2.29 Positron imaging analysis of assimilation and translocation of carbon and nitrogen sources in rice plant

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Introduction

Leaf photosynthesis is known to be affected by the levels of environmental nitrogen where the plants are grown[1]. It is also known that Nitrogen assimilation needs a carbon source to produce amino acid [2]. Thus, interaction between carbon assimilation and nitrogen assimilation is one of the most important factors regulating plant growth, in particular under elevated CO_2 conditions. The suppression of photosynthesis by CO_2 enrichment is associated with a decrease in total leaf nitrogen content[1]. This suggests that the elevated CO_2 condition may affect the assimilation and translocation of carbon and nitrogen sources.

It has been impossible to conduct dynamical studies in translocation and partitioning of fixed carbon as sugars and taken nitrogen as amino acids. Use of Positron Emitting Tracer Imaging System (PETIS) can visualize the real-time movement of these compounds and biosynthetic products [2,3]. Here we report the results of two experiments for rice plants: effects of nitrogen supply to soil water on $^{13}NO_3^-$ and $^{13}NH_4^+$ uptake; translocation of $^{11}CO_2$, $^{13}NO_3^-$ and $^{13}NH_4^+$ under elevated CO_2 conditions.

Experiments

Rice (*Oyza sativa* L. cv. Nipponbare) seeds were germinated in water and cultured hydroponically in a growth chamber with a 14-h light (25°C) / 10-h dark (20 °C). The procedure for production of $^{13}NO_3^-$, $^{13}NH_4^+$ and $^{11}CO_2$ was described elsewhere[3].

1) Effects of nitrogen supply to soil water on $^{13}NO_3^-$ and $^{13}NH_4^+$ uptake

$^{13}NH_4^+$ was fed to the roots of rice plants cultivated for a month under distinct conditions: control; 4-day nitrogen deficiency; pretreatment with 0.3 mM NH_4^+ for 2 h after 4-day nitrogen deficiency. Meanwhile, $^{13}NO_3^-$ was fed to the roots pretreated with 0.3 mM NO_3^- for 2 h after 4-day nitrogen deficiency.

2) Translocation of $^{11}CO_2$, $^{13}NO_3$ and $^{13}NH_4^+$ under elevated CO_2 conditions

After rice plants were cultured on tap water for 3 weeks, half of the group was transferred to ambient (40 Pa) conditions, and the other half to elevated CO_2 (140 Pa) conditions for 4 weeks. $^{13}NO_3^-$ and $^{13}NH_4^+$ were fed to the roots, and $^{11}CO_2$ was supplied at the middle part of the newest and second newest leaves through a

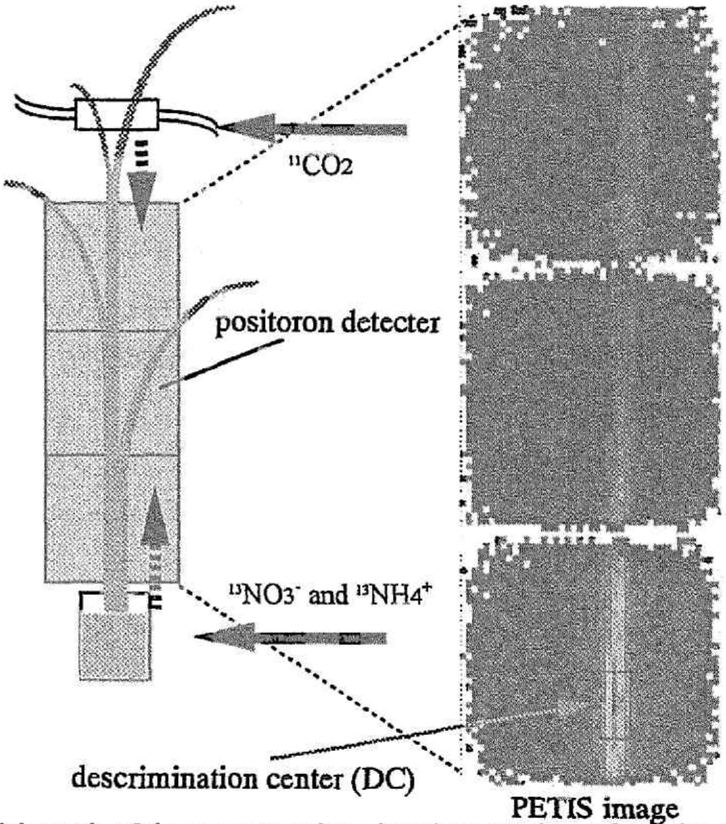

Fig. 1 Schematic of the present positron imaging experiment for a rice plant (left) and a resulting PETIS image (right).

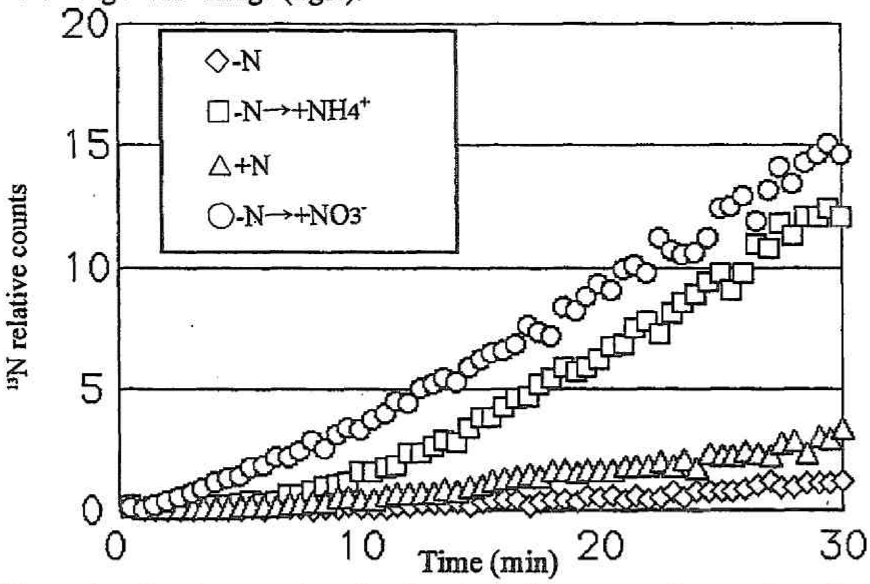

Fig. 2 ^{13}N translocation from roots to the descrimination center. Curves show the accumulated of radioactivity at the DC for different cultivation conditions: control (△) ; 4-day nitrogen deficiency (◇); pretreatment with 0.3 mM NH_4^+ for 2 h after 4-day nitrogen deficiency (□); pretreatment with 0.3 mM NO_3^- for 2 h after 4-day nitrogen deficiency (○) .

quvet to feed $^{11}CO_2$[4]. PETIS measurements were performed in the same CO_2 conditions as at the foregoing cultivation stage.

Results and discussion

1) Effects of nitrogen supply to soil water on $^{13}NO_3^-$ and $^{13}NH_4^+$ uptake: Figure 1 shows a PETIS image obtained for $^{13}NH_4^+$. From these imaging data, the time-course of ^{13}N radioactivity at the discrimination center (DC) [2] was obtained for the different pretreatment conditions, as shown in Fig. 2. This revealed that the pretreated rice with 0.3 mM NH_4^+ for 2 h after 4-day nitrogen deficiency and the pretreated rice plant with 0.3 mM NO_3^- for 2 h after 4-day nitrogen deficiency absorbed more amounts of ^{13}N throughout the experiment than the control plant and the plant cultivated in a 4-day nitrogen deficiency condition. This suggests that uptake of nitrogen sources from roots is induced by an increase of the nitrogen content around the roots.

It is possible that this induction of NH_4^+ uptake is caused by high affinity NH_4^+ transporter (*OsAMT1;2*) which is induced in NH_4^+-treated rice roots after nitrogen deficiency [5]. Analysis of mutant and transgenic rice of *OsAMT1; 2* gene will verify the hypothesis.

The observed uptake delay between $^{13}NO_3^-$ and $^{13}NH_4^+$ at the DC may result from the fact that NO_3^- is translocated directly without metabolism, whereas NH_4^+ needs to be assimilated into glutamine at the roots[2].

2) Translocation of $^{11}CO_2$, $^{13}NO_3^-$ and $^{13}NH_4^+$ under elevated CO_2 conditions

The results of this PETIS analysis detected no deference in translocation of $^{13}NO_3^-$, $^{13}NH_4^+$ and $^{11}CO_2$ between the rice plants cultivated in the ambient and elevated CO_2 conditions (data not shown). Although the elevated CO_2 condition may not affect the translocation of these compounds during a period of time as short as one hour, further experiments will be needed to confirm this phenomenon.

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