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Tomato plants reuptake root exudates and alter carbon isotope fractionation under phosphorus deficiency

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Plant roots are able to exude vast amounts of metabolites into the rhizosphere especially when subjected to phosphorus (P) deficiency to increase P solubility and thus its´ uptake. This causes noteworthy costs in terms of energy and carbon (C) for the plants. For this reason, we suggested that exudates reacquisition by roots could represent an energy saving strategy of plants. This study aimed at investigating the effect of P deficiency on the ability of hydroponically grown tomato plants to re-uptake specific metabolites generally present in root exudates by using ^{13}C-labelled molecules. Hence, tomato plants have been grown for 21 days in full and P deficient nutrient solution. Exudates reuptake has been assessed by immersion of roots in a solution containing ^{13}C labeled glycine, glucose, fructose, citrate, and malate. $\delta^{13}C$ analysis was performed using a Continuous Flow Isotope Ratio Mass Spectrometer (CFIRMS). Results revealed that P deficient tomato plants were able to take up significantly more citrate (+37%) and malate (+37%), when compared to controls. While also glycine (+42%) and fructose (+49%) uptake was enhanced in P shortage, glucose acquisition was not affected by plants nutritional status. Unexpectedly, results also highlighted that P deficiency leads to a ^{13}C enrichment in both tomato roots and shoots over time (shoots +2.66 ‰, roots +2.64 ‰, compared to control plants). This could be explained by stomata closure triggered by P deficiency resulting in an increased use of $^{13}CO_2$ in respect to $^{12}CO_2$, normally preferred by RuBisCO. Our findings highlight that tomato plants are able to take up a wide range of metabolites belonging to root exudates, thus optimizing C trade off. This trait is particularly evident when plants grew in P deficiency.