
Contents

Abstract	5
Zusammenfassung	6
Chapter 1 Introduction.....	7
Chapter 2 Materials and methods	13
2.1 Plant material.....	13
2.2 Growth conditions	14
2.3 Gas exchange measurements	15
2.3.1 Gas exchange system.....	15
2.3.2 Leaf chambers.....	17
2.3.3 Automation of the gas exchange system	18
2.3.4 Calculations and control measurements	19
2.4 Measurement of lateral diffusion inside leaves.....	19
2.4.1 Experimental protocol	19
2.4.2 Calculation of lateral gas conductance and conductivity	20
2.4.3 Data analysis.....	22
2.5 Dark respiration measurement	22
2.6 Gas exchange measurement in light	23
2.6.1 Analysis of CO ₂ response curves	24
2.6.2 Shading of the leaf part outside the leaf chamber	25
2.7 Gas exchange measurements under overpressure.....	25
2.7.1 Influence of air pressure on gas diffusion – theoretical considerations	27
2.8 Photosynthesis of partly shaded leaves.....	28
2.8.1 Measurement of chlorophyll fluorescence	28
2.8.1.1 Experimental conditions.....	29
2.8.1.2 Experimental protocol	29
2.8.2 Combined measurements of chlorophyll fluorescence and gas exchange	30
2.8.2.1 The experimental protocol.....	30
2.8.2.2 Data analysis.....	31
2.8.2.3 Estimation of measurement errors.....	33

Chapter 3 Results.....**35**

3.1 Diffusion inside leaves.....	35
3.1.1 Biometric parameters of the investigated leaves.....	35
3.1.2 Gas conductance and conductivity of the intercellular air space	36
3.1.3 Summary of diffusion inside leaves	40
3.2 Influence of lateral diffusion on gas exchange measurement.....	40
3.2.1 Measurement of dark respiration.....	40
3.2.2 Measurement of photosynthesis	42
3.2.3 Shading of the leaf part outside the leaf chamber	46
3.2.4 Summary of the impact of lateral diffusion on gas exchange measurements	48
3.3 Gas exchange measurement under overpressure in the leaf chamber.....	49
3.3.1 Measurement of dark respiration.....	49
3.3.2 Photosynthetic gas exchange under overpressure	51
3.3.3 Transpiration and overpressure	54
3.3.4 Summary of the impact of overpressure on gas exchange measurement.....	55
3.4 Chlorophyll fluorescence of partly shaded leaves	56
3.4.1 Well watered plants.....	56
3.4.2 Plants under drought stress.....	58
3.4.3 Quantification of the effect of lateral diffusion on photochemical and non-photochemical quenching.....	60
3.4.4 Re-watering of drought stressed plants	61
3.4.5 Summary of chlorophyll fluorescence of partly shaded leaves.....	62
3.5 Photosynthesis of leaves illuminated with lightflecks	63
3.5.1 Experiments with <i>Vicia faba</i>	64
3.5.2 Experiments with <i>Glycine max</i>	70
3.5.3 Summary of photosynthesis of leaves illuminated with lightflecks.....	76

Chapter 4 Discussion**79**

4.1 Carbon fluxes in and out of leaves.....	79
4.1.1 Influence of elevated CO ₂ on respiration – direct effect.....	79
4.1.2 Measurement artefacts.....	80
4.1.3 Gas conductance and conductivity in lateral and vertical direction.....	80
4.1.4 Gas fluxes in lateral direction.....	81
4.2 Influence of lateral diffusion on gas exchange measurement.....	82
4.2.1 Screening for species with different leaf anatomy	83
4.2.2 Influence of lateral diffusion on gas exchange in light	84
4.2.2.1 Lateral gradients within homobaric leaves caused by shading	86
4.3 Gas exchange measurement and overpressure.....	87
4.3.1 CO ₂ exchange under overpressure in homobaric leaves	88
4.3.2 Impact of air pressure on transpiration.....	89

4.4	Influence of leaf anatomy on gas exchange measurement - conclusion.....	90
4.5	Visualisation of lateral CO₂ diffusion	92
4.5.1	Stomatal conductance and lateral flux of CO ₂ inside leaves	93
4.6	Lightflecks	94
4.6.1	Photosynthesis under drought stress.....	95
4.6.2	Reduction of drought stress symptoms by lateral CO ₂ diffusion	98
4.7	Impact of lateral diffusion on photosynthesis - conclusion.....	100
4.8	Ecology of plants with homobaric leaves.....	101
References		103
Abbreviations		113
Appendix		117
Geometrical correction of conductance and conductivity		117