



Phenotyping *Nannochloropsis gaditana* under different conditions in controlled photobioreactors in laboratory and upscaled photobioreactors in greenhouse

Regina Braun

Forschungszentrum Jülich GmbH
Institute of Bio- and Geosciences
Plant Sciences (IBG-2)

Phenotyping *Nannochloropsis gaditana* under different conditions in controlled photobioreactors in laboratory and upscaled photobioreactors in greenhouse

Regina Braun

Schriften des Forschungszentrums Jülich
Reihe Energie & Umwelt / Energy & Environment

Band / Volume 221

ISSN 1866-1793

ISBN 978-3-89336-975-1

Contents

1	Introduction	1
1.1	Biofuels	1
1.2	Range of products from algae	3
1.3	<i>Nannochloropsis</i>	4
1.4	Endogenous rhythms	6
1.5	Photosynthesis	7
1.6	Photoprotection	9
1.6.1	Excited chlorophyll	9
1.6.2	Non-photochemical quenching	9
1.6.3	Xanthophyll cycle	10
1.7	Potential of photosynthetic microorganisms for industrial production of valuable products and as waste recyclers: A literature survey	13
1.7.1	Reactor design	15
1.7.1.1	Open ponds	15
1.7.1.2	Photobioreactors	16
1.7.1.3	Hybrid-system	18
1.7.1.4	Light transfer	18
1.7.1.5	Comparison of the productivity of open pond sys- tems with closed photobioreactors	19
1.7.2	Productivity	21
1.7.2.1	Limiting factors	21
1.7.2.2	Impact of cultivation conditions	24
1.7.2.3	Production in laboratory conditions	26
1.7.2.4	Production in a large scale	27
1.7.2.5	Lipid production	29
1.7.2.6	Production of polysaccharides	29
1.7.3	Wastewater treatment	30
1.7.4	Nutrient balance	31

1.7.5	Water footprint	33
1.7.5.1	Recycling	33
1.7.5.2	Comparison of water footprint for biodiesel production	34
2	Motivation	37
3	Materials and Methods	39
3.1	Organisms	39
3.2	Chemicals	39
3.3	Cultivation of stock cultures	39
3.4	Cultivation in photobioreactors in the laboratory	40
3.5	Measurements of OD	40
3.6	Chlorophyll a fluorescence measurements	40
3.7	Biomass dry weight	41
3.8	Cell number	42
3.9	Total-nitrogen	42
3.10	Nitrate	42
3.11	Pigment analysis	42
3.12	Chlorophyll a content	44
3.13	Treatments in photobioreactors in the laboratory	45
3.13.1	Experiments with <i>N. gaditana</i> SAG 2.99	45
3.13.2	Experiments with <i>N. gaditana</i> CCAP849/5	45
3.14	Cultivation in closed photobioreactors under greenhouse conditions	49
3.15	Statistical analysis	52
4	Results	53
4.1	Experiments under controlled conditions	53
4.1.1	Effects of circadian clock	53
4.1.1.1	Comparison of different LD regimes	53
4.1.1.2	Switch from 12 h/12 h and 18 h/6 h LD to LL	58
4.1.1.3	Effects of red and blue light	64
4.1.2	Evaluation of NPQ mutants under fluctuating conditions	69
4.1.2.1	LD cycles with constant and fluctuating light	69
4.1.2.2	Continuous light with constant and fluctuating light	82
4.1.2.3	Temperature cycles	88

4.2 Experiments under greenhouse conditions	96
4.2.1 Comparison of WT in four PBRs	96
4.2.2 Comparison of WT and <i>npq21</i>	111
5 Discussion	123
5.1 Laboratory experiments	123
5.1.1 Circadian and light control of chlorophyll accumulation and growth in <i>N. gaditana</i>	123
5.1.2 Distinct effects of blue and red light on <i>N. gaditana</i>	126
5.1.3 Growth of NPQ mutants	128
5.1.3.1 Light regimes	128
5.1.3.2 Temperature regimes	131
5.2 Greenhouse experiments	133
5.2.1 Production of <i>N. gaditana</i> biomass in the greenhouse PBRs .	133
5.2.2 Comparison between WT and <i>npq21</i>	135
6 Conclusion and Outlook	137
7 Supplementary	139
Bibliography	141
Abbreviations	161
List of Figures	165
List of Tables	173
Publications and Posters	175
Acknowledgements	177

Energie & Umwelt / Energy & Environment
Band / Volume 221
ISBN 978-3-89336-975-1

