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Biomass resource optimization tools in the food-fuel-environment context

Multiple and increasing demands for renewable resources affect the bio-economy as a whole but escalate in particular around bioenergy and biofuel. For many reasons, perennial crops, like short-rotation coppice (SRC), Miscanthus and grassland are attractive choices. The purpose of this talk is to illustrate in three examples the use of advanced mathematical optimization tools to increase the production and performance of whole systems exploiting synergies and calculating trade-offs.

Methodology: (1) A process-based model (PBM) for simulating trait and environmental effects on plant growth is to optimize G x E solutions for low-input SRC. (2) Up-scaled PBMs using scenario simulations for different crop systems were used to estimate available biomass resources and the yield gap resulting from fertilizer and livestock reduction. (3) A whole systems optimization framework, the Bioenergy Value Chain Model (BVCM) is presented that allows evaluating the biomass flow through the value chain under market and ecosystem constraints.

Findings: The PBM for SRC-willow identified a limited number of robust trait-related parameters that can be used to accelerate the selection and breeding process. An environmental (pedo-climatic) scenario analysis enabled us to ascertain the best variety for droughty environments with the highest water use efficiency and least impact on water resources. For UK grassland system we estimated a yield gap of 6 to 20 million tons of exploitable biomass when recommended N-fertilizer would be applied. Extending these results to the BVCM additional biogas from grassland biomass trade-offs from increased nitrous oxide emissions are calculated.

Conclusion: PBM for plant growth will be extended to optimize SRC traits for the industrial scale land reclamation of heavy metal contamination. Recommendations for best combinations of genotype x environment x management can be derived from these simulations and scaled up to optimize land use between bioenergy, food and other ecosystem services.

Fig: Modelling Tool Cascade

Biography

Dr Goetz Richter holds degrees in Agricultural and Environmental Sciences and has established himself as agricultural systems modeller with track records in climate change impact assessment, CC adaptation and mitigation using arable and perennial crops. Funded by Defra, the European Commission and RCUK, his group develops models for Soil-Plant-Atmosphere interactions at various scales, as tools for breeders to improve perennial biomass crops. For industry and policy-makers he provides agricultural feedstock maps for the bio-economy, used in the whole system optimization, e.g. for the Biomass /Energy Value Chain Models, initially funded by The Energy Technologies Institute and since 2013 by EPSRC. He optimizes process models using a Bayesian approach to improve our understanding of the Gene x Environment x Management interaction. He recently won an Innovate-UK project "Advancing Earth Observation Applications in Agriculture" which will enable to validate yield forecasts and assess the yield gap at the landscape scale.

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