Appendix A. Model equations.

State equations:

Carbon in vacuoles	$\dot{M}_{C_v}=F_{C_{av}}-h_g\times F_{C_m}-F_{C_g}-F_{C_{vs}}$	(A.1)
Carbon in structure	$\dot{M}_{C_s}=F_{C_{vs}}-(1-h_g)\times F_{C_m}$	(A.2)

C-fluxes:

Photosynthetic assimilation	$F_{C_{av}}=p\{I,C_{Ca}\}\times f\{M_{C_s}\}\times h_p\{C_{Cv}\}$	(A.3)
Growth	$F_{C_{vs}}=g\{T\}\times f\{M_{C_s}\}\times h_g\{C_{Cv}\}$	(A.4)
Maintenance respiration	$F_{C_m}=e\{T\}\times M_{C_s}$	(A.5)
Growth respiration	$F_{C_g}=\theta\times F_{C_{vs}}$	(A.6)

Additional relations:

Carbon concentration in the vacuoles	$C_{Cv}=\frac{M_{Cv}}{\lambda\times M_{Cs}}$	(A.7)
Uninhibited photosynthesis rate	$p\{I,C_{Ca}\}=\frac{\varepsilon\times I\times\sigma\times(C_{Ca}-C_{C^*})}{\varepsilon\times I+\sigma\times(C_{Ca}-C_{C^*})}\ C_{Ca}>C_{C^*}$	(A.8)
Photosynthesis inhibition function	$h_p\{C_{Cv}\}=1\Big/1+\left((1-b_p)\times\prod_v\Big/\prod_v\times\gamma\times C_{Cv}\right)^{s_p}$	(A.9)
Source depletion switching (inhibition) function	$h_g\{C_{Cv}\}=1\Big/1+\left(b_g\times\prod_v\Big/\gamma\times C_{Cv}\right)^{s_g}$	(A.10)
Canopy closure reduction function	$f\{M_{Cs}\}=1-e^{-a\times M_{Cs}}$	(A.11)
Specific maintenance respiration	$e\{T\}=K\times e^{c\times(T-T^*)}$	(A.12)
Maximum growth rate	$g\{T\}=v\times e\{T\}$	(A.13)
*Osmotic pressure in vacuoles (Pa)	$\prod_v=P_v+\prod_r$	(A.14)
Nitrate concentration in the vacuoles	$C_{Nv}=\prod_v-\gamma\times C_{Cv}\Big/\beta$	(A.15)
The mols of nitrates per unit of dry weight	$C_{NO3N}=C_{Nv}\times\frac{V_V}{M_{DM}}$	(A.16)
The vacuolar volume	$V_V=\lambda\times M_{Cs}$	(A.17)

Outputs:

Conversion between model states and experimental observations

Dry matter	$M_{DM}=\eta_{OMC}\times(M_{Cv}+M_{Cs})+\eta_{MMN}\times\left(\frac{\lambda\times\prod_v}{\beta}\times M_{Cs}-\frac{\gamma}{\beta}M_{Cv}\right)$	(A.18)
Fresh matter	$M_{fm}=1000\times\lambda\times M_{Cs}+M_{DM}$	(A.19)
Nitrate content	$C_{NO3}=10^6\times\eta_{NO3N}\times C_{NO3N}$	(A.20)

Appendix B. Parameter list.

Initial conditions:

M_{C_v}	non-structural carbon content	0.007	mol[C]m^{-2}[ground]
M_{C_s}	structural carbon content	0.0671	mol[C]m^{-2}[ground]

Input variables:

I	PAR inside the greenhouse	Wm^{-2}
C_{Ca}	CO2 concentration inside the greenhouse	ppm
T	air temperature	°C

Intermediate variables:

$F_{C_{av}}$	photosynthetic assimilation	mol[C] m^{-2} [ground] s^{-1}
$F_{C_{vs}}$	growth	mol[C] m^{-2} [ground] s^{-1}
F_{C_m}	maintenance respiration	mol[C] m^{-2} [ground] s^{-1}
F_{C_g}	growth respiration	mol[C] m^{-2} [ground] s^{-1}
C_{Cv}	carbon concentration in the vacuoles	mol[C]m^{-3}
C_{Nv}	nitrate concentration in the vacuoles	mol[N] m^{-3}
C_{NO3N}	the mols of nitrates per unit of dry weight	mol [NO3]kg^{-1}[m.s.]
V_V	the vacuolar volume	m^3m^{-2}[ground]

Functions:

p{I,C_{Ca}}	uninhibited photosynthesis rate	mol[C] m^{-2} [ground] s^{-1}
h_p{C_{Cv}}	photosynthesis inhibition function	dimensionless
h_g{C_{Cv}}	source depletion switching (inhibition) function	dimensionless
f{M_{Cs}}	canopy closure reduction function	dimensionless
e{T}	specific maintenance respiration	s^{-1}
g{T}	maximum growth rate	mol[C] m^{-2} [ground] s^{-1}

Output variables:

M_{DM}	dry matter	kg[m.s.]m^{-2}[ground]
M_{fm}	fresh matter	kg[m.s.]m^{-2}[ground]
C_{NO3}	nitrate content	ppm

Parameter values of the state equations:

Crop size

Leaf area closure parameter	a	0.2	m^2[ground]mol^{-1}[C]

Photosynthesis

Apparent light use efficiency	ε	0.04-0.07	$mol[C]mol^{-1}[PAP]$
CO_2 transport coefficient	σ	$1.4e^{-3}$	ms^{-1}

Respiration

Maintenance respiration coefficient	k	$0.4e^{-6}$	s^{-1}
Temperature effect parameter	c	0.0693	$°C^{-1}$
Growth respiration loss factor	θ	0.3	dimensionless
Growth rate coefficient without inhibition from a closed canopy	v	22.1	$mol[C]mol^{-2}[ground]$

Crop composition

Coefficient of osmotic carbon equivalence	γ	0.61	$m^3Pamol^{-1}[C]$
Carbon concentration calculation parameter	λ	1/1200	$m^3mol^{-1}[C]$

Attenuation

Slope parameter of photosynthesis inhibition function	h_p	s_p	10	dimensionless
Slope parameter of growth inhibition function	h_g	s_p	10	dimensionless
Threshold parameter of photosynthesis inhibition function	h_g	b_p	0.8	dimensionless
Threshold parameter of growth inhibition function	h_g	b_p	0.2	dimensionless

Values of constants of the model:

CO_2 compensation point	C_{C^*}	0.0011	$mol[C]mol^{-3}$
Reference temperature	T^*	20	°C
Osmotic pressure in the vacuoles	Π_v	580	Pa

Additional parameter values of output equations:

Regression parameter of C/N ratio in vacuoles	β	6.0	$m^3Pamol^{-1}[N]$

Values of constants of the output equations:

Organic matter in kg per mol C	η_{OMC}	0.03	$kg[DM]mol^{-1}[C]$
Minerals in kg per mol N in vacuoles	η_{MMN}	0.148	$kg[DM]mol^{-1}[N]$
kg nitrate per mol N	η_{NO3N}	0.062	$kg[NO_3]mol^{-1}[N]$