

Contents

List of Tables	IV
List of Figures	V
Abstract	VI
Zusammenfassung.....	VIII
1 General Introduction.....	1
1.1 The link between carbon and nitrogen.....	1
1.2 Stable isotopes.....	2
1.3 Post-photosynthetic carbon isotope fractionation	3
1.4 Post photosynthetic carbon isotope fractionation in carbohydrate biosynthesis.....	4
1.5 Thesis objectives	4
1.6 Thesis outline	5
1.7 References.....	7
2 Carbon isotope fractionations as influenced by nitrogen supply-Leaf.....	11
2.1 Introduction.....	12
2.2 Materials and methods.....	14
2.2.1 Plant material.....	14
2.2.2 Plant physiological variables.....	15
2.2.3 Respired CO ₂	15
2.2.4 Respiration rate.....	15
2.2.5 Enzyme activity	16
2.2.6 $\delta^{13}\text{C}$ values of bulk organic matter	17
2.2.7 Organic metabolites for bulk $\delta^{13}\text{C}$ analysis.....	17
2.2.8 Compound-specific $\delta^{13}\text{C}$ and concentration of amino and organic acids.....	18
2.2.9 Concentration of carbohydrates.....	19
2.2.10 Statistics and calculations.....	19
2.3 Results.....	19
2.3.1 Physiological variables	19
2.3.2 Isotopic composition of plant metabolites	20
2.3.3 Compound-specific isotopic composition of organic acids	20
2.3.4 Compound specific isotopic composition of amino acids.....	20
2.3.5 Enzyme activity	21
2.3.6 Concentration of carbohydrates.....	21
2.3.7 Relationships between respiration and organic acids	21
2.4 Discussion.....	21

2.4.1	Post-photosynthetic isotope fractionation suggests ^{13}C enriched substrate for dark respiration in plants supplied predominantly with NO_3^-	22
2.4.2	Anaplerotic reaction is responsible for ^{13}C -enriched respired CO_2	22
2.4.3	Different malate pools in plants supplied predominantly with NO_3^-	23
2.4.4	Carbohydrate concentrations are influenced by N supply	23
2.4.5	Different N species influence $\delta^{13}\text{C}$ of individual amino acids	24
2.5	Conclusions	24
2.6	Acknowledgements	25
2.7	References	26
2.8	Figures & Tables	30
2.9	Supplement	39
3	Carbon isotope fractionations as influenced by nitrogen supply-Root.....	43
3.1	Introduction	44
3.2	Materials and methods	46
3.2.1	Plant material	46
3.2.2	Respired CO_2	47
3.2.3	Respiration rate	47
3.2.4	Enzyme activity	47
3.2.5	Concentration of carbohydrates	48
3.2.6	$\delta^{13}\text{C}$ analysis of organic matter	49
3.2.7	Statistics and calculations	50
3.3	Results	51
3.3.1	Biomass and respiration rate	51
3.3.2	Isotopic composition of plant metabolites	51
3.3.3	Enzyme activity	52
3.3.4	Concentration of carbohydrates	52
3.3.5	Apparent isotope fractionation	52
3.3.6	Relationships and comparisons	53
3.4	Discussion	53
3.4.1	Apparent isotope fractionation is influenced by N-supply	53
3.4.2	Leaf transported malate supports NH_4^+ assimilation	54
3.4.3	OPPP and anaplerotic reactions support root NO_3^- assimilation	54
3.4.4	Individual amino acids were influenced by N supply	55
3.5	Conclusions	56
3.6	Acknowledgements	56
3.7	References	57
3.8	Figures & Tables	61

3.9	Supplement	71
4	Starch deficiency and carbon isotope fractionation	75
4.1	Introduction	76
4.2	Materials and methods	79
4.2.1	Plant material	79
4.2.2	Isotope ratio analyses of leaf dark-respired CO_2	80
4.2.3	Isotope ratio analysis of organic compounds	80
4.2.4	Sugar and starch concentration measurements	81
4.2.5	Leaf gas-exchange measurements	82
4.2.6	Data analysis and calculations	82
4.3	Results	82
4.3.1	Experiment 1: Screening of <i>pgm</i> mutants and wild type plants	82
4.3.2	Experiment 2: Diel cycle of N. <i>sylvestris</i> <i>pgm</i> mutants vs. wild type	83
4.3.3	Experiment 3: Leaf gas exchange measurements and modelling of $\delta^{13}\text{C}_M$	84
4.3.4	Apparent respiratory ^{13}C fractionation and correlations with $\delta^{13}\text{C}_{\text{substrates}}$	84
4.4	Discussion	85
4.4.1	Post-photosynthetic ^{13}C fractionations via pFBA in response to <i>pgm</i> -induced starch deficiency	85
4.4.2	<i>pgm</i> -induced starch deficiency affects daytime organic acid metabolism but not apparent respiratory ^{13}C fractionations	86
4.4.3	<i>pgm</i> -induced starch deficiency causes photosynthetic ^{13}C fractionation	87
4.5	Conclusion and Implications	88
4.6	Acknowledgements	88
4.7	References	89
4.8	Figures & Tables	94
4.9	Supplement	102
5.1	Summary	103
5.2	Outlook	108
5.3	References	109
	Acknowledgements	111
	Curriculum Vitae	113