S stable isotope discrimination in rice: isotope *vs* molecular phenotypes

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Sulfur has four stable isotopes: ^{32}S, ^{33}S, ^{34}S, and ^{36}S; their percentage abundances are 0.9499, 0.0075, 0.0425, and 0.0001 atom fraction, respectively. Mass differences among the S isotopes result in small but yet significant differences in their chemical and physical properties, which may produce considerable separation of the S isotopes during chemical reactions. The most abundant isotopes – ^{32}S and ^{34}S – are now commonly measured using elemental analyzers coupled with isotope ratio mass spectrometers, and S isotope abundance are generally express in term of $^{34}S/_{32}S$ abundance ratio, using the standard $\delta^{34}S$ notation:

$$\delta^{34}S = [(^{34}S/^{32}S)_{sample}/(^{34}S/^{32}S)_{VCDT} -1] \times 1000$$

which express the part per thousand deviation of the isotope ratio $^{34}S/^{32}S$ of a sample relative to an international standard, the Vienna Canyon Diablo Troilite (VCDT).

Unlike what has happened with carbon and nitrogen, natural abundance S stable isotope analysis techniques have scarcely been employed to study S allocation and metabolism in plants mainly because of the lack of knowledge about the $^{32}S/^{34}S$ isotope effects occurring during S metabolism and partitioning among the different organs. Most of the irreversible reactions involving S discriminate between ^{32}S and ^{34}S by favoring the light isotope (^{32}S), thus enriching in ^{34}S the residual substrate molecules left behind. That is to say, that irreversible reactions that do not consume all the substrate may likely produce a detectable fractionation of S stable isotopes at natural abundance, providing crucial insights in the understanding of S metabolic fluxes inside the plants, thus preventing costly or radioactive labeling.

Preliminary analyses performed on rice plants grown in complete nutrient solutions revealed some discrepancies amongst $\delta^{34}S$ values of the S source and total S measured in the whole biomass or organs. Total S in the whole plant was significantly depleted in ^{34}S by -1.40 ± 0.08 ‰ with respect to the S source. Moreover, the analysis of organ-specific $\delta^{34}S$ values measured for total S revealed that roots were depleted in ^{34}S by -0.52 ± 0.05 ‰ while shoots were enriched by 0.62 ± 0.04 ‰ relative to the same S source. Moreover, S stable isotope mass balance studies revealed that different isotope phenotypes can be associated to the preferential expresion of specific sulfate transporters involved in sulfate uptake.

Taken as a whole, data strongly indicate that $^{32}S/^{34}S$ isotope effects occur during sulfate uptake and S partitioning.