University of Thessaly
Department of Agriculture, Crop Production &
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Laboratory of Agronomy and Applied Crop Physiology
(UTH) Greece

BioKenaF:
A crop growth simulation model for kenaf

Seminar – May 9th 2006

Bolonga, Italy

"Present and future of kenaf as multipurpose crop"

(UTH) working group

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MSc − candidate

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Model

What is a model?

Model is a simplified representation of a system

System is a limited part of reality that contains interrelated elements. Examples: leaf, crop, earth, etc.

Why we need models?

Predictions / explanations / save time and money

BioKenaF

BioKenaF = SOCRATES−KENAF

SOCRATES developed by N.G. Danalatos (1993)

(ISBN: 90−5485−063−9CIP−DATA Koniklijke bibliotheek, de Haag, The Netherlands)

Simulates [cotton / maize / wheat] under Mediterranean conditions

SOil CRop ATmosphere Evaluation System

BioKenaF model is a dynamic explanatory model, based on assumption of the state − variable approach

The state of each system at any moment can be quantified and that changes in the state can be described by mathematical equations (de Wit, 1982)

Biokenaf simulation model

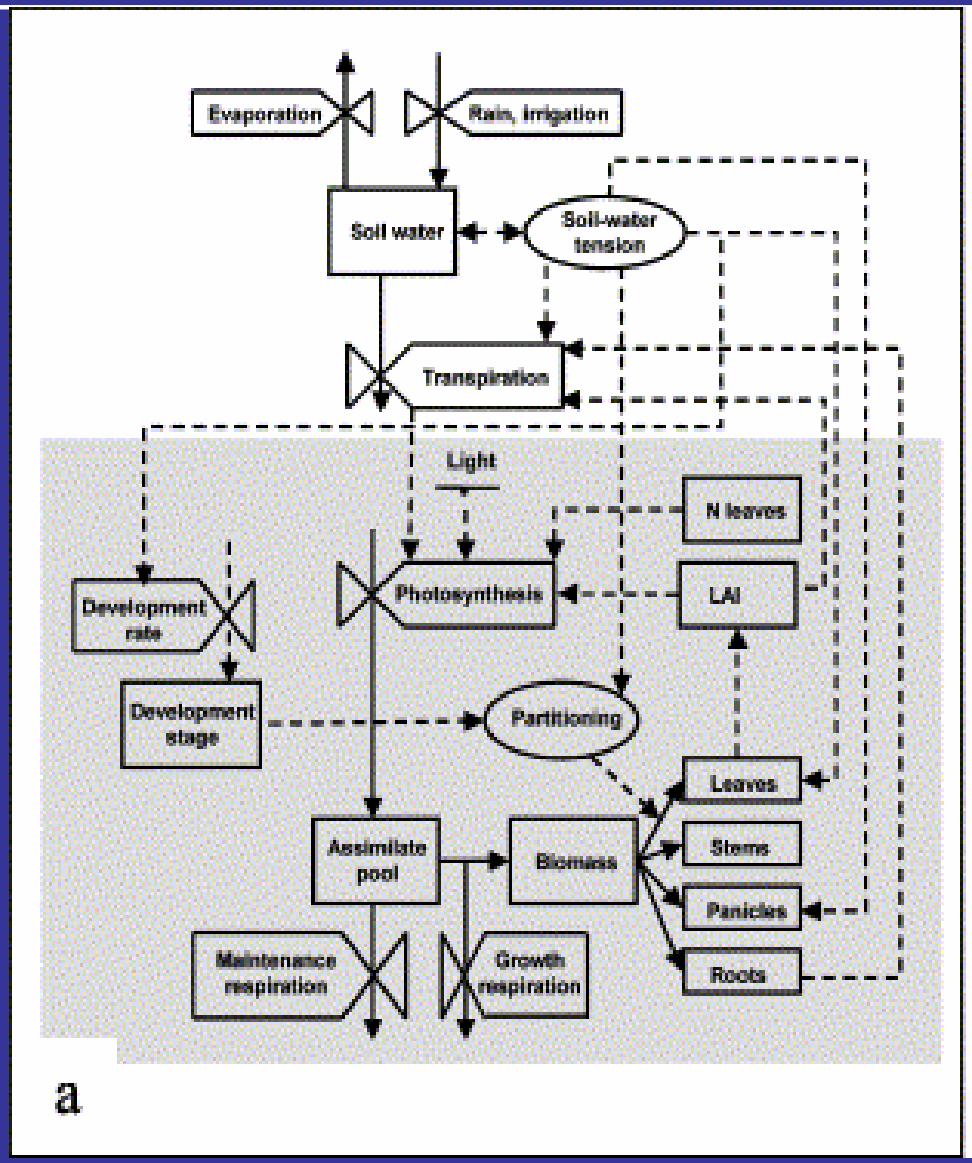
Biokenaf is dynamic (= change over the time) crop growth simulation model which can predicts kenaf yield (= potential and water limited production situation) under variable climatic conditions (= light, temperature, precipitation, relative humidity, wind speed, evapotranspiration, etc).

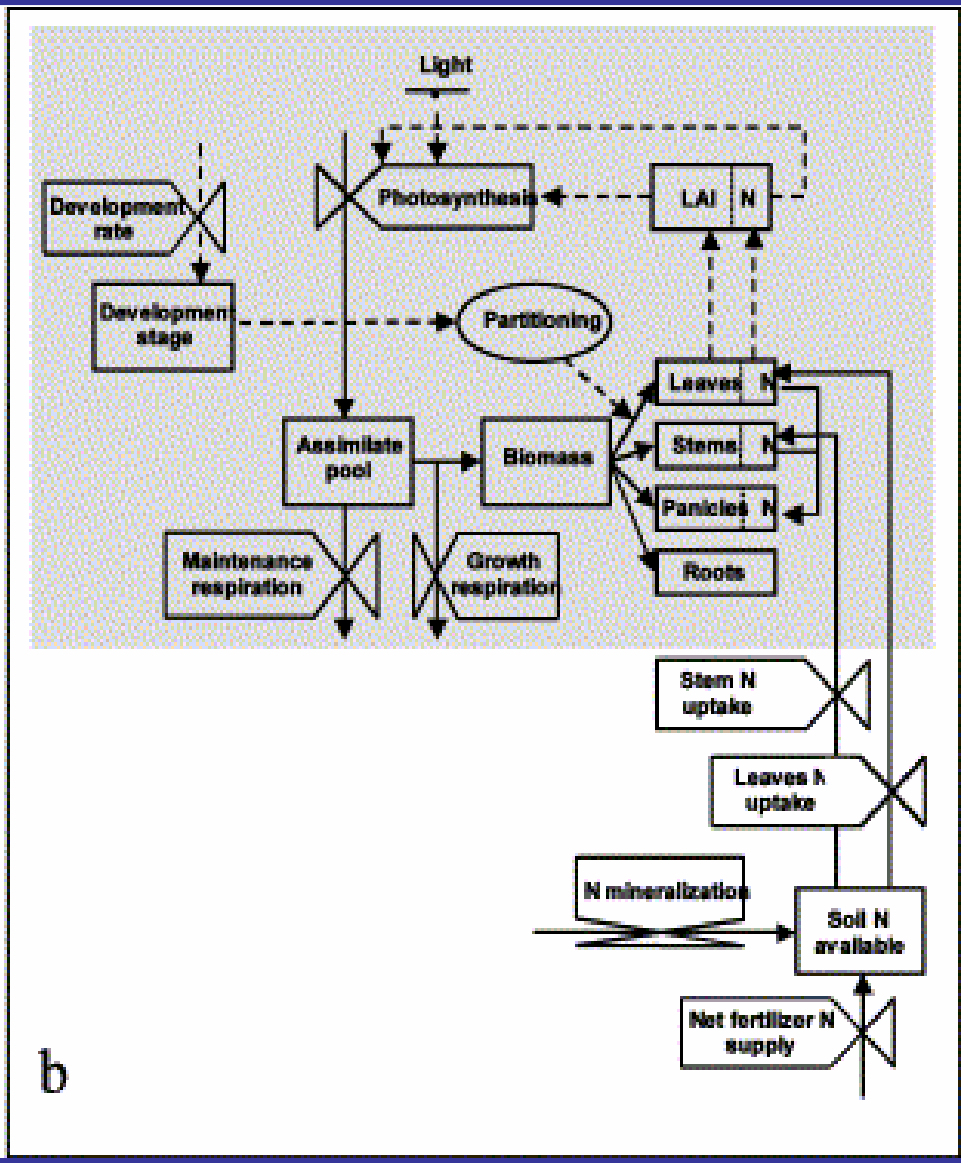
Time step = 1 day

Inputs: (location of the site, whether data, etc.)

Outputs: (TDW, SDW, LAI, etc.)

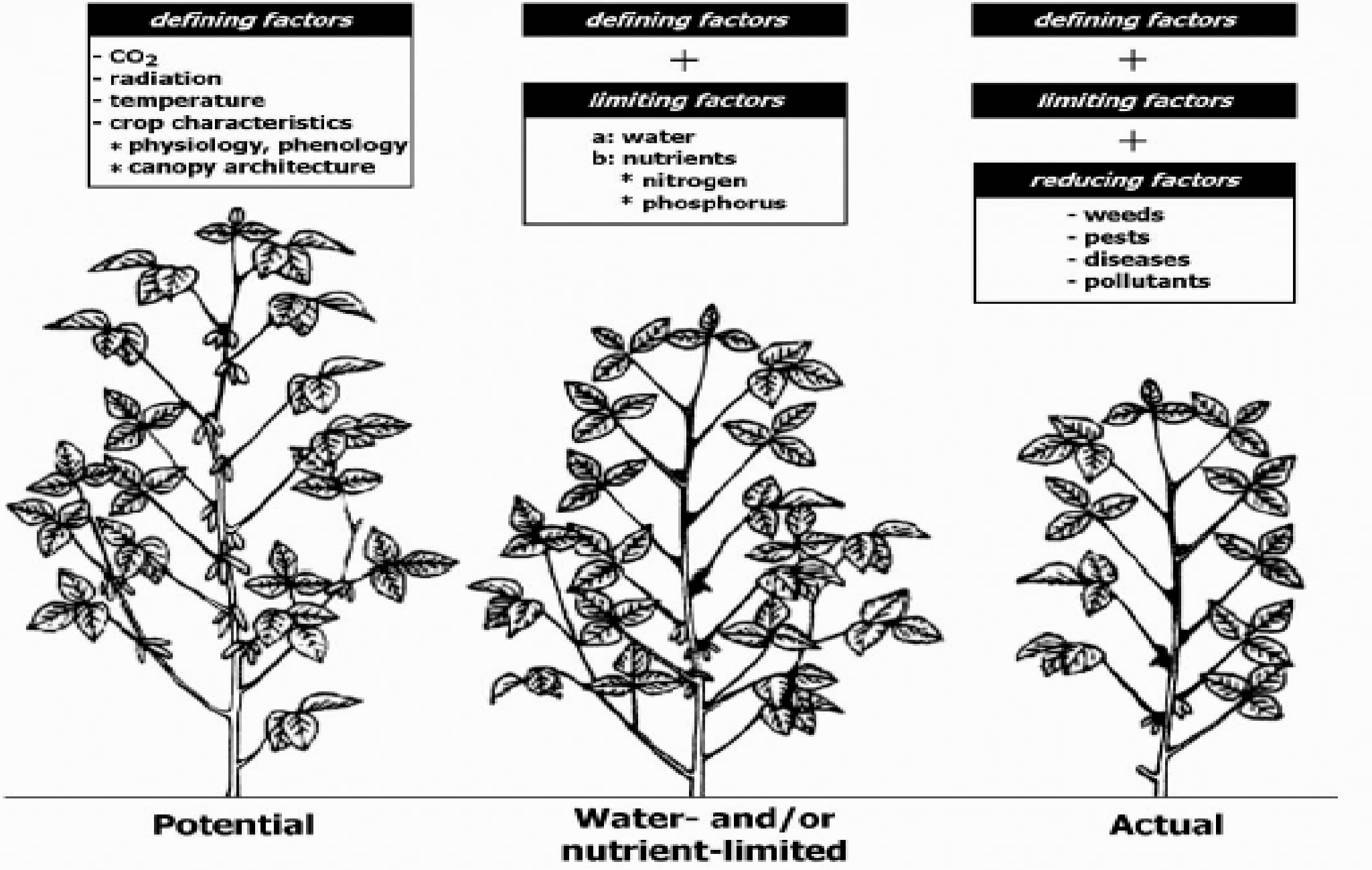
Wageningen−crop growth approach





(van Ittersum et al. 2003. Eur. J. Agron. 18:201−234)

Production levels [1]

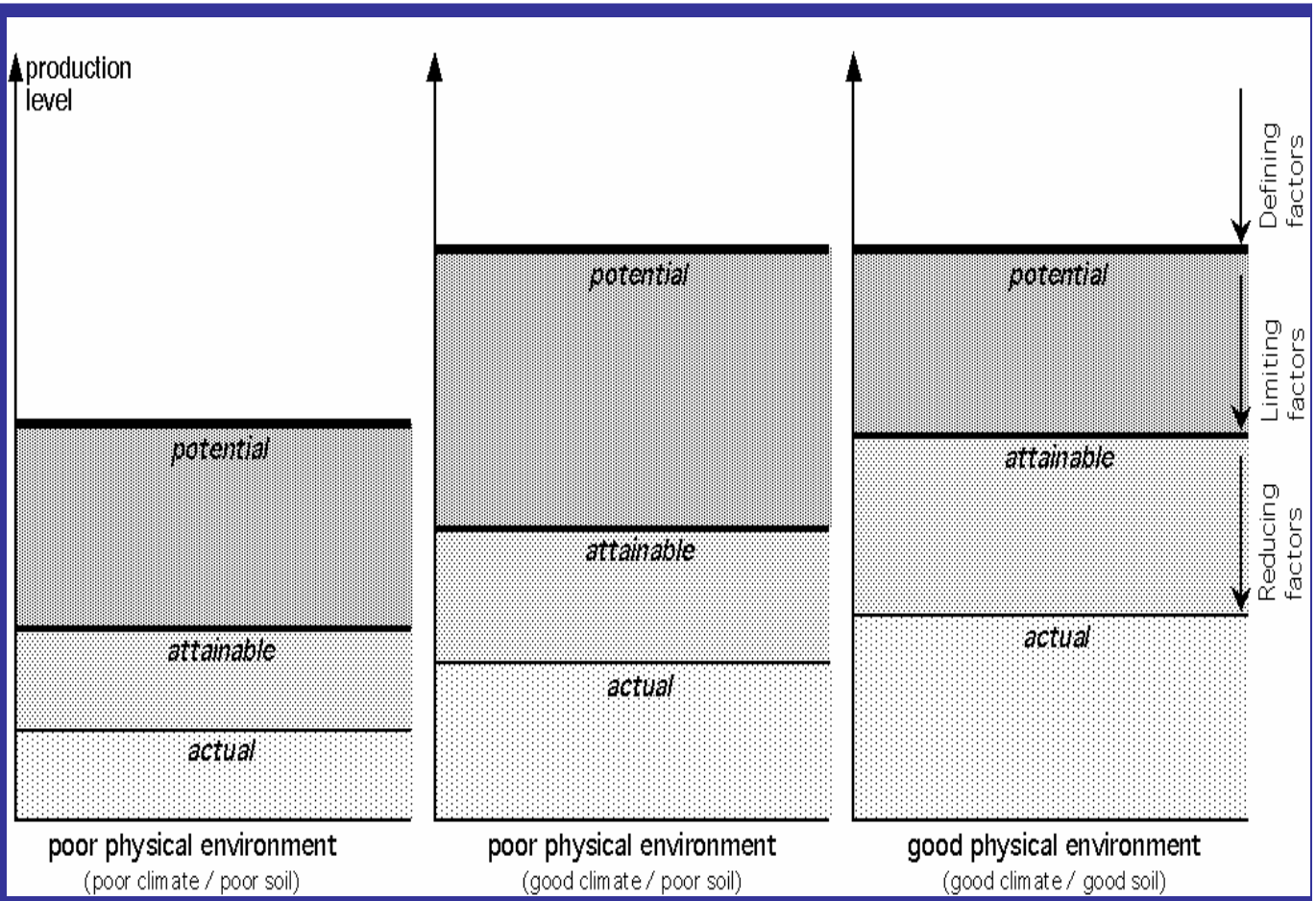


(van Ittersum et al. 2003)

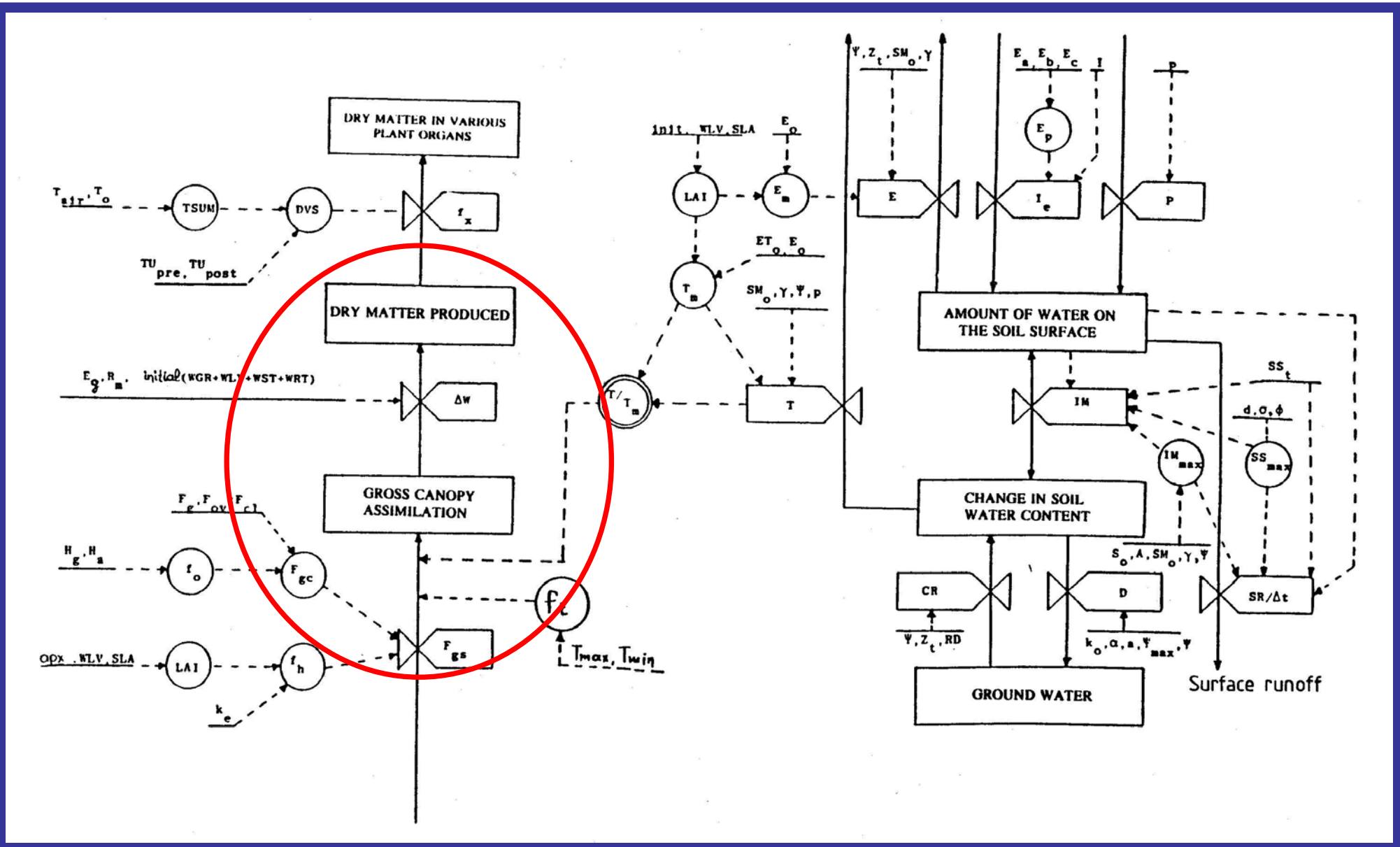
Production levels [2]

Classification:

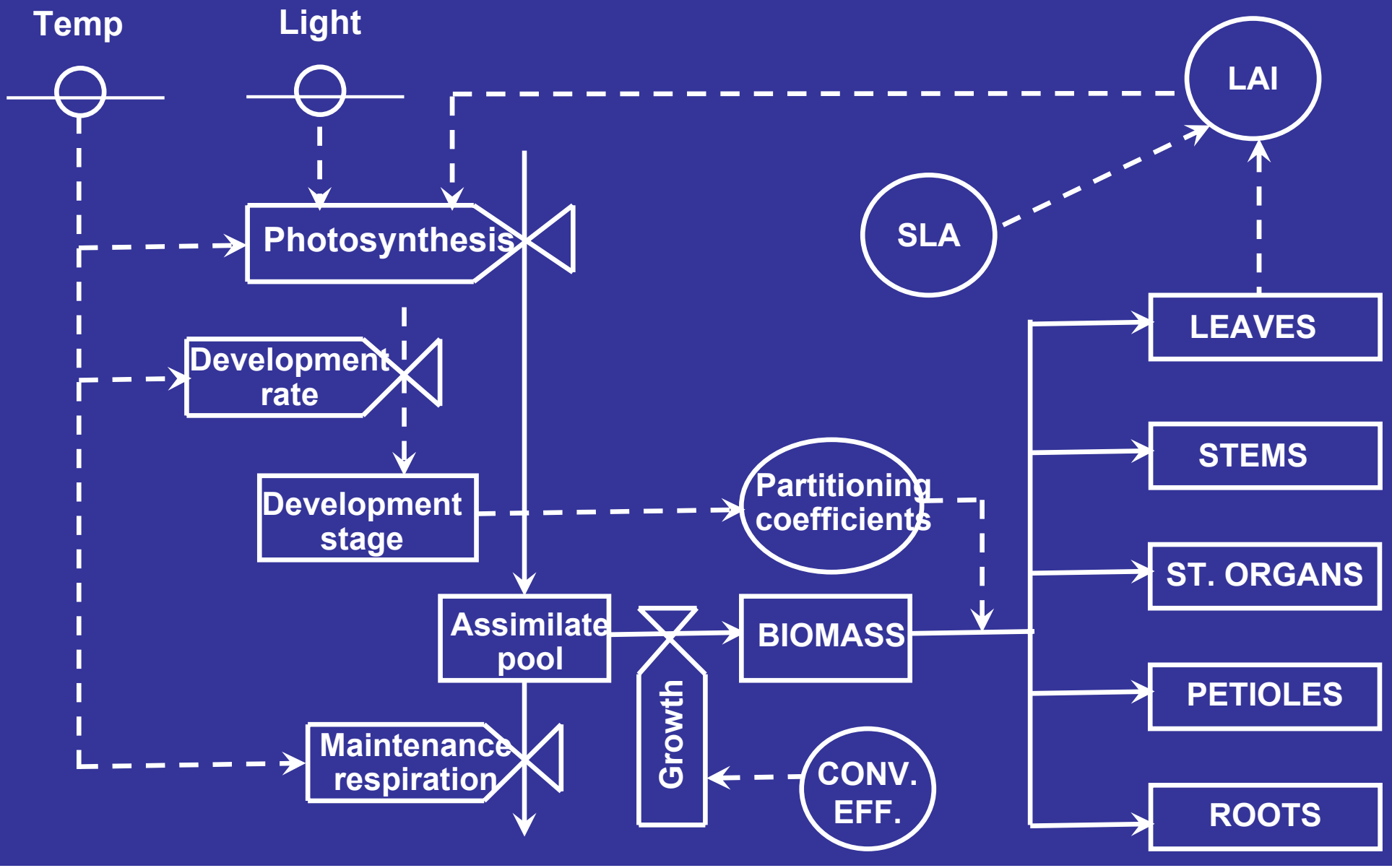
- Production level 1: **weather**
- Production level 2: **water**
- Production level 3: **nitrogen**
- Production level 4: **others**



Relation diagram



A subroutine of BioKenaF



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Symbols in relation diagram

State variable (TDW, SDW, LDW, etc)

Rate variable (growth, photosynthesis, respiration, etc)

Intermediate (auxiliary) variable (partitioning, growth conversion efficiency, etc)

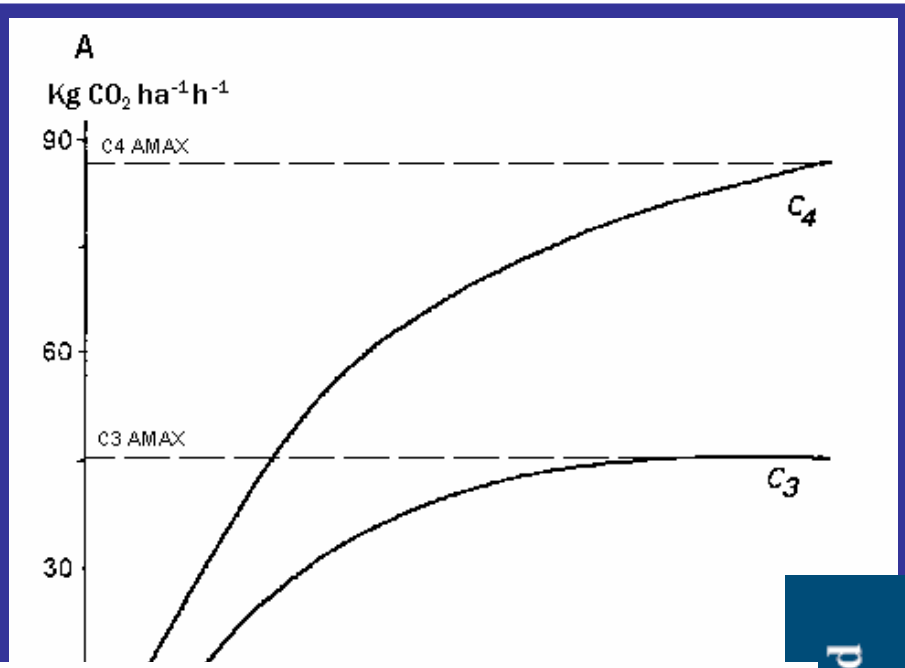
Constant or driving variable (light, temp., etc)

Material flow

Information flow

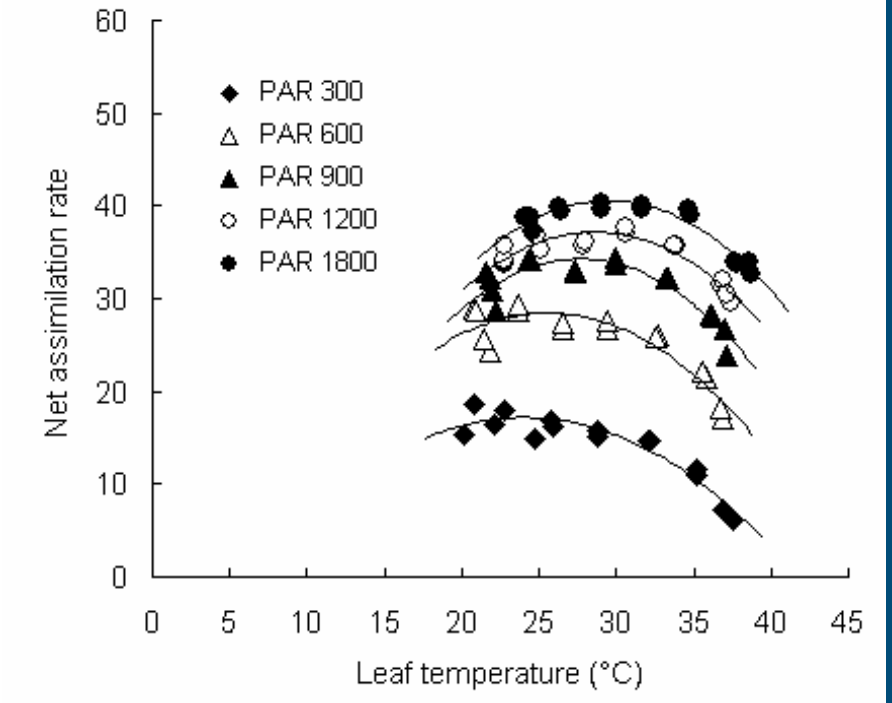
A subroutine of BioKenaF [1]

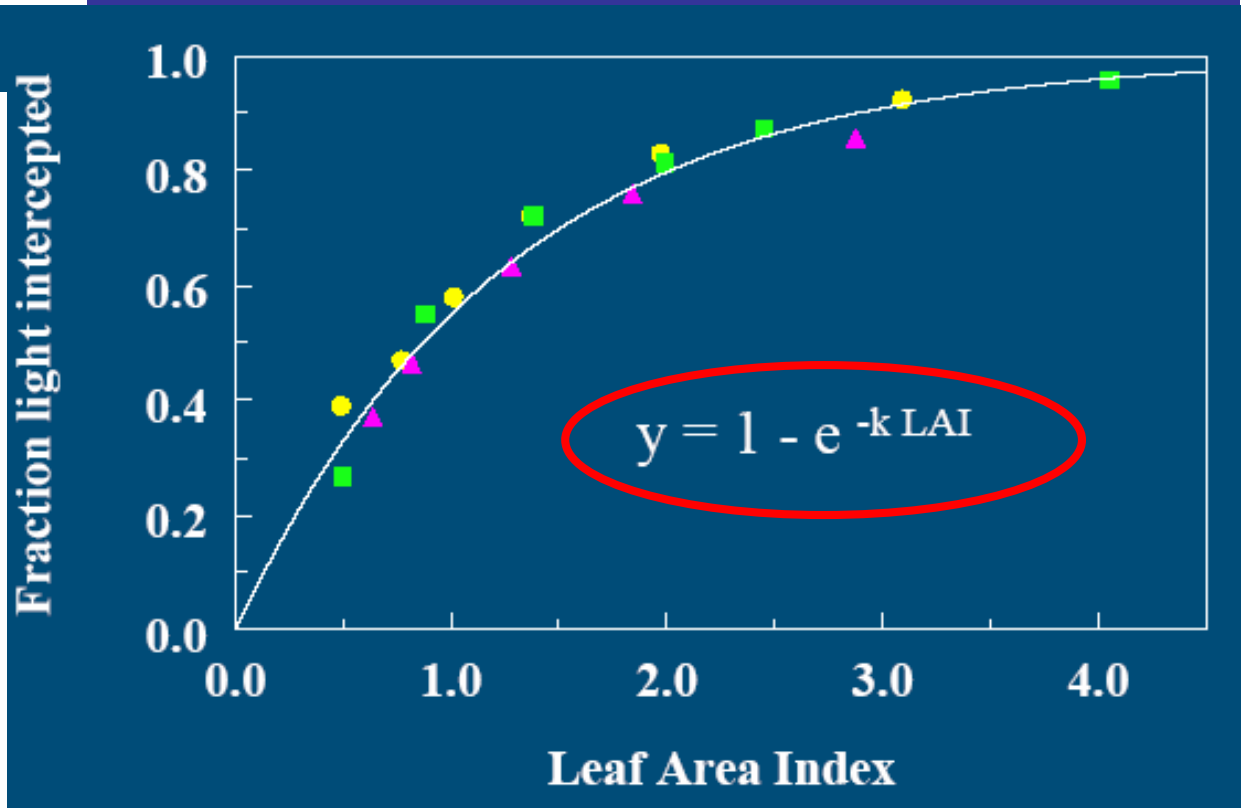
Photosynthesis / light interception



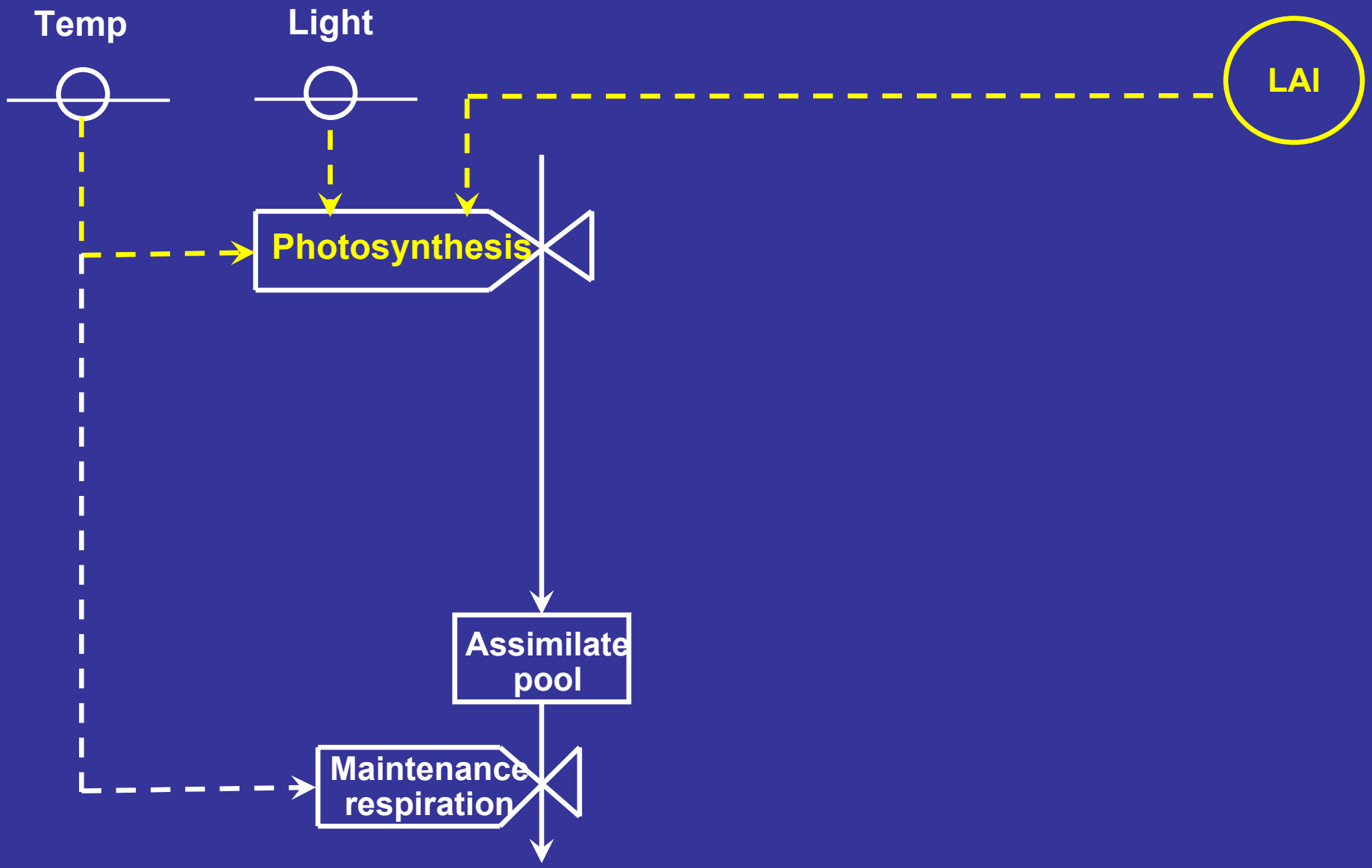
$$A_{gross} = A_{max}\,(1 - e^{\varepsilon * PAR / A_{max}})$$

where Amax = Anet max + Rdark

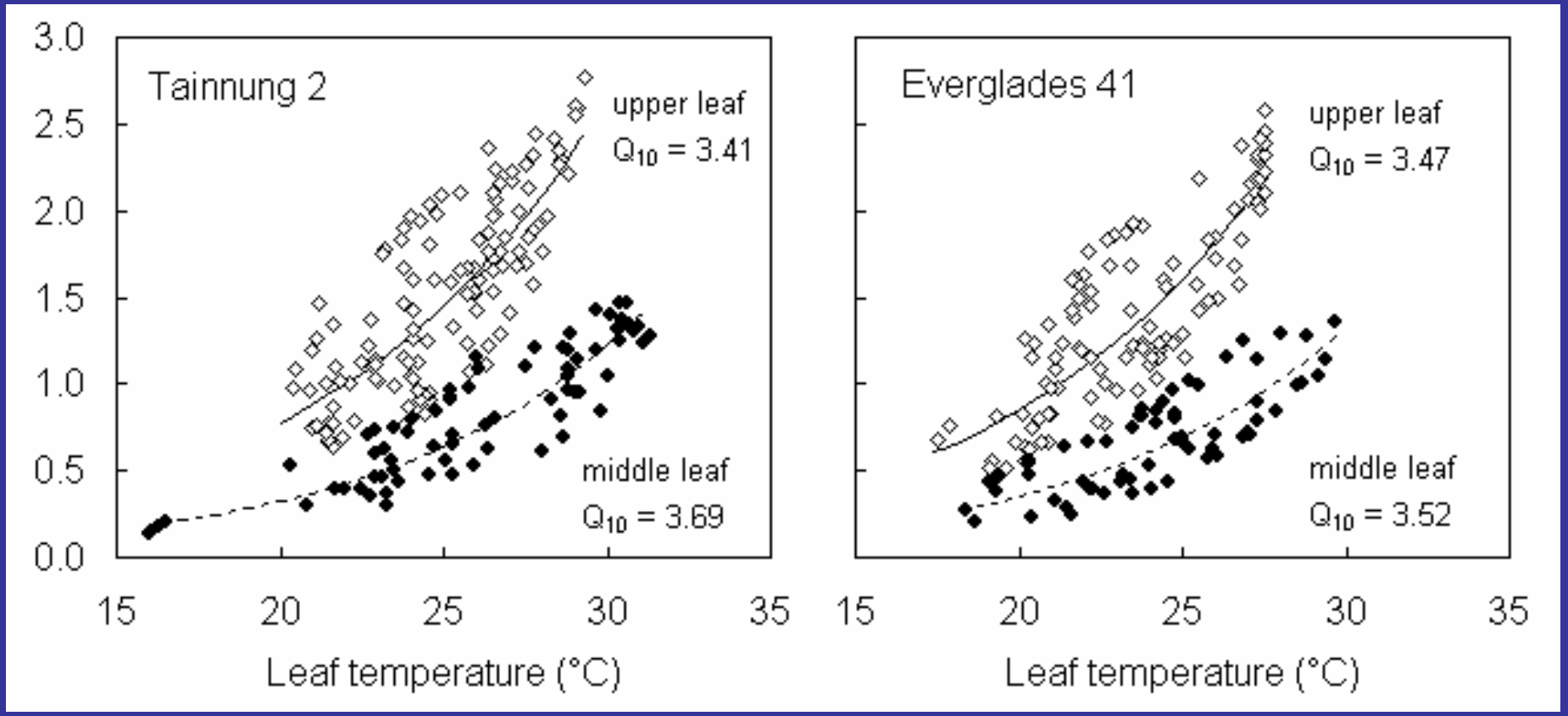




A subroutine of BioKenaF [2]



Respiration / temperature



Commonly in literature : $Q_{10} = 2^{(temp-25)/10}$ (van' t Hoff, 1889)

In BioKenaF we develop a new formula based on (modified Arrhenius model)

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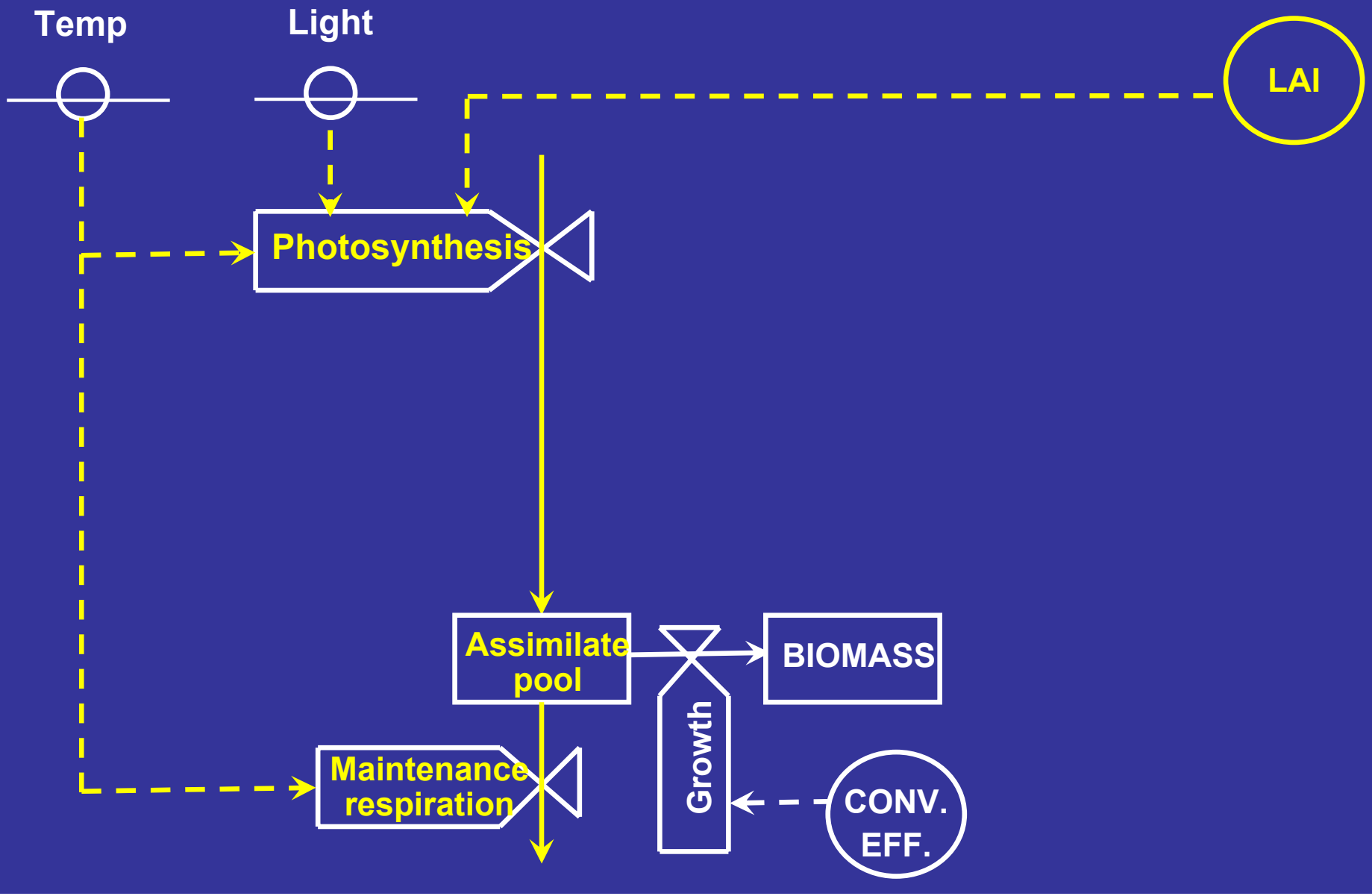
A subroutine of BioKenaF [3]



From light to Biomass (an example)

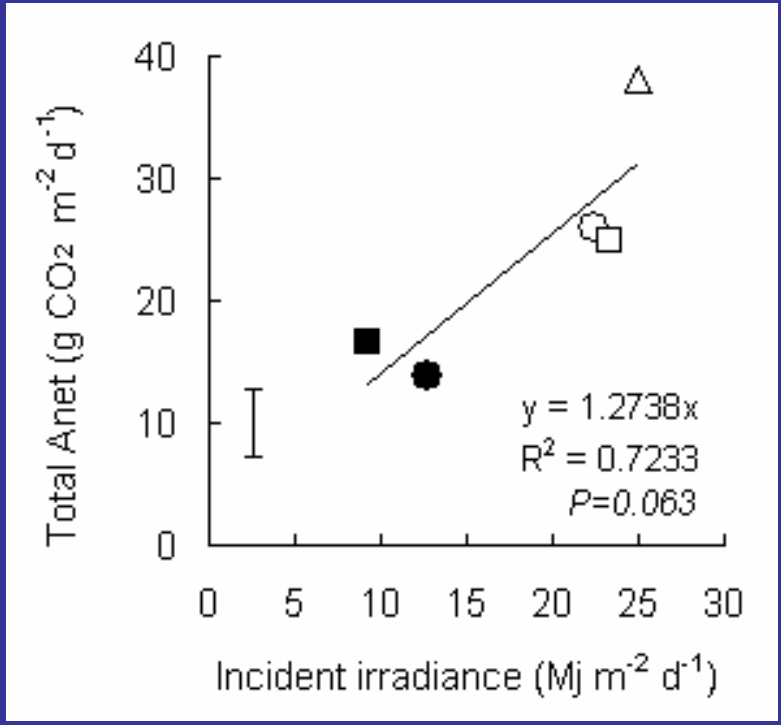
Light: 150 GJ (R global) ha^{-1} d^{-1}

→ (0.5)

75 GJ PAR

→ (ρ, ε; reflection coefficient, initial light use efficiency)

A gross: 500 kg CO_2 ha^{-1} d^{-1}



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A gross: 500 kg CO_2 ha^{-1} d^{-1}

→ (30/44)

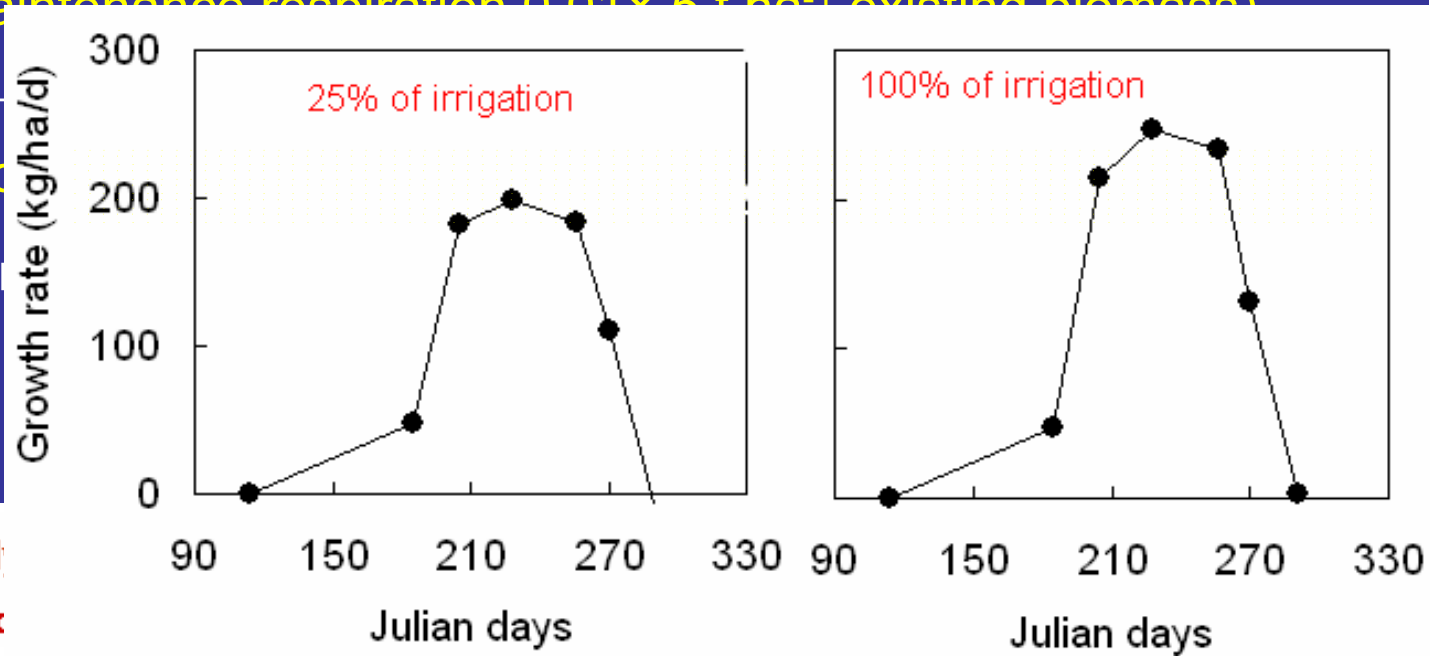
340 kg CH_2O ha^{-1} d^{-1}

→ (ma

290 kg CH_2O ha

→ (gr

200 kg dry matte



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A gross: 500 kg CO_2 ha^{-1} d^{-1}

→ (30/44)

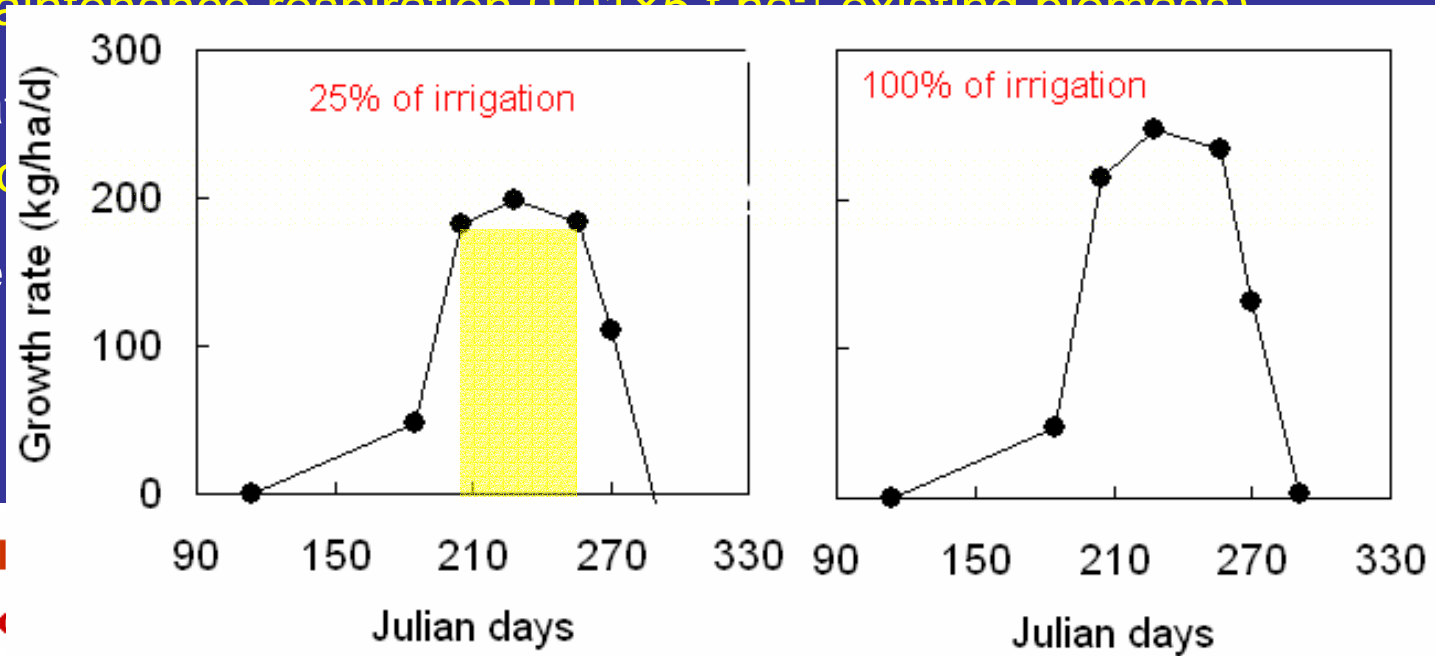
340 kg CH_2O ha^{-1} d^{-1}

→ (maintenance respiration 0.01×5 t ha^{-1} existing biomass)

290 kg CH_2O ha

→ (gr

200 kg dry matte



From light to Biomass (an example)

Light: 150 GJ (R global) ha^{-1} d^{-1}

↓ (0.5)

75 GJ PAR

↓ (ρ, ε; reflection coefficient, initial light use efficiency)

A gross: 500 kg CO_2 ha^{-1} d^{-1}

↓ (30/44)

340 kg CH_2O ha^{-1} d^{-1}

↓ (maintenance respiration 0.01×5 t ha^{-1} existing biomass)

290 kg CH_2O ha^{-1} d^{-1}

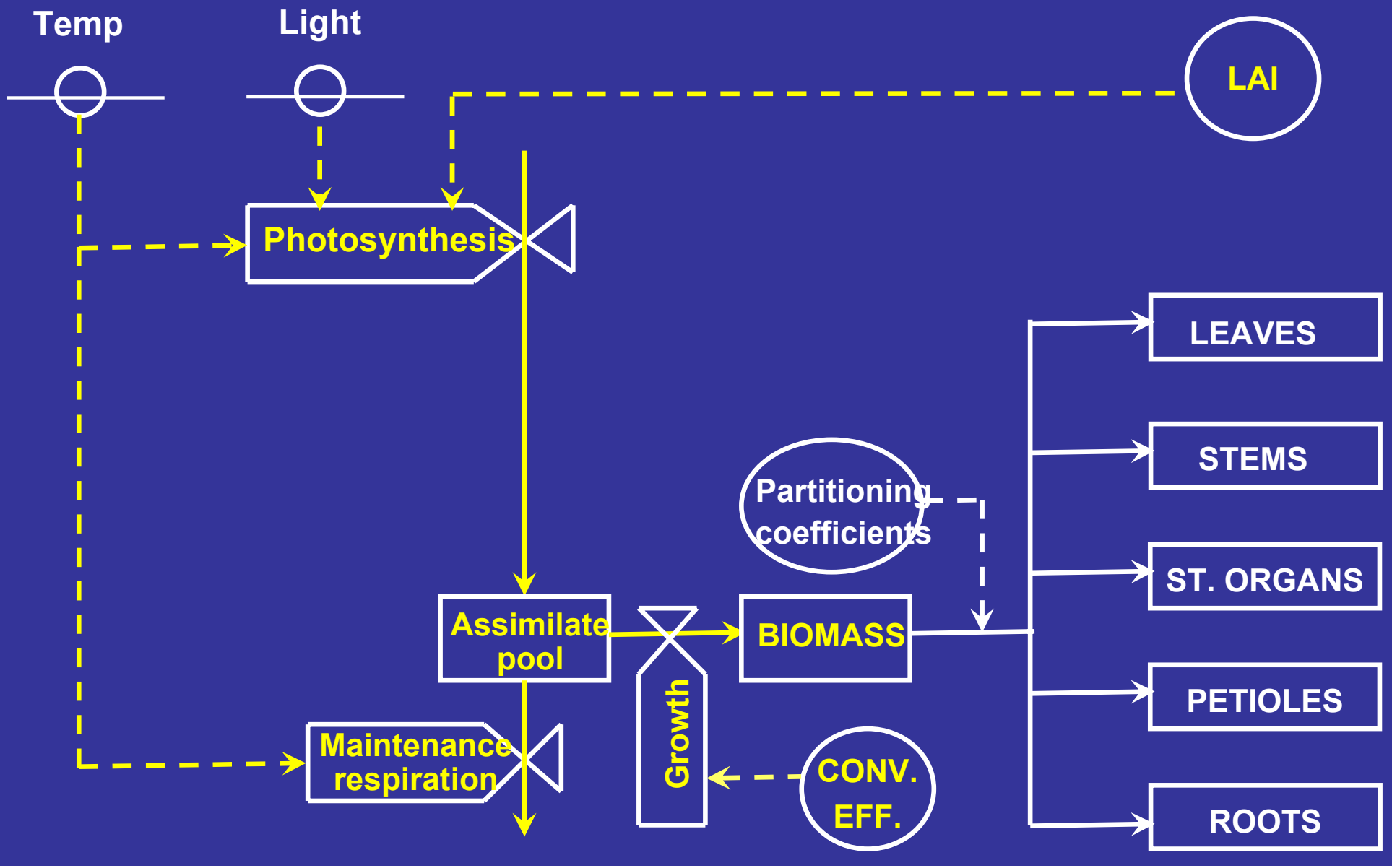
↓ (growth × 0.7 kg DM kg^{-1} CH_2O)

200 kg dry matter ha^{-1} d^{-1}

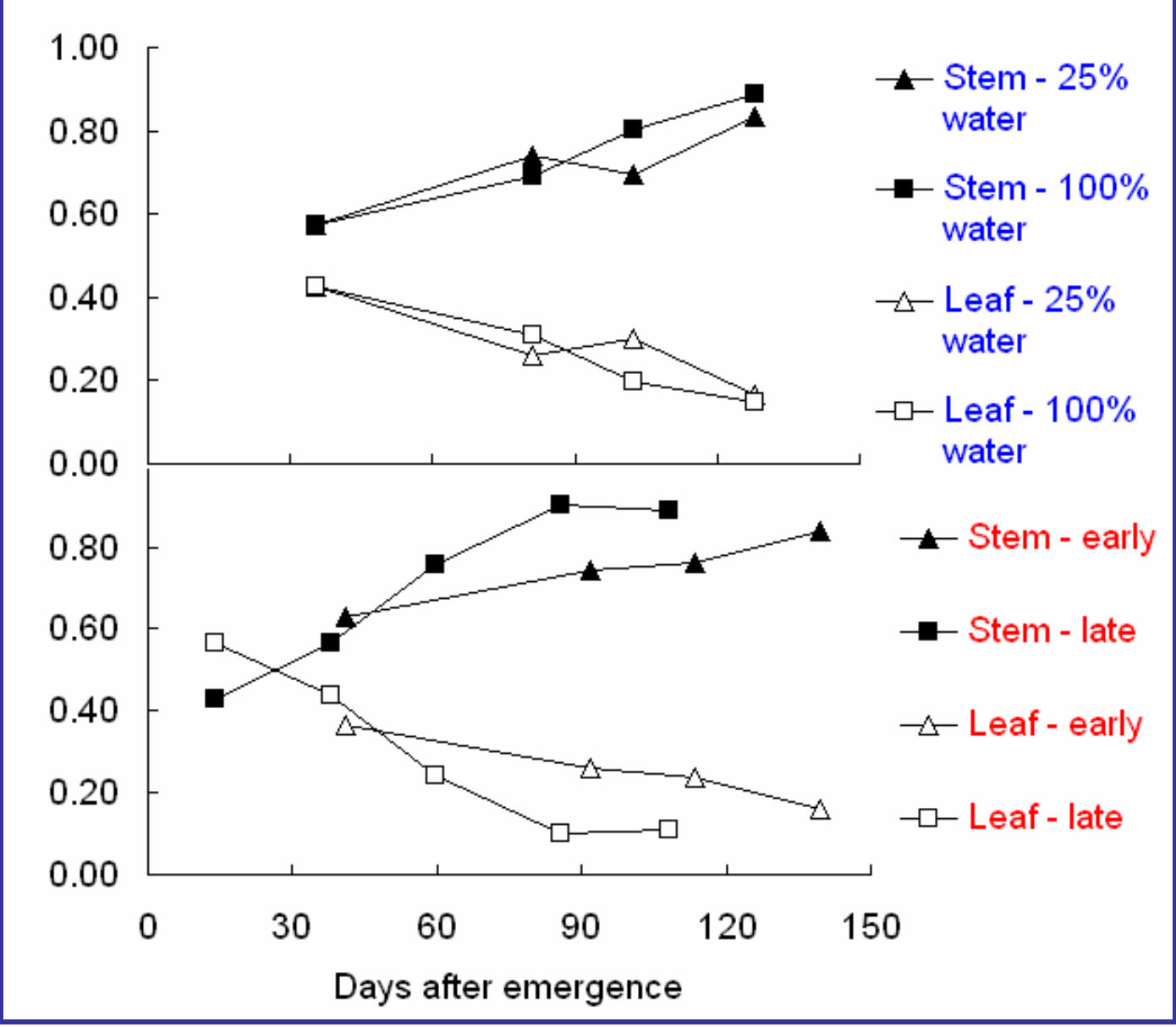
↓ (assumption constant growth rates × 60 days)

Yield: 12 t ha^{-1}

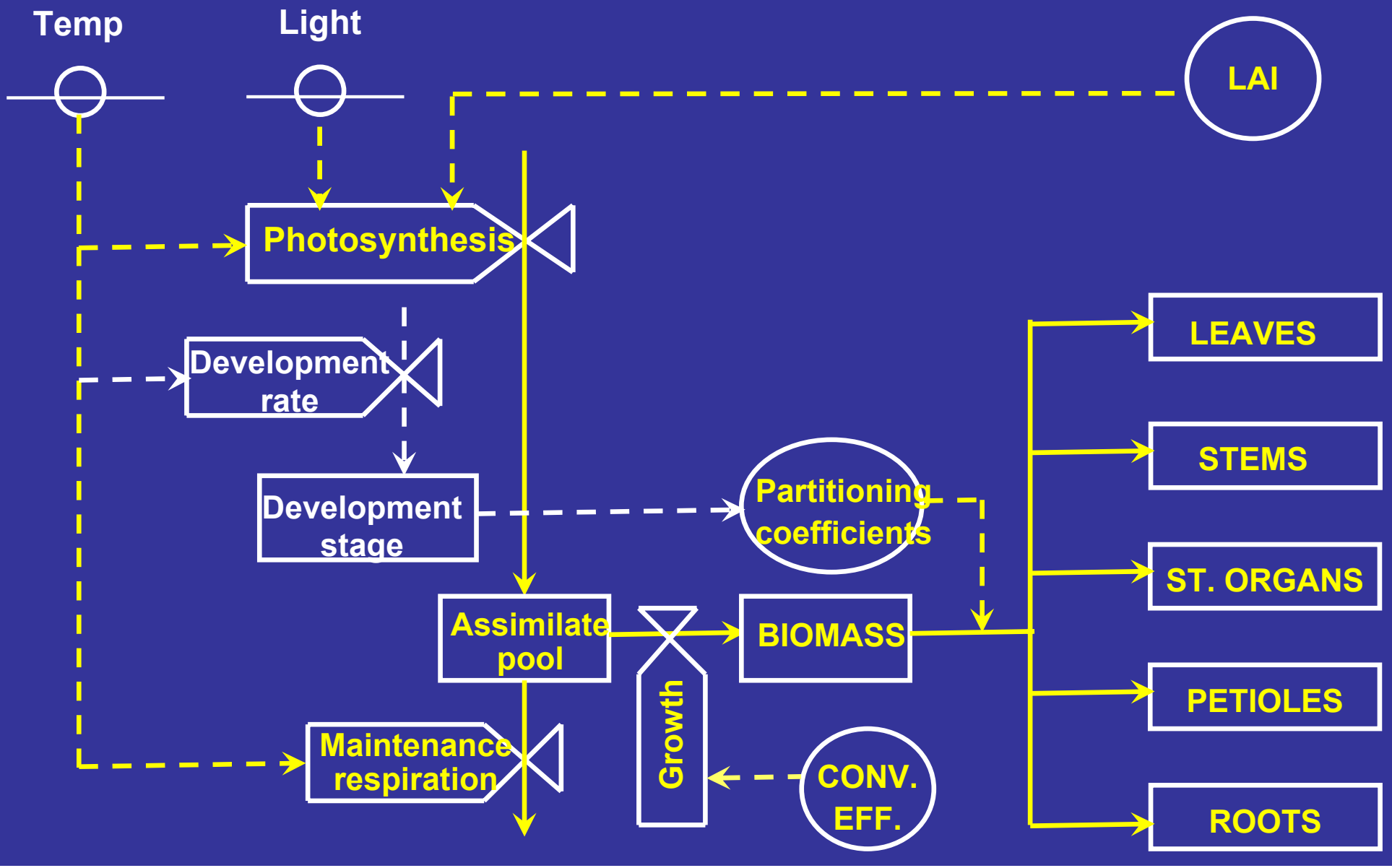
A subroutine of BioKenaF [4]



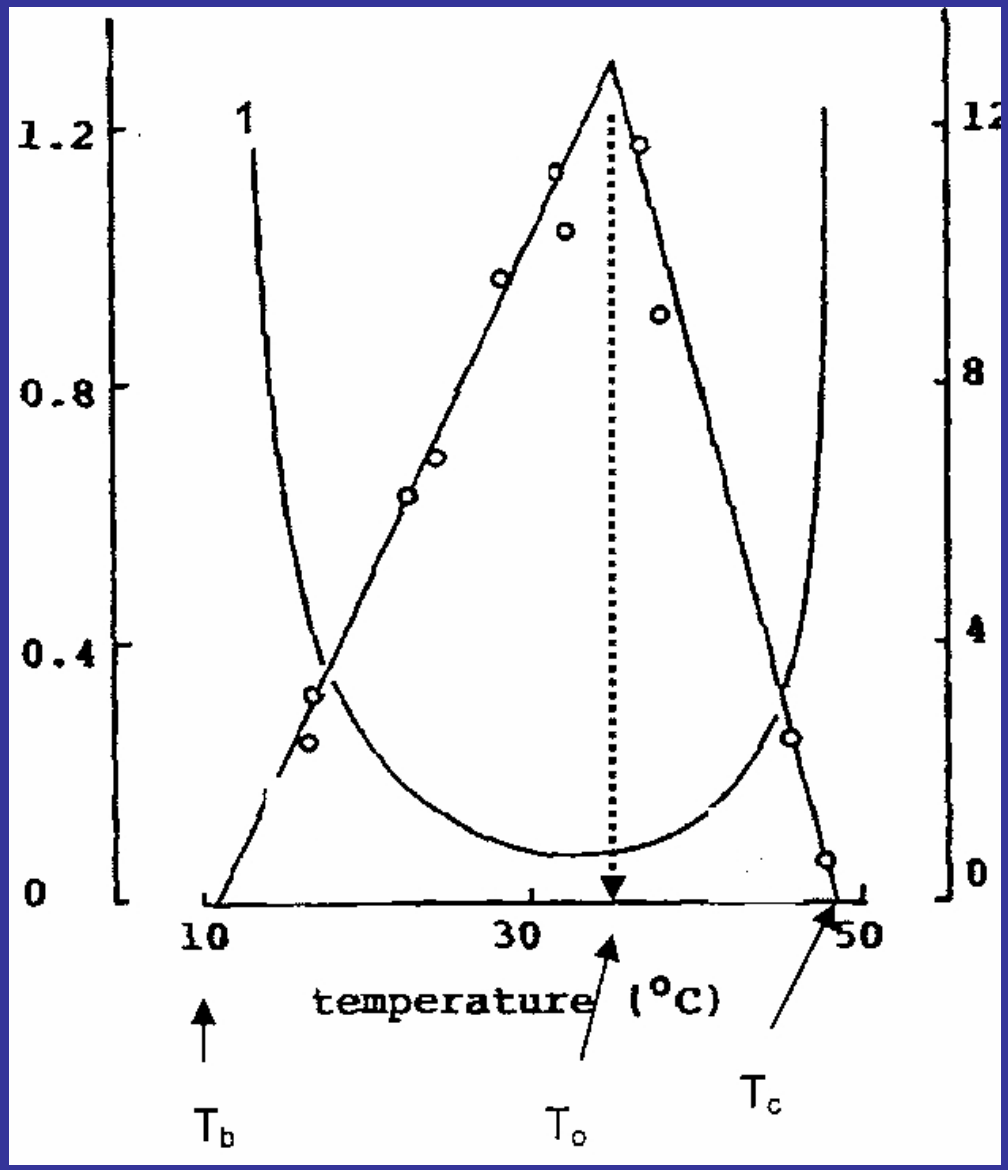
Dry matter distribution coefficients



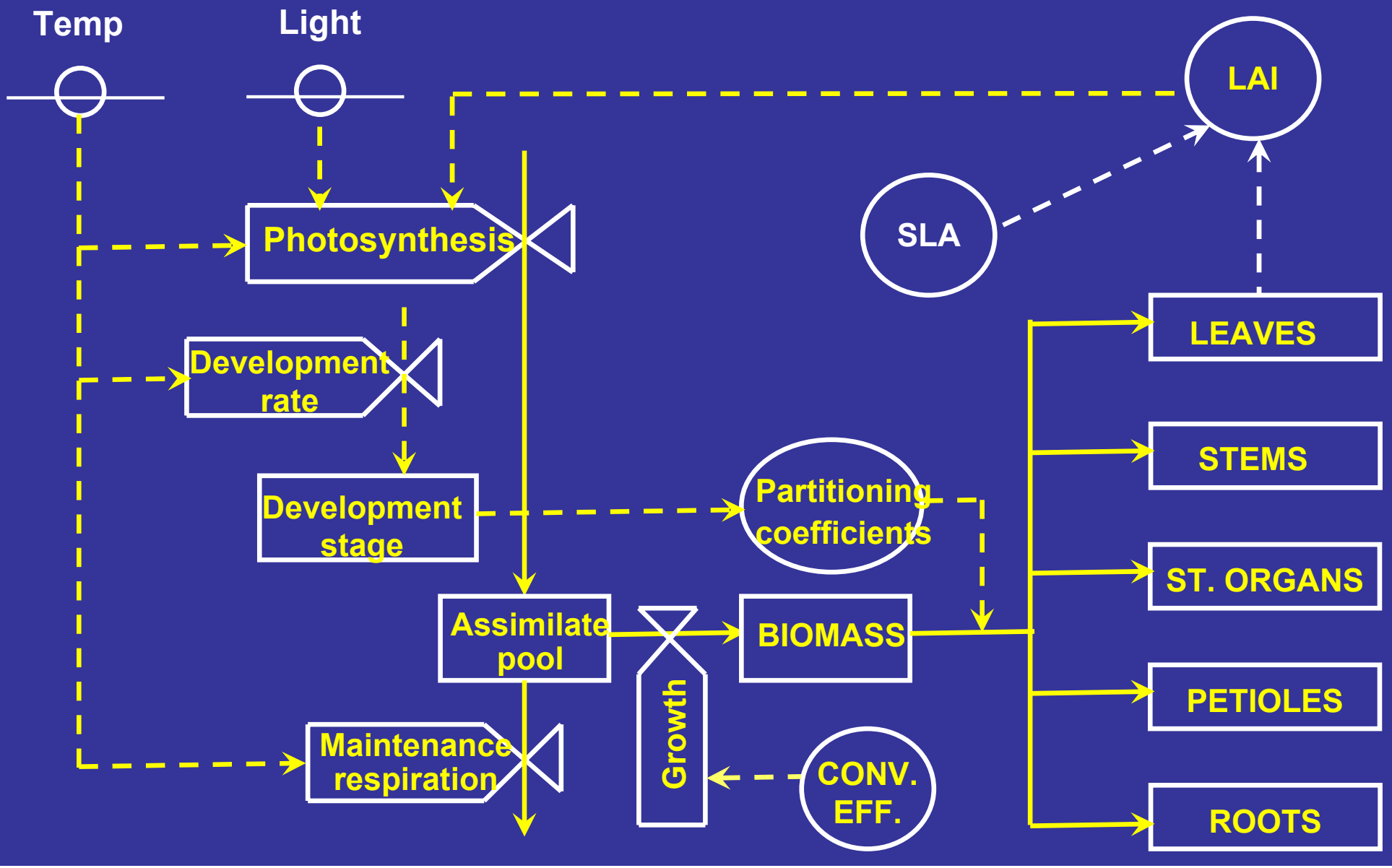
A subroutine of BioKenaF [5]



Development rate



A subroutine of BioKenaF [6]



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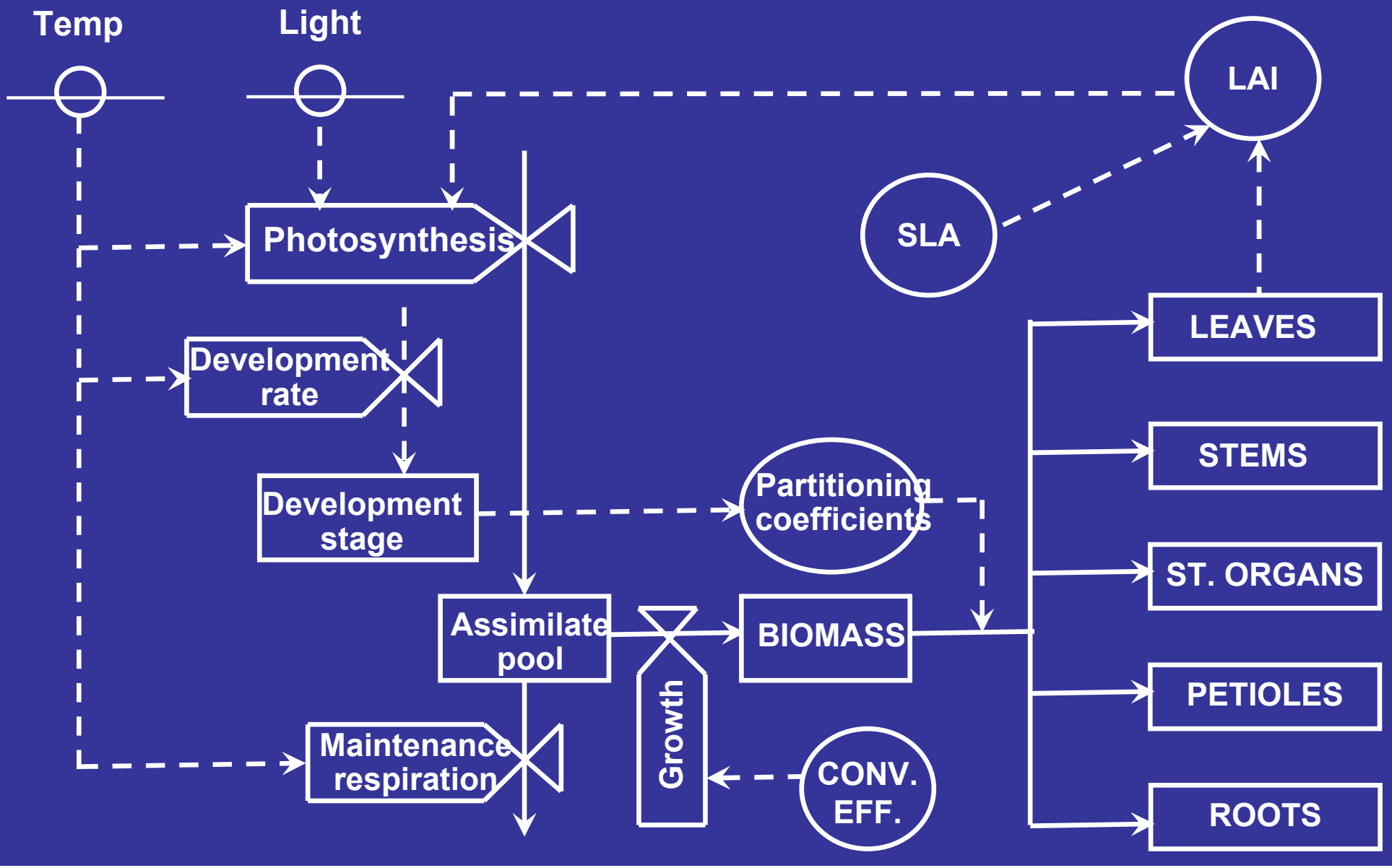
A subroutine of BioKenaF



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Model equations (just an example)

$$DSO = 1370 \times \left[1 + 0.033 \times \cos\left(2 \times \pi \times \frac{DAY}{365}\right)\right] \times \int_0^{DAYL} \sin(B)\,dt \quad Jm^{-2}d^{-1}$$

$$AVRAD = DSO \times ATMTR \quad Jm^{-2}d^{-1}$$

$$ATMTR = \left(a + b \times \frac{n}{DAYL}\right)$$

$$DEC = -\arcsin\left(\sin(23.45 \times RAD) \times \cos\left(2 \times \pi \times \frac{DAY + 10}{365}\right)\right)$$

$$SSIN = \sin(RAD \times LAT) \times \sin(DEC)$$

$$CCOS = \cos(RAD \times LAT) \times \cos(DEC)$$

$$DAYL = 12 \times \left[1 + \frac{2 \times \arcsin\left(\frac{SSIN}{CCOS}\right)}{\pi}\right] \quad hours$$

$$\sin(B) = SSIN + CCOS \times \cos\left(\frac{2 \times \pi \times (HOUR + 12)}{24}\right)$$

$$KDIF = 0.8 \times \sqrt{1 - SCV} \qquad SCV = 0.2$$

$$KDIRBL = \frac{0.5}{\sin(B)}$$

$$KDIRT = KDIRBL \times \sqrt{1 - SCV}$$

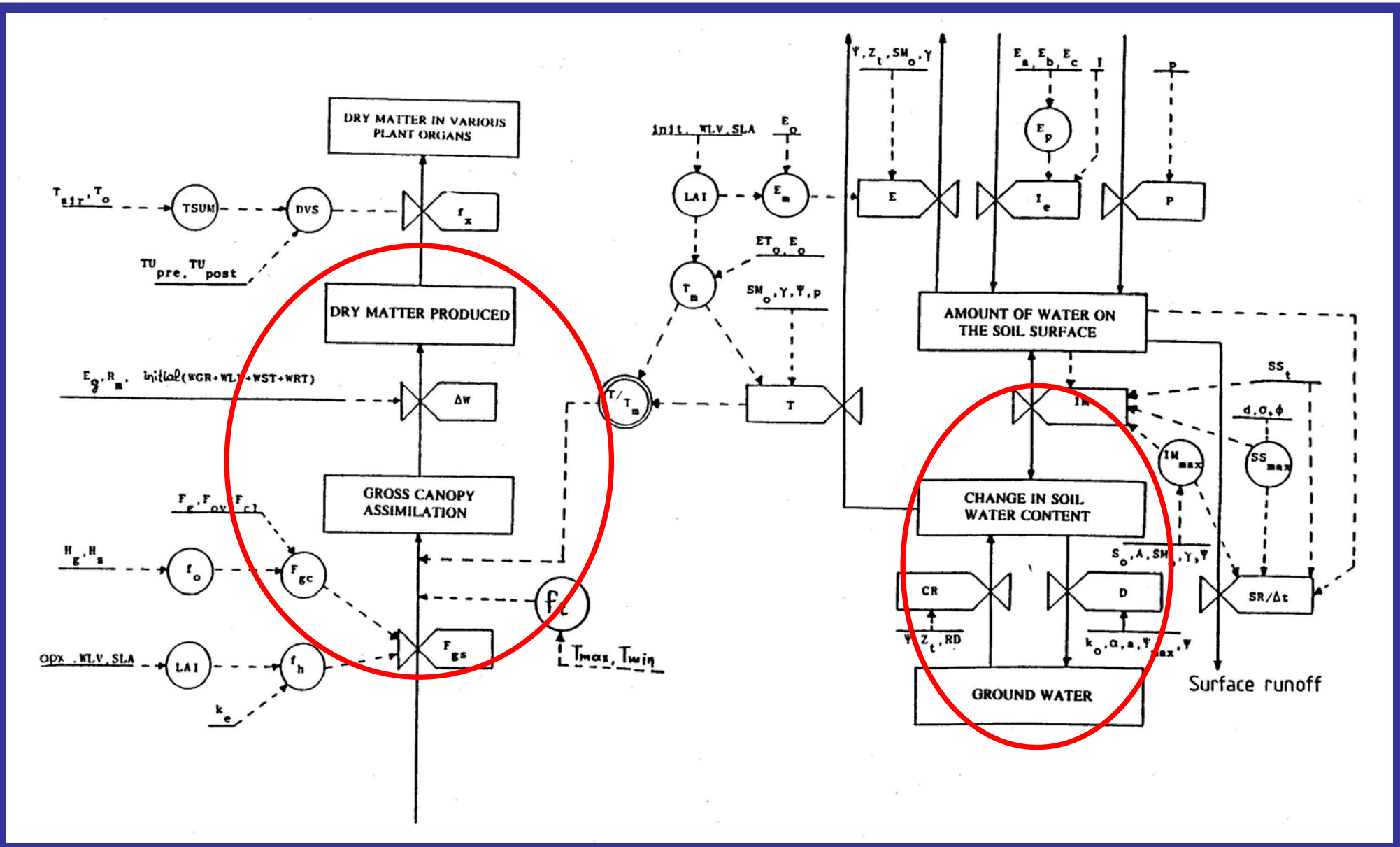
$$REFH = \frac{1 - \sqrt{1 - SCV}}{1 + \sqrt{1 - SCV}}$$

$$REFS = REFH \times \frac{1}{0.5 + \sin(B)}$$

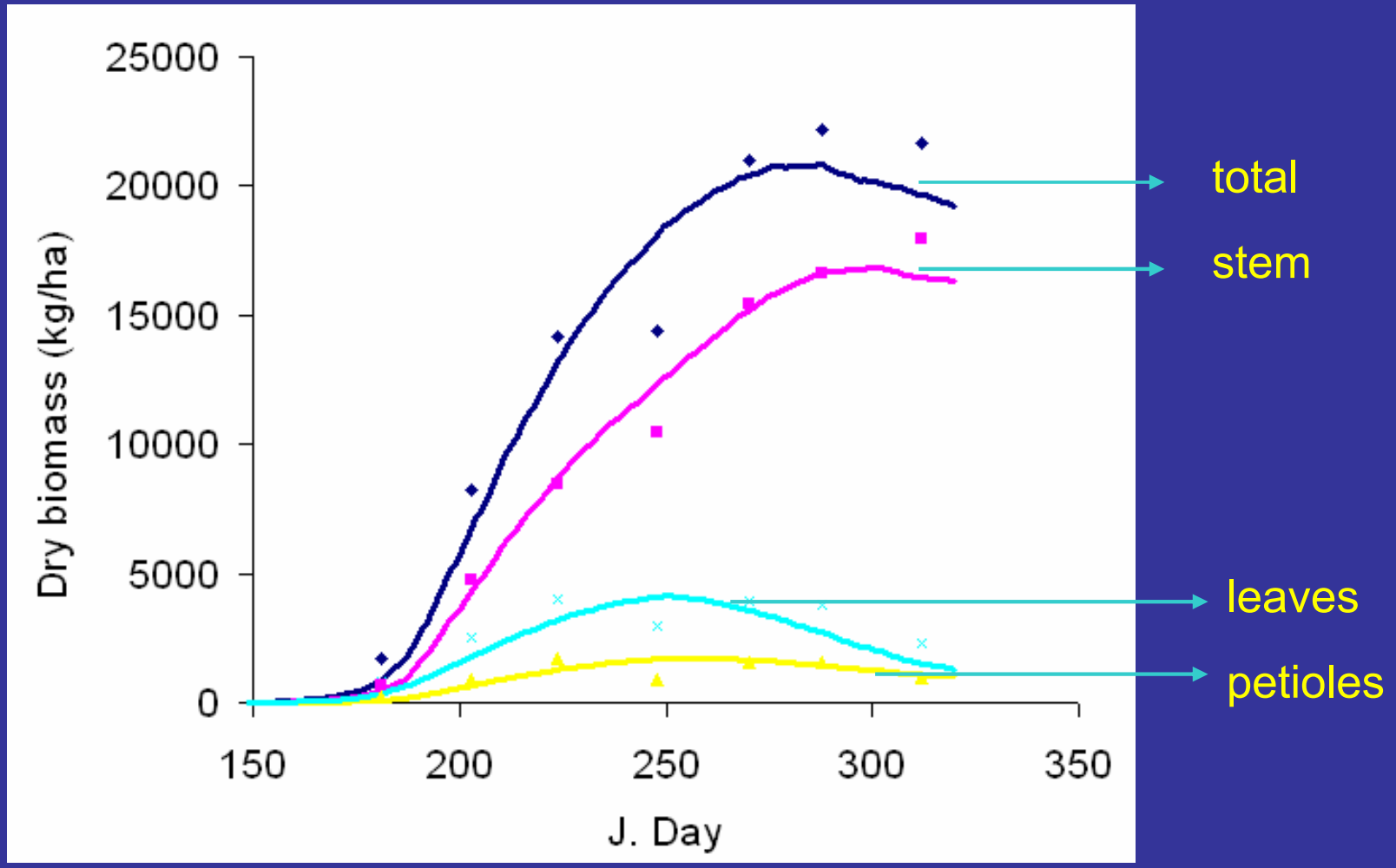
$$FSLLA = e^{-KDIRBL \times LAI}$$

$$VISSHD = VISDF + VIST - VISD \qquad Jm^{-2}(leaf)s^{-1}$$

more…

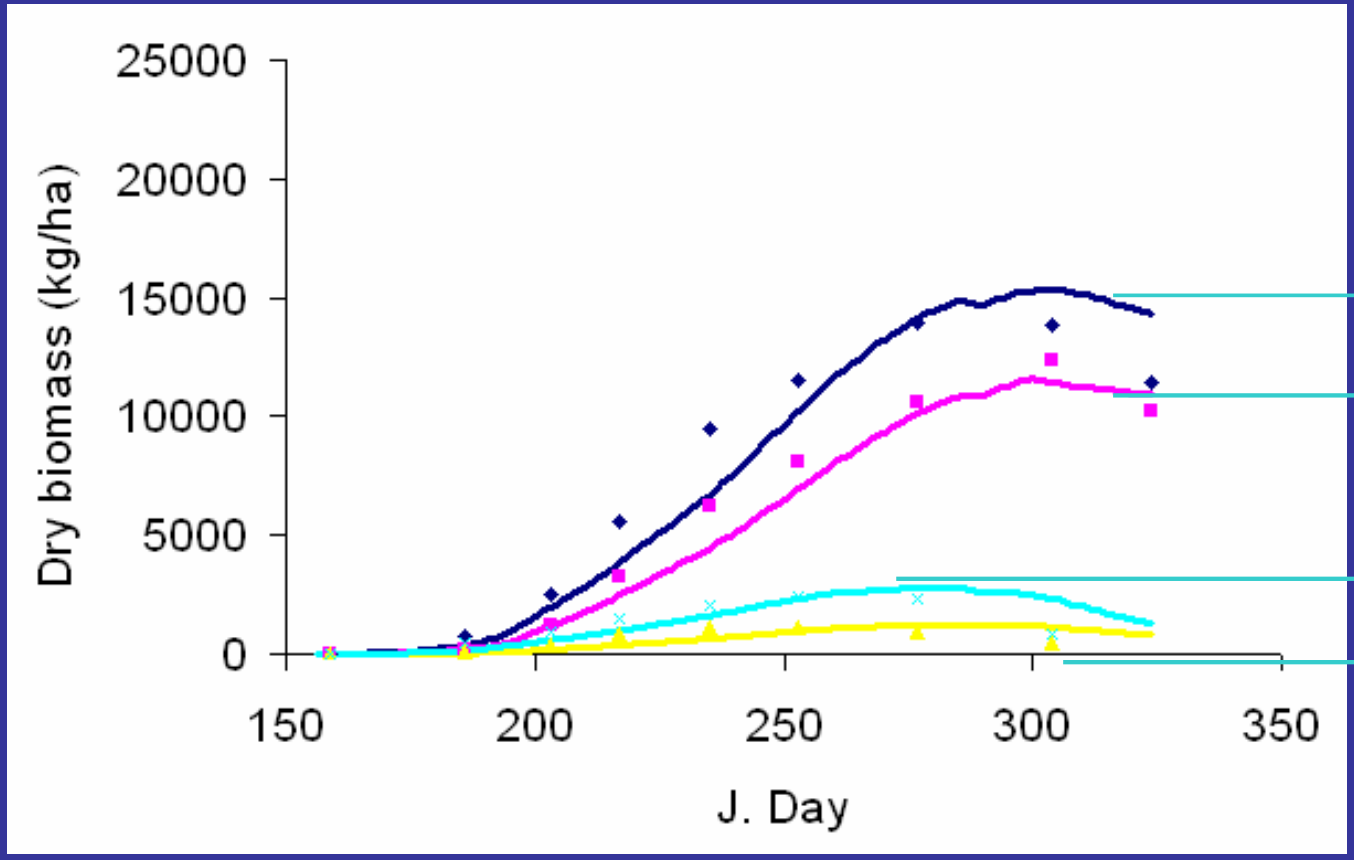

DRY MATTER IN VARIOUS PLANT ORGANS
DRY MATTER PRODUCED
GROSS CANOPY ASSIMILATION
TSUM
DVS
LAI
T
ΔW
CHANGE IN SOIL WATER CONTENT
AMOUNT OF WATER ON THE SOIL SURFACE
GROUND WATER
CR
D
SR/Δt
Surface runoff

Predictions



Year 2003, potential productivity

Predictions



Year 2004, water limited

Thank you for your attention !

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