Introduction

Higher plants regulate nutrient flow from source to sink organ in response to developmental status and environmental changes. In order to understand the source-sink interrelations, it is necessary to develop an experimental system that can measure the change in assimilation and translocation of nutrients corresponding to various conditions.

Recently, the positron-emitting tracer imaging system (PETIS), which can non-invasively capture serial images of distribution of a radioactive tracer, has been widely used for the study of nutrient behavior (reviewed in Fujimaki, 2007). In this study, we focus on micronutrient dynamics in an intact plant, and developed analytical methods for monitoring carbon translocation and nitrogen fixation using short-lived radioactive tracer gases and PETIS.

The analysis of carbon translocation

^{11}C (half life: 20.4 min)-labeled radioactive carbon dioxide gas ($^{11}CO_2$) was produced by bombarding a nitrogen gas target with an energetic proton beam delivered from a cyclotron. We fed $^{11}CO_2$ to leaf blades of 4-week-old rice plants (*Oryza sativa* L.), and serial images of ^{11}C, which represent translocation of photoassimilate, were obtained using PETIS.

In order to understand source-sink interrelations, we manipulated source and sink strength by treating tested rice plants with *p*-chlorobenzenesulfonic acid (PCMBS), an inhibitor of sucrose transporters. $^{11}CO_2$ was repetitively fed to the same plants before and after PCMBS treatments and the translocations of photoassimilate were monitored using PETIS. We developed an analytical algorithm to estimate the velocity of ^{11}C-photoassimilate flow from the serial images, and applied to the experimental data. As a result, a decrease in the velocity after PCMBS treatments was successfully detected.

The analysis of nitrogen fixation

^{13}N (half life: 10.0 min)-labeled radioactive nitrogen gas ($^{13}N_2$) was produced by bombarding a carbon dioxide gas target with an energetic proton beam. We newly developed a rapid method to purify $^{13}N_2$ using gas chromatography apparatus. We fed the purified $^{13}N_2$ to the underground part of 4-week-old nodulated soybean plants (*Glycine max* (L.) Merr.) with defined concentrations of O_2 and N_2. Serial images of distribution of ^{13}N were obtained using PETIS, and obvious signal of ^{13}N was observed at the nodules. We also succeeded in the quantitative estimation of the rates of nitrogen fixation non-invasively. To our knowledge, this is the first example of real-time imaging of nitrogen fixation in an intact plant with nodules.

References

Fujimaki S (2007) The positron emitting tracer imaging system (PETIS), a most-advanced imaging tool for plant physiology. ITE Letters on Batteries, New Technologies & Medicine 8: C1-C10