GUIDED READING: Understanding and Modeling of Agricultural Systems 001.2.2067 - 2 credits

Lecturer: Jhonathan Ephrath

The student will read, present and discuss with the lecturer, research papers dealing with the subjects mentioned below. The student will be guided as to possible papers to choose so that a comprehensive picture is built of how plants synthesis and regulate metabolites and what techniques are used for this topic.

Component	Weight
Presentations	80%
Class discussions	20%
Total:	100%

Course Description:

During the first 4 classes, Students will learn concepts involved in developing models of the soil-plant-atmosphere system with a focus primarily on plant growth and development. Course will provide an in-depth survey on different approaches used in explanatory crop models to simulate crop gas exchange (photosynthesis and transpiration), organ expansion rates, carbon allocation, and crop phenology. The course will include 4 lectures of the teacher of the course and 9 lectures of the student according to reading assignments.

Course Objectives:

To give to the students the ability to understand the concepts of using models that describe agricultural activities (irrigation, fertilization) together with physiological processes taking place in plants.

The course does not deal with programing and the participants do not need to have any experience in computer science.

Course Structure:

i**) Why do we need models for agriculture - Introduction**

Student -examples of computerized decision support as used in irrigation management, yield-gap analyses, and geospatial food security

ii) **Modeling theory / Systems analysis**

Student -Models as abstraction of reality; Descriptor variables and system behavior; Conceptual overview of model building / testing / validation

iii) **The soil-plant-atmosphere system**

Student -Basic concepts involving soil physics, plant physiology, and meteorology; Plant as the central component of the system

iv) **Crop modeling overview**

Lecture (Teacher) -Why are more complicated models needed?

v) **Crop growth 1: Radiation Use Efficiency (RUE) – reading and student assignment**

Student -concept of LAI, light extinction through the canopy, leaf angles

Vi **Photosynthesis, transpiration, and energy balances –**

reading and student assignment:

i) Student - Crop growth and Photosynthesis

ii) Stomatal conductance and water use
Student -Overview of transpiration, stomatal conductance, water use efficiency

iii) Coupling energy balance to gas exchange
Lecture (Teacher) -Concepts involved in scaling up from leaf-level to canopy

Viii **Phenology, organ growth, and carbon demand. reading and student assignment**

i) Plant Development versus Phenology
Student -Difference between modeling particular developmental stages versus predicting progression among developmental stages; Identification of developmental stages for particular crops; Correlations with temperature
Lecture (Teacher): Thermal time. Students will be given data for spreadsheet and asked to construct thermal time model. In-class assignment will include study of sensitivity analyses of development response using their thermal time model in which different growing seasons (with different temperatures) are provided.

iX **Plant Stresses**
i) Nitrogen stress
Student -When does a plant experience nitrogen stress?; how is nitrogen demand quantified? what is nitrogen used for?
ii) Water stress
Student -When does a plant experience water stress; how to quantify water demand?; what happens to the plant when water stressed?; Discuss impacts on leaf expansion, stomatal conductance, root: shoot ratios
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References:

Other References *(only from 1990 and onward)*

De Vries, F.W.T. Penning and R. Rabbinge. 1995. Models in research and education, planning and practice. In (Eds: A.J. Haverokort and D.K.L. MacKerron): Potato Ecology and Modelling of Crops under Conditions Limiting Growth, Kluwer Academic Publishers, the Netherlands, pp1-18.

Salazar, M.R., J.E. Hook, A. Garcia y Garcia, J.O. Paz, B. Chaves, and G. Hoogenboom. 2012. Estimating irrigation water use for maize in the Southeastern USA: A modeling approach. Ag. Wat. Manage., 107: 104-111.

Resop, J.P., Fleisher, D.H., Wang, Q., Timlin, D.J., and Reddy. V.R. Combining explanatory crop models with geospatial data for regional analyses of crop yield using field-scale modeling units. Comp. and Elect. in Agr. 89: 51-61. 2012.

Resop, J.P., Fleisher, D.H., Timlin, D.J., and Reddy, V.R. Biophysical constraints to potential production capacity of potatoes over the U.S. eastern seaboard. Agron. J. 106: 43-56, 2014.

Mathematical / Modeling Concepts

Thornley, J.H.M. and I.R. Johnson. 1990. Plant and Crop Modelling: A Mathematical Approach to Plant and Crop Physiology. Oxford University Press, New York. Chapter 1: Dynamic Modelling, p 3. – 44. [overview of empiricism, mechanism, dynamic models for crop behavior]

(soil)-Plant-Atmosphere Overview

Campbell, G.S. and J. M. Norman. An Introduction to Environmental Biophysics – 2nd ed. 2000. Springer-Verlag, New York, NY.
Chapter 10: Radiation Basics, pp. 147-165. [Electromagnetic spectrum SW, LW basics]
Chapter 11: Radiation Fluxes in Natural Environments, pp. 167-184 [energy balance]

Loomis, R.S. and D.J. Connor. Crop Ecology. Productivity and management in agricultural systems. Cambridge University Press, New York, NY.
Chapter 4: Genetic resources, pp. 82-103. [overview of cultivar responses]
Chapter 6: Aerial Environment, pp. 131-163. [SW and LW radiation basics, net radiation, and energy balance]

Rabbinge, R. 1993. The ecological background of food production. Pages 2-29 in: Crop Protection and Sustainable Agriculture. Ciba Foundation 77. D. J. Chadwick and J. Marsh, eds. John Wiley & Sons, Chichester, UK. [Potential, Attainable, Actual production]

Van Ittersum, M. K., and Rabbinge, R. 1997. Ecology for analysis and quantification of agricultural input-output combinations. Field Crops Res. 52:197-208. [Potential, Attainable, Actual production]

Light Interception / Attenuation

Loomis, R.S. and D.J. Connor. Crop Ecology. Productivity and management in agricultural systems. Cambridge University Press, New York, NY.
Chapter 2: Community Concepts, pp 34-39. [overview of LAI, light interception, crop growth rate]

Campbell, G.S. and J. M. Norman. An Introduction to Environmental Biophysics – 2nd ed. 2000. Springer-Verlag, New York, NY.

Chapter 15: The light environment of plant canopies, pp. 247 – 275 [in depth light interception, sunlit / shaded approaches]

Crop Growth Rates – Modeling leaf level photosynthesis

Bernacchi, C.J., J.E. Bagley, S.P. Serbin, U.M. Ruiz-Vera, D.M. Rosenthal, and A. Vanloocke. 2013. Modelling C3 photosynthesis from the chloroplast to the ecosystem. Plant, Cell & Environment 36: 1641-1657 [nice and concise overview]

Kim, Soo-Hyung and J. H. Lieth. 2003. A coupled model of photosynthesis, stomatal conductance and transpiration for a rose leaf (Rosa hybrid L.). Annals of Botany, 91: 771-781.

Soil x Plant Overview

Loomis, R.S. and D.J. Connor. Crop Ecology. Productivity and management in agricultural systems. Cambridge University Press, New York, NY.

Soil Resources 164 – 192.

Water Demand

Campbell, G.S. and J. M. Norman. An Introduction to Environmental Biophysics – 2nd ed. 2000. Springer-Verlag, New York, NY.

Chapter 14: Plants and Plant Communities, pp 223-246 [review of energy balance for leaf and canopy; examples of sunlit / shaded photosynthesis

Loomis, R.S. and D.J. Connor. Crop Ecology. Productivity and management in agricultural systems. Cambridge University Press, New York, NY.

Chapter: 9 Water Relations, pp. 224-256. [brief overview of transpiration, crop coefficients]

Soil Water Balance

J.T. Richie. 1998. Soil Water Balance and Plant Water Stress.Understanding Options for Agricultural Production. Kluwer Acadmemic pubs 41-54.

Growth, Respiration, Partitioning

Loomis, R.S. and D.J. Connor. Crop Ecology. Productivity and management in agricultural systems. Cambridge University Press, New York, NY.

Chapter 11: Respiration and Partitioning

N balance – soil

Loomis, R.S. and D.J. Connor. Crop Ecology. Productivity and management in agricultural systems. Cambridge University Press, New York, NY.

Chapter 8: Nitrogen Processes

N balance – plant

Godwin and Singh. 1998. Understanding options for Agricultural Production. Tsuji, Hoogenboom, Thornton, Eds. Nitrogen balance and crop response to nitrogen in upland and lowland systems.55-78

Greenwood, D.J. and A. Draycott. 1995. Modelling uptake of nitrogen, phosphate and potassium in relation to crop growth. P. Kabat, B. Marshall, B.J. van den Broek, J. Vos, and H. van Keulen (eds). Modelling and Parameterization of the Soil-Plant-Atmosphere System:

A Comparison of Potato Growth Models. Wageningen Pers, Wageningen, The Netherlands, 1995. Pp. 155- 175

N transformation, movement, and uptake

Ma, L., L.R. Ahuja, and T.W. Bruulsema. 2009. Current status and future needs in modeling plant nitrogen uptake: a preface. In: (Ma, Ahuja, Bruulsema, eds): Quantifying and Understanding Plant Nitrogen Uptake for Systems Modeling. CRC Press, Taylor & Francis Group, Boca Raton, FL. Pp. 1-12.

Godwin and Singh. 1998. Nitrogen balance and crop response to nitrogen in upland and lowland cropping systems. In: (Tsuji et al eds) Understanding Options for Agricultural Production. Kluwer Academic Publishers, Great Brittain, ppg 55-78

Timlin, Kouznetsov, Fleisher, Kim, and Reddy. 2009. Simulation of nitrogen demand and uptake in potato using a carbon-assimilation approach. In: Ma et al eds. Plant Nitrogen Uptake for Systems Modeling, pp. 219-244.

N stress

J. Vos. 1995. Nitrogen and the growth of potato crops. In: (Haverkort and MacKerron, eds). Potato Ecology and Modelling of Crops under Conditions Limiting Growth. Kluwer Academic Publishers, the Netherlands, 115-128.

Biotic stress

Teng, P.S., W.D. Batchelor, H.O. Pinnschmidt, and G.G. Wilkerson. 1998. Simulation of pest effects on crops using coupled pest-crop models: the potatential for decision support. In: (Tsuji et al eds) Understanding Options for Agricultural Production. Kluwer Academic Publishers, Great Brittain, ppg 221-266.

Climate change

Boote, K.J., J.W. Jones, J.W. White, S. Asseng, and J.I. Lizaso. 2013. Putting mechanisms into crop production models. Plant, Cell & Env. 36: 1658-1672

Fleisher, D.H., D. Timlin, K.R. Reddy, V.R. Reddy, Y. Yang, and S-H Kim. 2011. Effects of CO2 and Temperature on Crops: Lessons from SPAR Growth Chambers. In: (Hillel and Rosenzweig, eds) Handbook of Climate Change and AgroEcosystems: Impacts, Adaptation, and Mitigation. Imperial College Press. London. Pp. 55-86.

Kimball. B. 2011. Lessons from FACE: CO2 Effects and Interactions with Water, Nitrogen and Temperature. In: (Hillel and Rosenzweig, eds) Handbook of Climate Change and AgroEcosystems: Impacts, Adaptation, and Mitigation. Imperial College Press. London. Pp. 87 – 108.