Use of Phenometrics PBR101 Bench-Top Algal Photo Bioreactor for the Optimization and Prediction of Production Scale Yields

T.J. Alavosus, Ph.D.*, M. Chaparian, Ph.D., and M. Mugavero
Phenometrics, Inc., 2727 Alliance Drive, Lansing, MI 48910

Introduction: The Challenge of Scale-Up for Use of Algae as a Renewable Source of Biofuel

Various strains of microalgae have been used as a source of lipids for biofuel production. Many biofuels are based on long-chain mono-alkyl (methyl, ethyl, or propyl) esters derived from plant oil or animal fat. These fatty acid esters are usually formed by reacting alcohol with the lipids extracted from the oil or fat.

Certain strains of microalgae can contain up to 70% or greater lipids, greatly exceeding the oil productivity of the best producing terrestrial plants. These lipids are readily harvested by squeezing in a large press, often followed by extraction with hexanes.

Algae is completely renewable and grows much faster than other plant sources of lipids, producing high-volume, high-lipid-density material, with many harvests (crops) per year per acre (doubling time can be as fast as 3.5 hours). However, scale up from discovery to production is not a linear process or easily extrapolated from small scale production in flasks.

The Phenometrics PBR101 algal photo bioreactor was designed to overcome this limitation and provide a direct method to proceed from discovery to production scale up.

Ideally, a small-scale (i.e., bench-top) reactor would be used to mimic the yield of a large-scale system. Antiquated techniques, however, such as flasks, open-air ponds, aquariums, and lab-ware “reactors” provide little-to-no reliable scalability. Further, experimental controls are very difficult to implement with these methods. The bottom line: they are of little predictive value in determining the best conditions for a given strain, or strain identification for a prescribed set of conditions, required to optimize biomass and/or by-product yield.

The PBR101 Photo BioReactor was designed specifically do optimize many of the most critical conditions for algae growth, following with direct up-scale large-scale reactors. Conditions and parameters controlled include:

- Programmable diurnal light cycles and intensity
- Programmable temperature (may be linked to light cycles if desired)
- Controlled gas flows (such as CO_2 and others)
- pH measurement
- Agitation (via mixing)
- Continuous-flow or measured injection turbidistatic cultivation via specially designed turbidistat pump
- Various illumination options
- Independent control and data capture from up to 256 individual PBR101 reactors from a single computer

Objective: A Productivity Comparison Between a 1-Acre Growth Raceway Pond and the Phenometrics PBR101

An experiment was performed to directly compare the productivity of a real-world large scale bioreactor (a raceway pond) after up-scaling from the Phenometrics PBR101 Photo BioReactor.

The objective was to establish the correlation between biomass productivity in PBR101 systems and a AA outdoor 1-acre growth raceway ponds.

Methods:

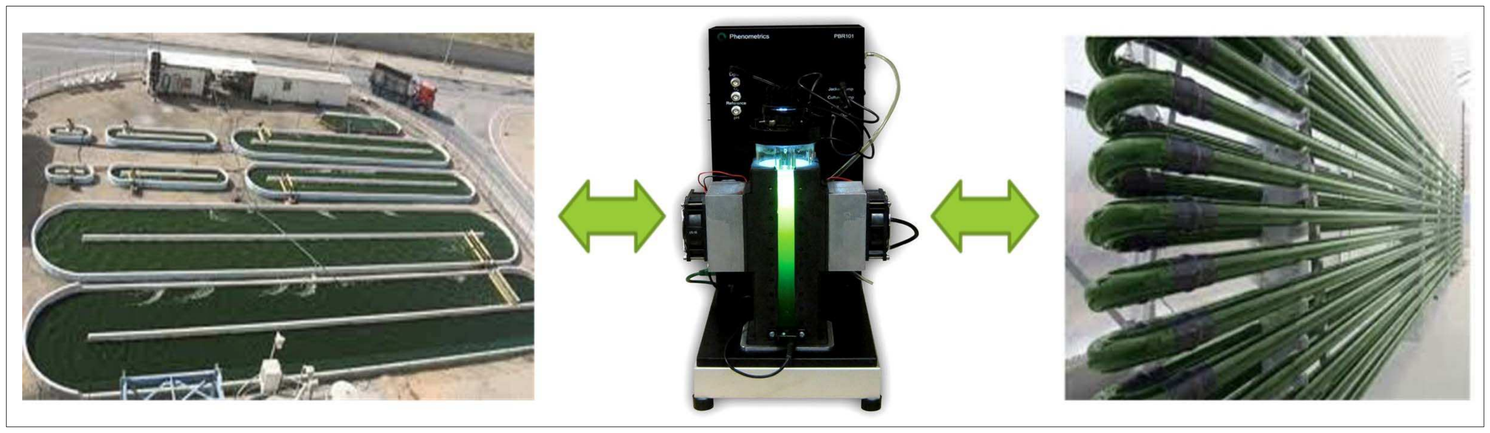
Environmental data (temperature and PAR) recorded at a pilot facility was programmed into a matrix of PBR101s and used to compare productivities in the two systems. The average daily aerial productivity was calculated.

Conditions that were duplicated in the PBR101:

- Temperature
- Photosynthetically Active Radiation (PAR)
- pH
- Carbon delivery

Conditions that can not be duplicated in the PBR101:

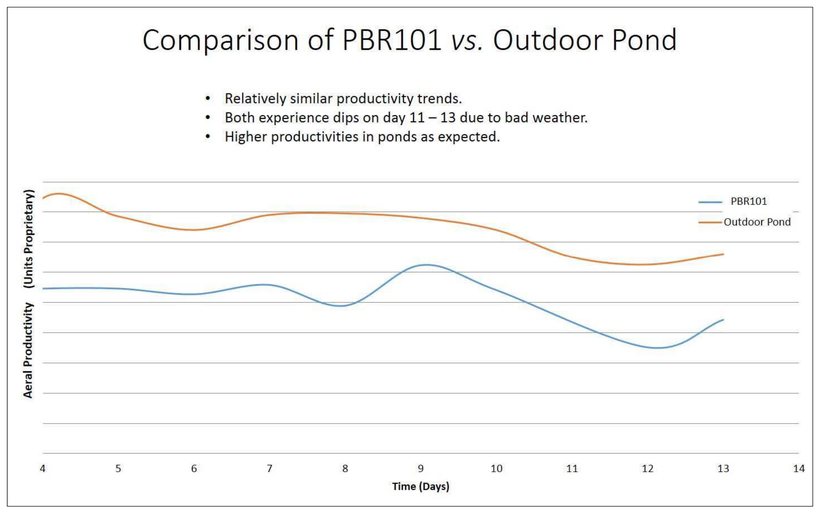
- Humidity
- Evaporation rate
- Wind
- Solar irradiance (spectrum/light quality)
- Mixing (to a certain extent)
- Interaction with foreign microorganisms such as grazers, algae, etc.
- Rainfall

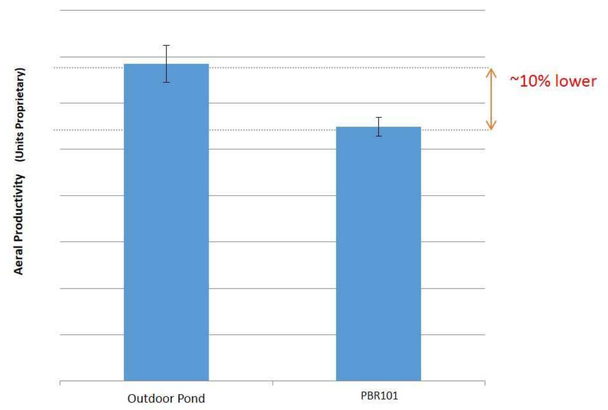


The PBR101 can be used to predict yields in both open (ponds) and closed production systems

Results: A Comparison of Average Productivities Between the Phenometrics PBR101 and AA 1-Acre Growth Raceway Ponds

- The PBR101 estimated production scaled in the raceway within 10%
- Similar up-scale values have been demonstrated by other PBR101 users; typically a slight increase (such as was seen here) is observed upon up-scale





Conclusions:

- The Phenometrics PBR101 determines the best conditions for algal yield that may be readily up-scaled to production
- This includes accurate prediction of scaled production at the lab bench
- This allows selection of the best producing strain for production for a local environment
- It also provides for rapid exploration and optimization of production conditions (optimized by use of a PBR101 matrix)
- All of the above combine to provide a clear path to scale-up, reducing Capital Expenditure (CAPEX) risk and time, while optimizing growth, production, and return-on-investment (ROI)

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