Assessing micro-algae productivities with scenario studies

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Why scenario models?

Realisation of micro-algae cultivation is still in early phase of development. There is a need to assess the potential of algae production under large-scale conditions. The only alternative for developing ideas on large-scale processing by developing models based on the best available current knowledge. By applying scenario studies to the models, one can deal with the uncertainty in data and models.

Modelling framework for productivity scenarios

We have developed a modelling framework to assess the micro-algae productivity as function of outdoor light conditions, reactor geometry, and species specific growth characteristics (Figure 1). The model is applicable to:

- Any algae species
- Location specific weather and light conditions
- Reactor designs based on: raceway ponds, flat panels, and horizontal and vertically stacked tubular photobioreactors.

Growth models can be exchanged when desired.

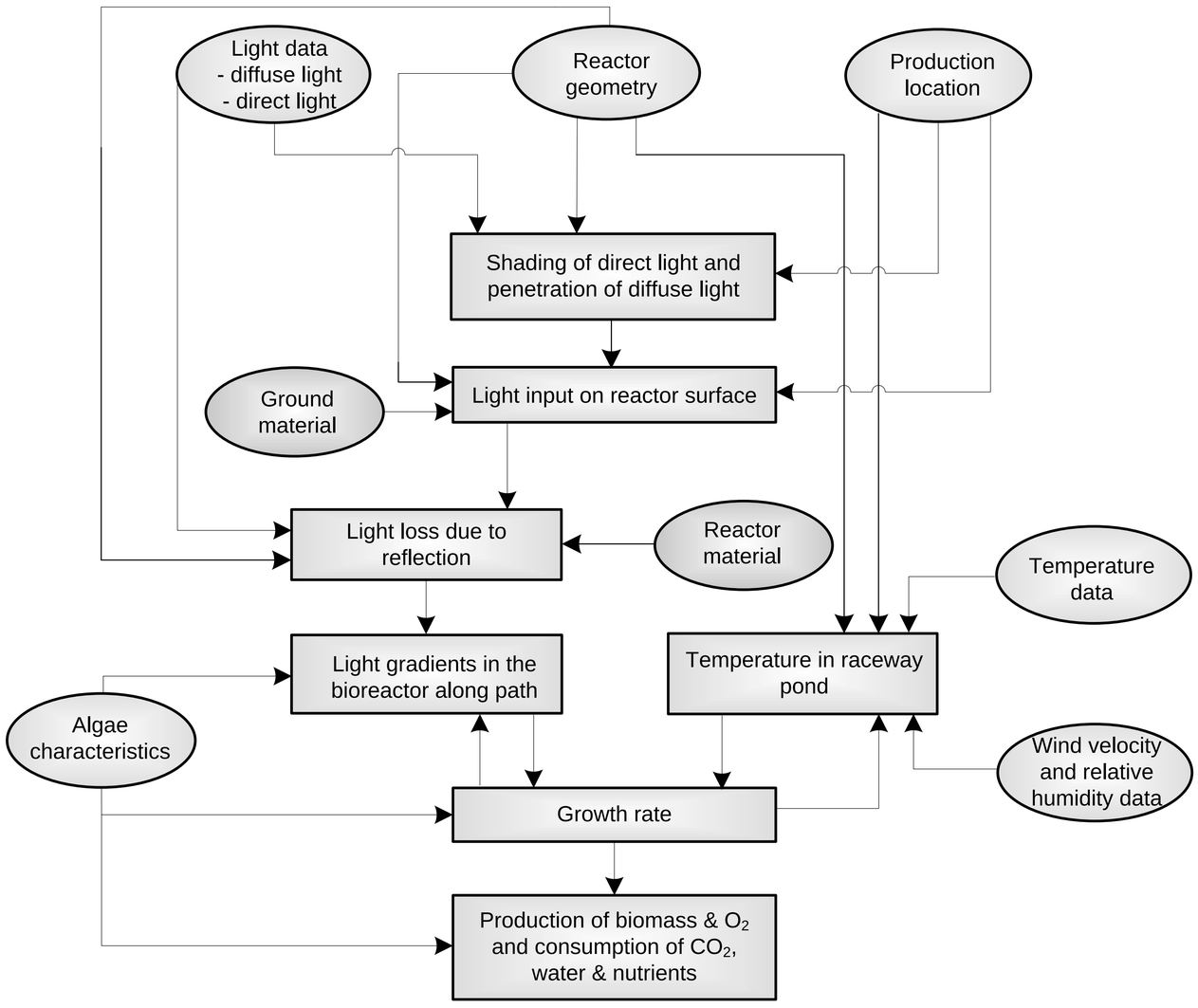
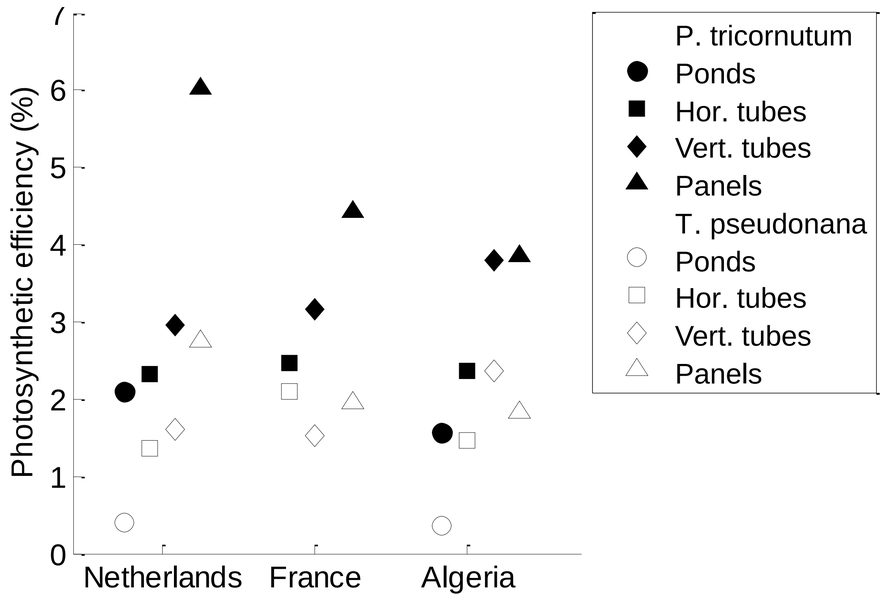


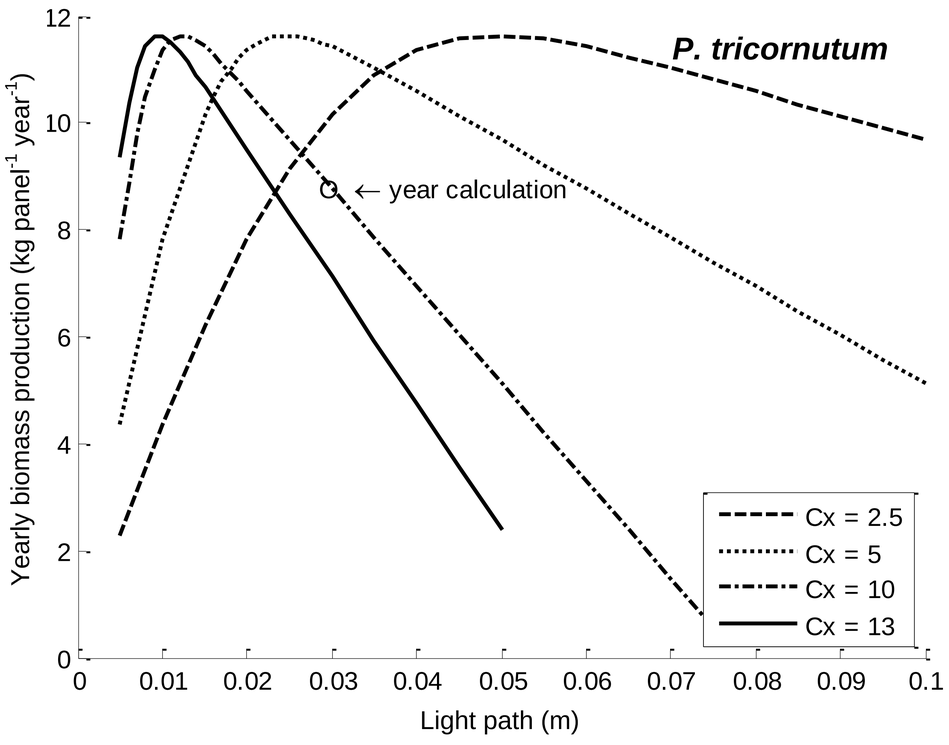
Figure 1. The modelling framework for assessing micro-algae productivity under various scenarios. The ovals indicate the model inputs. The blocks are representing the internal model calculations.

Photosynthetic efficiency (PE) performance



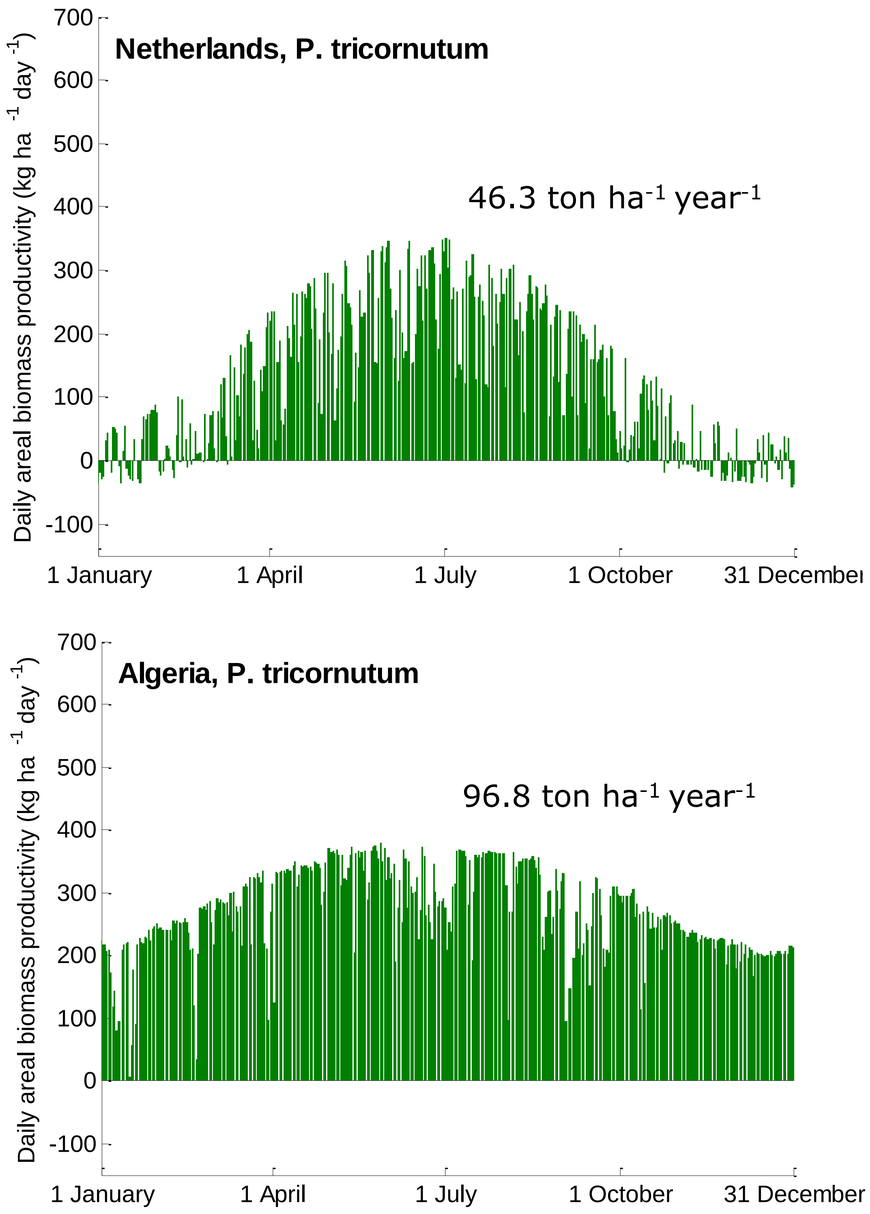
← Figure 2. It is common to assume that the PE performance increases from raceway ponds (1-2%), to horizontal tubes (3%), to vertical systems (4-5%). However, our scenario results indicate that the PE is a result of the combination of reactor geometry, algae species characteristics, and location specific light angles, light intensities, and day length.

Design + operating conditions



← Figure 3. The yearly biomass production is influenced by the light path and the biomass concentration (here shown for vertical flat panels and light conditions of the Netherlands). In this case the same reactor productivity can be achieved with 4 combinations of design and operating conditions. However, the optima are not equally stable. The circle indicates the reported literature value of which yearly productivity can be achieved for this algae species in a reactor with a 0.03 m light path.

Yearly production patterns



↗ Figure 4. Yearly production patterns for a horizontal tubular photobioreactor (0.06 m light path) in Netherlands and Algeria. For each location the horizontal distance between tubes was optimised, as well as the biomass concentration (constant during the year).

Conclusions

The modelling framework with scenarios allows to: explore trends in productivity and performance based on current designs and for new concepts, indicate critical points in the reactor designs and which design and algae parameters are essential to know accurately, quantify consequences of uncertainty, and thereby guide future research.

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References

Slegers PM *et al*. Scenario evaluation of open pond microalgae production. Algal Research. 2013;2:358-68.

Slegers PM *et al*. Design scenarios for flat panel photobioreactors. Applied Energy. 2011;88:3342-53.

Slegers PM *et al*. Scenario analysis of large-scale algae production in tubular photobioreactors. Applied Energy. 2013;105:395-406.