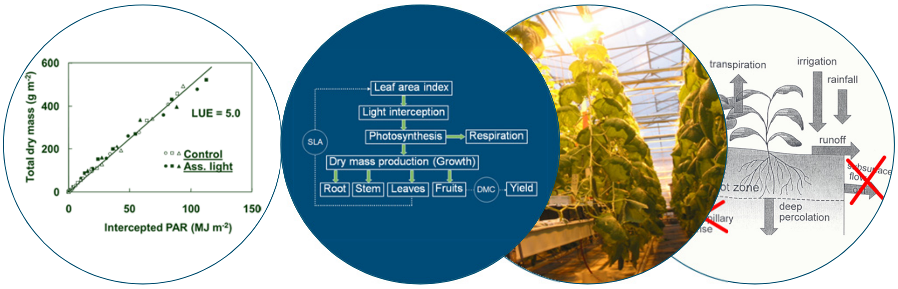
Simulation of biomass production

Dry Mass Production



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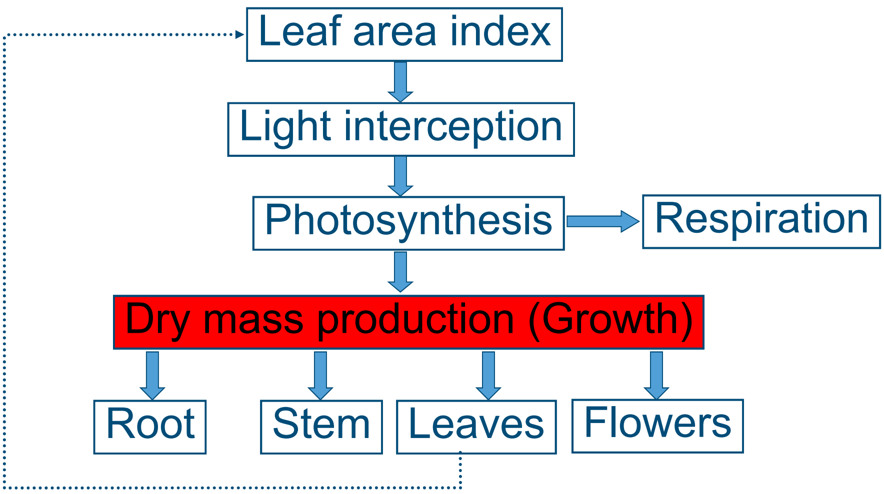
The processes: step by step - Growth



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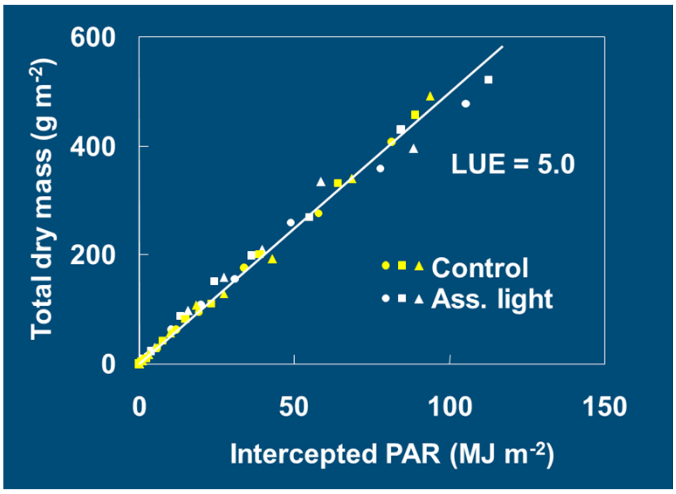
Light use efficiency (LUE, g MJ^{-1}) in winter: 3 plant densities and - or + assimilation light for cut chrysanthemum



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Simulation of biomass production

– Dry matter production: a simple LUE model –

$dW/dt = LUE\ (1-e^{-k\ LAI})\ I$

dW/dt = growth rate (g DM m^{-2} d^{-1})

LUE = light use efficiency (g DM MJ^{-1}PAR)

k = extinction coefficient

LAI = Leaf area index

I = Photosynthetic Active Radiation (PAR) incident on crop (MJ m^{-2} d^{-1})

Assumes constant LUE !

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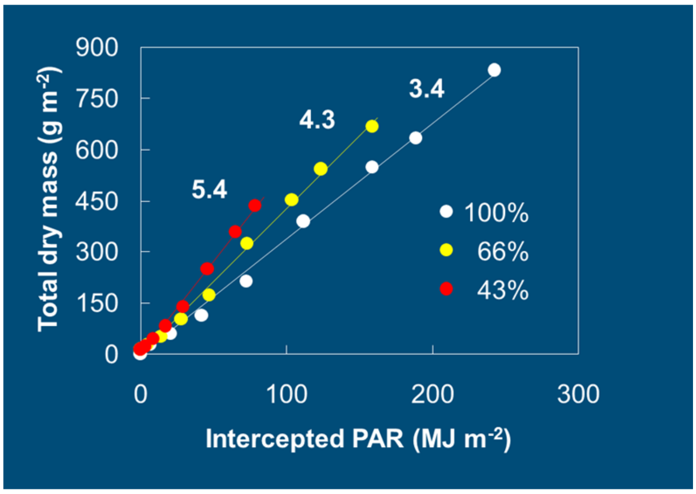
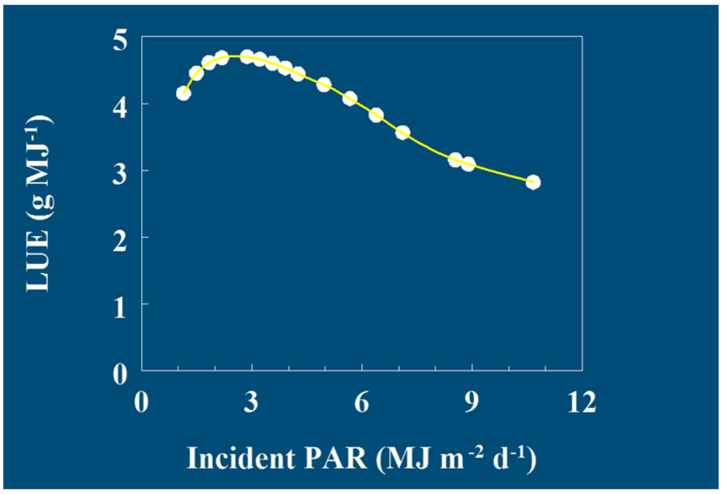
Light use efficiency (LUE, g MJ^{-1}) in summer at 3 light levels (shade screens) for cut chrysanthemum



A fixed value for the LUE, will not work over the whole season/year, because LUE is depend on LIGHT LEVEL

Simulation of biomass production

– Simulated light use efficiency for crop with LAI = 3 –



Very high light intensity will give **lower LUE** because of light **saturation**

Simulation of biomass production

Dry matter production: explanatory crop growth model

$$dW/dt = C_f\,(P_{gd} - R_m)$$

dW/dt = Crop Growth Rate (g DM m^{-2} d^{-1})

P_{gd} = Crop gross Assimilation Rate (g CH_2O m^{-2} d^{-1})

(In the model all leaves have identical photosynthetic properties)

R_m = Maintenance Respiration Rate (g CH_2O m^{-2} d^{-1})

f (Organ Dry Weight, Temperature, RGR)

$\mathbf{C_f}$ = Conversion Efficiency (g DM $g^{-1}CH_2O$)

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Simulation of biomass production

Dry matter production: explanatory crop growth model

Why can we expect that the relative effect of temperature on crop growth is larger at low light than at high light ???

<u>In other words</u>: crop growth rate changes with a different percentage when temperature rises from 15 to 25°C at low light, compared to high light levels. Why ?

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Simulation of biomass production

Dry matter production: explanatory crop growth model

Temp	Low light intensity			High light intensity		
	Pg	Rm	$dW/dt=C_f(P_{gd} - R_m)$	Pg	Rm	$dW/dt=C_f(P_{gd} - R_m)$
15°C	10	4	6*Cf	30	4	26*Cf
25°C	10	8	2*Cf	30	8	22*Cf
	% decrease		(6-2)/6=66%	% decrease		(26-22)/26=16%

- At higher temperature gross assimilation rate (Pg) doesn't change much, but 10°C difference will lead to twice as much as respiration rate (Rm).
- Light intensity doesn't have effect on Rm, but will influence Pg.
- From the table, we can see that crop growth rate changes with a different percentage (66% at low light and 16% at high light)
- Rm is not depend on light level. At low light intensity, Rm is the main part of gross assimilation.
- You can choose any number (logical), many numerical examples are possible, but they will give you the same conclusion

Simulation of biomass production

– 'Homework' question –

Assume that salinity stress increases maintenance respiration rate.

Why can this explain that elevated CO_2 reduces salt stress in wheat?

→Please answer this question by yourself, and you can refer to the answers from previous question.

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Simulation of biomass production

– Dry matter production: a simple LUE model –

$dW/dt = LUE\ (1-e^{-k\ LAI})\ I$

dW/dt = growth rate (g DM m^{-2} d^{-1})

LUE = light use efficiency (g DM <u>MJ^{-1} PAR</u>)

k = extinction coefficient

LAI = Leaf area index

Be aware of differences in dimensions

I = Photosynthetic Active Radiation (PAR) incident on crop

(MJ m^{-2} d^{-1})

Assumes constant LUE !

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Simulation of biomass production

- Be aware of differences in units !!! -

For example:

A radiation use efficiency of 3.0 g MJ^{-1} PAR

is the same as

A radiation use efficiency of <u>??</u> g MJ^{-1} global radiation

→ 1 PAR = 2 global radiation

Global radiation	PAR	LUE
2	1	3
1	0.5	1.5

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- Leaf area development -

Function of plant developmental stage (temperature)

[works reasonably well in the field, not in greenhouses]

Predicted from simulated leaf dry weight

SLA needed (Specific Leaf Area = leaf area/leaf mass; $cm^2\ g^{-1}$)

- constant
- function of plant age/physiological age
- function of season
- environmental conditions

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- Leaf area development (cont.) -

In model LINTUL:

When LAI < 0.75 $m^2\ m^{-2}$ and TSUM < 330 °Cd

Leaf growth exponential and RGR_L depends on temperature

Else

SLA = constant and increase in LAI calculated as

SLA × increase in leaf dry weight (g m^{-2})

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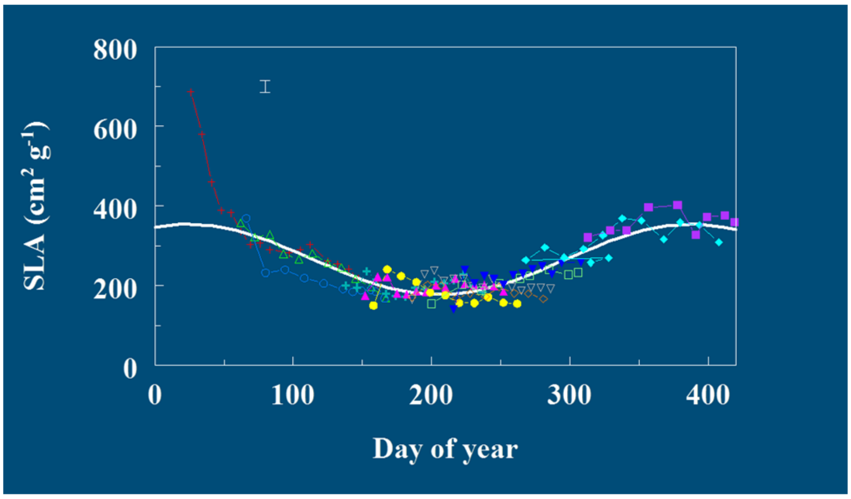
Seasonal effect on SLA (Leaf area/Leaf mass)



(regression on 12 experiments)

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- From fruit dry weight to fresh weight -

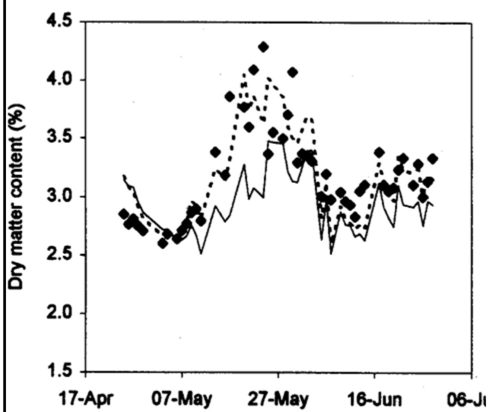

Fig.4. Time course of measured (symbols) and simulated (lines) DM content of harvestable cucumber fruits during a growing season in a greenhouse at a daily temperature of 23.2±0.4°C. DM content was simulated as a function of fruit age, temperature and fresh weight according to Marcelis (1992b) (——) or a positive linear relationship to the source/sink ratio of the past 5 days was added to the formula (----); this relation was derived from the experiment shown. Experimental conditions and calculation of source/sink ratio are described by Marcelis (1992a, 1994).

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