Review of Crop Models from Wageningen

AGRON 590 MG: Crop-Soil Modeling

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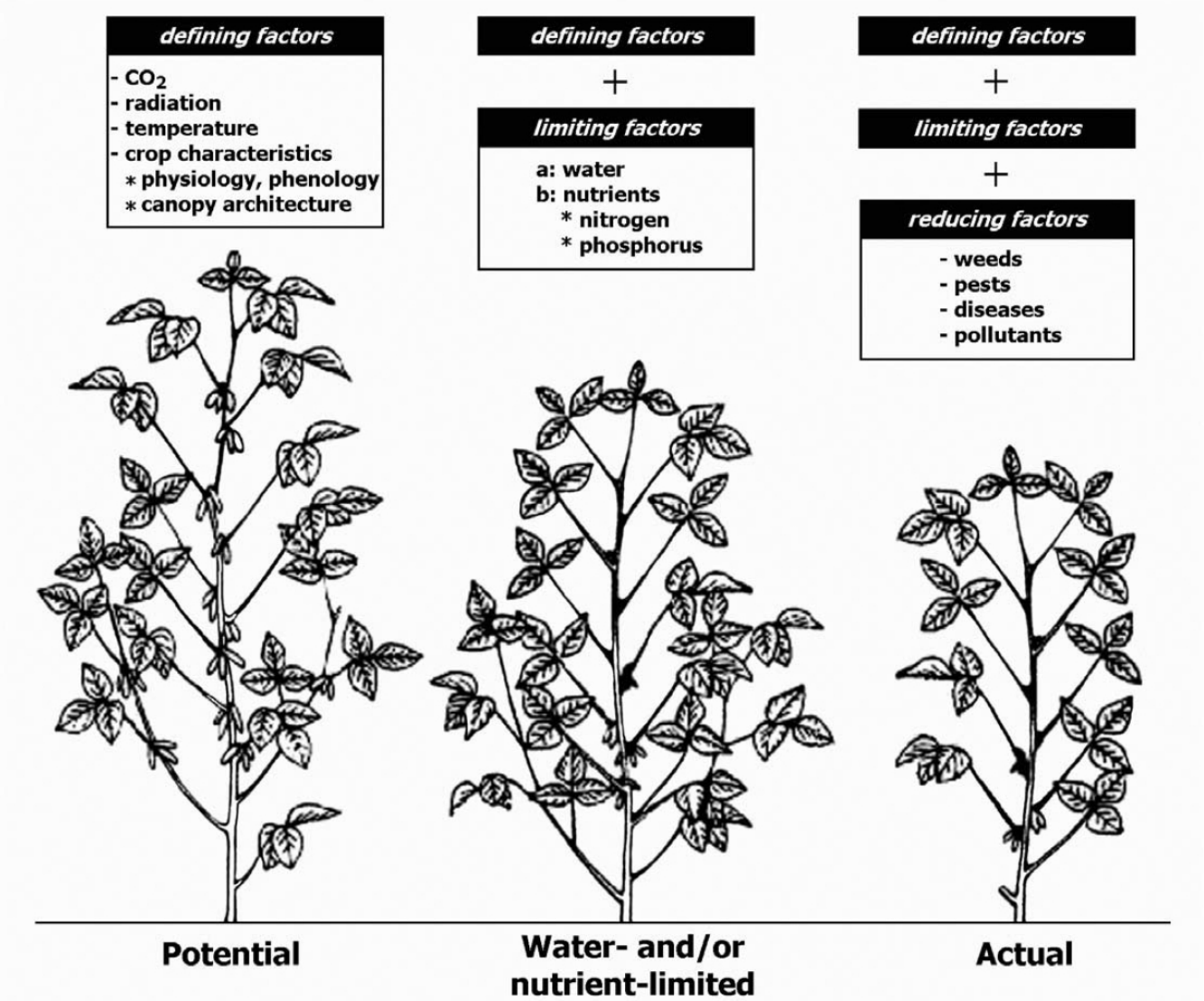
Sep 3, 2010

Classifying the Wageningen Models

- a hierarchy in growth and production factors;
- objectives of the models, required scale and detail
- application domains, i.e. research, education and decision

Hierarchy in growth factors



Objectives, scale and detail

- Explanatory (underlying process)
- Descriptive (relationships)

Application domain

- Wageningen models are mainly oriented to research
- Formulate and test hypothesis
- Teaching
- Wagenigen models have been used less frequently for decision support

Potential production

- Radiation (or Light) Use Efficiency based
- Photosynthesis based
- Water Use Efficiency based

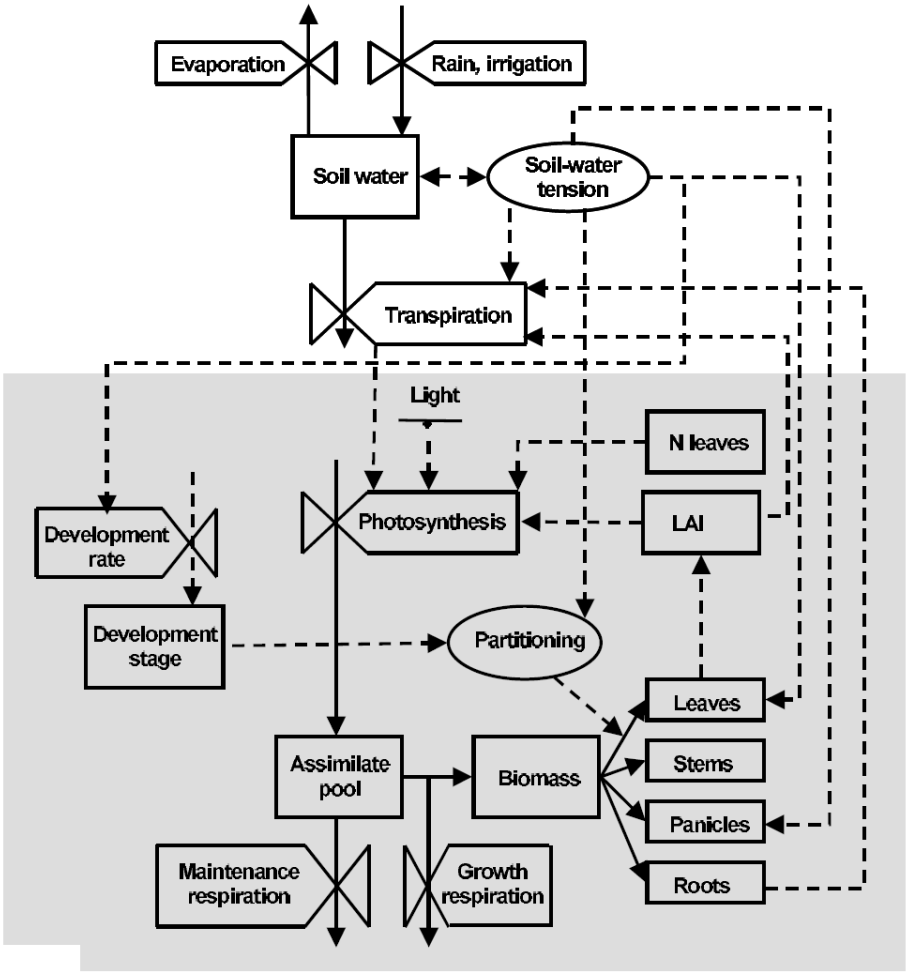
Water and nutrient limited

- "tipping bucket"
- Richards potential driven

Leaf Area Index

What is it? (area of leaf/area of ground) How do we measure it? What simplification are we making?

Crop-Soil Model



a

- Photosynthesis
- Respiration
- Allocation
- Transpiration
- Water stress

Why model?

- Science is concerned with prediction.
- Conceptual model are hypotheses
- Models are logically and quantitatively constructed series of beliefs about how a system works

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Simple Crop Model

- interception of incident solar radiation by the leaf canopy
- conversion of the intercepted radiation to plant dry matter
- Partition of dry matter into harvestable organs

$$Y = Q \times I \times \varepsilon \times H$$

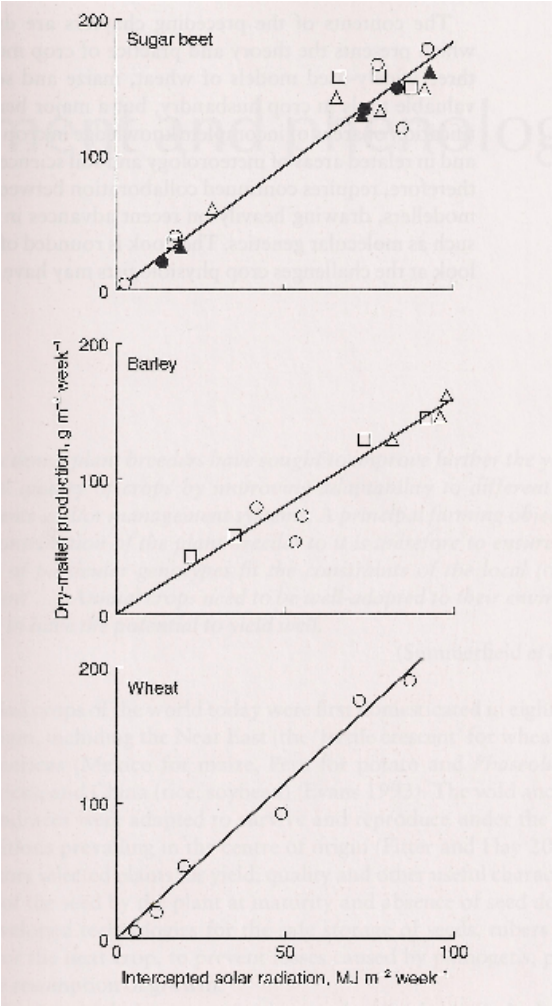
$$Q = \text{Radiation}$$

$$I = \text{Interception efficiency}$$

$$\varepsilon = \text{Conversion efficiency}$$

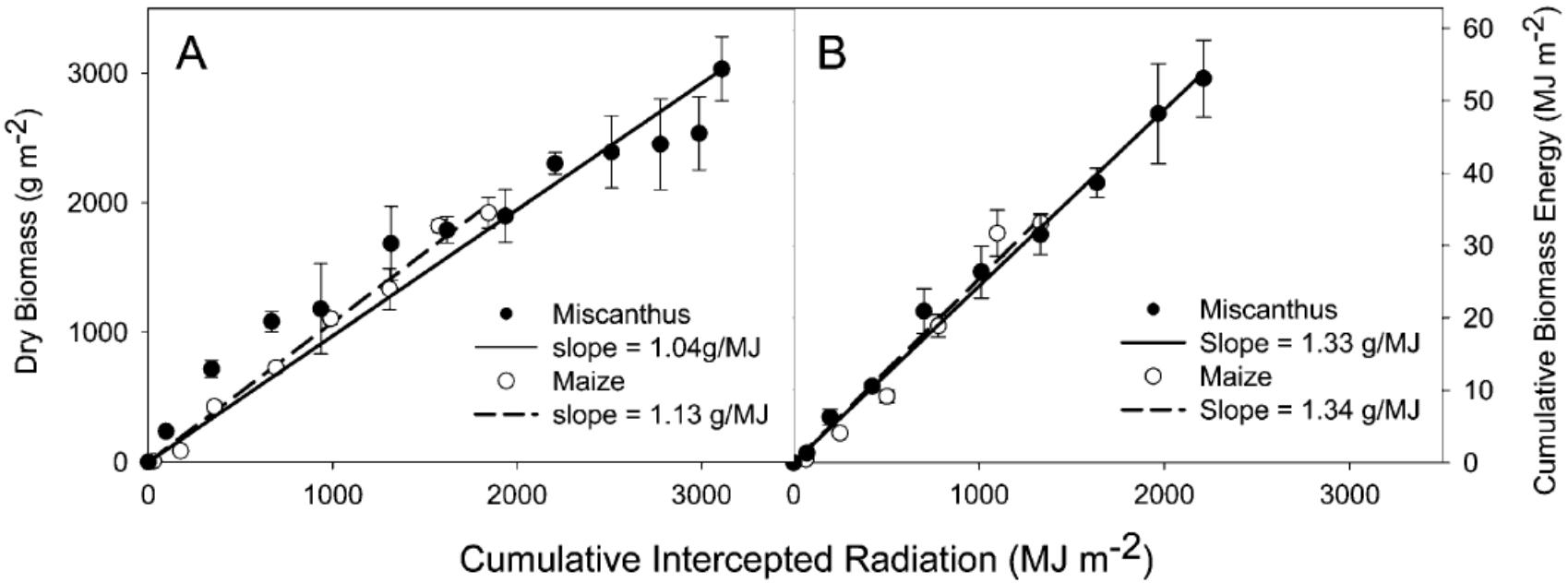
$$H = \text{Harvest index}$$

Relationship between Radiation and Biomass



Relationship between Radiation and Biomass

(A) 2007, (B) 2008



Why was Miscanthus 59% more productive than maize?

Simple Crop Models

$$W = \int_{Tt=e}^{Tt=pm} R \cdot dt$$

where

$$\frac{dW}{dt}$$

$=$ rate (R) of change of dry weight $(g\ m^{-2}d^{-1})$ Typical value might be around 20 $g\ m^{-2}d^{-1}$ (10-30)

Let us try this for corn

$$W = \int_{e}^{pm} R \cdot dt$$

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$$W = R \cdot \int_{e}^{pm} dt$$

$$W = R \cdot [pm - e]$$

Let us assume emergence day of the year is 127 and physiological maturity 252

Let us try this for corn

$$W = \int_{s}^{pm} R \cdot dt$$

$$W = R \cdot \int_{e}^{pm} dt$$

$$W = R \cdot [pm - e]$$

$$W = 20 \cdot [252 - 127]$$

$$W = 2500$$

Let us try this for corn

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$$W = 2500$$

What does 2500 mean?

Let us try this for corn

$$W = \int_{e}^{pm} R \cdot dt$$

$$W = R \cdot \int_{e}^{pm} dt$$

$$W = R \cdot [pm - e]$$

$$W = 20 \cdot [252 - 127]$$

$$W = 2500$$

2500 $g\ m^{-2}$ or 25 $Mg\ ha^{-1}$ total biomass of corn 12.5 $Mg\ ha^{-1}$ grain (199 bushels ac^{-1})

Limitations of the previous approach?

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- Not limited by radiation, water or nutrients
- growth rate is constant (linear)
- Does not take into account genetics
- Does not take into account management, pest or weeds

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where
Q = Quantum flux
RUE = Radiation Use Efficiency

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$$W = \int_{e}^{pm} Q \cdot f(LAI) \cdot RUE \cdot dt$$

where
Q = Quantum flux
RUE = Radiation Use Efficiency
f(LAI) = efficiency of interception which depends on LAI (Leaf Area Index)

How can we improve the model?

$$Y = \int_{e}^{pm} Q \cdot f(LAI) \cdot RUE \cdot g(W) \cdot dt$$

where
Q = Quantum flux
RUE = Radiation Use Efficiency
f(LAI) = efficiency of interception which depends on LAI (Leaf Area Index)
g(W) = fraction of total biomass harvested (harvest index)

"Models should be made simple, but not simpler"

"A crucial notion in choosing either to use or develop a model is balance. Balance means that the model should be sufficiently but not overly detailed for the question that is to be addressed."