, popular Japanese varieties and landraces from Asia. The observed variation was explained by both of the gas exchange activity through stomata and carboxylation activity in the mesophyll cells. The high yielding varieties from US tended to show the greater stomatal density per unit leaf area[1)]. The study showed that there is a room to improve the photosynthetic capacity of soybean by combining the beneficial traits observed in the various genetic resources.

Typically, it takes several minutes per sample to measure the leaf photosynthesis using the conventional open gas exchange systems. This is due to the stabilization time of the CO_2 concentration in the leaf chamber. The present study developed the new instrument based on the closed system, which directly detects the instantaneous decrease of the CO_2 concentration caused by the photosynthesis of single leaf enclosed in the leaf chamber. The developed instrument, MIC-100, enables the 7 times greater measurement throughput of the leaf photosynthesis with the practical accuracy compared with the conventional ones[2)]. MIC-100 will be a powerful tool to conduct the screening of the photosynthetic capacity among large scaled plant populations.

The leaf photosynthetic rate does not respond immediately to the sudden increase of light intensity, but gradually responds with significant delay. This study elucidated that the potential loss of the carbon gain was up to 20% due to the existence of this delay in the photosynthetic response[3)]. The significant natural genetic variation of the speed of photosynthetic response to the fluctuating light intensity was observed among rice and soybean varieties, and it was regulated independently from the photosynthetic capacity under the steady state. The response of the leaf photosynthesis to the light fluctuation will be one of the key traits to improve the biomass productivity of crop species.

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