# Genetic determination of natural variant gene for leaf photosynthetic rate in rice

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Genetic improvement of leaf photosynthetic capacity is a promising strategy for increasing crop productivity. Two different approaches, genetic engineering of photosynthetic machineries and genetic determination of natural variant gene, have been utilized. Many studies based on the former approach has been conducted with several success, while limited progress on the latter approach has been made, despite a wide range of intraspecific variation in photosynthetic rate has been acknowledged[1)]. My colleagues and I identified physiological mechanisms of the variation in leaf photosynthetic rate among rice cultivars and underlying genetic factors. First, we selected two contrasting cultivars, high-yielding *indica* Takanari and *japonica* Koshihikari, from diverse genetic resources and clarified the physiological reasons of the photosynthetic difference. Second, by QTL analysis using backcrossed inbred lines and chromosome segment substitution lines derived from the two cultivars, we identified 8 independent loci for leaf photosynthetic rate, which were consistently expressed over multiple years[2)]. Third, we developed a series of rice lines carrying up to five genetic regions by DNA marker assisted selection, and found some lines showed higher photosynthetic rate by 50% than Koshihikari[3)]. Fourth, we found that Takanari has rapid photosynthetic induction response to the step change of light intensity relative to Koshihikari and evaluated the dynamics of metabolites in Calvin-Benson cycle, stomatal conductance and electron transport during photosynthetic induction. The series of our studies emphasized that natural genetic resources are the potential source to dramatically improve photosynthetic capacity of crop species. We are trying to determine causal genes of these QTLs with their molecular functions, which should contribute to establish new breeding strategies of rice as well as other crops. We are also trying to identify important genetic factors from the wide range of rice cultivars, and to understand molecular network controlling photosynthetic dynamics across the whole growing season. We believe that the comprehensive understandings of natural variation of photosynthesis would allow us to easily control crop photosynthesis and eventually enhance productivity.

1) Adachi S. et al. 2020. Genetic determination for source capacity to support breeding of high-yielding rice (*Oryza sativa*). *Molecular Breeding* 40, 20.
2) Adachi S. et al. 2019. Genetic architecture of leaf photosynthesis in rice revealed by different types of reciprocal mapping populations. *Journal of Experimental Botany* 70:5131-5144.
3) Takai T., Adachi S. et al. 2013. A natural variant of *NAL1*, selected in high-yield rice breeding programs, pleiotropically increases photosynthesis rate. *Scientific Reports* 3:2149.