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A STRUCTURED APPROACH TO MODELLING THE ASSIMILATION OF A HETEROGENEOUS CANOPY, IMPLEMENTED AS A MODEL FOR THE GROWTH OF COMPETING SPRING WHEAT CULTIVARS

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1. INTRODUCTION

The model presented in this paper was written for simulating the growth of several wheat cultivars in mixture. Notwithstanding this specific purpose, an effort has been made to develop a model structure which may be of use in simulating photosynthesis of heterogeneous canopies in general. A distinction between different types of light absorbing and photosynthesizing surfaces of heterogeneous canopies may be necessary because they belong to different, competing populations, or they differ in optical behaviour (extinction coefficient), or they differ in photosynthetic behaviour. Such a situation is for example given when growth of competing species is modelled or when assimilation not only of leaves but also of other organs (e.g. ears) has to be accounted for.

Modelling of the light distribution and photosynthesis is essentially based on the model of de Wit et al. (1978) for homogeneous monocultures and the extension of this model by Spitters & Aerts (1983) to mixed canopies. This latter model is improved here by introducing a rigorous modular structure and by incorporating the revised procedures to calculate and to handle the different components of incoming radiation (Spitters et al., 1986; Spitters, 1986) and to integrate photosynthesis over time intervals within the day (Goudriaan, 1986). Furthermore, different types of photosynthesizing organs (leaf blades, leaf sheaths + stems, ears) are distinguished in the presented model. The derivation of daily net assimilation from daily gross assimilation and the distribution of net assimilates over plant organs proceed according to Van Keulen et al. (1982).

2. SCOPE OF THE MODEL

The model simulates plant growth under potential conditions: gross production is only dependent on light absorption and temperature and unrestricted by the supplies of water and nutrients or the occurrence of pests, diseases and weeds.

As stated above, the model was written to simulate the growth of wheat. Features of wheat are largely restricted to the actual values of parameters. Still, there are two structural accomodations to the species wheat:

1) light absorption and photosynthesis of ears and stems is included;
2) the total yellow fraction of leaves is assumed to be positioned below the total green fraction.

If a potential user of our model decides that point (2) is inappropriate, he has to perform structural adjustments (replacement of the subroutine YELDI1). Such adjustments are unnecessary for the omission of point (1), which can be achieved by assigning appropriate values to switch parameters.

3. DESCRIPTION OF THE MODEL

3.1 Concepts underlying the model

a) For each type of assimilating surface (e.g. the leaves of one competitor) a 2-parametric light response curve is assumed:

$$A(I) = AMAX \cdot (1. - \exp(-I \cdot EFF/AMAX)) \qquad (1)$$

I : absorbed photosynthetically active radiation ($J/m^{**2}/s$)
A : assimilation rate (kg CO_2/ha/h)
AMAX : assimilation rate at light saturation (kg CO_2/ha/h)
EFF : initial light use efficiency (kg CO_2/ha/h)/(J/m**2/s), defined as

$$\lim_{I \to 0} A(I)/I \qquad (2)$$

b) From the daily global irradiance, the diurnal courses of diffuse and direct photosynthetically active radiation are estimated.

c) On their vertical path through the canopy, the direct and diffuse flux attenuate exponentially:

$$I(x_1) = I(x_2) \cdot \exp(-\sum_{s=1}^{NST} AI_s(x_1,x_2) \cdot K(s)) \qquad x_1 < x_2 \qquad (3)$$

x : height above ground (cm)
I(x) : light intensity (J/m**2/s) at height x above the ground
AIs (x1, x2): area index (ha surface/ha ground) of the fraction of surface type s that is positioned between the boundaries x1 and x2.
NST : number of distinguished surface types
K(s) : extinction coefficient of surface type s
The extinction coefficients K(s) differ for diffuse and direct light.

d) The light absorbed by a vertically homogeneous mixture of surface types is distributed over the constituent surface types according to their areas, weighted by their extinction coefficients.

e) Maintenance respiration of each plant organ is obtained by multiplying its weight by an organ specific relative rate of respiration and a factor accounting for the influence of temperature.

f) The allocation of dry matter over the various organs (leaves, stems, roots, ears) is a function of the developmental state. This developmental state is defined as a linear function of the temperature sum.

g) The efficiency of transforming net assimilates into dry matter is an organ specific constant.

3.2 Model structure

The model is written in CSMP. It can be viewed as being composed of 3 main modules which encompass submodules. This structure is outlined in Table 1, the program flow in Table 2.

3.3 Description of the modules

3.3.1 Vertical distribution of light absorbing surfaces

Principle

The basic principle is characterized as follows. The vertical distribution of a surface type is described by a density function AID of the argument h' (height above ground/height of the plant top). AID may be an arbitrary function fulfilling the constraints

$$AID(h') \geqq 0 \qquad \text{for} \qquad 0 \leqq h' \leqq 1 \qquad (4i)$$

$$\int_0^1 AID(h')\ dh' = 1 \qquad (4ii)$$

Let the total area index of surface type s be TAI_s and x1(l), x2(l) (cm above ground) the boundaries of canopy layer l. Then $AI_{s,l}$, the area index of surface type s positioned in canopy layer l, is calculated as

Table 1:
Module structure of the model. (MP) denotes that the respective calculations are performed by the main program.

Module function		Subroutines
I. VERTICAL DISTRIBUTION OF LIGHT ABSORBING SURFACES		
I.1	area indices (ha surface/ha ground) of the various surface types	(MP)
I.2	boundary heights defining canopy layers	STRATA
I.3	distribution of surface area over the canopy layers	VERDI2 CLFRAC YELDI1 YELDI2
II. DAILY GROSS ASSIMILATION		
II.1	daylength and diffuse fraction of daily global radiation	ASTRO FRADIF
II.2	instantaneous intensity and direct fraction of incoming light, sine of sun height	INSTIR
II.3	instantaneous rates of assimilation	PHOTOC
II.4	integration of the instantaneous assimilation rate over the day	DAYASS
III. DRY MATTER INCREMENT		
III.1	maintenance respiration	(MP)
III.2	allocation of net production and resulting rates of biosynthesis; dying process of organ tissues	(MP)

Table 2:

Program flow of the model. MP denotes the main program. Module numbers explained in Table 1.

MODULE	SUBROUTINES	SECTION
I.3 (preparation)	MP → VPRE1	INITIAL
	MP → VPRE2	
I.1	MP	DYNAMIC
I.2	MP → STRATA	
I.3	MP → VERDI2 → CLFRAC	
	MP → YELDI1	
	MP → VERDI2 → CLFRAC	
	MP → YELDI2	
II.4	MP → DAYASS → ASTRO	
II.1	DAYASS → FRADIF	
II.2	DAYASS → INSTIR	
II.3	DAYASS → PHOTOC	
III.1	MP	
III.2	MP	

$$AI_{s,1} = AI_s\,(x_1(1), x_2(1)) = TAI_s \cdot \int_{h'(x_1)}^{h'(x_2)} AID_s(h')\,dh' \tag{5}$$

where $$h'(x) = \begin{cases} x/H(s) & 0 \leq x \leq H(s) \\ 1 & x > H(s) \end{cases}$$

with H(s) denoting the height (cm) of the genotype to which surface type s belongs.

Module I.1: Area indices

For leaves and stems (including leaf sheaths) the area indices are obtained by multiplying the respective dry matter weights by their surface area ratios. The area index of ears is assumed to be zero until anthesis. Then its value is determined by multiplying the aboveground biomass with a conversion factor. During post anthesis growth the ear area is assumed to be constant. The yellow fraction of the ear area is introduced as a forcing function of days after emergence.

Module I.2: Definition of canopy layers

The canopy is stratified into layers of equal thickness. The number of layers is chosen dependent on the summed leaf area indices of all competitors.

Module I.3: Distribution of surface area over the layers

Stems and leaves are each distributed vertically according to the three parametric density function.

$$AID\,(h') = (-a\,h'^{z} + a + c) * \text{normalization constant} \tag{6}$$

with AID (h') : normalized surface area density at h'

h' : height above ground level divided by plant height

a, c, z : function parameters

Fig. 1 illustrates how the parameters a, c and z determine the shape of the curve. The normalization constant serves to fulfil constraint (4ii) and is accordingly given by

$$\int_{h'=0}^{1} (-ah'^{z} + a + c)\, dh' = a \cdot (1 + \frac{c}{a} - \frac{1}{z+1}) = NC \qquad (7)$$

As the form of the function as well as the parameter values are assumed to be constant during the growing season, the normalization constant is evaluated in the initial section of the program. The surface area index within a horizontal layer bounded by the relative heights h'_1 and h'_2 is calculated at every time step as

$$TAI \cdot NC \cdot \int_{h'_1}^{h'_2} (a + c - a\, h'^{z})\, dh' =$$

$$TAI \cdot NC \cdot a \cdot (A1 \cdot (h'_2 - h'_1) - A2 \cdot (h'^{z+1}_2 - h'^{z+1}_1)) \qquad (8)$$

where TAI is the total area index of the considered surface, NC is the normalization constant, and A1 (= 1 + c/a) and A2 (= 1/(z+1)) are auxiliary variables calculated in the initial section of the program.

The function AID is assumed to characterize the distribution of total leaf area and total stem area respectively, encompassing the green as well as the yellow fraction. Thus a subdivision into a green and a yellow fraction of the surface area is necessary. For leaves as well as stems, it is assumed that the total yellow fraction is positioned below the total green fraction.

The ear area is assumed to be distributed as a homogeneous layer. This is equivalent to defining the vertical area density function (AID) as

$$AID(h') = \begin{cases} 1/d & \text{for } 1-d \leq h' \leq 1 \\ 0 & \text{otherwise} \end{cases}$$

where d is the thickness of the ear layer divided by the plant height. The yellow fraction of the ear area is assumed to be distributed vertically homogeneously within the ear layer.

3.3.2 Daily gross assimilation

Principles

The daily assimilation is obtained by a weighted summation (= numerical integration) of the instantaneous assimilation rates of selected time points during the day. The instantaneous assimilation rates are calculated from the instantaneous intensities of direct and diffuse light and accounting for the canopy architecture.

Module II.1: daylength and diffuse fraction of daily global radiation

The diffuse fraction of daily global radiation is derived from the measured global radiation according to Spitters et al. (1986).

Module II.2: instantaneous intensity and direct fraction of incoming light, sine of sun height

Given the calendar day, the latitude of the location and the diffuse fraction of daily global radiation, the instantaneous intensities of diffuse and direct visible radiation are estimated according to Spitters et al. (1986).

Module II.3: instantaneous rates of assimilation

The instantaneous assimilation rate of a competitor is derived from the instantaneous direct and diffuse light flux and the canopy structure. It is viewed as the sum of the rates performed by its different assimilating surfaces (leaf blades, stems + leaf sheaths, ears).

The instantaneous assimilation rate of a surface type (e.g. the leaves of one competitor) is derived by partitioning its total area into fractions each of which is exposed to an approximately uniform irradiation level. For each fraction, the instantaneous assimilation rate is obtained from the corresponding photosynthetic light response curve. This partitioning of the surface area belonging to one surface type is achieved by distributing it over the canopy layers (Module I.3). Within each layer, a sunlit and a shaded fraction are distinguished. This procedure can be formally summarized as

$$A_c = \sum_{s=1}^{NST} \sum_{l=1}^{NCL} (A(s,l / shaded) + A(s,l/sunlit)) \cdot l(c,s) \qquad (9)$$

A_c: instanteneous assimilation rate of competitor c

s: subscript denoting the surface type

l: subscript denoting the canopy layer

NST: number of surface types

NCL: number of canopy layers

A(s,l/shaded): instantaneous assimilation rate performed by the shaded fraction of surface type s which is positioned in canopy layer 1

A(s,1/sunlit): instantaneous assimilation rate performed by the sunlit fraction of surface type s which is positioned in canopy layer 1

1(c,s): switch function, having the value 1 if surface type s belongs to competitor c and 0 otherwise.

We now present in some detail how the rates A (s,1/...) are calculated. The basic task consists of coupling a submodel for vertical light distribution within the canopy to a submodel for the distribution of absorption over the different components within a canopy layer.

Several major steps are repeated for each canopy layer:

1) calculation of the diffuse and direct flux absorbed by the whole canopy layer,
2) calculation of absorption intensities for the sunlit and shaded parts of the canopy layer,
3) calculation of absorption intensities for the sunlit and shaded parts of each of the different surface types present in the canopy layer,
4) calculation of assimilation rate of the sunlit and shaded parts of the different surface types present in the canopy layer,

The thus obtained partial assimilation rates (A(s,1/...)) are then summed according to (9).

<u>ad 1</u>:

Light entering the canopy is composed of 2 fluxes: a diffuse flux and a direct flux.

Within the canopy the diffuse flux originates from 2 sources: light that has entered the canopy as diffuse light and light that has entered the canopy as direct light but that has been scattered within the canopy. To manage bookkeeping, 3 fluxes are discerned within the canopy:

a) diffuse light that had entered the canopy as diffuse light ("DIF")
b) light (diffuse and direct) that had entered the canopy as direct light ("DRF")
c) direct light ("DIR")

Note that flux DIR is part of flux DRF. These 3 fluxes are extincted exponentially within the canopy. For each surface type s, the extinction coefficients differ for the 3 fluxes: Kdif(s), Kdrf(s), Kdir(s) for fluxes DIF, DRF, DIR, respectively.

The ratios between these 3 coefficients are approximately the same for all surface types and only dependent on sun height (Goudriaan, 1982):

K dir(s) = CDIR (sun height) * K dif(s) (10i)

$$K\ drf(s) = CDRF\ (sun\ height) * K\ dif(s) \qquad (10ii)$$

This linearity facilitates compact algorithms for calculating the absorption within a canopy layer and the distribution of this absorption over the constituent surfaces.

Several auxiliary variables are defined. Let DIF_o, DRF_o and DIR_o denote the net downward fluxes of DIF, DRF and DIR at the top of the canopy. It holds

$$DIF_o = IRR*(1.-FDIR)*(1.-REFLC_{dif}) \qquad (11i)$$
$$DRF_o = IRR*FDIR(1.-REFLC_{dir}) \qquad (11ii)$$
$$DIR_o = IRR*FDIR \qquad (11iii)$$

where IRR is the intensity and FDIR is the direct fraction of the light flux incident at top of the canopy and $REFLC_{dif}$ and $REFLC_{dir}$ are the reflection coefficients of the canopy for diffuse and direct light.

Let further $FR_{dif}(x)$, $FR_{drf}(x)$ and $FR_{dir}(x)$ denote the fraction of DIF_o, DRF_o and DIR_o that penetrates to the height level x (cm) above the ground. By considering these auxiliary variables we only have to calculate the FR_{dif}-values for the layer boundaries in order to obtain readily the rates with which the layers absorb all 3 fluxes. This follows from equations (3) and (10i):

$$FR_{dir}(x) = \exp\left(- \sum_{s=1}^{NST} AI_s(x,x'(CT)\ .\ K_{dir}(s)\right)$$

$$= \exp\left(- CDIR\ .\ \sum_{s=1}^{NST} AI_s(x,x'(CT))\ .\ K_{dif}(s)\right)$$

$$= (FR_{dif}(x))^{CDIR} \qquad (12i)$$

and, analogously,

$$FR_{drf}(x) = \ldots = (FR_{dif}(x))^{CDRF} \qquad (12ii)$$

Here x'(CT) denotes the height of the canopy top.

Defining as further auxiliary variable the "extinction capacity of a layer l for diffuse light"

$$ECDIF(l) = \sum_{s=1}^{NST} AI_{s,l}\ .\ K_{dif}(s) \qquad (13)$$

we describe the 3 parallel absorption processes using the single loop structure:

$FR_{dif}^{u} = 1$

DO 1000 l = 1,NCL

$FR_{dif}^{d} = FR_{dif}^{u} \cdot \exp(-ECDIF(l))$

$AFR_{dif} = FR_{dif}^{u} - FR_{dif}^{d}$

$AFR_{drf} = (FR_{dif}^{u})^{CDRF} - (FR_{dif}^{d})^{CDRF}$

$AFR_{dir} = (FR_{dif}^{u})^{CDIR} - (FR_{dif}^{d})^{CDIR}$

1000 CONTINUE (14)

where NCL denotes the number of canopy layers, the superscipts u and d relate the function value to the upper and lower layer boundary, and AFR dir, drf, dir is the absorbed fraction of DIF_o, DRF_o, DIR_o, respectively.

The layer absorbs direct ($LABS_{dir}$) and diffuse ($LABS_{dif}$) light with the rates

$$LABS_{dir} = DIR_o \cdot AFR_{dir} \quad (15i)$$

$$LABS_{dif} = DIF_o \cdot AFR_{dif} + DRF_o \cdot AFR_{drf} - LABS_{dir} \quad (15ii)$$

ad 2:

From AFR_{dir}, the absorbed fraction of direct light, the sunlit fraction of the canopy layer (SLLA) can be derived (Goudriaan, 1982) approximately as

$$SLLA = AFR_{dir} \;/\; (KDIR \cdot TCLAI) \cdot KDIF \;/\; \sqrt{1-SCV} \;/\; 0.8 \quad (16)$$

with TCLAI denoting the summed area index of all surfaces present in the layer, KDIR, KDIF the area-weighted average of their extinction coefficients for diffuse, direct light and SCV the scattering coefficient.

The light absorption performed by the shaded part ($LABS_{sh}$) of the canopy layer is

$$LABS_{sh} = LABS_{dif} * (1 - SLLA) \qquad (17i)$$

and the rate of light absorption performed by the sunlit part ($LABS_{su}$) is

$$LABS_{su} = LABS_{dif} * SLLA + LABS_{dir} \qquad (17ii)$$

<u>ad 3</u>:

From the light absorption by the shaded and by the sunlit part of the whole layer, the absorption rates of the sunlit and shaded parts of every surface type separately are calculated. The basic assumption is that the sunlit fraction of the total canopy layer is equal to the sunlit fraction of every single surface type. We thus obtain immediately (compare concept 3.1 d) the absorption rate per surface area of the shaded part of the surface type s positioned in layer 1:

SABS (s,1/shaded) =

$$LABS_{sh}(1) \frac{(1-SLLA_1) \cdot AI_{s,1} \cdot K_{dif}(s)}{\sum_{s'=1}^{NST} (AI_{s',L} \cdot (1-SLLA_1) \cdot K_{dif}(s'))} \cdot \frac{1}{(1 - SLLA_1) \cdot AI_{s,1}}$$

$$= \frac{1}{ECDIF(1) \cdot (1-SLLA_1)} \cdot K_{dif}(s) \qquad (18)$$

where ECDIF is again the extinction capacity of the canopy layer defined by (13).

From the linear relationship between K_{dif}, K_{dir} and K_{drf} (10i, 10ii) it follows that the absorption rate per surface area of the sunlit part of surface type s positioned in canopy layer 1 can be formulated analogously

$$SABS\ (s,1/sunlit) = LABS_{su}(1) \frac{1}{ECDIF(1) \cdot SLLA_1} \cdot K_{dif}\ (s) \qquad (19)$$

The compactness of the distribution algorithm is emphasized: two layer specific auxiliary variables (1./(ECDIF*SLLA) and (1./(ECDIF*(1.-SLLA)) only have to be multiplied with a surface type specific constant $K_{dif}(s)$).

ad 4:

Using the photosynthetic light response functions, from the absorption rates per surface area the corresponding assimilation rates per surface area are derived. For obtaining the assimilation rates per ground area (A(s,l/...) in (9)), these rates per surface area are multiplied by the respective surface area index. For the sunlit and shaded part of the surface this is the layer specific surface area index (Al,s,l) multiplied by SLLA and (1.-SLLA) respectively.

Module II.4: Integration of the instantaneous assimilation rate over the day

Following Goudriaan (1986), daily assimilation (DA)is calculated by a 3-point Gaussian integration of the instantaneous assimilation rate (A):

$$DA = \sum_{i=1}^{3} A(t_i) * W_i \qquad (20)$$

where $t_{1,2,3}$ and $W_{1,2,3}$ are being appropriate time points and weighting factors.

3.3.3 Dry matter increment

Module III.1: Maintenance respiration

The rate of maintenance respiration is obtained by calculating its value for a standard temperature (15°C) and multiplying this with the factor

Q10 ** (0.1 * T - 1.5)

where T denotes the actual air temperature (°C) and Q10 the increase of the respiration rate caused by a temperature increase of 10°C.

The rate of maintenance respiration at the standard temperature is the sum of the rates of the different organs: leaves, stems, roots and ears. These rates are calculated as the dry matter weight of living organ tissue multiplied by an organ specific relative rate of respiration (kg CH_2O/kg DM/d). For leaves, this relative rate is described as a function of developmental state. The relative rates of the other organs are invariant parameters.

Module III.2: Allocation of net production and resulting rates of biosynthesis; dying process of organ tissues

Daily net production is distributed over the organs, leaves, stems, roots and ears according to allocation factors. These factors are formulated as functions of the developmental state. The transformation of allocated net production (kg CH_2O) into new dry matter (kg biomass) is performed with organ specific efficiences.

Parallel to biosynthesis, a dying process changes the weight of living organ tissues. The daily transformation of living into dead biomass is calculated by multiplying the live organ weight with an organ specific relative dying rate (kg/kg/d). These relative rates are formulated as functions of the number of days since emergence.

4. PERFORMANCE OF THE MODEL

The model has been applied to simulate field experiments with 12 spring wheat cultivars (Rennau & Spitters, in prep.). Monocultures and mixtures were grown at a range of plant densities. For experimental details and further results see Kramer (1984) and Spitters & Kramer (1986).

The model representation of inter-cultivar variation was restricted by the availability of data. It concerned the following 4 attributes: initial weight and leaf area (22 days after emergence), dry matter allocation to leaves as fraction of the allocation to the shoot, plant height and "dying" rates of leaves and grains.

A more detailed discussion of the model performance will be given in Rennau & Spitters (in prep.). Here we only present the performance of the model to simulate the biomass relations between the cultivars when growing in mixture. For this, a measure Δ LN is defined for the productivity of a cultivar relative to the average productivity level:

$$\Delta LN_i = LN(W_i) - \overline{LN(W)} \approx LN\ (W_i/\overline{W}) \qquad (21)$$

where W_i is the aboveground biomass of genotype i, $\overline{W}$ and $\overline{LN(W)}$ denote the average of W_i and $LN(W_i)$ over all genotypes, and LN points to the natural logarithm.

Mixtures have been grown at total plant densities of 25, 44, 100 and 400 plants/m**2. For these experiments, the measured and simulated LN-values, averaged over the 4 densities, are shown in Fig. 2. Given the incomplete knowledge about the genetic variation of physiological and morphological attributes, we judge the model performance to be satisfactory.

5. GENERAL DISCUSSION

The model presented in this paper describes the growth of competing populations. As pointed out in the introduction, competition can be viewed as a special case of the general situation that the canopy description has to account for more than one type of light absorbing and photosynthesizing surface.

The model is an attempt to realize a modular structure directed towards representing a family of systems - heterogeneous canopies - rather than a specific system - competing genotypes. We do not claim that the modelling of another system of this family does not demand structural changes, but the modular structure confines the adjustments to few, exchangeable subunits of the program (subroutines). This principle will be illustrated by briefly sketching the "use" of the model for a quite different system with a heterogeneous canopy.

Consider a system consisting of a wheat crop and a pathogen covering a fraction of its leaves with variable density. It is assumed that the initial light use efficiency and the AMAX-value are reduced by the pathogen and the relationships between these reductions and the pathogen density are known quantitatively.

Evidently the canopy can be viewed as consisting of n surface types - leaves with different classes of pathogen density. These surface types differ with respect to their photosynthetic parameters. An appropriate approach for describing the vertical distribution of these surface types is first to distribute the total leaf area and to subdistribute this subsequently over the leaf classes.

For the first step the model offers a general implementation which is independent from the specific choice of a vertical area density function. A rather flexible 3-parametric function is used, but this can easily be replaced by an alternative without sacrificing the general distribution algorithm (subroutine VERDI). To implement the second step, a new subroutine has to be written which is called after the distribution of the total leaf area. This two step procedure runs analogously to the subdistribution of total surface area into its green and yellow fraction which is performed in the present model version.

Considering the local character of the adjustments this example may serve to illustrate the economy achieved by a modular approach in the longer run.

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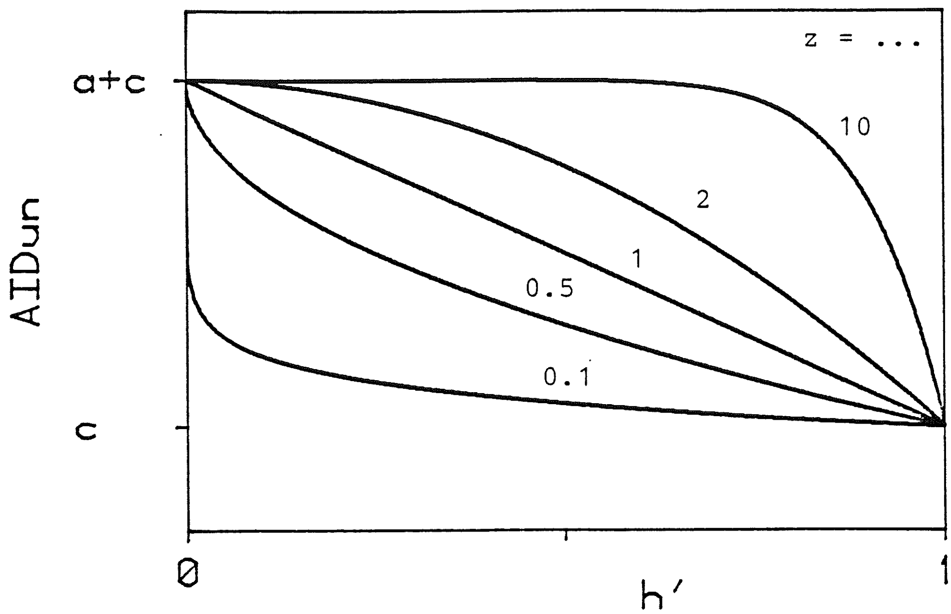

Fig. 1: Shape of the unnormalized leaf area density function AIDun := $- a h'^z + a + c$ for different values of the parameter z; h' denotes the height above the ground divided by the plant height; the function values for h' = 0 and h' = 1 are c+a and c, respectively

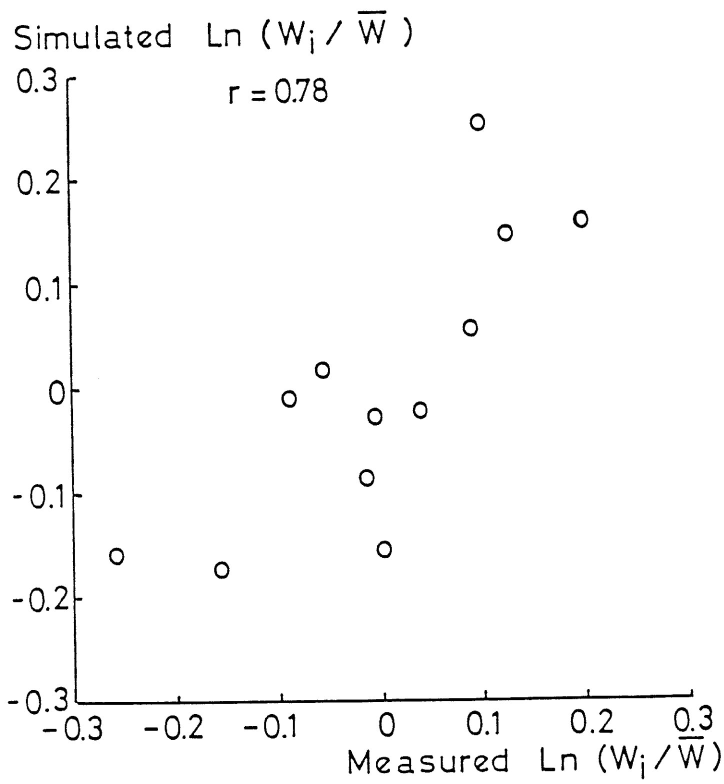

Fig. 2. Performance of the model to fit the relative biomass production of 12 spring wheat cultivars grown in mixture. The aboveground biomass (W_i) of cultivar i was expressed relative to the population mean ($\overline{W}$) and represented by the natural logarithm ln ($W_i/\overline{W}$). Each point represents the value of one cultivar, averaged over the 4 plant densities (25, 44, 100 and 400 plants/m^2) at which the mixtures were grown.

Component layout

F	:	function
GA	:	array; i-th component → genotype with actual reference i
GL	:	array; i-th component → genotype with library reference i
C	:	array, i-th component → canopy layer i, counted from the top
CG	:	array; component (i-1) + j → canopy layer i, counted from the top, and genotype with the actual reference j
Gn	:	array; first n components → genotype with library reference 1, next n components → genotype with library reference 2, etc.
S	:	scalar (no array)

Appendix A: Listing of the model

```
TITLE          COMPETITION BETWEEN WHEAT GENOTYPES
/     DIMENSION EARATA(27)
/     DIMENSION EAI(27)
/     DIMENSION FCHN(27)
/     DIMENSION HEI(27)
/     DIMENSION OGBM(27)
STORAGE SAI(27),YFST(27),KLSTEM(27), KLEAR(27)
STORAGE AGE(27),LAI(27),GASSP(27),STORE(144)
STORAGE V(27), EARSUR(27), LAID(144),SAID(144),EAID(144)
STORAGE ULCL(25), KL(27),PKL(27),EFF(27),EEFF(27),SEFF(27)
STORAGE YFLVS(27),LAIL(25),ECDIF(25)
STORAGE COR(27),DISPA1(200),DISPA2(200),DISPA3(200)
STORAGE CULTP(27),  DVS(27), EAMAX(27),AMAX(27), PAMAX(27),SAMAX(27)
STORAGE OGBMPP(27), YFEAR(27)
STORAGE IWLVS(27), IWST(27), IWRT(27), IARLF(27), IDVSV(27)
STORAGE EMERG(27), EXIST(27), APPEAR(27), PLOP(27)
STORAGE LNDVBM(27),XEAI(20)
FIXED DNSP, V, NSP, NCL, I, L,  K, A, G
FIXED STPSWI,EAPSWI,C,COMIND,AUXINT

*****************************************************************
***                    INITIALIZATION                         ***
*****************************************************************
INITIAL
NOSORT

***              BASIC SPECIFICATIONS

*   NUMBER  OF GENOTYPES DESCRIBED IN THE PARAMETER SET
PARAM  DNSP = 12

*   NUMBER OF COMPETING GENOTYPES SIMULATED IN THE PRESENT CASE
PARAM  NSP = 12

*** LATITUDE OF LOCATION ***
PARAM  LAT = 52.

***   SWITCH PARAMETERS FOR CHOOSING FROM  ALTERNATIVE ALGORITHMS

*      THE LEAF AREA INDEX CAN BE INTRODUCED AS A FORCING FUNCTION BY
*      ASSIGNING TO THE SWITCH PARAMETER "LAISWI" THE VALUE 1
*      INSTEAD OF 0
PARAM LAISWI = 0.

*      SWITCH PARAMETER FOR DECIDING WHETHER THE ABBSORPTION
*      OF STEMS IS ACCOUNTED FOR WHEN MODELLING THE EXTINCTION
*      OF LIGHT WITHIN THE CANOPY
PARAM STASWI = 1.

*      SWITCH PARAMETER FOR DECIDING WHETHER THE PHOTOSYNTHESIS
*      OF STEMS  IS ACCOUNTED FOR WHEN CALCULATING THE DAILY
*      ASSIMILATIION (NOTE THAT IN THIS CASE ALSO THE ABSORPTION OF STEMS
*      MUST BE ACCOUNTED FOR, THAT IS "STASWI = 1")
PARAM STPSWI = 1

*      SWITCH PARAMETER FOR DECIDING WHETHER THE ABBSORPTION
*      OF EARS IS ACCOUNTED FOR WHEN CALCULATING THE EXTINCTION
*      OF LIGHT WITHIN THE CANOPY
PARAM EAASWI = 1.

*      SWITCH PARAMETER FOR DECIDING WHETHER THE PHOTOSYNTHESIS
*      OF EARS IS ACCOUNTED FOR WHEN CULCULATING THE DAILY
*      ASSIMILATIION (NOTE THAT IN THIS CASE ALSO THE ABSORPTION OF EARS
*      MUST BE CONSIDERED, THAT IS EAASWI = 1).
PARAM EAPSWI = 1
```

```
*** S I M U L A T I O N   P R O J E C T   S P E C I F I C   I N P U T

***     INITIAL  STATE   OF   THE   POPULATIONS

TITLE         SIMULATION PROJECT:  REAMIX 15 X 15
LABEL         SIMULATION PROJECT:  REAMIX 15 X 15

*     WEIGHTS OF LEAVES, STEMS, ROOTS;
*     (KG/HA / (FREQUENCY OF THE GENOTYPE) / "DENSITY FACTOR")
*     (EXPLANATION OF "DENSITY FACTOR" : SEE BELOW)
TABLE IWLVS (1-12) = 1.273,  1.460,  1.666,  1.079,  1.323,  1.623,...
                     1.226,  1.196,  1.365,  1.296,  1.359,  1.219
TABLE IWST (1-12)  = 0.569,  0.596,  0.703,  0.493,  0.594,  0.783,...
                     0.597,  0.487,  0.570,  0.499,  0.619,  0.483
TABLE IWRT (1-12)  = 1.228,  1.371,  1.579,  1.048,  1.278,  1.604,...
                     1.215,  1.122,  1.290,  1.196,  1.319,  1.135

*     LEAF AREA
*     (M**2/HA / (FREQUENCY OF THE GENOTYPE) / "DENSITY FACTOR")
TABLE IARLF (1-12) = 25.533, 28.759, 33.867, 28.567, 27.978, 34.030,...
                     26.267, 24.452, 27.619, 28.989, 26.174, 26.037

*     "DENSITY FACTOR" WITH WHICH THE PARAMETER VALUES FOR INITIAL
*     WEIGHTS AND THE INITIAL LEAF AREA ARE MULTIPLIED AT THE
*     INITIALIZATION OF THE POPULATION
*     (INTRODUCTION OF THIS PARAMETER SPARES THE NECESSITY OF
*     REWRITING THE ARRAYS WITH INITIAL WEIGHTS AND LEAF AREAS
*     WHEN DIFFERENT PLANT DENSITIES ARE ASSUMED)
PARAM DFAC = 108.

*     DEVELOPMENTAL STATE
TABLE IDVSV (1-12) = 0.21345,  0.22085,  0.22485,  0.21010, ...
                     0.21717,  0.20662,  0.21345,  0.20339, ...
                     0.20339,  0.20026,  0.20026,  0.20662

*     TIME COURSE OF LN (LEAF AREA(M**2/HA))
*     (FOR THE INTRODUCTION OF THE LEAF AREA AS FORCING FUNCTION)
FUNCTION LNLAT,1. = 0.,6.60719,  22.,8.06840,  29.,9.0655, ...
                   36.,9.67608,  41.,9.75777,  49.,10.1414
FUNCTION LNLAT,12.= 0.,6.60719,  22.,8.06840,  29.,9.0655, ...
                   36.,9.67608,  41.,9.75777,  49.,10.1414
FUNCTION YFRLVT,1.  = 0.,0.,  49.,0.
FUNCTION YFRLVT,12. = 0.,0.,  49.,0.

*     PLANTS/M2
PARAM PSM = 400.

***    TIME SPECIFICATIONS

*   DAY OF EMERGENCE
TABLE EMERG  (1-12) = 12 * 107.

*   FIRST DAY OF SIMULATED GROWTH (NOT NECESSARILY THE DAY OF
*   EMERGENCE)
TABLE APPEAR (1-12) = 12 * 129.

*   FIRST DAY OF SIMULATION (HAS TO BE AT LEAST
*   1 DAY BEFORE GROWTH SIMULATION STARTS)
PARAM START = 106.

*   LAST DAY OF SIMULATION
PARAM STOP  = 231.
FINISH  TIME = STOP
```

```
*****************************************************************************
***     PARAMETRIC CHARACTERIZATION OF THE VERTICAL DISTRIBUTION OF      ***
***                   LEAVES,  STEMS    AND   EARS                        ***
*****************************************************************************

*   3 PARAMETERS USE FOR CHARACTERIZING THE VERTICAL DISTRIBUTION
*   OF THE LEAF AREA
*   (THE UNNORMALIZED LEAF AREA DENSITY FUNCTION (M**2/M**3)
*   IS ASSUMED TO HAVE THE FORM:
*    Y = A -   A * H**Z + C
*   WITH A,C AND Z PARAMETERS AND H:= HEIGHT ABOVE GROUND/PLANT HEIGHT)
PARAM LA = 1., LC = 0., LZ = 50.

      DISPA1,DUM = VPRE1 (DNSP,LA,LC,LZ)

*   3 PARAMETERS USE FOR CHARACTERIZING THE VERTIACL DISTRIBUTION
*   OF THE STEM AREA
*   (THE UNNORMALIZED STEM AREA DENSITY FUNCTION (M**2/M**3)
*   IS ASSUMED TO HAVE THE FORM:
*    Y = A -   A * H**Z + C
*   WITH A,C AND Z PARAMETERS AND H:= HEIGHT ABOVE GROUND/PLANT HEIGHT)
PARAM SA = 1., SC = 0., SZ = 50.

      DISPA2,DUM = VPRE1 (DNSP,SA,SC,SZ)

*    1 PARAMETER USED FOR CHARACTERIZING THE VERTICAL DISTRIBUTION OF EARS
*    (IT IS ASSUMED THAT THE EARS OF A GIVEN GENOTYPE ARE DISTRIBUTED
*    IN A HOMONEGEOUS LAYER THAT EXTENDS FROM THE PLANT TOP
*    TO A DISTANCE BELOW (CM) GIVEN BY THE PARAMETER "VEEL")
PARAM VEEL = 20.

      DISPA3,DUM = VPRE2 (DNSP,VEEL)

***          THE WHO-IS-WHO  OF COMPETITING GENOTYPES

*   THE GENOTYPES SIMULATED IN THE PRESENT CASE ARE
*   NUMBERED FROM 1 TO NSP; THE ARRAY  V  LINKS THIS ACTUAL
*   REFERENCES ("A") TO THE NUMBERS USED IN THE PARAMETER
*   LIBRARY (LIBRARY REFERENCE - "L")

*   EXAMPLE:
*        "TABLE V (1-12) = 2, 5, 8, 9 * 11"
*   PRODUCES - DEPENDENT ON THE PARAMETER "NSP" -
*   THE FOLLOWING MIXTURE COMPOSITIONS:
*        "NSP=1" =''  MONOCULTURE OF VARIETY 2
*        "NSP=2" =''  BINARY MIXTURE WITH THE VARIETIES 2 AND 5
*        "NSP=3" =''  MIXTURE WITH THE VARIETIES 2, 5, 8
*   AND SO ON
TABLE V(1-12)    = 12 * 1

*   GENOTYPE FREQUENCIES
*   (SUM OVER THE NSP GENOTYPES PRESENTLY SIMULATED MUST BE 1  !)
TABLE COR (1-12) = 12 * 8.333333333E-2

***                 SOME TECHNICAL PREPARATIONS

*   FOR USE OF THE RERUN-FACILITIES SOME VARIABLES
*   HAVE TO BE SET ZERO

         DO 737 A = 1,NSP
         GASSP(A) = 0.
         FCHN(A)  = 0.
         LAI(A)   = 0.
         YFLVS(A) = 0.
         SAI(A)   = 0.
         YFST(A)  = 0.
```

```
          DVS(A)    = 0.
          DVRV(A)   = 0.
          DVRR(A)   = 0.
          EARATA(A)= 0.
          OGBM(A)   = 0.
          OGBMPP(A)= 0.
          LNDVBM(A)= 0.
          GRLVS(A) = 0.
          DRLVS(A) = 0.
          GRST (A) = 0.
          DRST (A) = 0.
          GRRT (A) = 0.
          GRGR (A) = 0.
737       CONTINUE

       AUXINT = MAXCL * NSP
          DO 738  A = 1, AUXINT
          LAID(A) = 0.
          SAID(A) = 0.
          EAID(A) = 0.
738       CONTINUE

************************************************************************
***                        SYSTEM  DYNAMICS                          ***
************************************************************************
DYNAMIC
NOSORT
***       CHECKING THE NECESSITY TO MODEL GROWTH PROCESSES
***                  ON THE PRESENT DAY

       DAY = TIME

*    ARE PLANTS PRESENT OR EXPECTED TO APPEAR ON THE FOLLOWING DAY?
*    (TO KNOW THIS MAY SAVE THE COMPUTER LOTS OF CALCULATIONS)
          DO 719 A = 1,NSP
          L = V(A)
          PLOP(A) = INSW(APPEAR(L) - 0.9 - TIME, 0.,1.) * ...
                    INSW(TIME - APPEAR(L) + 1.1, 0.,1.)
          EXIST(A)= INSW (DAY-APPEAR(L) + 1.E-8, 0., 1.)
719       CONTINUE
       XEXIST  = 0.
       XPLOP   = 0.
          DO 865 A = 1,NSP
          XEXIST    = XEXIST + EXIST(A)
          XPLOP     = XPLOP  + PLOP (A)
865       CONTINUE
       GROWTH = INSW(XEXIST-.1, 0., 1.)
       ARRIVE = INSW(XPLOP -.1, 0., 1.)
       IF ((GROWTH + ARRIVE).LE.0.)  GOTO 7020

************************************************************************
*                        WEATHER     DATA                              *
************************************************************************

*   DAILY GLOBAL RADIATION (J / M**2 / D)
       DTR = AFGEN (DTRT, DAY) * 1.E4

*   AVERAGE AIR TEMPERATURE (DEGREES C)
        TMPA = (AFGEN (MXTT,DAY) + AFGEN (MNTT, DAY) ) * 0.5

*   AVERAGE AIR TEMPERATURE DURING DAYLIGHT PERIOD
        EAVT = AFGEN (MXTT, DAY) - 0.25 * (AFGEN (MXTT, DAY) - ...
               AFGEN (MNTT, DAY))
```

```
***********************************************************************
*                          DEVELOPMENT                                *
***********************************************************************

*   PRE- AND POST-ANTHESIS DEVELOPMENTAL RATES
*   (EQUATIONS ACCORDING TO VAN KEULEN(85));
*   TIME SINCE EMERGENCE
         DO 8100 A = 1, NSP
         L = V(A)
         XD1      = CULTP(L) * AMAX1 (0., 0.00094 * TMPA -0.00046)...
                    *  INSW (DVSV(A) -1., 1., 0.)
         DVRV(A) = XD1 * EXIST(A) + PLOP(A) * IDVSV(L)
         XD2      = AMAX1(0., 0.000913 * TMPA + 0.003572 )
         DVRR(A) = XD2 * INSW (DVSV(A)-1.,0.,1.) * EXIST(A)
         AGE(A)  = AMAX1(0.,DAY - EMERG(L))
8100     CONTINUE
      DVSV = INTGRL (0,  DVRV, 12)
      DVSR = INTGRL (0., DVRR, 12)
         DO 9000 A = 1, NSP
         DVS (A) = AMIN1 (1., 0.5 * (DVSV(A) + DVSR(A)))
9000     CONTINUE
      IF (GROWTH.LE.0.5)  GOTO 20000

***********************************************************************
*        VERTICAL DISTRIBUTION OF LIGHT ABSORBING SURFACES            *
***********************************************************************

***   =====================   ***
***   A R E A  I N D I C E S  ***
***   =====================   ***

***   L E A F   A R E A  ***

*       DECISION WHETHER LEAF AREA DEVELOPMENT IS MODELLED
*       DYNAMICALLY OR INTRODUCED AS A FORCING FUNCTION
      IF (LAISWI.GT.0.5) GOTO 1011

*     LEAF AREA DEVELOPMENT IS MODELLED DYNAMICALLY AND NOT INTRODUCED
*     AS A FORCING FUNCTION
         DO 1002 A = 1,NSP
         IF (EXIST(A).LT.0.5)     GOTO 1002
         LR = V(A)
         SLA = TWOVAR(SLATB,DVS(A),LR) * 1.E-4
         LAI(A)   = (WLVS(A) + WDLVS(A)) * SLA
         IF (LAI(A).LT.1.E-6)    THEN
            TYPE 4999,A
4999        FORMAT (' SPECIES ',I5,' WITH LAI = 0 ')
            GOTO 1002
         ENDIF
         YFLVS(A)= WDLVS(A) / (WDLVS(A) + WLVS(A))
1002     CONTINUE
      GOTO 1012
1011  CONTINUE

*     DEVELOPMENT OF LEAF AREA IS INTRODUCED AS A FORCING FUNCTION
         DO 1005 A = 1,NSP
         IF (EXIST(A).LT.0.5)   GOTO 1005
         L = V(A)
         LR = V(A)
         XLNLA = TWOVAR (LNLAT,AGE(A),LR)
         LAI(A)     = EXP(XLNLA) * 1.E-4
         YFLVS(A)   = TWOVAR (YFRLVT, AGE(A), LR)
1005     CONTINUE
1012     CONTINUE
```

```
***   S T E M  A R E A  ***

         DO 950 A = 1,NSP
         IF (EXIST(A).LT.0.5)       GOTO 950
         SAI(A)   = (WST(A)  + WDST(A))  * SSTA * 1.E-4
         IF (SAI(A).LT.1.E-6)   THEN
            TYPE 5001,A
5001        FORMAT (' SPECIES ',I5,' WITH SAI = 0 ')
            GOTO 950
         ENDIF
         YFST(A)  =  WDST(A) / (WDST(A)  + WST(A))
950      CONTINUE

***   E A R   A R E A   ***

*   EAR AREA INDEX (DETERMINED BY THE ABOVEGROUND BIOMASS AT ANTHESIS)
        DO 148 A = 1, NSP
          L = V(A)
          LR= V(A)
          IF (EXIST(A).LT.0.5)       GOTO 148
          IF (EARATA(A).GT.1.E-6)    GOTO 149
          IF (DVS(A).LT.0.5)         GOTO 148
          EARATA(A) = EARSUR(L) * OGBM(A) * 1.E-5
149       CONTINUE
          EAI(A) = EARATA(A) * AFGEN(EARGRT,DVS(A))
          YFEAR(A)  =  1. - TWOVAR(GFET,AGE(A),LR)
148       CONTINUE

***     ====================================================    ***
***     B O U N D A R Y   H E I G H T S   S E P A R A T I N G   ***
***                 T H E   C A N O P Y   L A Y E R S           ***
***     ====================================================    ***

***   NUMBER OF DISTINGUISHED CANOPY LAYERS

PARAM CLPERL = 12., MINCL  = 12., MAXCL  = 12.

      XLAIT = 0.
         DO  8000 A = 1, NSP
         XLAIT = XLAIT + LAI(A)
8000     CONTINUE
       XNCL   = LIMIT (MINCL,MAXCL,XLAIT * CLPERL)
       NCL      = XNCL

***   BOUNDARIES OF CANOPY LAYERS

*   HEIGHT DEVELOPMENT IS INTRODUCED AS A FORCING FUNCTION ("HEITB")
      MAXHEI = 0.
         DO 7000 A = 1, NSP
         LR = V(A)
         HEI (A) = TWOVAR (HEITB,AGE(A), LR)
         IF (HEI(A).GT.MAXHEI)  MAXHEI = HEI (A)
7000     CONTINUE
      IF (MAXHEI.LT.1.E-3)   THEN
         TYPE 4997,MAXHEI
4997     FORMAT (' MAXHEI = ',F10.4 )
         MAXHEI = 1.E-3
      ENDIF

*    UPPER LIMITS ("ULCL") OF THE NCL CANOPY LAYERS (CM ABOVE THE GROUND);
*    THE CHOSEN LAYERS HAVE IDENTICAL THICKNESS

      CALL STRATA (MAXHEI,NCL,ULCL)
```

```
***       ================================          ***
***       D I S T R B I T I O N   O F   T H E       ***
***       A R E A    I N D I C E S   O V E R        ***
***       T H E    C A N O P Y    L A Y E R S       ***
***       ================================          ***

*     THE POTENTIAL EXTINCTION COEFFICIENT OF LEAVES IS CORRECTED
*     TO ACCOUNT FOR THE STRONG CLUSTERING OF LEAVES THAT YOUNG
*     PLANT EXHIBIT
          DO 530 A = 1,NSP
          L = V(A)
          KL(L)   = PKL(L) * AFGEN(KLREDT,DVS(A))
530       CONTINUE
          DO 981 K = 1,NCL
          LAIL(K)   = 0.
          ECDIF(K)= 0.
981       CONTINUE

***    DISTRIBUTION OF LEAF AREA

*      DISTRIBUTION OF THE TOTAL LEAF AREA
       CALL VERDI2 (NSP,DNSP,V,EXIST,...
                    NCL,HEI,ULCL,...
                    LAI,KL,DISPA1,...
                    LAID,LAIL,ECDIF,...
                    CHECK1,CHECK2,CHECK3)

*      DERIVED DISTRIBUTION OF THE GREEN LEAF AREA
       CALL YELDI1 (NSP,NCL,LAI,LAID,YFLVS)

***    DISTRIBUTION OF STEM AREA

*      DISTRIBUTION OF THE TOTAL STEM AREA
       CALL VERDI2 (NSP,DNSP,V,EXIST,...
                    NCL,HEI,ULCL,...
                    SAI,KLSTEM,DISPA2,...
                    SAID,LAIL,ECDIF,...
                    CHECK4,CHECK5,CHECK6)

*      DERIVED DISTRIBUTION OF THE GREEN STEM AREA
       CALL YELDI1 (NSP,NCL,SAI,SAID,YFST)
       IF (EAASWI.LT.0.5)  GOTO  9876

***    DISTRIBUTION OF EAR AREA

*      DISTRIBUTION OF THE TOTAL EAR AREA
       CALL VERDI2 (NSP,DNSP,V,EXIST,...
                    NCL,HEI,ULCL,...
                    EAI,KLEAR,DISPA3,...
                    EAID,LAIL,ECDIF,...
                    CHECK7,CHECK8,CHECK9)

*      DERIVED DISTRIBUTION OF THE GREEN EAR AREA
       CALL YELDI2 (NSP,NCL,EAID,YFEAR)

          DO 4869 A = 1,NSP
          XEAI(A) = EAI(A)
4869      CONTINUE
          DO 4870 A = 1,NSP*NCL
          STORE(A) = EAID(A)
4870      CONTINUE

************************************************************************
*        D A I L Y     G R O S S      P R O D U C T I O N             *
************************************************************************

9876     CONTINUE

***    ACTUAL VALUES OF AMAX
```

```
      TRAMAX =  AFGEN (TRAMAT,EAVT)
         DO 1710 A=1,NSP
         L = V(A)
         SRAMAX    = AFGEN (SRAMAT,DVS(A))
         AMAX(L) = PAMAX(L) * TRAMAX * SRAMAX
1710     CONTINUE

***   DAILY GROSS PRODUCTION

      GASSP,DUM, DAYL,IRR,INST1,FRDFD,FRDR = ...
      DAYASS (DAY,DTR,LAT,NCL,NSP,DNSP,V,STPSWI,EAPSWI,...
              LAID,SAID,EAID,LAIL,ECDIF,KL,KLSTEM,KLEAR,...
              AMAX,SAMAX,EAMAX,EFF,SEFF,EEFF)

**********************************************************************
*         D Y N A M I C S    O F    D R Y   M A T T E R             *
**********************************************************************

***    ==========================================     ***
***    M A I N T E N A N C E    R E S P I R A T I O N    ***
***    ==========================================     ***

*   MAINTENANCE RESPIRATION IS SUBTRACTED FROM THE GROSS PRODUCTION
      TEMR = Q10 ** (0.1 * TMPA - 1.5)
         DO 5000 A = 1, NSP
         XMRO =  WLVS(A) *  BMRCLV * AFGEN (LVRRT,DVS(A)) + ...
                 WST(A)  *  BMRCST                        + ...
                 WRT(A)  *  BMRCRT                        + ...
                 WGR(A)  *  BMRCGR
         RMNT     = AMIN1 (TEMR * XMRO, GASSP(A) )
         FCHN (A)   = GASSP (A) - RMNT
5000     CONTINUE
20000    CONTINUE
         IF ((GROWTH+ARRIVE).LT.0.5) GOTO 7020

***   ===========================================================   ***
***   A L L O C A T I O N    O F    N E T    P R O D U C T I O N   ***
***    T O    T H E    D I F F E R E N T    O R G A N S   A N D    ***
***       I T S    T R A N S F O R M A T I O N    I N T O          ***
***                   D R Y    M A T T E R;                         ***
***       T R A N S F O R M A T I O N   O F  L I V E   I N T O     ***
***                D E A D   D R Y   M A T T E R                    ***
***   ===========================================================   ***

***   RATES DRY MATTER ACCUMULATION IN LEAVES, STEMS, GRAINS, ROOTS
         DO 70 A = 1, NSP
         L = V(A)
         LR = V(A)
         IF (DAY.LE.APPEAR(L)-2)    GOTO 70

***   ROOTS AND SHOOT   ***

         FSH       =  TWOVAR (FSHTB,DVS(A),LR)
         XGRRT     =  FCHN(A) * (1.- FSH) * EFCRT + ...
                      PLOP(A) * IWRT(L) * COR(A) * DFAC
         DRRT      =  WRT(A) * AFGEN(DRRTB,AGE(A))
         GRRT(A) =  XGRRT - DRRT
      WRT          =  INTGRL (0., GRRT,  12)
         GSHOOT  =  FCHN(A) * FSH

***   LEAVES   ***

         FLVS       = TWOVAR (FLVST, DVS(A), LR)
         XGRLVS     = GSHOOT *  FLVS    * EFCLVS + ...
                      PLOP(A) * IWLVS(L) * COR(A) * DFAC
         DRLVS(A)   = WLVS(A) * TWOVAR(DRLVTB,AGE(A),LR)
         GRLVS (A) = XGRLVS   - DRLVS (A)
```

```
      WLVS        =  INTGRL (0., GRLVS, 12)
      WDLVS       =  INTGRL (0., DRLVS, 12)

***   STEMS   ***

         FST       = TWOVAR (FSTT, DVS(A), LR)
         XGRST     = GSHOOT  * FST  * EFCST + ...
                     PLOP(A) * IWST(L) * COR(A) * DFAC
         DRST(A)   = WST(A)  * AFGEN (DRSTTB,AGE(A))
         GRST(A)   = XGRST   - DRST(A)
      WST         =  INTGRL (0., GRST,  12)
      WDST        =  INTGRL (0., DRST,  12)

***   GRAINS   ***

         FGR       =  1. - FLVS - FST
         GRGR  (A) =  GSHOOT * FGR  * EFCGR
70       CONTINUE
      WGR         =  INTGRL (0,  GRGR,  12)

***************************************************************
*                 GROWTH RECORDING                            *
***************************************************************

      IF (GROWTH.LE.0.5)  GOTO 7020

*   ABOVEGROUND BIOMASS ( KG/HA), G/PLANT )
         DO 7010 A = 1,NSP
         OGBM(A)    = WLVS(A) + WDLVS(A) + WST(A) + WDST(A)+ WGR(A)
         IF (COR(A).LT.1.E-6)  THEN
            TYPE 5002,A
5002        FORMAT (' SPECIES ',I5,' WITH COR = 0 ')
            GOTO 7010
         ENDIF
         OGBMPP(A) = OGBM(A) / ( 10. * PSM * COR(A))
         7010     CONTINUE

*   AVERAGE, VARIANCE AND COEFFICIENT OF VARIATION OF ABOVEGROUND
*   BIOMASS PER PLANT
       AV,VAR,CV = EVAL1 (NSP,OGBMPP,COR)

*   DELTA - LN - VALUES
      LNDVBM,DUM = LNDCAL (NSP,OGBMPP,COR)
7020    CONTINUE

***************************************************************
*          P A R A M E T E R    L I B R A R Y                 *
***************************************************************

***    PHYSIOLOGICAL PARAMETERS USED FOR DESCRIBING THE GROWTH
***                 OF 12 SPRING WHEAT VARIETIES

***  DEVELOPMENTAL RATE  ***
*   VARIETY SPECIFIC FACTOR USED FOR DESCRIBING THE PREANTHESIS
*   DEVELOPMENTAL RATE (OBTAINED BY FITTING THE EQUATION GIVEN BY
*   VAN KEULEN(85) TO OBSERVED DURATIONS UNTIL ANTHESIS)
TABLE  CULTP (1-12) = 1.4066,  1.4554,  1.4817,  1.3845, ...
                      1.4311,  1.3616,  1.4066,  1.3403, ...
                      1.3403,  1.3197,  1.3197,  1.3616

***  OPTICAL PROPERTIES  ***

*   EXTINCTION COEFFICIENT OF EARS AND STEMS
*   (ESTIMATION ACCORDING TO DE GROOT (85) (PERS. COMMUNICATION)
TABLE  KLEAR  (1-12) = 12 * 0.4
TABLE  KLSTEM (1-12) = 12 * 0.4
```

```
*    POTENTIAL EXTINCTION COEFFICIENT OF LEAVES
*    (NOT FULLY REALIZED DURING THE FIRST DAYS OF GROWTH)
TABLE  PKL (1-12) = 12 * 0.60

*    REDUCTION FACTOR FOR THE EXTINCTION COEFFICIENT OF LEAVES,
*    ACCOUNTING FOR THE LEAF CLUSTERING EXHIBITED BY YOUNG PLANTS
FUNCTION KLREDT = 0.,0.6,  0.1,1.,  1.1,1.

***   PHOTOSYNTHETIC CHARACTERISTICS  ***

*    POTENTIAL AMAX (KG CO2 / HA / H) AND LIGHT USE EFFICIENCY
*    (KG CO2 / HA / H / (J / M2 / S) OF LEAVES
TABLE PAMAX (1-12) = 12 * 40.
TABLE EFF   (1-12) = 12 *   .45

*    REDUCTION FACTOR OF AMAX ACCOUNTING FOR THE EFFECT
*    OF SENESCENCE; VALUES AS FUNCTION OF THE DEVELOPMENTAL STATE
FUNCTION SRAMAT = 0.,1.,  0.5,1.,  1.,0.5

*    REDUCTION FACTOR OF AMAX ACCOUNTING
*    FOR THE EFFECT OF TEMPERATUR; VALUES AS FUNCITION OF
*    THE AVERAGE TEMPERATURE ( C) DURING DAYLIGHT PERIOD
FUNCTION TRAMAT = 0.,0.,  10.,1.,  25.,1.,  35.,0.01

*    AMAX (KG CO2 / HA / H) OF STEMS
TABLE SAMAX (1-12) = 12 * 20.

*    INITIAL LIGHT USE EFFICIENCY OF STEMS
*    (KG CO2 / HA / H /  (J/S/CM**2)
TABLE SEFF (1-12)  = 12 * 0.45

*    AMAX (KG CO2 / HA / H) OF EARS
TABLE EAMAX (1-12) = 12 * 20.

*    INITIAL LIGHT USE FFICIENCY OF EARS
*    (KG CO2 / HA / H /  (J/S/CM**2)
TABLE EEFF  (1-12) = 12 * 0.22

***  DEVELOPMENT OF THE EAR AREA  ***
*    EAR SURFACE AT ANTHESIS DIVIDED BY ABOVEGROUND BIOMASS AT
*    ANTHESIS (CM**2 / G)
*    (LARGE VALUES BELONG TO GENOTYPES WITH AWNS, SMALL TO
*    GENOTYPES WITHOUT AWNS)
TABLE EARSUR (1-12) = 8.64, 8.64, 15.98, 15.98, 8.64, 8.64,...
                      8.64, 8.64, 15.98,  8.64, 8.64, 8.64

*    GROWTH OF THE EAR AREA ( (EARSURFACE/PLANT) / (EARSURFACE/PLANT AT
*    ANTHESIS)  AS FUNCTION OF THE DEVELOPMENT STATE
FUNCTION EARGRT = 0.,0.,   0.4999,0.,  0.5,1.,  1.1,1.

*    THICKNESS OF THE EAR LAYER BELONGING
*    TO A SINGLE GENOTYPE (CM)
PARAM VEEL = 20.

***  GREEN FRACTION OF THE EAR AREA  ***

*    VALUES AS FUNCTION OF THE NUMBER OF DAYS AFTER EMERGENCE
FUNCTION GFET,  1.= 0.,1.,   67.,1.000,  103.,0.200,  107.,0.125, ...
                            112.,0.050,  117.,0.025,  130.,0.,  131.,0.
FUNCTION GFET,  2.= 0.,1.,   65.,1.000,  103.,0.250,  107.,0.138, ...
                            112.,0.050,  117.,0.000,  130.,0.,  131.,0.
FUNCTION GFET,  3.= 0.,1.,   64.,1.000,  103.,0.327,  107.,0.319, ...
                            112.,0.029,  117.,0.014,  130.,0.,  131.,0.
FUNCTION GFET,  4.= 0.,1.,   68.,1.000,  103.,0.422,  107.,0.352, ...
                            112.,0.205,  117.,0.000,  130.,0.,  131.,0.
```

```
FUNCTION GFET,  5.= 0.,1.,   66.,1.000,  103.,0.263,  107.,0.163, ...
                            112.,0.050,  117.,0.050,  130.,0.,  131.,0.
FUNCTION GFET,  6.= 0.,1.,   69.,1.000,  103.,0.200,  107.,0.150,...
                            112.,0.050,  117.,0.000,  130.,0.,  131.,0.
FUNCTION GFET,  7.= 0.,1.,   67.,1.000,  103.,0.200,  107.,0.138, ...
                            112.,0.050,  117.,0.000,  130.,0.,  131.,0.
FUNCTION GFET,  8.= 0.,1.,   70.,1.000,  103.,0.225,  107.,0.150, ...
                            112.,0.050,  117.,0.000,  130.,0.,  131.,0.
FUNCTION GFET,  9.= 0.,1.,   70.,1.000,  103.,0.509,  107.,0.375, ...
                            112.,0.118,  117.,0.007,  130.,0.,  131.,0.
FUNCTION GFET, 10.= 0.,1.,   71.,1.000,  103.,0.288,  107.,0.188, ...
                            112.,0.113,  117.,0.000,  130.,0.,  131.,0.
FUNCTION GFET, 11.= 0.,1.,   71.,1.000,  103.,0.375,  107.,0.213, ...
                            112.,0.075,  117.,0.000,  130.,0.,  131.,0.
FUNCTION GFET, 12.= 0.,1.,   69.,1.000,  103.,0.238,  107.,0.163, ...
                            112.,0.100,  117.,0.000,  130.,0.,  131.,0.

***  RELATIVE DYING RATES OF LEAVES  ***
*  VALUES AS FUNCTION OF THE NUMBER OF DAYS AFTER EMERGENCE
FUNCTION DRLVTB,  1.= 0.,0.,  66.,0.,  67.,0.024,  102.,0.024, ...
        103.,0.038,  106.,0.038,  107.,0.197,  111.,0.197, ...
        112.,0.392,  116.,0.392,  117.,0.452,  131.,0.452
FUNCTION DRLVTB,  2.= 0.,0.,  64.,0.,  65.,0.033,  102.,0.033, ...
        103.,0.092,  106.,0.092,  107.,0.234,  111.,0.234, ...
        112.,0.818,  116.,0.818,  117.,0.818,  131.,0.818
FUNCTION DRLVTB,  3.= 0.,0.,  63.,0.,  64.,0.045,  102.,0.045, ...
        103.,0.045,  106.,0.045,  107.,0.156,  111.,0.156, ...
        112.,0.197,  116.,0.197,  117.,0.443,  131.,0.443
FUNCTION DRLVTB,  4.= 0.,0.,  67.,0.,  68.,0.038,  102.,0.038, ...
        103.,0.075,  106.,0.075,  107.,0.139,  111.,0.139, ...
        112.,0.838,  116.,0.838,  117.,0.838,  131.,0.838
FUNCTION DRLVTB,  5.= 0.,0.,  65.,0.,  66.,0.030,  102.,0.030, ...
        103.,0.077,  106.,0.077,  107.,0.178,  111.,0.178, ...
        112.,0.356,  116.,0.356,  117.,0.412,  131.,0.412
FUNCTION DRLVTB,  6.= 0.,0.,  68.,0.,  69.,0.033,  102.,0.033, ...
        103.,0.111,  106.,0.111,  107.,0.189,  111.,0.189, ...
        112.,0.830,  116.,0.830,  117.,0.830,  131.,0.830
FUNCTION DRLVTB,  7.= 0.,0.,  66.,0.,  67.,0.038,  102.,0.038, ...
        103.,0.168,  106.,0.168,  107.,0.197,  111.,0.197, ...
        112.,0.810,  116.,0.810,  117.,0.810,  131.,0.810
FUNCTION DRLVTB,  8.= 0.,0.,  69.,0.,  70.,0.033,  102.,0.033, ...
        103.,0.118,  106.,0.118,  107.,0.189,  111.,0.189, ...
        112.,0.830,  116.,0.830,  117.,0.830,  131.,0.830
FUNCTION DRLVTB,  9.= 0.,0.,  69.,0.,  70.,0.022,  102.,0.022, ...
        103.,0.134,  106.,0.134,  107.,0.164,  111.,0.164, ...
        112.,0.381,  116.,0.381,  117.,0.412,  131.,0.412
FUNCTION DRLVTB, 10.= 0.,0.,  70.,0.,  71.,0.024,  102.,0.024, ...
        103.,0.087,  106.,0.087,  107.,0.165,  111.,0.165, ...
        112.,0.850,  116.,0.850,  117.,0.850,  131.,0.850
FUNCTION DRLVTB, 11.= 0.,0.,  70.,0.,  71.,0.027,  102.,0.027, ...
        103.,0.105,  106.,0.105,  107.,0.140,  111.,0.140, ...
        112.,0.140,  116.,0.140,  117.,0.488,  131.,0.488
FUNCTION DRLVTB, 12.= 0.,0.,  68.,0.,  69.,0.030,  102.,0.030, ...
        103.,0.148,  106.,0.148,  107.,0.234,  111.,0.234, ...
        112.,0.818,  116.,0.818,  117.,0.818,  131.,0.818

***  RELATIVE DYING RATE OF ROOTS  ***
*  VALUES AS FUNCTION OF THE NUMBER OF DAYS AFTER EMERGENCE
FUNCTION DRRTB =  0.,0.,        67.,0.,        68.,0.0061, 102.,0.0061,...
                103.,0.0206,  106.,0.0206,  107.,0.037,  111.,0.037, ...
                112.,0.073,   131.,0.073

***  RELATIVE DYING RATE OF STEMS  ***
*  VALUES AS FUNCTION OF THE NUMBER OF DAYS AFTER EMERGENCE
FUNCTION DRSTTB=  0.,0.,        67.,0.,        68.,0.0076, 102.,0.0076,...
                103.,0.0258,  106.,0.0258,  107.,0.047,  111.,0.047, ...
                112.,0.091,   131.,0.091
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*** DEVELOPMENT OF PLANT HEIGHT ***
*   VALUES AS FUNCTION OF THE NUMBER OF DAYS AFTER EMERGENCE
FUNCTION HEITB,  1. = 0., 5.,  40.,34.,  55.,64.,  72.,89.,  130.,73.
FUNCTION HEITB,  2. = 0., 5.,  40.,30.,  55.,56.,  72.,81.,  130.,63.
FUNCTION HEITB,  3. = 0., 5.,  40.,37.,  55.,66.,  72.,91.,  130.,78.
FUNCTION HEITB,  4. = 0., 5.,  40.,32.,  55.,54.,  72.,81.,  130.,66.
FUNCTION HEITB,  5. = 0., 5.,  40.,32.,  55.,58.,  72.,81.,  130.,70.
FUNCTION HEITB,  6. = 0., 5.,  40.,31.,  55.,58.,  72.,97.,  130.,82.
FUNCTION HEITB,  7. = 0., 5.,  40.,34.,  55.,58.,  72.,82.,  130.,70.
FUNCTION HEITB,  8. = 0., 5.,  40.,26.,  55.,55.,  72.,92.,  130.,74.
FUNCTION HEITB,  9. = 0., 5.,  40.,34.,  55.,57.,  72.,88.,  130.,74.
FUNCTION HEITB, 10. = 0., 5.,  40.,30.,  55.,55.,  72.,89.,  130.,69.
FUNCTION HEITB, 11. = 0., 5.,  40.,28.,  55.,59.,  72.,94.,  130.,77.
FUNCTION HEITB, 12. = 0., 5.,  40.,27.,  55.,58.,  72.,93.,  130.,79.

*** MAINTENANCE RESPIRATION ***

*   "Q10-PARAMTER"
PARAM Q10 = 2.

*** RELATIVE RESPIRATION RATES OF LEAVES, STEMS, ROOTS, GRAINS ***

PARAM BMRCLV = 0.03, BMRCST = 0.015, BMRCRT = 0.01, BMRCGR = 0.01

*   REDUCTION FACTOR ACCOUNTING FOR THE EFFECT OF SENESCENCE ON THE
*   RESPIRATION RATE OF LEAVES; VALUES AS FUNCTION OF THE
*   DEVELOPMENTAL STATE
FUNCTION LVRRT  = 0.,1.,  0.5,1.,  0.5001,0.5,  1.1,0.5

*** GROWTH EFFICIENCY ***

PARAM EFCLVS = 0.68, EFCST  = 0.66, EFCRT  = 0.69, EFCGR  = 0.70

*** DRY MATTER ALLOCATION  ***

*   FRACTION OF NET ASSIMILATION ALLOCATED TO THE  L E A V E S,
*   DIVIDED BY THE FRACTION ALLOCATED TO THE SHOOT
*   VALUES AS FUNCTION OF THE DEVELOPMENTAL STATE
FUNCTION FLVST, 1.=  0.,0.61,  0.10671,0.61,  ...
      0.10672,0.65,  0.14981,0.65,  0.14982,0.54,  0.22581,0.54, ...
      0.22582,0.47,  0.26921,0.47,  0.26922,0.32,  0.31265,0.32, ...
      0.40000,0.04,  0.50001,0.,     1.,0.
FUNCTION FLVST, 2.=  0.,0.65,  0.11041,0.65, ...
      0.11042,0.66,  0.15501,0.66,  0.15502,0.56,  0.23361,0.56, ...
      0.23362,0.42,  0.27851,0.42,  0.27852,0.32,  0.32350,0.32, ...
      0.40000,0.04,  0.50001,0.,     1.,0.
FUNCTION FLVST, 3.=  0.,0.64,  0.11241,0.64,  ...
      0.11242,0.58,  0.15781,0.58,  0.15782,0.54,  0.23781,0.54, ...
      0.23782,0.42,  0.28361,0.42,  0.28362,0.32,  0.32394,0.32, ...
      0.40000,0.04,  0.50001,0.,     1.,0.
FUNCTION FLVST, 4.=  0.,0.59,  0.10511,0.59,  ...
      0.10512,0.65,  0.14741,0.65,  0.14742,0.56,  0.22221,0.56, ...
      0.22222,0.55,  0.26501,0.55,  0.26502,0.32,  0.30774,0.32, ...
      0.40000,0.04,  0.50001,0.,     1.,0.
FUNCTION FLVST, 5.=  0.,0.62,  0.10861,0.62,  ...
      0.10862,0.63,  0.15241,0.63,  0.15242,0.53,  0.22971,0.53, ...
      0.22972,0.42,  0.27391,0.42,  0.27392,0.32,  0.31810,0.32, ...
      0.40000,0.04,  0.50001,0.,     1.,0.
FUNCTION FLVST, 6.=  0.,0.60, 0.10331,0.60,  ...
      0.10332,0.65,  0.14501,0.65,  0.14502,0.54,  0.21851,0.54, ...
      0.21852,0.44,  0.26061,0.44,  0.26062,0.32,  0.30265,0.32, ...
      0.40000,0.04,  0.50001,0.,     1.,0.
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```
FUNCTION FLVST, 7.=  0.,0.60,  0.10671,0.60,  ...
      0.10672,0.62,  0.14981,0.62,  0.14982,0.51,  0.22581,0.51, ...
      0.22582,0.57,  0.26921,0.57,  0.26922,0.32,  0.31265,0.32, ...
      0.40000,0.04,  0.50001,0.,    1.,0.
FUNCTION FLVST, 8.=  0.,0.65,  0.10171,0.65,  ...
      0.10172,0.68,  0.14271,0.68,  0.14272,0.59,  0.21511,0.59, ...
      0.21512,0.53,  0.25651,0.53,  0.25652,0.32,  0.29792,0.32, ...
      0.40000,0.04,  0.50001,0.,    1.,0.
FUNCTION FLVST, 9.=  0.,0.64,  0.10171,0.64,  ...
      0.10172,0.64,  0.14271,0.64,  0.14272,0.55,  0.21511,0.55, ...
      0.21512,0.36,  0.25651,0.36,  0.25652,0.32,  0.29792,0.32, ...
      0.40000,0.04,  0.50001,0.,    1.,0.
FUNCTION FLVST,10.=  0.,0.65,  0.10011,0.65,  ...
      0.10012,0.70,  0.14051,0.70,  0.14052,0.61,  0.21181,0.61, ...
      0.21182,0.46,  0.25261,0.46,  0.25262,0.32,  0.29334,0.32, ...
      0.40000,0.04,  0.50001,0.,    1.,0.
FUNCTION FLVST,11.=  0.,0.62,  0.10011,0.62,  ...
      0.10012,0.71,  0.14051,0.71,  0.14052,0.61,  0.21181,0.61, ...
      0.21182,0.48,  0.25261,0.48,  0.25262,0.32,  0.29334,0.32, ...
      0.40000,0.04,  0.50001,0.,    1.,0.
FUNCTION FLVST,12.=  0.,0.64,  0.10331,0.64,  ...
      0.10332,0.67,  0.14501,0.67,  0.14502,0.57,  0.21851,0.57, ...
      0.21852,0.43,  0.26061,0.43,  0.26062,0.32,  0.30265,0.32, ...
      0.40000,0.04,  0.50001,0.,    1.,0.

*  FRACTION OF NET ASSIMILATION ALLOCATED TO THE   S T E M S,
*  DIVIDED BY THE FRACTION ALLOCATED TO THE SHOOT
*  VALUES AS FUNCTION OF THE DEVELOPMENTAL STATE
FUNCTION FSTT,  1.=  0.,0.39,  0.10671,0.39,  ...
      0.10672,0.35,  0.14981,0.35,  0.14982,0.46,  0.22581,0.46, ...
      0.22582,0.53,  0.26921,0.53,  0.26922,0.68,  0.31265,0.68, ...
      0.40000,0.96,  0.50001,0.,    1.,0.
FUNCTION FSTT,  2.=  0.,0.35,  0.11041,0.35, ...
      0.11042,0.34,  0.15501,0.34,  0.15502,0.44,  0.23361,0.44, ...
      0.23362,0.58,  0.27851,0.58,  0.27852,0.68,  0.32350,0.68, ...
      0.40000,0.96,  0.50001,0.,    1.,0.
FUNCTION FSTT,  3.=  0.,0.36,  0.11241,0.36,  ...
      0.11242,0.42,  0.15781,0.42,  0.15782,0.46,  0.23781,0.46, ...
      0.23782,0.58,  0.28361,0.58,  0.28362,0.68,  0.32394,0.68, ...
      0.40000,0.96,  0.50001,0.,    1.,0.
FUNCTION FSTT,  4.=  0.,0.41,  0.10511,0.41,  ...
      0.10512,0.35,  0.14741,0.35,  0.14742,0.44,  0.22221,0.44, ...
      0.22222,0.45,  0.26501,0.45,  0.26502,0.68,  0.30774,0.68, ...
      0.40000,0.96,  0.50001,0.,    1.,0.
FUNCTION FSTT,  5.=  0.,0.38,  0.10861,0.38,  ...
      0.10862,0.37,  0.15241,0.37,  0.15242,0.47,  0.22971,0.47, ...
      0.22972,0.58,  0.27391,0.58,  0.27392,0.68,  0.31810,0.68, ...
      0.40000,0.96,  0.50001,0.,    1.,0.
FUNCTION FSTT,  6.=  0.,0.40, 0.10331,0.40,  ...
      0.10332,0.35,  0.14501,0.35,  0.14502,0.46,  0.21851,0.46, ...
      0.21852,0.56,  0.26061,0.56,  0.26062,0.68,  0.30265,0.68, ...
      0.40000,0.96,  0.50001,0.,    1.,0.
FUNCTION FSTT,  7.=  0.,0.40,  0.10671,0.40,  ...
      0.10672,0.38,  0.14981,0.38,  0.14982,0.49,  0.22581,0.49, ...
      0.22582,0.43,  0.26921,0.43,  0.26922,0.68,  0.31265,0.68, ...
      0.40000,0.96,  0.50001,0.,    1.,0.
FUNCTION FSTT,  8.=  0.,0.35,  0.10171,0.35,  ...
      0.10172,0.32,  0.14271,0.32,  0.14272,0.41,  0.21511,0.41, ...
      0.21512,0.47,  0.25651,0.47,  0.25652,0.68,  0.29792,0.68, ...
      0.40000,0.96,  0.50001,0.,    1.,0.
FUNCTION FSTT,  9.=  0.,0.36,  0.10171,0.36,  ...
      0.10172,0.36,  0.14271,0.36,  0.14272,0.45,  0.21511,0.45, ...
      0.21512,0.64,  0.25651,0.64,  0.25652,0.68,  0.29792,0.68, ...
      0.40000,0.96,  0.50001,0.,    1.,0.
FUNCTION FSTT, 10.=  0.,0.35,  0.10011,0.35,  ...
      0.10012,0.30,  0.14051,0.30,  0.14052,0.39,  0.21181,0.39, ...
      0.21182,0.54,  0.25261,0.54,  0.25262,0.68,  0.29334,0.68, ...
      0.40000,0.96,  0.50001,0.,    1.,0.
```

```
FUNCTION FSTT, 11.= 0.,0.38, 0.10011,0.38, ...
      0.10012,0.29, 0.14051,0.29, 0.14052,0.39, 0.21181,0.39, ...
      0.21182,0.52, 0.25261,0.52, 0.25262,0.68, 0.29334,0.68, ...
      0.40000,0.96, 0.50001,0., 1.,0.
FUNCTION FSTT ,12.= 0.,0.36, 0.10331,0.36, ...
      0.10332,0.33, 0.14501,0.33, 0.14502,0.43, 0.21851,0.43, ...
      0.21852,0.57, 0.26061,0.57, 0.26062,0.68, 0.30265,0.68, ...
      0.40000,0.96, 0.50001,0., 1.,0.

*   FRACTION OF NET ASSIMILATION ALLOCATED TO THE SHOOT,
*   DEPENDENT ON THE DEVELOPMENTAL STATE
FUNCTION FSHTB, 1.= 0.,0.5, 0.25,0.8, 0.5,1., 1.,1.
FUNCTION FSHTB,12.= 0.,0.5, 0.25,0.8, 0.5,1., 1.,1.

***  SPECIFIC LEAF AREA  ***
*   VALUES AS FUNCTION OF THE DEVELOPMENTAL STATE
*     (M**2 / KG)
FUNCTION SLATB, 1.= 0.,21.570, 1.,     21.570
FUNCTION SLATB, 2.= 0.,21.848, 1.,     21.848
FUNCTION SLATB, 3.= 0.,20.786, 1.,     20.786
FUNCTION SLATB, 4.= 0.,23.348, 1.,     23.348
FUNCTION SLATB, 5.= 0.,22.227, 1.,     22.227
FUNCTION SLATB, 6.= 0.,21.459, 1.,     21.459
FUNCTION SLATB, 7.= 0.,22.457, 1.,     22.457
FUNCTION SLATB, 8.= 0.,22.041, 1.,     22.041
FUNCTION SLATB, 9.= 0.,20.396, 1.,     20.396
FUNCTION SLATB,10.= 0.,21.478, 1.,     21.478
FUNCTION SLATB,11.= 0.,21.124, 1.,     21.124
FUNCTION SLATB,12.= 0.,22.758, 1.,     22.758

***  SPECIFIC STEM AREA  ***
*     ( M**2 / KG )
PARAM SSTA = 2.5

METHOD RECT

**********************************************************************
*                 W E A T H E R          D A T A                     *
**********************************************************************

*   DAILY GLOBAL RADIATION (J/CM**2/D)
FUNCTION DTRT= ...
              96.,1873., 97.,1593., 98., 834., 99., 902.,100.,    0.,...
             101.,   0.,102.,   0.,103.,2165.,104.,2124.,105.,2083.,...
             106.,2070.,107.,1928.,108.,1894.,109., 411.,110.,1166.,...
             111.,1631.,112.,2159.,113., 959.,114.,2097.,115.,1341.,...
             116., 314.,117., 877.,118.,1847.,119., 367.,120., 629.,...
             121.,2105.,122.,2132.,123.,2345.,124.,1979.,125.,2227.,...
             126.,2589.,127.,1696.,128.,1363.,129., 957.,130.,2486.,...
             131.,2774.,132.,2701.,133.,2627.,134.,2691.,135.,2767.,...
             136.,2656.,137.,2089.,138.,2233.,139.,1998.,140.,2601.,...
             141.,2004.,142.,2567.,143.,2778.,144.,1943.,145., 833.,...
             146.,1580.,147.,2040.,148.,1671.,149.,1623.,150.,1326.,...
             151.,2310.,152.,1336.,153.,1319.,154.,2324.,155., 628.,...
             156.,1737.,157.,2798.,158.,2594.,159., 970.,160.,1885.,...
             161.,2365.,162., 949.,163.,2053.,164.,2584.,165.,2214.,...
             166.,1707.,167.,1485.,168., 870.,169.,1383.,170.,1147.,...
             171., 667.,172.,1521.,173.,1369.,174.,1398.,175.,1543.,...
             176.,1355.,177.,1892.,178.,1720.,179.,1735.,180., 799.,...
             181.,1573.,182.,2212.,183.,1065.,184.,1542.,185.,1652.,...
             186., 878.,187.,1329.,188.,2219.,189.,1007.,190., 635.,...
             191., 779.,192., 428.,193., 618.,194.,1194.,195.,1348.,...
             196.,1017.,197.,1735.,198.,1031.,199.,1263.,200., 753.,...
             201., 389.,202., 655.,203., 540.,204.,2615.,205.,2592.,...
             206.,2141.,207.,2414.,208.,2153.,209.,1667.,210.,1700.,...
```

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                211.,2282.,212., 556.,213.,2290.,214.,2044.,215.,2073.,...
                216.,1507.,217.,1480.,218.,1393.,219.,1296.,220.,1455.,...
                221.,1799.,222.,1814.,223.,1563.,224.,1264.,225.,1238.,...
                226.,1164.,227., 724.,228.,1989.,229., 928.,230.,1705.,...
                231.,1045.,232.,1372.,233.,1115.,234.,1364.,235.,1229.,...
                236.,1073.,237., 579.,238.,1895.,239.,2087.,240.,1819.,...
                241., 704.,242., 928.,243., 820.,244., 779.,245.,1572.

*   DAILY TEMPERATUR MAXIMA ( C)
FUNCTION MXTT=      ...
                 96.,10.9, 97.,11.8, 98., 8.0, 99., 7.4,100., 7.9 ,     ...WAG1980
                101., 9.3,102.,13.2,103.,15.8,104.,19.3,105.,21.6 ,     ...WAG1980
                106.,22.3,107.,22.3,108.,18.6,109., 9.5,110.,10.1 ,     ...WAG1980
                111., 9.1,112.,10.8,113., 8.5,114.,11.1,115.,12.1 ,     ...WAG1980
                116., 7.8,117.,12.5,118.,14.1,119., 9.1,120.,10.1 ,     ...WAG1980
                121.,12.1,122.,19.5,123.,14.9,124.,13.9,125.,14.1 ,     ...WAG1980
                126.,13.1,127.,16.7,128.,13.1,129.,10.0,130.,14.9 ,     ...WAG1980
                131.,17.9,132.,21.0,133.,23.6,134.,21.1,135.,20.1 ,     ...WAG1980
                136.,19.3,137.,18.4,138.,20.5,139.,22.9,140.,24.6 ,     ...WAG1980
                141.,24.2,142.,22.6,143.,15.1,144.,14.1,145.,13.2 ,     ...WAG1980
                146.,15.7,147.,18.8,148.,20.7,149.,19.6,150.,17.8 ,     ...WAG1980
                151.,15.7,152.,17.2,153.,18.6,154.,19.5,155.,18.6 ,     ...WAG1980
                156.,23.5,157.,27.0,158.,27.2,159.,17.8,160.,19.5 ,     ...WAG1980
                161.,24.1,162.,20.0,163.,22.3,164.,23.5,165.,26.9 ,     ...WAG1980
                166.,28.4,167.,20.8,168.,19.8,169.,19.3,170.,18.2 ,     ...WAG1980
                171.,17.7,172.,16.3,173.,17.1,174.,15.9,175.,17.2 ,     ...WAG1980
                176.,15.8,177.,17.8,178.,17.7,179.,16.7,180.,13.6 ,     ...WAG1980
                181.,16.4,182.,17.7,183.,18.3,184.,18.8,185.,18.4 ,     ...WAG1980
                186.,16.1,187.,17.9,188.,20.9,189.,18.0,190.,16.4 ,     ...WAG1980
                191.,16.0,192.,16.5,193.,14.0,194.,16.2,195.,16.8 ,     ...WAG1980
                196.,18.0,197.,17.7,198.,15.0,199.,16.4,200.,17.3 ,     ...WAG1980
                201.,16.5,202.,17.6,203.,14.5,204.,20.0,205.,23.9 ,     ...WAG1980
                206.,22.8,207.,26.9,208.,29.1,209.,24.8,210.,24.5 ,     ...WAG1980
                211.,26.5,212.,20.4,213.,23.9,214.,25.7,215.,28.3 ,     ...WAG1980
                216.,28.8,217.,23.5,218.,21.1,219.,21.4,220.,23.0 ,     ...WAG1980
                221.,21.9,222.,20.0,223.,21.1,224.,23.9,225.,18.0 ,     ...WAG1980
                226.,18.9,227.,21.3,228.,26.5,229.,22.7,230.,23.3 ,     ...WAG1980
                231.,22.5,232.,21.0,233.,22.5,234.,19.4,235.,16.9 ,     ...WAG1980
                236.,15.1,237.,13.8,238.,18.6,239.,22.2,240.,24.0 ,     ...WAG1980
                241.,18.8,242.,21.7,243.,18.4,244.,17.3,245.,19.1 ,     ...WAG1980
                246.,20.4,247.,22.3,248.,17.6,249.,18.6,250.,20.7

*   DAILY TEMPERATURE MINIMA ( C)
FUNCTION MNTT=      ...
                 96.,-3.5, 97.,-2.2, 98.,-1.4, 99., 1.5,100., 1.8 ,     ...WAG1980
                101., 1.9,102.,-2.2,103., 3.1,104., 7.0,105., 8.8 ,     ...WAG1980
                106., 3.1,107., 3.2,108., 4.9,109., 1.3,110., 1.8 ,     ...WAG1980
                111., 0.9,112., 0.5,113., 0.0,114.,-2.4,115., 4.5 ,     ...WAG1980
                116., 4.2,117., 0.6,118.,-0.8,119., 2.5,120., 2.8 ,     ...WAG1980
                121., 4.4,122., 7.9,123., 6.8,124., 3.7,125., 2.9 ,     ...WAG1980
                126., 3.7,127., 3.2,128., 4.7,129., 1.4,130., 0.9 ,     ...WAG1980
                131., 2.9,132., 1.9,133.,10.1,134.,10.4,135., 9.3 ,     ...WAG1980
                136., 5.6,137., 2.0,138., 2.9,139., 7.4,140., 4.7 ,     ...WAG1980
                141., 5.6,142., 8.0,143., 5.5,144., 0.8,145., 8.7 ,     ...WAG1980
                146., 6.4,147., 5.8,148., 6.7,149., 6.8,150., 5.3 ,     ...WAG1980
                151., 3.8,152., 4.0,153., 5.5,154., 4.2,155., 7.1 ,     ...WAG1980
                156.,13.0,157., 7.1,158., 9.2,159., 7.7,160., 5.4 ,     ...WAG1980
                161., 9.4,162.,14.2,163.,12.1,164.,10.8,165.,16.5 ,     ...WAG1980
                166.,15.4,167.,12.8,168.,11.5,169.,11.1,170.,10.3 ,     ...WAG1980
                171., 9.2,172., 9.5,173., 9.8,174., 9.3,175., 9.6 ,     ...WAG1980
                176.,10.0,177., 7.9,178., 4.0,179., 7.3,180., 8.6 ,     ...WAG1980
                181., 9.5,182.,11.2,183.,11.0,184.,12.3,185.,12.2 ,     ...WAG1980
                186., 8.3,187.,10.6,188.,11.2,189.,14.3,190.,12.6 ,     ...WAG1980
                191.,11.8,192.,12.9,193.,11.8,194.,10.8,195.,10.5 ,     ...WAG1980
                196.,11.2,197.,10.8,198., 7.3,199., 7.2,200.,12.7 ,     ...WAG1980
                201.,14.0,202.,12.0,203., 7.7,204., 7.1,205.,12.2 ,     ...WAG1980
                206.,10.9,207.,11.2,208.,17.0,209.,14.1,210.,14.2 ,     ...WAG1980
```

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          211.,17.0,212.,13.4,213.,12.5,214.,16.0,215.,12.6 ,    ...WAG1980
          216.,15.6,217.,13.7,218.,17.5,219.,15.8,220.,14.2 ,    ...WAG1980
          221.,11.2,222., 6.8,223.,10.6,224.,14.3,225.,15.1 ,    ...WAG1980
          226.,12.8,227.,16.0,228.,15.1,229.,15.5,230.,16.4 ,    ...WAG1980
          231.,14.4,232.,13.2,233.,13.8,234.,12.9,235.,11.1 ,    ...WAG1980
          236., 9.4,237., 7.0,238., 3.0,239., 4.3,240., 6.4 ,    ...WAG1980
          241.,10.5,242.,14.6,243.,13.3,244., 9.2,245., 7.0 ,    ...WAG1980
          246., 6.6,247.,10.5,248.,11.5,249.,11.5,250.,11.7

**********************************************************************
***************  OUTPUT AND RUN CONTROL  ***************************
**********************************************************************
NOSORT
TIMER FINTIM = 231., TIME = 126., DELT=1., PRDEL=1., OUTDEL=1.
PRINT OGBMPP(1-12)
END
STOP


**********************************************************************
*****          SUBROUTINES CALLED FROM   DYNAMIC             *****
**********************************************************************

      SUBROUTINE STRATA (MAXHEI,NCL,ULCL)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C     SUBROUTINE CALCULATING THE BOUNDARY HEIGHTS SEPERATING THE        C
C             CANOPY LAYERS; THE LAYERS HAVE EQUAL THICKNESS            C
C                    INPUT PARAMETERS:                                  C
C     MAXHEI  :  CANOPY HEIGHT                                     [CM] C
C     NCL     :  NUMBER OF CANOPY LAYERS                                C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                    OUTPUT PARAMETERS:                                 C
C     ULCL    :  UPPER LIMITS OF CANOPY LAYERS                     [CM] C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL(A-Z)
      INTEGER NCL,K
      DIMENSION ULCL (NCL+1)
      THK = MAXHEI / NCL
         DO 10 K = 1,NCL
         ULCL(K) = MAXHEI - (K-1) * THK
 10      CONTINUE
      ULCL(NCL+1) = 0.
      RETURN
      END

      SUBROUTINE VPRE1 (DNSP,A,C,Z,DISPA,DUM)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C    SUBROUTINE WRITING AN ARRAY CONTAINING PARAMETERS AND/OR AUXILIARY C
C      VARIABLES USED FOR THE VERTICAL DISTRIBUTON OF A SURFACE TYPE;   C
C    THE ARRAY PRODUCED BY "VPRE1" REFLECTS THE SITUATION THAT FOR ALL  C
C    DESCRIBED GENOTYPES THE VERTICAL AREA DENSITY FUNCTION OF THE      C
C    SURFACE IS GIVEN BY                                                C
C         Y  =  ( A * X**Z  + A  +  C) / NORMALIZATION CONSTANT         C
C     AND THAT ITS 3 PARAMETERS (A,C,Z) ARE IDENTICAL FOR ALL GENOTYPES C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                    INPUT PARAMETERS:                                  C
C     DNSP    :  DESCRIBED NUMBER OF GENOTYPES                          C
C     A,C,Z   :  PARAMETERS CHARACTERIZING THE VERTICAL AREA DENSITY    C
C                FUNCTION                                               C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                    OUTPUT PARAMETERS:                                 C
C     DISPA   :  ARRAY CONTAINING PARAMETERSAND/OR AUXILIARY VARIABLES  C
C                USED FOR THE VERTICAL DISTRIBUTION OF A SURFACE TYPE   C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
```

```
      IMPLICIT REAL (A-Z)
      INTEGER   DNSP,A,G,COUNT
      DIMENSION DISPA (72)
      DIMENSION X (6)
      X(1)  = 0.
      X(2)  = 1. +  C/A
      X(3)  = 1. / (Z+1.)
      X(4)  = X(2) - X(3)
      X(5)  = Z + 1.
      X(6)  = 0.
      COUNT = 0
         DO 15251 A = 1,DNSP
            DO 15252 G = 1,6
            COUNT = COUNT + 1
            DISPA(COUNT) = X(G)
15252       CONTINUE
15251    CONTINUE
      RETURN
      END

      SUBROUTINE VPRE2 (DNSP,D,DISPA,DUM)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C    SUBROUTINE WRITING AN ARRAY CONTAINING PARAMETERS AND/OR AUXILIARY   C
C      VARIABLES USED FOR THE VERTICAL DISTRIBUTON OF A SURFACE TYPE;     C
C    THE ARRAY PRODUCED BY "VPRE2" REFLECTS THE SITUATION THAT FOR ALL    C
C    DESCRIBED GENOTYPES THE VERTICAL AREA DENSITY FUNCTION OF THE        C
C    SURFACE IS GIVEN BY                                                  C
C                  1 / D ,   1-D `=  X  `=  1                             C
C         Y  =                                                            C
C                  0         ,   OTHERWIZE                                C
C     AND THAT ITS  PARAMETER (D) IS IDENTICAL FOR ALL GENOTYPES   C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                         INPUT PARAMETERS:                               C
C     DNSP    :  DESCRIBED NUMBER OF GENOTYPES                            C
C     D       :  PARAMETER CHARACTERIZING THE VERTICAL AREA DENSITY       C
C                FUNCTION                                                 C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                         OUTPUT PARAMETERS:                              C
C     DISPA   :  ARRAY CONTAINING PARAMETERSAND/OR AUXILIARY VARIABLES    C
C                USED FOR THE VERTICAL DISTRIBUTION OF A SURFACE TYPE     C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL (A-Z)
      INTEGER A,G,COUNT,DNSP
      DIMENSION X(6)
      DIMENSION DISPA (72)
      X(1) = 1.
      X(2) = D
         DO 128 G = 3,6
         X(G) = 0.
128      CONTINUE
      COUNT = 0
         DO 698 A = 1,DNSP
            DO 699 G = 1,6
            COUNT = COUNT + 1
            DISPA(COUNT) = X(G)
699         CONTINUE
698      CONTINUE
      RETURN
      END
```

```
      SUBROUTINE CLFRAC (DISPA,L,LOWLIM,UPLIM,HEIGHT,TAI,CLAI)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C      SUBROUTINE CALCULATING THE AREA INDEX OF THAT FRACTION OF A      C
C            SURFACE TYPE WHICH IS POSITIONED IN A CANOPY LAYER         C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                         INPUT PARAMETERS:                             C
C      DISPA  :  ARRAY CONTAINING PARAMETERS AND/OR AUXILIARY VARIABLES  C
C                USED FOR DESCRIBING THE VERTICAL DISTRIBUTION OF A      C
C                SURFACE TYPE                                           C
C      L      :  LIBRARY REFERENCE OF THE GENOTYPE                      C
C      LOWLIM :  LOWER BOUNDARY HEIGHT OF THE CONSIDERED CANOPY LAYER [CM]C
C      UPLIM  :  UPPER BOUNDARY HEIGHT OF THE CONSIDERED CANOPY LAYER [CM]C
C      HEIGHT :  PLANT HEIGHT OF THE GENOTYPE                           C
C      TAI    :  TOTAL AREA INDEX OF THE SURFACE TYPE                   C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                         OUTPUT PARAMETERS:                            C
C      CLAI   :  AREA INDEX OF THAT FRACTION OF THE SURFACE TYPE WHICH   C
C                IS POSITIONED IN THE CANOPY LAYER                      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL(A-Z)
      INTEGER L,XADRES,XFUNC
      DIMENSION DISPA (72)
C     CHOOSE THE DISTRIBUTION FUNCTION
      XADRES = (L-1) * 6 + 1
      XFUNC  = DISPA(XADRES)
      IF (XFUNC.EQ.1)  GOTO 88877
C     DISTRIBUTION FUNCTION :
C     Y = A - A * X**Z + C
      LOW = AMAX1 (0.,LOWLIM / HEIGHT)
      UP  = AMIN1 (1.,UPLIM  / HEIGHT)
      IF (LOWLIM.GE.HEIGHT.  OR.
     1    UP.    LE.1.E-5    )  THEN
         CLAI = 0.
      ELSE
         X0 = DISPA(XADRES+4)
         X1 = DISPA(XADRES+1) * (UP-LOW)
         X2 = DISPA(XADRES+2) * ( UP ** X0   -   LOW ** X0 )
         CLAI = (X1 - X2) / DISPA(XADRES+3)   * TAI
      ENDIF
      GOTO 90909
88877 CONTINUE
C     DISTRIBUTION FUNCTION :
C
C                  1 / D ,    1-D  `=  X  `=  1
C         Y  =
C                  0          ,    OTHERWIZE
C
      LIM1 = AMAX1 (0.,HEIGHT - DISPA (XADRES+1))
      LIM2 = AMAX1 (0.,HEIGHT - DISPA (XADRES+2))
      THICK = LIM2 - LIM1
      IF (TAI.  LE. 1.E-6.  OR.
     1    THICK.LE. 1.E-6.  OR.
     1    UPLIM.LE. LIM1.   OR.
     1    LOWLIM.GE.LIM2)      THEN
         CLAI = 0.
      ELSE
         XU = AMIN1 (UPLIM, LIM2)
         XL = AMAX1 (LOWLIM,LIM1)
         CLAI = (XU - XL) / THICK * TAI
      ENDIF
90909 CONTINUE
      RETURN
      END

      SUBROUTINE VERDI2 (NSP,DNSP,V,EXIST,
     1                   NCL,HEI,ULCL,
     1                   AI,ECOF,DISPA,
     1                   AID,LAIL,ECDIF,
     1                   CHECK1,CHECK2,CHECK3)
```

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C   SUBROUTINE DISTRIBUTING THE AREA INDEX OF A SURFACE TYPE OVER THE     C
C   CANOPY LAYERS; FOR EACH CANOPY LAYER, THE EXTINCTION CAPACITY AND     C
C      THE TOTAL AREA INDEX OF ALL CONTAINED SURFACES IS ENHANCED         C
C        CORRESPONDINGLY TO THE CONTRIBUTION OF THIS SURFACE TYPE         C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                         INPUT PARAMETERS:                               C
C     NSP     :  NUMBER OF GENOTYPES                                      C
C     DNSP    :  DESCRIBED NUMBER OF GENOTYPES                            C
C     V       :  ARRAY LINKING THE ACTUAL REFERENCES OF THE GENOTYPES     C
C                TO THEIR LIBRARY REFERENCES                              C
C     NCL     :  NUMBER OF CANOPY LAYERS                                  C
C     HEI     :  PLANT HEIGHTS OF THE GENOTYPES                           C
C     ULCL    :  BOUNDARY HEIGHTS SEPRERATING THE CANOPY LAYERS           C
C     AI      :  AREA INDICES OF THE VARIOUS GENOTYPES                    C
C     ECOF    :  EXTINCTION COEFFICIENTS OF THIS SURFACE TYPE BELONGING   C
C                TO THE VARIOUS GENOTYPES                                 C
C     DISPA   :  ARRAY CONTAINING PARAMETERSAND/OR AUXILIARY VARIABLES    C
C                USED FOR THE VERTICAL DISTRIBUTION OF A SURFACE TYPE     C
C     LAIL    :  CONTAINS FOR EACH OF THE NCL CANOPY LAYERS THE           C
C                SUM OF AREA INDICES BELONGING TO ABSORBING SURFACES      C
C                (LEAVES, STEMS, EARS...) POSITIONED IN IT        [HA/HA] C
C     ECDIF   :  AS LAIL, BUT THE CONTRIBUTING AREA INDICES ARE           C
C                MULTIPLIED BY THE CORRESPONDING EXTINCTION               C
C                COEFFICIENTS FOR DIFFUSE LIGHT                   [HA/HA] C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                         OUTPUT PARAMETERS:                              C
C     AID     :  DISTRIBUTION OF THE TOTAL AREA INDEX OF THE CONSIDERED   C
C                SURFACE TYPE OVER CANOPY LAYERS AND COMPETITORS          C
C     LAIL    :  CONTAINS FOR EACH OF THE NCL CANOPY LAYERS THE           C
C                SUM OF AREA INDICES BELONGING TO ABSORBING SURFACES      C
C                (LEAVES, STEMS, EARS...) POSITIONED IN IT        [HA/HA] C
C     ECDIF   :  AS LAIL, BUT THE CONTRIBUTING AREA INDICES ARE           C
C                MULTIPLIED BY THE CORRESPONDING EXTINCTION               C
C                COEFFICIENTS FOR DIFFUSE LIGHT                   [HA/HA] C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL (A-Z)
      INTEGER V,K,A,C,NSP,DNSP,NCL,L
      DIMENSION V     (NSP)
      DIMENSION EXIST (NSP)
      DIMENSION HEI   (NSP)
      DIMENSION ULCL  (NCL+1)
      DIMENSION AI    (NSP)
      DIMENSION ECOF  (DNSP)
      DIMENSION DISPA (72)
      DIMENSION AID   (NSP*NCL)
      DIMENSION LAIL  (NCL)
      DIMENSION ECDIF (NCL)
      C = 0
      CHECK1 = 0.
         DO 565 K = 1,NCL
         LOWLIM = ULCL(K+1)
         UPLIM  = ULCL(K)
            DO 566 A = 1,NSP
            C  = C + 1
            L  = V(A)
            XAI = AI(A)
            XHEI= HEI(A)
            CALL CLFRAC (DISPA,L,LOWLIM,UPLIM,XHEI,XAI,CLAI)
            CHECK1   = CHECK1 + CLAI
            AID (C)   = CLAI
            LAIL  (K)= LAIL  (K) + CLAI
            ECDIF (K)= ECDIF (K) + CLAI * ECOF(L)
566         CONTINUE
565      CONTINUE
      CHECK2 = 0.
         DO 1729 A = 1,NSP
         CHECK2 = CHECK2 + AI(A)
1729     CONTINUE
```

```
C     CHECKING THE CORRECT DISTRIBUTION
      IF (CHECK2.LT.1.E-5)  THEN
         CHECK3 = CHECK1
      ELSE
         CHECK3 = ABS(CHECK1-CHECK2) / CHECK2
      ENDIF
      IF (CHECK3.GT.0.01)      TYPE 88661
88661 FORMAT (' INCORRECT DISTRIBUTION ALGORITHM ')
      RETURN
      END

      SUBROUTINE YELDI1 (NSP,NCL,AI,GAID,YFRAC)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C   SUBROUTINE DERIVING THE DISTRIBUTION OF THE GREEN FRACTION OF A       C
C       SURFACE TYPE OVER CANOPY LAYERS AND COMPETITORS FROM THE          C
C          CORRESPONDING DISTRIBUTION OF THE TOTAL SURFACE AREA;          C
C   THE DERIVATION REFLECTS THE SITUATION THAT THE TOTAL GREEN FRACTION   C
C                IS POSITIONED ABOVE THE TOTAL YELLOW FRACTION            C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                      INPUT PARAMETERS:                                  C
C     NSP     :  NUMBER OF GENOTYPES                                      C
C     NCL     :  NUMBER OF CANOPY LAYERS                                  C
C     AI      :  TOTAL AREA INDICES OF THE VARIOUS GENOTYPES              C
C     YFRAC   :  YELLOW FRACTIONS OF THE TOTAL AREA INDICES               C
C                BELONGING TO THE VARIOUS GENOTYPES                       C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                      OUTPUT PARAMETERS:                                 C
C     GAID    :  DISTRIBUTION OF THE GREEN AREA INDEX OF THE CONSIDERED   C
C                SURFACE TYPE OVER CANOPY LAYERS AND COMPETITORS          C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL (A-Z)
      INTEGER NSP,NCL,A,K
      DIMENSION AI    (NSP)
      DIMENSION GAID  (NSP*NCL)
      DIMENSION YFRAC (NSP)
         DO 1914 A = 1,NSP
         XCUMGR = 0.
         XGRAI  = AI(A) * (1.-YFRAC(A))
            DO 1915 K = A, (NCL-1) * NSP + A, NSP
            GAID (K) = LIMIT (0.,GAID(K), XGRAI - XCUMGR)
            XCUMGR   = XCUMGR + GAID(K)
1915        CONTINUE
1914     CONTINUE
      RETURN
      END

      SUBROUTINE YELDI2 (NSP,NCL,GAID,YFRAC)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C   SUBROUTINE DERIVING THE DISTRIBUTION OF THE GREEN FRACTION OF A       C
C       SURFACE TYPE OVER CANOPY LAYERS AND COMPETITORS FROM THE          C
C          CORRESPONDING DISTRIBUTION OF THE TOTAL SURFACE AREA;          C
C   THE DERIVATION REFLECTS THE SITUATION THAT THE GREEN FRACTION         C
C         IS DISTRIBUTED UNIFORMLY FROM GROUND TO PLANT TOP               C
C                IS POSITIONED ABOVE THE TOTAL YELLOW FRACTION            C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                      INPUT PARAMETERS:                                  C
C     NSP     :  NUMBER OF GENOTYPES                                      C
C     NCL     :  NUMBER OF CANOPY LAYERS                                  C
C     YFRAC   :  YELLOW FRACTIONS OF THE TOTAL AREA INDICES               C
C                BELONGING TO THE VARIOUS GENOTYPES                       C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                      OUTPUT PARAMETERS:                                 C
C     GAID    :  DISTRIBUTION OF THE GREEN AREA INDEX OF THE CONSIDERED   C
C                SURFACE TYPE OVER CANOPY LAYERS AND COMPETITORS          C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
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      IMPLICIT REAL (A-Z)
      INTEGER NSP,NCL,A,K
      DIMENSION GAID (NSP * NCL)
      DIMENSION YFRAC (NSP)
         DO 8001 A = 1,NSP
            DO 8002 K = A, (NCL-1) * NSP + A, NSP
            GAID (K) = GAID (K) * (1. - YFRAC(A))
8002        CONTINUE
8001     CONTINUE
      RETURN
      END

      SUBROUTINE ASTRO(DAY,LAT,DTR,DAYL,SININT,
     $                 SINLD,COSLD)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C     SUBROUTINE CALCULATING THE DAYLENGTH [H] AND 3 AUXILIARY VARIABLES  C
C     NEEDED FOR DESCRIBING THE INSTANTANEOUS RADIATION FOR A GIVEN       C
C                      TIMEPOINT OF THE DAY                               C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                      INPUT PARAMETERS:                                  C
C      DAY     :  NUMBER OF CALENDAR DAY                                  C
C      LAT     :  LATITUDE OF LOCATION                                    C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                      OUTPUT PARAMETERS:                                 C
C     DAYL     :  DAYLENGTH                                           [H] C
C     SINLD    :  AUXILIARY VARIABLE                                      C
C     COSLD    :  AUXILIARY VARIABLE                                      C
C     SININT   ;  AIXILIARY VARIABLE                                      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL(A-Z)
      PI=3.1415926
      RAD=PI/180.
      DEC=-23.45*COS(2*PI*(DAY+10.)/365.)
      SINLD=SIN(RAD*LAT)*SIN(RAD*DEC)
      COSLD=COS(RAD*LAT)*COS(RAD*DEC)
      AOB=SINLD/COSLD
      DAYL=12.0*(1.0+2.0*ASIN(AOB)/PI)
      SININT=DAYL*(SINLD+0.4*(SINLD*SINLD+COSLD*COSLD*0.5) ) +
     $12.0*COSLD*(2.0+3.0*0.4*SINLD)*SQRT(1.0-AOB*AOB)/PI
      RETURN
      END

      SUBROUTINE FRADIF (DAY,DTR,DAYL,SINLD,COSLD,FRDFD)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C     SUBROUTINE CALCULATING THE DIFFUSE FRACTION OF DAILY VISIBLE        C
C                            RADIATION                                    C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                      INPUT PARAMETERS:                                  C
C      DAY     :  NUMBER OF CALENDAR DAY                                  C
C      DTR     :  DAILY GLOBAL RADIATION                        [J/M**2/D] C
C      DAYL    :  DAYLENGTH                                           [H] C
C      SINLD   :  AUXILIARY VARIABLE                                      C
C      COSLD   :  AUXILIARY VARIABLE                                      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                      OUTPUT PARAMETERS:                                 C
C      FRDFD   :  DIFFUSE FRACTION OF DAILY VISIBLE RADIATION             C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL(A-Z)
      PI=3.1415926
C     SOLAR CONSTANT (J/M**2/S)
      SC = 1370.
      SCACT = SC * (1. + 0.033 * COS(360.*DAY/365.))
C     AVERAGE SINE OF SOLAR ALTITUDE
      INTBET= 3600. * (DAYL * SINLD + 24./PI * COSLD *
     $        SQRT(1.- (SINLD/COSLD)**2))
C     EXTRATERRESTRIAL IRRADIATION (J/M**2/D)
      EXTEIR= INTBET * SCACT
C     ATMOSPHERIC TRANSMISSION ON DAY BASIS
      ATD   = DTR / EXTEIR
```

```
C     FRACTION DIFFUSE LIGHT ON DAY BASIS
      IF (ATD.GE.0.35)  FRDF = 1.33 - 1.46 * ATD
      IF (ATD.LT.0.35)  FRDF = 1.    - 2.3  * (ATD-0.07)**2
      FRDFD  =  LIMIT(0.23,1.,FRDF)
      RETURN
      END

       SUBROUTINE INSTIR (DAYL,HOUR,DTR,FRDFD,SINLD,COSLD,SININT,
     $                      IRR,SINB,FRDR)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C     SUBROUTINE CALCULATING THE SINE OF SUN HEIGHT AND THE INTENSITY    C
C     [J/M**2/S]    AND DIRECT FRACTION OF INSTANTANEOUS VISIBLE         C
C                         RADIATION                                      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                      INPUT PARAMETERS:                                 C
C      DAYL   :  DAYLENGTH                                          [H] C
C      HOUR   :  ACTUAL HOUR OF THE DAY                                  C
C      DTR    :  DAILY GLOBAL RADIATION                       [J/M**2/D] C
C      FRDFD  :  DIFFUSE FRACTION OF DAILY VISIBLE RADIATION             C
C      SINLD  :  AUXILIARY VARIABLE                                      C
C      COSLD  :  AUXILIARY VARIABLE                                      C
C      SININT :  AUXILIARY VARIABLE                                      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                      OUTPUT PARAMETERS:                                C
C      IRR    :   INTENSITY OF INSTANTANEOUS VISIBLE RADIATION [J/M**2/S] C
C      FRDR   :   DIRECT FRACTION OF VISIBLE RADIATION                   C
C      SINB   :   SINE OF SUN HEIGHT                                     C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL (A-Z)
      PI = 3.1415926
         SINB = AMAX1(0.,SINLD + COSLD * COS(2. *
     1             PI * (HOUR+12.)/24.))
         SFF = SINB * (1. + 0.4 * SINB)
         IRR = SFF * DTR * 0.5 / (SININT * 3600.)
         AUXFRD= (1. - FRDFD)  *   (1.08 - 0.0095 *
     $              EXP (4.6 * (HOUR-12.) / (0.5*DAYL)))
         FRDR = LIMIT(0.,1.,AUXFRD)
3000     CONTINUE
      RETURN
      END

      SUBROUTINE PHOTOC (NCL, NSP, DNSP, V, STESWI, EARSWI,
     1                   LAIFIX,SAIFIX, EAIFIX,  LAIL, ECDIF,
     1                   KL, KLSTEM, KLEAR,
     1                   AMAX,SAMAX,EAMAX, EFF, SEFF, EEFF,
     1                   IRR, FRDR, SINB, PROD)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                        SUBROUTINE CALCULATING                          C
C       I N S T A N T A N E O U S   RATES OF GROSS ASSIMILATION [KG/HA/H] C
C     OF NSP COMPETITORS FORMING A CANOPY DESCRIBED IN TERMS OF NCL      C
C     CANOPY LAYERS; OPTIONALLY, THE PHOTOSYNTHESIS OF STEMS AND EARS    C
C     CAN BE INCLUDED                                                    C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                      INPUT PARAMETERS:                                 C
C      IRR    :  INTENSITY OF VISIBLE RADIATION               [J/M**2/S] C
C      FRDR   :  DIRECT FRACTION OF VISIBLE RADIATION                    C
C      SINB   :  SINUS OF SUN HEIGHT                                     C
C                                                                        C
C      THE OTHER INPUT PARAMETERS ARE EXPLAINED IN THE HEAD PART OF      C
C                        THE SUBROUTINE    D A Y A S S                   C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                      OUTPUT PARAMETERS:                                C
C     PROD    :  INSTANTANEOUS ASSIMILATION RATES OF THE NSP SPECIES     C
C                                                             [KG/HA/H]  C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
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      IMPLICIT REAL (A-Z)
      INTEGER G,K,A,DNSP,NSP,V,NCL,C,STESWI,EARSWI
      DIMENSION LAIFIX  (NCL*NSP)
      DIMENSION SAIFIX  (NCL*NSP)
      DIMENSION EAIFIX  (NCL*NSP)
      DIMENSION LAIL    (NCL)
      DIMENSION ECDIF   (NCL)
      DIMENSION V       (NSP)
      DIMENSION KL      (DNSP)
      DIMENSION KLSTEM  (DNSP)
      DIMENSION KLEAR   (DNSP)
      DIMENSION AMAX    (DNSP)
      DIMENSION SAMAX   (DNSP)
      DIMENSION EAMAX   (DNSP)
      DIMENSION EFF     (DNSP)
      DIMENSION SEFF    (DNSP)
      DIMENSION EEFF    (DNSP)
      DIMENSION PROD    (NSP)
C     SCATTERING COEFFICIENT (ASSUMED TO BE EQUAL FOR ALL LIGHT
C     ABSORBING STRUCTURES
      SCV = 0.2
C     AN AUXILIARY VARIABLE ("SQV")
      SQV = SQRT (1. - SCV)
C     REFLECTION COEFFICIENT OF THE CANOPY
      REFLC = (1. - SQV) / (1. + SQV)
C     INTENSITIES (J/CM**2/S) OF DIRECT LIGHT ("DIR") AND OF INDIRECT
C     LIGHT ("DIF") ABOVE THE CANOPY AT THE CONSIDERED TIMEPOINT
         DIF = IRR * (1.- FRDR)  *   (1. - REFLC)
         DIR = IRR * FRDR
            DO 4 A = 1,NSP
            PROD(A) = 0.
4           CONTINUE
C     MULTIPLICATION FACTORS FOR CONVERTING THE EXTINCTION OF DIFFUSE
C     LIGHT  INTO THE EXTINCTION OF LIGHT INTENSITY WHEN THE INCOMING
C     RADIATION IS DIRECT ("CONDRF") AND INTO THE EXTINCTION OF
C     THE DIRECT COMPONENT OF INCOMING DIRECT RADIATION ("CONDIR")
C     (CONDRF = KDRF/KDIR, CONDIR = KDIR/KDIF)
         CONDIR = 0.5 / (SINB * SQV * 0.8)
         CONDRF = CONDIR * SQV
C     FRACTION OF LIGHT ENTERING THE CANOPY
         DIFOUT = 1.
C     LOOP ACCOUNTING FOR THE DIFFERENT LEAF LAYERS
            DO 2 K = 1,NCL
C     KDIF AND KDIR OF THE COMPOSITE LEAF LAYER, OBTAINED BY
C     AVERAGING THE LAI-WEIGHTED VALUES OF THE CONTRIBUTING
C     SPECIES (USED FOR CALCULATING THE SUNLIT LEAF AREA)
      IF (LAIL(K).LT.1.E-4)   THEN
         TYPE 5011,K
5011     FORMAT (' CANOPY LAYER ',I5,' WITH LAIL = 0 ')
         GOTO 2
      ENDIF
      IF (ECDIF(K).LT.1.E-4)  THEN
          TYPE 5012,K
5012      FORMAT (' CANOPY LAYER',I5,' WITH ECDIF = 0 ')
          GOTO 2
      ENDIF
            KDIF = ECDIF(K) / LAIL(K)
            KDIR = KDIF * CONDIR
C     FRACTIONS  OF DIFFUSE LIGHT ENTERING (DIFIN) AND LEAVING
C     (DIFOUT) THE CONSIDERED LEAF LAYER
            DIFIN  = DIFOUT
            DIFOUT = DIFIN * EXP(-ECDIF(K))
C     FRACTION OF DIFFUSE LIGHT ABSORBED IN THE LAYER ("ADIF"),
C     OF DIRECT LIGHT ABSORBED IN THE LAYER AS DIRECT LIGHT ("ADDIR")
C     AND OF DIRECT LIGHT ABSORBED IN THE LAYER AS DIRECT OR
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C     INDIRECT LIGHT ("ATDIR")  (1/S)
            ADIF  = DIFIN            -  DIFOUT
            EDDIR = DIFIN**CONDIR    -  DIFOUT**CONDIR
            ADDIR = EDDIR  * (1.-SCV)
            ATDIR = (DIFIN**CONDRF   -  DIFOUT**CONDRF) * (1.-REFLC)
C     FRACTION OF SUNLIT LEAF AREA IN THE LAYER
            SLLA  = EDDIR / (KDIR*LAIL(K)) * KDIF/SQV/0.8
            IF (SLLA.LT.1.E-10)  THEN
               TYPE 5020
5020           FORMAT (' SLLA = 0 ')
               GOTO 2
            ENDIF
C     ABSORPTION RATE (J/S) OF THE SUNLIT PART OF THE LEAF LAYER ("SUNA")
C     AND OF THE SHADOWED PART ("SHAA") (1/S)
            SUMDIF = DIF * ADIF  + DIR * (ATDIR-ADDIR)
            SHAA   = SUMDIF * (1. - SLLA)
            SUNA   = SLLA * SUMDIF  + DIR * ADDIR

C      ***    ASSIMILATION PERFORMED BY LEAVES    ***
               DO 3 A = 1,NSP
               L = V(A)
               C = (K-1) * NSP + A
               LEAFAR  =  LAIFIX (C)
C     ABSORPTION RATE (J/CM**2 LEAF/S) OF SUNLIT LEAVES ("ABSDIR")
C     AND OF SHADED LEAVES ("ABSDIF")
              ABSDIR = SUNA * KL(L)/(ECDIF(K)  *    SLLA)
              ABSDIF = SHAA * KL(L)/(ECDIF(K)  * (1. - SLLA))
C      THE ASSIMILATION OF SUNLIT AND SHADED LEAFAREA IS
C      ADDED TO THE OVERALL PRODUCTION OF THE SPECIES WITHIN
C      THE CONSIDERED LEAF LAYER
              IF (AMAX(L).LT.1.E-3)   THEN
                 TYPE 5014,L
5014             FORMAT (' SPECIES ',I5,' WITH AMAX = 0 ! ')
                 GOTO 3
              ENDIF
              PROD1  = AMAX(L) * (1. - EXP(-EFF(L)*ABSDIF/AMAX(L)))
              PROD2  = AMAX(L) * (1. - EXP(-EFF(L)*ABSDIR/AMAX(L)))
              PROD(A)= PROD(A) + LEAFAR *
     $                   (SLLA*PROD2 + (1. - SLLA) * PROD1)
3             CONTINUE
         IF (STESWI.EQ.0)   GOTO 80
C      ***      ASSIMILATION PERFORMED BY STEMS      ***
C      ABSORPTION RATE (J/CM**2 STEM/S) OF SUNLIT STEMAREA ("STADIR")
C      AND OF SHADED STEMAREA ("STADIF")
            STADIR =  SUNA * KLSTEM(L)/(ECDIF(K) * SLLA)
            STADIF =  SHAA * KLSTEM(L)/(ECDIF(K) * (1. - SLLA))
C      THE ASSIMILATION OF SUNLIT AND SHADED STEMAREA IS
C      ADDED TO THE OVERALL PRODUCTION OF THE SPECIES WITHIN
C      THE CONSIDERED LEAF LAYER
               DO 70 A = 1,NSP
               L = V(A)
               C = (K-1) * NSP + A
               STEMAR  =  SAIFIX (C)
              IF (SAMAX(L).LT.1.E-3)   THEN
                 TYPE 5015,L
5015             FORMAT (' SPECIES ',I5,' WITH SAMAX = 0 ! ')
                 GOTO 70
              ENDIF
               PROD1 = SAMAX(L)*(1.- EXP(-SEFF(L) * STADIF/SAMAX(L)))
               PROD2 = SAMAX(L)*(1.- EXP(-SEFF(L) * STADIR/SAMAX(L)))
               PROD(A)   =  PROD(A) + STEMAR *
     1                        (SLLA * PROD2 + (1. - SLLA) * PROD1)
70             CONTINUE
80          IF (EARSWI.EQ.0)  GOTO  2
```

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C       ***    ASSIMILATION PERFORMED BY EARS    ***
C       ABSORPTION RATE  (J/CM**2 EAR/S) OF SUNLIT EARARE ("EARDIR")
C       AND OF SHADED EARARE ("EARDIF")
             EARDIR =  SUNA * KLEAR(L) / (ECDIF(K) *       SLLA)
             EARDIF =  SHAA * KLEAR(L) / (ECDIF(K) * (1. - SLLA))
C       THE ASSIMILATION OF SUNLIT AND SHADED EARAREA IS
C       ADDED TO THE OVERALL PRODUCTION OF THE SPECIES WITHIN
C       THE CONSIDERED LEAF LAYER
                  DO 75 A = 1,NSP
                  L = V(A)
                  C = (K-1) * NSP + A
                  EARAR  =  EAIFIX  (C)
               IF (EAMAX(L).LT.1.E-3)   THEN
                  TYPE 5016,L
5016              FORMAT (' SPECIES ',I5,' WITH EAMAX = 0 ! ')
                  GOTO 75
               ENDIF
                  PROD1 = EAMAX(L)*(1.-EXP(-EEFF(L)* EARDIF/EAMAX(L)))
                  PROD2 = EAMAX(L)*(1.-EXP(-EEFF(L)* EARDIR/EAMAX(L)))
                  PROD(A)  =  PROD(A) + EARAR *
     1                        (SLLA * PROD2 + (1. - SLLA) * PROD1)
75                CONTINUE
2           CONTINUE
C       NOW THE LOOP HAS GONE THROUGH ALL LEAF LAYERS AND ALL COMPETITORS
          DO 85 A = 1,NSP
          PROD(A) = PROD(A) * 30. / 44.
85        CONTINUE
      RETURN
      END

      SUBROUTINE DAYASS (DAY,DTR,LAT,NCL,NSP,DNSP,V,STESWI,EARSWI,
     $                   LAID,SAID,EAID,LAIL,ECDIF,
     $                   KL,KLSTEM,KLEAR,
     $                   AMAX,SAMAX,EAMAX,EFF,SEFF,EEFF,
     $                   GASSP,DUM,DAYL,IRR,INST1,FRDFD,FRDR)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                     SUBROUTINE CALCULATING THE                          C
C                   D A I L Y   GROSS ASSIMILATION        [KG/HA/D]       C
C     OF NSP COMPETITORS FORMING A CANOPY DESCRIBED IN TERMS OF NCL       C
C     CANOPY LAYERS; OPTIONALLY, THE PHOTOSYNTHESIS OF STEMS AND EARS     C
C     CAN BE INCLUDED                                                     C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                         INPUT PARAMETERS:                               C
C       DAY     :  NUMBER OF CALENDAR DAY                                 C
C       DTR     :  DAILY GLOBAL RADIATION                   [J/M**2/D]    C
C       LAT     :  LATITUDE OF LOCATION                                   C
C       NCL     :  NUMBER OF DESCRIBED CANOPY LAYERS                      C
C       NSP     :  NUMBER OF SPECIES MODELLED IN THE PRESENT CASE         C
C       DNSP    :  NUMBER OF SPECIES DESCRIBED IN THE PARAMETER           C
C                  SECTION OF THE MAIN PROGRAMM                           C
C       V       :  ARRAY RELATING THE NUMBER USED TO DENOTE               C
C                  A SPECIES IN THE PARAMETER SECTION OF THE MAIN         C
C                  PROGRAM TO THE NUMBER USED IN THE ACTUAL RUN           C
C       STESWI,                                                           C
C       EARSWI  :  SWITCH PARAMETERS DETERMINING IF PHOTOSYNTHESIS OF     C
C               :  STEMS (EARS) IS TO BE INCLUDED                         C
C       LAID    :  DISTRIBUTION OF LAI (GREEN LEAVES ONLY) OVER SPECIES   C
C                  AND LAEF LAYER                              [HA/HA]    C
C       SAID    :                                                         C
C       EAID    :  AS LAIFIX, BUT FOR GREEN STEM AND GREEN                C
C                  EAR AREA                                    [HA/HA]    C
C                  (IF PHOTOSYNTHESIS OF STEMS (EARS) IS TO BE NEGLECTED, C
C                  SAIFIX (EAIFIX) MAY BE ANY DUMMY ARRAY WITH A DIMENSION C
C                  GREATER OR EQUAL "NSP*NCL" (THUS FOR EXAMPLE "LAIFIX") C
C       LAIL    :  CONTAINS FOR EACH OF THE NCL CANOPY LAYERS THE         C
C                  SUM OF AREA INDICES BELONGING TO ABSORBING SURFACES    C
C                  (LEAVES, STEMS, EARS...) POSITIONED IN IT   [HA/HA]    C
C       ECDIF   :  AS LAIL, BUT THE CONTRIBUTING AREA INDICES ARE         C
C                  MULTIPLIED BY THE CORRESPONDING EXTINCTION             C
C                  COEFFICIENTS FOR DIFFUSE LIGHT              [HA/HA]    C
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C       KL,                                                             C
C       KLSTEM,                                                         C
C       KLEAR  :  EXTINCTION COEFFICIENTS FOR DIFFUSE LIGHT OF LEAVES   C
C                 STEMS, EARS                                           C
C       AMAX,                                                           C
C       SAMAX,                                                          C
C       EAMAX  :  AMAX VALUES OF LEAVES, STEMS, EARS          [KG/HA/D] C
C       EFF,                                                            C
C       SEFF,                                                           C
C       EEFF   :  LIGHT USE EFFICIENCY OF LEAVES,STEMS,EARS             C
C                                              [KG/HA/D/(J/S/M**2)]  C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                      OUTPUT PARAMETERS:                               C
C      GASSP  :  GROSS ASSIMILATION OF THE NSP SPECIES        [KG/HA/D] C
C      DUM    :  DUMMY PARAMETER                                        C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL (A-Z)
      INTEGER G,K,A,DNSP,NSP,V,NCL,C,STESWI,EARSWI
      DIMENSION LAID  (NCL*NSP)
      DIMENSION SAID  (NCL*NSP)
      DIMENSION EAID  (NCL*NSP)
      DIMENSION LAIL    (NCL)
      DIMENSION ECDIF   (NCL)
      DIMENSION V       (NSP)
      DIMENSION KL      (DNSP)
      DIMENSION KLSTEM  (DNSP)
      DIMENSION KLEAR   (DNSP)
      DIMENSION AMAX    (DNSP)
      DIMENSION SAMAX   (DNSP)
      DIMENSION EAMAX   (DNSP)
      DIMENSION EFF     (DNSP)
      DIMENSION SEFF    (DNSP)
      DIMENSION EEFF    (DNSP)
      DIMENSION GASSP   (NSP)
      DIMENSION INSTAS  (27)
      DIMENSION WEIGHT  (3)
      DIMENSION DIR     (3)
      DIMENSION INTENS  (3)
      DIMENSION SNUS   (3)
C     CALCULATE DAYLENGTH AND 3 AUXILIARY VARIABLES WHICH
C     ARE NEEDED FOR DESCRIBING INSTANTANEOUS IRRADIATION
      CALL ASTRO (DAY,LAT,DTR,
     1           DAYL,SININT,SINLD,COSLD)
C     CALCULATE THE DIFFUSE FRACTION OF DAILY IRRADIATION
      CALL FRADIF(DAY,DTR,DAYL,SINLD,COSLD,
     1           FRDFD)
C     WEIGHTING FACTORS USED IN THE 3-POINT GAUSS INTEGRATION
      WEIGHT(1) = 1.
      WEIGHT(2) = 1.6
      WEIGHT(3) = 1.
      XGAUS = SQRT (0.15)
         DO 445 A = 1,NSP
         GASSP(A) = 0.
445      CONTINUE
         DO 6000 G=1,3
C     SELECT TIMEPOINT DURING THE DAY
         HOUR = 12. + DAYL * 0.5 * (0.5 + (G-2.) * XGAUS)
C     DESCRIBE INSTANTANEOUS IRRADIATION (INTENSITY, DIRECT
C     FRACTION AND SINUS OF SUN HEIGHT)
         CALL INSTIR (DAYL,HOUR,DTR,FRDFD,SINLD,COSLD,SININT,
     1               IRR,SINB,FRDR)
         DIR(G)    = FRDR
         INTENS(G) = IRR
         SNUS (G)  = SINB
```

```
C     CALCULATE INSTANTANEOUS ASSIMILATION RATES OF THE NSP COMPETITORS
C     (KG CHO / HA / HA)
         CALL PHOTOC (NCL,NSP,DNSP,V,STESWI,EARSWI,LAID,SAID,EAID,
     1         LAIL,ECDIF,KL,KLSTEM,KLEAR,AMAX,SAMAX,EAMAX,EFF,SEFF,
     1         EEFF,IRR,FRDR,SINB,
     1               INSTAS)
         INST1 = INSTAS(1)
C      WEIGHTED SUMMATION OF INSTANTANEOUS ASSIMILATION RATES
            DO 5 A = 1,NSP
            GASSP(A) = GASSP(A) + INSTAS(A) * WEIGHT(G)
5           CONTINUE
6000     CONTINUE
      WRITE (20,2620) FRDFD,DIR(1),DIR(2),DIR(3),INTENS(1),
     1                INTENS(2),INTENS(3),SNUS(1),SNUS(2),SNUS(3)
2620  FORMAT (10(F11.5))
C      FINISHING THE INTEGRATION PROCEDURE
         DO 6 A=1,NSP
         GASSP(A) = GASSP(A) / 3.6 * DAYL
6        CONTINUE
      RETURN
      END

      SUBROUTINE EVAL1 (DIM,ARR,PROB,EXVA,VAR,CV)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C   SUBROUTINE  CALCULATING EXPECTION VALUE, VARIACE AND THE COEFFICIENT  C
C                    OF VARIATION OF A CHANCE VARIABLE                    C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                          INPUT PARAMETERS:                               C
C     DIM      :  NUMBER OF VALUES OF THE CHANCE VARIABLE                  C
C     ARR      :  VALUES OF THE CHANCE VARIABLE                            C
C     PROB     :  PROBABILITIES ASSOCIATED WITH THE VALUES                 C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                          OUTPUT PARAMETERS:                              C
C     EXVA     :  EXPECTATION VALUE                                        C
C     VAR      :  VARIANCE                                                 C
C     CV       :  COEFFICIENT OF VARIATION                                 C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL (A-Z)
      INTEGER DIM,J
      DIMENSION ARR (DIM)
      DIMENSION PROB(DIM)
      IF (DIM.EQ.1 )  THEN
         EXVA = ARR(1)
         VAR  = 0.
      ELSE
         SUMX = 0.
         SUMXX = 0.
            DO 851 J = 1,DIM
            SUMX  = SUMX   +  ARR(J)      * PROB(J)
            SUMXX = SUMXX  +  ARR(J)**2   * PROB(J)
851         CONTINUE
         EXVA = SUMX
         VAR  = SUMXX - SUMX**2
      ENDIF
      IF (EXVA.LT.1.E-8)  GOTO 9013
      IF (VAR. LT.1.E-8)   THEN
         CV = 0.
      ELSE
         CV = SQRT(VAR) / EXVA
      ENDIF
9013  CONTINUE
      RETURN
      END
```

```
      SUBROUTINE LNDCAL (NSP,OGBMPP,PROB,LNDVBM,DUM)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C            SUBROUTINE  CALCULATING  DELTA - LN - VALUES                  C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                         INPUT PARAMETERS:                                C
C     NSP     :  NUMBER OF GENOTYPES                                       C
C     OBBMPP  :  ABOVE GROUND BIOMASS PER PLANT                        [G] C
C     PROB    :  FREQUENCIES OF THE GENOTYPES                              C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                         OUTPUT PARAMETERS:                               C
C     LNDBVBM :  DELTA - LN - VALUES                                       C
C     DUM     :  DUMMY VARIABLE                                            C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL (A-Z)
      INTEGER NSP,A
      DIMENSION OGBMPP(NSP)
      DIMENSION PROB  (NSP)
      DIMENSION LNDVBM(NSP)
      IF (NSP.EQ.1) GOTO 7020
      SUMLN = 0.
         DO 851 A = 1,NSP
         IF   (OGBMPP(A).LT.1.E-3)   GOTO 851
         SUMLN = SUMLN + ALOG(OGBMPP(A)) * PROB(A)
851      CONTINUE
      AVLN = SUMLN
         DO 852 A = 1,NSP
         LNDVBM(A) = ALOG(AMAX1(6.73795E-3, OGBMPP(A))) - AVLN
852      CONTINUE
7020  CONTINUE
      RETURN
      END
ENDJOB
```

Appendix B: List of abbreviations

Name	Component layout	Definition	Dimension
	(S)	single value	
	(GA)	array; the i-th component refers to the genotype with the actual reference i	
	(GL)	array; the i-th component refers to the genotype with the library reference i	
	(C)	array; the i-th component refers to the i-th canopy layer (counted from the top)	
	(CG)	array; component 1,....,NSP refer to canopy layer 1 and the genotype with the actual reference 1,....,NSP; component NSP+1,....,2*NSP refer to canopy layer 2 and the genotype with the actual reference 1,....,NSP; and so on	
	(G6)	array; component 1,....,6 refer to the genotype with the library reference 1; component 7,....12 refer to the genotype with the library reference 2; and so on	
	(F)	function table	
A	(S)	actual reference of a genotype (can be 1,...,NSP)	
AGE	(GA)	number of days since emergence	
AMAX	(GL)	photosynthetic rate of leaves at light saturation	kg CO2/ha/h
APPEAR	(GL)	calendar day on which the population of the considered genotype is initialized	
ARRIVE	(GA)	switch variable assuming the value 1 on days preceding a day of population initialization and the value 0 on other days	
AV	(S)	average aboveground biomass per plant	g/plant
BMRCLV	(S)	relative rate of maintenance respiration of leaves at reference temperature	kg/kg/d
BMRCGR	(S)	relative rate of maintenance respiration of grains at reference temperature	kg/kg/d
BMRCRT	(S)	relative rate of maintenance respiration of roots at reference temperature	kg/kg/d
BMRCST	(S)	relative rate of maintenance respiration of stems at reference temperature	kg/kg/d
CLPERL	(S)	number of canopy layers which are defined per unit of the summed leaf area indices of all populations	
CULTP	(GL)	parameter characterizing the dependence of DVRV on temperature	
CV	(S)	coefficient of variation of aboveground biomass per plant	
DAY	(S)	calendar day	
DFAC	(S)	"plant density factor" with which the parameter values for the initial weights of leaves, stems and roots are multiplied at the initialization of the populations	
DISPA1	(G6)	array containing auxiliary variables used for distributing the leaf area over the canopy layers	
DISPA2	(G6)	array containing auxiliary variables used for distributing the stem area over the canopy layers component layout as for array DISPA1	
DISPA3	(G6)	array containing auxiliary variables used for distributing the ear area over the canopy layers	
DNSP	(S)	number of genotypes described in the parameter library	
DRLVS	(GA)	relative dying rate of leaves	kg/ha/d
DRLVTB	(F)	relative dying rate of leaves as function of the developmental state, dependent on the library reference of the genotype	kg/kg/d
DRRT	(S)	dying rate of roots	kg/ha/d
DRRTTB	(F)	relative dying rate of roots as function of the developmental state	kg/kg/d
DRST	(GA)	dying rate of stems	kg/ha/d

DRSTTB	(F)	relative dying rate of stems as function of the developmental state	kg/kg/d
DTR	(S)	daily global radiation	J/m**2/d
DTRT	(F)	DTR as function of the calendar day	
DVRR	(GA)	rate of post-anthesis development	1/d
DVRV	(GA)	rate of pre-anthesis development	1/d
DVS	(GA)	developmental state (0 at emergence, 1 at dead ripeness)	
DVSR	(GA)	state of post-anthesis development (0 at anthesis, 1 at dead ripeness)	
DVSV	(GA)	state of pre-anthesis development (0 at emergence, 1 at dead ripeness)	
EAI	(GA)	index of total ear area	ha/ha
EAID	(CG)	index of the green ear area belonging to a considered genotype and positioned in a considered canopy layer	ha/ha
EAMAX	(GL)	photosynthetic rate of ears at light saturation	kg CO2/ha/h
EARATA	(GA)	ear area index at anthesis	ha/ha
EARGRT	(F)	ratio between the present ear area and the ear area at anthesis as function of the developmental state	
EARSUR	(GL)	ratio of the ear area and the aboveground biomass at anthesis	cm**2/g
EAVT	(S)	average air temperature during the daylight part of the day	C
ECDIF	(C)	"extinction capacity" of a canopy layer, defined as the sum of the products of area index and extinction coefficient of all contained surfaces	
EEFF	(GL)	initial light use efficiency of ears	kg CO2/ha/h/(J/m**2/s)
EFF	(GL)	initial light use efficiency of leaves	kg CO2/ha/h/(J/m**2/s)
EMERG	(GL)	calendar day on which the considered genotype emerges	
EFCGR	(S)	efficiency of biosynthesis of grain tissue from carbohydrates	kg/kg
EFCLVS	(S)	efficiency of biosynthesis of leaf tissue from carbohydrates	kg/kg
EFCRT	(S)	efficiency of biosynthesis of root tissue from carbohydrates	kg/kg
EFCST	(S)	efficiency of biosynthesis of stem tissue from carbohydrates	kg/kg
EXIST	(GA)	switch variable assuming the value 0 before the initialization of the population and the value 1 from that timepoint on	
FCHN	(GA)	daily net assimilation	kg/ha/d
FGR	(S)	fraction of net production allocated to the grains, divided by the fraction allocated to the shoot	
FLVS	(S)	fraction of net production allocated to the leaves, divided by the fraction allocated to the shoot	
FLVST	(F)	FLVS as function of the developmental state, dependent on the library reference of the genotype	
FSH	(S)	fraction of net production allocated to the shoot	
FSHT	(F)	FSH as function of the developmental state, dependent on the library reference of the genotype	
FST	(S)	fraction of net production allocated to the stems, divided by the fraction allocated to the shoot	
FSTT	(F)	FST as function of the developmental state, dependent on the library reference of the genotype	
GASSP	(GA)	daily gross assimilation	kg/ha/d
GFET	(F)	green fraction of the ear area as function of the number of days since emergence, dependent on the library reference of the genotype	
GRGR	(GA)	growth rate of grains	kg/ha/d
GRLVS	(GA)	net growth rate of living leaf tissue	kg/ha/d
GROWTH	(S)	switch variable assuming the value 0 before any population is initialized and the value 1 from the first initialization on	
GSHOOT	(S)	rate of assimilate allocation to the shoot	kg/ha/d
HEI	(GA)	plant height	cm
HEITB	(F)	HEI as function of the number of days since emergence, dependent on the library reference of the genotype	cm
IDVSV	(GL)	initial value of DVSV	
IWLVS	(GL)	initial dry weight of leaves, divided by the frequency of the genotype and the "density factor" DFAC	kg/ha

IWRT	(GL)	initial dry weight of roots, divided by the frequency of the genotype and the "density factor" DFAC	kg/ha
IWST	(GL)	initial dry weight of stems, divided by the frequency of the genotype and the "density factor" DFAC	kg/ha
KL	(GL)	extinction coefficient of leaves	
KLEAR	(GL)	extinction coefficient of ears	
KLREDT	(F)	reduction factor for the extinction coefficient of leaves, accounting for leaf clustering of young plants; values as function of the developmental state	
KLSTEM	(GL)	extinction coefficient of stems	
L	(S)	library reference of a genotype (can be 1,...,DNSP)	
LA,LC, LZ	(S)	parameters for characterizing the vertical area density function of leaf area	
LAI	(GA)	index of total leaf area	ha/ha
LAID	(CG)	index of the green leaf area belonging to a given genotype and positioned in a given canopy layer	ha/ha
LAIL	(C)	"total area index of a canopy layer": sum of the area indices of all surfaces contained in the considered canopy layer	ha/ha
LAT	(S)	latitude of location	
LC	(S)	see LA	
LNDVBM	(GA)	defined as: LN(OGBMPP) - E (LN(OGBMPP)) (with E denoting the expectation value referring to the genotypes present in the mixed population)	
LNLAT	(F)	ln (leaf area) as function of the number of days since emergence, dependent on the library reference of the genotype	
LVRRT	(F)	reduction factor for the maintenance repiration of leaves accounting for the effect of senescence; values as function of the developmental state	
LZ	(S)	see LA	
MAXCL	(S)	maximal number of canopy layers	
MAXHEI	(S)	height of the canopy	cm
MNTT	(F)	daily temperature minimum as function of the calendar day	C
MXTT	(F)	daily temperature maximum as function of the calendar day	C
MINCL	(S)	minimal number of canopy layers	
NCL	(S)	number of canopy layers	
NSP	(S)	number of genotypes competing in the actual simulation	
OGBM	(GA)	aboveground biomass	kg/ha
OGBMPP	(GA)	aboveground biomass	g/plant
PAMAX	(GL)	potential photosynthetic rate of leaves at light saturation (possible reduction dependent on developmental state and temperature)	kg CO2/ha/h
PKL	(GL)	potential extinction coefficient of leaves	
PLOP	(GA)	switch variable assuming the value 1 on the day before the considered population is initialized; on other days the value is 0	
PSM	(S)	total number of plants per m**2	m** -2
RMNT	(S)	rate of maintenance respiration	kg/ha/d
SA,SC,SZ	(S)	parameters for characterizing the vertical area density function of stem area	
SAI	(GA)	index of total stem area	ha/ha
SAID	(CG)	index of the green stem area belonging to a considered genotype and positioned in a considered canopy layer	ha/ha
SC	(S)	see SA	
SAMAX	(GL)	photosynthetic rate of stems at light saturation	kg CO2/ha/h
SEFF	(GL)	initial light use efficiency of stems	kg CO2/ha/h/(J/m**2/s)
SLA	(S)	specific leaf area	m**2/kg
SLATB	(F)	SLA as function of the developmental state, dependent on the library reference of the genotype	m**2/kg
SRAMAX	(S)	reduction factor of AMAX accounting for the effect of senescence	
SRAMAT	(F)	SRAMAX as function of the developmental state	
SSTA	(S)	specific stem area	m**2/kg
START	(S)	calendar day on which the simulation starts	
STOP	(S)	calendar day on which the simulation finishes	

SWI...	(S)	switch parameter whose function is explained in the program listing (initial section)	
SZ	(S)	see SA	
TEMR	(S)	factor accounting for the effect of temperature on the rate of maintenance respiration	
THK	(S)	thickness of the canopy layers	cm
TRAMAX	(S)	reduction factor of AMAX accounting for the effect of temperature	
TRAMAT	(F)	TRAMAX as function of the average temperature during daylight period (C)	
ULCL	(C)	upper limit of a canopy layer	cm
V	(GA)	array linking the actual references of the genotypes (A) to their library references (L)	
VAR	(S)	variance of aboveground biomass per plant (referring to the genotyps present in the mixed population	(g/plant)**2
VEEL	(S)	thickness of the ear layer belonging to a single genotype	cm
WDLVS	(GA)	dry weight of dead leaves	kg/ha
WDST	(GA)	dry weight of dead stems	kg/ha
WGR	(GA)	dry weight of grains	kg/ha
WLVS	(GA)	dry weight of living leaves	kg/ha
WRT	(GA)	dry weight of living roots	kg/ha
WST	(GA)	dry weight of living stems	kg/ha
X...	(S)	auxiliary variable	
YFEAR	(GA)	yellow fraction of ear area	
YFLVS	(GA)	yellow fraction of leaf area	
YFST	(GA)	yellow fraction of stem area	

Appendix A: Listing of the model

```
TITLE          COMPETITION BETWEEN WHEAT GENOTYPES
/      DIMENSION EARATA(27)
/      DIMENSION EAI(27)
/      DIMENSION FCHN(27)
/      DIMENSION HEI(27)
/      DIMENSION OGBM(27)
STORAGE SAI(27),YFST(27),KLSTEM(27), KLEAR(27)
STORAGE AGE(27),LAI(27),GASSP(27),STORE(144)
STORAGE V(27), EARSUR(27), LAID(144),SAID(144),EAID(144)
STORAGE ULCL(25), KL(27),PKL(27),EFF(27),EEFF(27),SEFF(27)
STORAGE YFLVS(27),LAIL(25),ECDIF(25)
STORAGE COR(27),DISPA1(200),DISPA2(200),DISPA3(200)
STORAGE CULTP(27),  DVS(27), EAMAX(27),AMAX(27), PAMAX(27),SAMAX(27)
STORAGE OGBMPP(27), YFEAR(27)
STORAGE IWLVS(27), IWST(27), IWRT(27), IARLF(27), IDVSV(27)
STORAGE EMERG(27), EXIST(27), APPEAR(27), PLOP(27)
STORAGE LNDVBM(27),XEAI(20)
FIXED DNSP, V, NSP, NCL, I, L,  K, A, G
FIXED STPSWI,EAPSWI,C,COMIND,AUXINT

****************************************************************
***                  INITIALIZATION                          ***
****************************************************************
INITIAL
NOSORT

***              BASIC SPECIFICATIONS

*   NUMBER  OF GENOTYPES DESCRIBED IN THE PARAMETER SET
PARAM  DNSP = 12

*   NUMBER OF COMPETING GENOTYPES SIMULATED IN THE PRESENT CASE
PARAM  NSP = 12

*** LATITUDE OF LOCATION ***
PARAM  LAT = 52.

***   SWITCH PARAMETERS FOR CHOOSING FROM  ALTERNATIVE ALGORITHMS

*       THE LEAF AREA INDEX CAN BE INTRODUCED AS A FORCING FUNCTION BY
*       ASSIGNING TO THE SWITCH PARAMETER "LAISWI" THE VALUE 1
*       INSTEAD OF 0
PARAM LAISWI = 0.

*       SWITCH PARAMETER FOR DECIDING WHETHER THE ABBSORPTION
*       OF STEMS IS ACCOUNTED FOR WHEN MODELLING THE EXTINCTION
*       OF LIGHT WITHIN THE CANOPY
PARAM STASWI = 1.

*       SWITCH PARAMETER FOR DECIDING WHETHER THE PHOTOSYNTHESIS
*       OF STEMS  IS ACCOUNTED FOR WHEN CALCULATING THE DAILY
*       ASSIMILATIION (NOTE THAT IN THIS CASE ALSO THE ABSORPTION OF STEMS
*       MUST BE ACCOUNTED FOR, THAT IS "STASWI = 1")
PARAM STPSWI = 1

*       SWITCH PARAMETER FOR DECIDING WHETHER THE ABBSORPTION
*       OF EARS IS ACCOUNTED FOR WHEN CALCULATING THE EXTINCTION
*       OF LIGHT WITHIN THE CANOPY
PARAM EAASWI = 1.

*       SWITCH PARAMETER FOR DECIDING WHETHER THE PHOTOSYNTHESIS
*       OF EARS IS ACCOUNTED FOR WHEN CULCULATING THE DAILY
*       ASSIMILATIION (NOTE THAT IN THIS CASE ALSO THE ABSORPTION OF EARS
*       MUST BE CONSIDERED, THAT IS EAASWI = 1).
PARAM EAPSWI = 1
```

```
*** S I M U L A T I O N   P R O J E C T   S P E C I F I C   I N P U T

***    INITIAL  STATE  OF  THE  POPULATIONS

TITLE        SIMULATION PROJECT:  REAMIX 15 X 15
LABEL        SIMULATION PROJECT:  REAMIX 15 X 15

*     WEIGHTS OF LEAVES, STEMS, ROOTS;
*     (KG/HA / (FREQUENCY OF THE GENOTYPE) / "DENSITY FACTOR")
*     (EXPLANATION OF "DENSITY FACTOR" : SEE BELOW)
TABLE IWLVS (1-12) = 1.273,  1.460,  1.666,  1.079,  1.323,  1.623,...
                     1.226,  1.196,  1.365,  1.296,  1.359,  1.219
TABLE IWST (1-12)  = 0.569,  0.596,  0.703,  0.493,  0.594,  0.783,...
                     0.597,  0.487,  0.570,  0.499,  0.619,  0.483
TABLE IWRT (1-12)  = 1.228,  1.371,  1.579,  1.048,  1.278,  1.604,...
                     1.215,  1.122,  1.290,  1.196,  1.319,  1.135

*     LEAF AREA
*     (M**2/HA / (FREQUENCY OF THE GENOTYPE) / "DENSITY FACTOR")
TABLE IARLF (1-12) = 25.533, 28.759, 33.867, 28.567, 27.978, 34.030,...
                     26.267, 24.452, 27.619, 28.989, 26.174, 26.037

*     "DENSITY FACTOR" WITH WHICH THE PARAMETER VALUES FOR INITIAL
*     WEIGHTS AND THE INITIAL LEAF AREA ARE MULTIPLIED AT THE
*     INITIALIZATION OF THE POPULATION
*     (INTRODUCTION OF THIS PARAMETER SPARES THE NECESSITY OF
*     REWRITING THE ARRAYS WITH INITIAL WEIGHTS AND LEAF AREAS
*     WHEN DIFFERENT PLANT DENSITIES ARE ASSUMED)
PARAM DFAC = 108.

*     DEVELOPMENTAL STATE
TABLE IDVSV (1-12) = 0.21345,  0.22085,  0.22485,  0.21010, ...
                     0.21717,  0.20662,  0.21345,  0.20339, ...
                     0.20339,  0.20026,  0.20026,  0.20662

*     TIME COURSE OF LN (LEAF AREA(M**2/HA))
*     (FOR THE INTRODUCTION OF THE LEAF AREA AS FORCING FUNCTION)
FUNCTION LNLAT,1. = 0.,6.60719,  22.,8.06840,  29.,9.0655, ...
                    36.,9.67608,  41.,9.75777,  49.,10.1414
FUNCTION LNLAT,12.= 0.,6.60719,  22.,8.06840,  29.,9.0655, ...
                    36.,9.67608,  41.,9.75777,  49.,10.1414
FUNCTION YFRLVT,1.  = 0.,0.,  49.,0.
FUNCTION YFRLVT,12. = 0.,0.,  49.,0.

*     PLANTS/M2
PARAM PSM = 400.

***    TIME SPECIFICATIONS

*   DAY OF EMERGENCE
TABLE EMERG  (1-12) = 12 * 107.

*   FIRST DAY OF SIMULATED GROWTH (NOT NECESSARILY THE DAY OF
*   EMERGENCE)
TABLE APPEAR (1-12) = 12 * 129.

*   FIRST DAY OF SIMULATION (HAS TO BE AT LEAST
*   1 DAY BEFORE GROWTH SIMULATION STARTS)
PARAM START = 106.

*   LAST DAY OF SIMULATION
PARAM STOP  = 231.
FINISH  TIME = STOP
```

```
***************************************************************************
***     PARAMETRIC CHARACTERIZATION OF THE VERTICAL DISTRIBUTION OF     ***
***                  LEAVES,  STEMS    AND    EARS                      ***
***************************************************************************

*   3 PARAMETERS USE FOR CHARACTERIZING THE VERTICAL DISTRIBUTION
*   OF THE LEAF AREA
*   (THE UNNORMALIZED LEAF AREA DENSITY FUNCTION (M**2/M**3)
*   IS ASSUMED TO HAVE THE FORM:
*    Y = A -  A * H**Z + C
*   WITH A,C AND Z PARAMETERS AND H:= HEIGHT ABOVE GROUND/PLANT HEIGHT)
PARAM LA = 1., LC = 0., LZ = 50.

      DISPA1,DUM = VPRE1 (DNSP,LA,LC,LZ)

*   3 PARAMETERS USE FOR CHARACTERIZING THE VERTIACL DISTRIBUTION
*   OF THE STEM AREA
*   (THE UNNORMALIZED STEM AREA DENSITY FUNCTION (M**2/M**3)
*   IS ASSUMED TO HAVE THE FORM:
*    Y = A -  A * H**Z + C
*   WITH A,C AND Z PARAMETERS AND H:= HEIGHT ABOVE GROUND/PLANT HEIGHT)
PARAM SA = 1., SC = 0., SZ = 50.

      DISPA2,DUM = VPRE1 (DNSP,SA,SC,SZ)

*    1 PARAMETER USED FOR CHARACTERIZING THE VERTICAL DISTRIBUTION OF EARS
*    (IT IS ASSUMED THAT THE EARS OF A GIVEN GENOTYPE ARE DISTRIBUTED
*    IN A HOMONEGEOUS LAYER THAT EXTENDS FROM THE PLANT TOP
*    TO A DISTANCE BELOW (CM) GIVEN BY THE PARAMETER "VEEL")
PARAM VEEL = 20.

      DISPA3,DUM = VPRE2 (DNSP,VEEL)

***          THE WHO-IS-WHO  OF COMPETITING GENOTYPES

*   THE GENOTYPES SIMULATED IN THE PRESENT CASE ARE
*   NUMBERED FROM 1 TO NSP; THE ARRAY  V  LINKS THIS ACTUAL
*   REFERENCES ("A") TO THE NUMBERS USED IN THE PARAMETER
*   LIBRARY (LIBRARY REFERENCE - "L")

*   EXAMPLE:
*        "TABLE V (1-12) = 2, 5, 8, 9 * 11"
*   PRODUCES - DEPENDENT ON THE PARAMETER "NSP" -
*   THE FOLLOWING MIXTURE COMPOSITIONS:
*        "NSP=1" ="  MONOCULTURE OF VARIETY 2
*        "NSP=2" ="  BINARY MIXTURE WITH THE VARIETIES 2 AND 5
*        "NSP=3" ="  MIXTURE WITH THE VARIETIES 2, 5, 8
*   AND SO ON
TABLE V(1-12)    = 12 * 1

*   GENOTYPE FREQUENCIES
*   (SUM OVER THE NSP GENOTYPES PRESENTLY SIMULATED MUST BE 1  !)
TABLE COR (1-12) = 12 * 8.333333333E-2

***                 SOME TECHNICAL PREPARATIONS

*   FOR USE OF THE RERUN-FACILITIES SOME VARIABLES
*   HAVE TO BE SET ZERO

         DO 737 A = 1,NSP
         GASSP(A) = 0.
         FCHN(A)  = 0.
         LAI(A)   = 0.
         YFLVS(A) = 0.
         SAI(A)   = 0.
         YFST(A)  = 0.
```

```
         DVS(A)    = 0.
         DVRV(A)   = 0.
         DVRR(A)   = 0.
         EARATA(A)= 0.
         OGBM(A)   = 0.
         OGBMPP(A)= 0.
         LNDVBM(A)= 0.
         GRLVS(A)  = 0.
         DRLVS(A)  = 0.
         GRST  (A) = 0.
         DRST  (A) = 0.
         GRRT  (A) = 0.
         GRGR  (A) = 0.
737      CONTINUE

      AUXINT = MAXCL * NSP
         DO 738  A = 1, AUXINT
         LAID(A) = 0.
         SAID(A) = 0.
         EAID(A) = 0.
738      CONTINUE

***********************************************************************
***                     SYSTEM  DYNAMICS                            ***
***********************************************************************
DYNAMIC
NOSORT
***       CHECKING THE NECESSITY TO MODEL GROWTH PROCESSES
***                  ON THE PRESENT DAY

      DAY = TIME

*    ARE PLANTS PRESENT OR EXPECTED TO APPEAR ON THE FOLLOWING DAY?
*    (TO KNOW THIS MAY SAVE THE COMPUTER LOTS OF CALCULATIONS)
         DO 719 A = 1,NSP
         L = V(A)
         PLOP(A) = INSW(APPEAR(L) - 0.9 - TIME, 0.,1.) * ...
                   INSW(TIME - APPEAR(L) + 1.1, 0.,1.)
         EXIST(A)= INSW (DAY-APPEAR(L) + 1.E-8, 0., 1.)
719      CONTINUE
      XEXIST   = 0.
      XPLOP    = 0.
         DO 865 A = 1,NSP
         XEXIST    = XEXIST + EXIST(A)
         XPLOP     = XPLOP  + PLOP (A)
865      CONTINUE
      GROWTH = INSW(XEXIST-.1, 0., 1.)
      ARRIVE = INSW(XPLOP -.1, 0., 1.)
      IF ((GROWTH + ARRIVE).LE.0.)  GOTO 7020

***********************************************************************
*                      WEATHER     DATA                               *
***********************************************************************

*   DAILY GLOBAL RADIATION (J / M**2 / D)
      DTR = AFGEN (DTRT, DAY) * 1.E4

*   AVERAGE AIR TEMPERATURE (DEGREES C)
       TMPA = (AFGEN (MXTT,DAY) + AFGEN (MNTT, DAY) ) * 0.5

*   AVERAGE AIR TEMPERATURE DURING DAYLIGHT PERIOD
       EAVT = AFGEN (MXTT, DAY) - 0.25 * (AFGEN (MXTT, DAY) - ...
              AFGEN (MNTT, DAY))
```

```
***********************************************************************
*                          DEVELOPMENT                               *
***********************************************************************

*   PRE- AND POST-ANTHESIS DEVELOPMENTAL RATES
*   (EQUATIONS ACCORDING TO VAN KEULEN(85));
*   TIME SINCE EMERGENCE
         DO 8100 A = 1, NSP
         L = V(A)
         XD1      = CULTP(L) * AMAX1 (0., 0.00094 * TMPA -0.00046)...
                    *  INSW (DVSV(A) -1., 1., 0.)
         DVRV(A) = XD1 * EXIST(A) + PLOP(A) * IDVSV(L)
         XD2      = AMAX1(0., 0.000913 * TMPA + 0.003572 )
         DVRR(A) = XD2 * INSW (DVSV(A)-1.,0.,1.) * EXIST(A)
         AGE(A)   = AMAX1(0.,DAY - EMERG(L))
8100     CONTINUE
      DVSV = INTGRL (0,  DVRV, 12)
      DVSR = INTGRL (0., DVRR, 12)
         DO 9000 A = 1, NSP
         DVS (A) = AMIN1 (1., 0.5 * (DVSV(A) + DVSR(A)))
9000     CONTINUE
      IF (GROWTH.LE.0.5)  GOTO 20000

************************************************************************
*        VERTICAL DISTRIBUTION OF LIGHT ABSORBING SURFACES             *
************************************************************************

***   =====================   ***
***   A R E A  I N D I C E S   ***
***   =====================   ***

***   L E A F   A R E A  ***

*       DECISION WHETHER LEAF AREA DEVELOPMENT IS MODELLED
*       DYNAMICALLY OR INTRODUCED AS A FORCING FUNCTION
      IF (LAISWI.GT.0.5) GOTO 1011

*     LEAF AREA DEVELOPMENT IS MODELLED DYNAMICALLY AND NOT INTRODUCED
*     AS A FORCING FUNCTION
         DO 1002 A = 1,NSP
         IF (EXIST(A).LT.0.5)     GOTO 1002
         LR = V(A)
         SLA = TWOVAR(SLATB,DVS(A),LR) * 1.E-4
         LAI(A)   = (WLVS(A) + WDLVS(A)) * SLA
         IF (LAI(A).LT.1.E-6)   THEN
            TYPE 4999,A
4999        FORMAT (' SPECIES ',I5,' WITH LAI = 0 ')
            GOTO 1002
         ENDIF
         YFLVS(A)= WDLVS(A) / (WDLVS(A) + WLVS(A))
1002     CONTINUE
      GOTO 1012
1011  CONTINUE

*     DEVELOPMENT OF LEAF AREA IS INTRODUCED AS A FORCING FUNCTION
         DO 1005 A = 1,NSP
         IF (EXIST(A).LT.0.5)   GOTO 1005
         L = V(A)
         LR = V(A)
         XLNLA = TWOVAR (LNLAT,AGE(A),LR)
         LAI(A)     = EXP(XLNLA) * 1.E-4
         YFLVS(A)   = TWOVAR (YFRLVT, AGE(A), LR)
1005     CONTINUE
1012     CONTINUE
```

```
***   S T E M   A R E A   ***

         DO 950 A = 1,NSP
         IF (EXIST(A).LT.0.5)       GOTO 950
         SAI(A)   = (WST(A)  + WDST(A))  * SSTA * 1.E-4
         IF (SAI(A).LT.1.E-6)   THEN
            TYPE 5001,A
5001        FORMAT (' SPECIES ',I5,' WITH SAI = 0 ')
            GOTO 950
         ENDIF
         YFST(A)  =  WDST(A) / (WDST(A)  + WST(A))
950      CONTINUE

***   E A R   A R E A   ***

*   EAR AREA INDEX (DETERMINED BY THE ABOVEGROUND BIOMASS AT ANTHESIS)
       DO 148 A = 1, NSP
          L = V(A)
          LR= V(A)
          IF (EXIST(A).LT.0.5)       GOTO 148
          IF (EARATA(A).GT.1.E-6)    GOTO 149
          IF (DVS(A).LT.0.5)         GOTO 148
          EARATA(A) = EARSUR(L) * OGBM(A) * 1.E-5
149       CONTINUE
          EAI(A) = EARATA(A) * AFGEN(EARGRT,DVS(A))
          YFEAR(A)  =  1. - TWOVAR(GFET,AGE(A),LR)
148       CONTINUE

***    ======================================================    ***
***    B O U N D A R Y   H E I G H T S   S E P A R A T I N G     ***
***                T H E   C A N O P Y   L A Y E R S             ***
***    ======================================================    ***

***   NUMBER OF DISTINGUISHED CANOPY LAYERS

PARAM CLPERL = 12., MINCL  = 12., MAXCL  = 12.

      XLAIT = 0.
         DO  8000 A = 1, NSP
         XLAIT = XLAIT + LAI(A)
8000     CONTINUE
       XNCL   = LIMIT (MINCL,MAXCL,XLAIT * CLPERL)
       NCL       = XNCL

***   BOUNDARIES OF CANOPY LAYERS

*   HEIGHT DEVELOPMENT IS INTRODUCED AS A FORCING FUNCTION ("HEITB")
      MAXHEI = 0.
         DO 7000 A = 1, NSP
         LR = V(A)
         HEI (A) = TWOVAR (HEITB,AGE(A), LR)
         IF (HEI(A).GT.MAXHEI)  MAXHEI = HEI (A)
7000     CONTINUE
      IF (MAXHEI.LT.1.E-3)   THEN
         TYPE 4997,MAXHEI
4997     FORMAT (' MAXHEI = ',F10.4 )
         MAXHEI = 1.E-3
      ENDIF

*   UPPER LIMITS ("ULCL") OF THE NCL CANOPY LAYERS (CM ABOVE THE GROUND);
*   THE CHOSEN LAYERS HAVE IDENTICAL THICKNESS

      CALL STRATA (MAXHEI,NCL,ULCL)
```

```
***        ===================================           ***
***        D I S T R B I T I O N   O F   T H E           ***
***        A R E A   I N D I C E S   O V E R             ***
***        T H E   C A N O P Y   L A Y E R S             ***
***        ===================================           ***

*     THE POTENTIAL EXTINCTION COEFFICIENT OF LEAVES IS CORRECTED
*     TO ACCOUNT FOR THE STRONG CLUSTERING OF LEAVES THAT YOUNG
*     PLANT EXHIBIT
          DO 530 A = 1,NSP
          L = V(A)
          KL(L)  = PKL(L) * AFGEN(KLREDT,DVS(A))
530       CONTINUE
          DO 981 K = 1,NCL
          LAIL(K)  = 0.
          ECDIF(K)= 0.
981       CONTINUE

***    DISTRIBUTION OF LEAF AREA

*      DISTRIBUTION OF THE TOTAL LEAF AREA
       CALL VERDI2 (NSP,DNSP,V,EXIST,...
                    NCL,HEI,ULCL,...
                    LAI,KL,DISPA1,...
                    LAID,LAIL,ECDIF,...
                    CHECK1,CHECK2,CHECK3)

*      DERIVED DISTRIBUTION OF THE GREEN LEAF AREA
       CALL YELDI1 (NSP,NCL,LAI,LAID,YFLVS)

***    DISTRIBUTION OF STEM AREA

*      DISTRIBUTION OF THE TOTAL STEM AREA
       CALL VERDI2 (NSP,DNSP,V,EXIST,...
                    NCL,HEI,ULCL,...
                    SAI,KLSTEM,DISPA2,...
                    SAID,LAIL,ECDIF,...
                    CHECK4,CHECK5,CHECK6)

*      DERIVED DISTRIBUTION OF THE GREEN STEM AREA
       CALL YELDI1 (NSP,NCL,SAI,SAID,YFST)
       IF (EAASWI.LT.0.5)  GOTO  9876

***    DISTRIBUTION OF EAR AREA

*      DISTRIBUTION OF THE TOTAL EAR AREA
       CALL VERDI2 (NSP,DNSP,V,EXIST,...
                    NCL,HEI,ULCL,...
                    EAI,KLEAR,DISPA3,...
                    EAID,LAIL,ECDIF,...
                    CHECK7,CHECK8,CHECK9)

*      DERIVED DISTRIBUTION OF THE GREEN EAR AREA
       CALL YELDI2 (NSP,NCL,EAID,YFEAR)

          DO 4869 A = 1,NSP
          XEAI(A) = EAI(A)
4869      CONTINUE
          DO 4870 A = 1,NSP*NCL
          STORE(A) = EAID(A)
4870      CONTINUE

*************************************************************************
*        D A I L Y     G R O S S     P R O D U C T I O N              *
*************************************************************************

9876     CONTINUE

***    ACTUAL VALUES OF AMAX
```

```
      TRAMAX =  AFGEN (TRAMAT,EAVT)
         DO 1710 A=1,NSP
         L = V(A)
         SRAMAX    = AFGEN (SRAMAT,DVS(A))
         AMAX(L) = PAMAX(L) * TRAMAX * SRAMAX
1710     CONTINUE

***   DAILY GROSS PRODUCTION

      GASSP,DUM, DAYL,IRR,INST1,FRDFD,FRDR = ...
      DAYASS (DAY,DTR,LAT,NCL,NSP,DNSP,V,STPSWI,EAPSWI,...
              LAID,SAID,EAID,LAIL,ECDIF,KL,KLSTEM,KLEAR,...
              AMAX,SAMAX,EAMAX,EFF,SEFF,EEFF)

***********************************************************************
*        D Y N A M I C S    O F    D R Y    M A T T E R             *
***********************************************************************

***    ==============================================    ***
***    M A I N T E N A N C E    R E S P I R A T I O N    ***
***    ==============================================    ***

*   MAINTENANCE RESPIRATION IS SUBTRACTED FROM THE GROSS PRODUCTION
      TEMR = Q10 ** (0.1 * TMPA - 1.5)
         DO 5000 A = 1, NSP
         XMR0 =  WLVS(A) *  BMRCLV * AFGEN (LVRRT,DVS(A)) + ...
                 WST(A)  *  BMRCST                        + ...
                 WRT(A)  *  BMRCRT                        + ...
                 WGR(A)  *  BMRCGR
         RMNT    = AMIN1 (TEMR * XMR0, GASSP(A) )
         FCHN (A)  = GASSP (A) - RMNT
5000     CONTINUE
20000    CONTINUE
         IF ((GROWTH+ARRIVE).LT.0.5) GOTO 7020

***   ========================================================    ***
***   A L L O C A T I O N    O F    N E T    P R O D U C T I O N    ***
***    T O    T H E    D I F F E R E N T    O R G A N S   A N D    ***
***        I T S    T R A N S F O R M A T I O N    I N T O        ***
***                    D R Y    M A T T E R;                      ***
***       T R A N S F O R M A T I O N    O F  L I V E    I N T O   ***
***                 D E A D    D R Y    M A T T E R               ***
***   ========================================================    ***

***   RATES DRY MATTER ACCUMULATION IN LEAVES, STEMS, GRAINS, ROOTS
         DO 70 A = 1, NSP
         L = V(A)
         LR = V(A)
         IF (DAY.LE.APPEAR(L)-2)    GOTO 70

***   ROOTS AND SHOOT   ***

         FSH     =  TWOVAR (FSHTB,DVS(A),LR)
         XGRRT   =  FCHN(A) * (1.- FSH) * EFCRT + ...
                    PLOP(A) * IWRT(L) * COR(A) * DFAC
         DRRT    =  WRT(A) * AFGEN(DRRTB,AGE(A))
         GRRT(A) =  XGRRT - DRRT
      WRT          =  INTGRL (0., GRRT,  12)
         GSHOOT  =  FCHN(A) * FSH

***   LEAVES   ***

         FLVS       = TWOVAR (FLVST, DVS(A), LR)
         XGRLVS     = GSHOOT *  FLVS   * EFCLVS + ...
                      PLOP(A) * IWLVS(L) * COR(A) * DFAC
         DRLVS(A)   = WLVS(A) * TWOVAR(DRLVTB,AGE(A),LR)
         GRLVS (A) = XGRLVS   - DRLVS (A)
```

```
      WLVS         =  INTGRL (0., GRLVS, 12)
      WDLVS        =  INTGRL (0., DRLVS, 12)

***   STEMS    ***

         FST       = TWOVAR (FSTT, DVS(A), LR)
         XGRST     = GSHOOT  * FST  * EFCST + ...
                     PLOP(A) * IWST(L) * COR(A) * DFAC
         DRST(A)   = WST(A)  * AFGEN (DRSTTB,AGE(A))
         GRST(A)   = XGRST   - DRST(A)
      WST          =  INTGRL (0., GRST,  12)
      WDST         =  INTGRL (0., DRST,  12)

***   GRAINS   ***

         FGR       =  1. - FLVS - FST
         GRGR  (A) =  GSHOOT * FGR  * EFCGR
70       CONTINUE
      WGR          =  INTGRL (0,  GRGR,  12)

****************************************************************
*                  GROWTH RECORDING                             *
****************************************************************

      IF (GROWTH.LE.0.5)  GOTO 7020

*    ABOVEGROUND BIOMASS ( KG/HA), G/PLANT )
         DO 7010 A = 1,NSP
         OGBM(A)    = WLVS(A) + WDLVS(A) + WST(A) + WDST(A)+ WGR(A)
         IF (COR(A).LT.1.E-6)  THEN
            TYPE 5002,A
5002        FORMAT (' SPECIES ',I5,' WITH COR = 0 ')
            GOTO 7010
         ENDIF
         OGBMPP(A) = OGBM(A) / ( 10. * PSM * COR(A))
         7010     CONTINUE

*    AVERAGE, VARIANCE AND COEFFICIENT OF VARIATION OF ABOVEGROUND
*    BIOMASS PER PLANT
      AV,VAR,CV = EVAL1 (NSP,OGBMPP,COR)

*    DELTA - LN - VALUES
      LNDVBM,DUM = LNDCAL (NSP,OGBMPP,COR)
7020   CONTINUE

****************************************************************
*          P A R A M E T E R   L I B R A R Y                    *
****************************************************************

***    PHYSIOLOGICAL PARAMETERS USED FOR DESCRIBING THE GROWTH
***               OF 12 SPRING WHEAT VARIETIES

***  DEVELOPMENTAL RATE  ***
*    VARIETY SPECIFIC FACTOR USED FOR DESCRIBING THE PREANTHESIS
*    DEVELOPMENTAL RATE (OBTAINED BY FITTING THE EQUATION GIVEN BY
*    VAN KEULEN(85) TO OBSERVED DURATIONS UNTIL ANTHESIS)
TABLE  CULTP (1-12) = 1.4066,  1.4554,  1.4817,  1.3845, ...
                      1.4311,  1.3616,  1.4066,  1.3403, ...
                      1.3403,  1.3197,  1.3197,  1.3616

***  OPTICAL PROPERTIES  ***

*    EXTINCTION COEFFICIENT OF EARS AND STEMS
*    (ESTIMATION ACCORDING TO DE GROOT (85) (PERS. COMMUNICATION)
TABLE  KLEAR  (1-12) = 12 * 0.4
TABLE  KLSTEM (1-12) = 12 * 0.4
```

```
*   POTENTIAL EXTINCTION COEFFICIENT OF LEAVES
*   (NOT FULLY REALIZED DURING THE FIRST DAYS OF GROWTH)
TABLE  PKL (1-12) = 12 * 0.60

*   REDUCTION FACTOR FOR THE EXTINCTION COEFFICIENT OF LEAVES,
*   ACCOUNTING FOR THE LEAF CLUSTERING EXHIBITED BY YOUNG PLANTS
FUNCTION KLREDT = 0.,0.6,  0.1,1.,  1.1,1.

***   PHOTOSYNTHETIC CHARACTERISTICS  ***

*   POTENTIAL AMAX (KG CO2 / HA / H) AND LIGHT USE EFFICIENCY
*   (KG CO2 / HA / H / (J / M2 / S) OF LEAVES
TABLE PAMAX (1-12) = 12 * 40.
TABLE EFF   (1-12) = 12 *  .45

*   REDUCTION FACTOR OF AMAX ACCOUNTING FOR THE EFFECT
*   OF SENESCENCE; VALUES AS FUNCTION OF THE DEVELOPMENTAL STATE
FUNCTION SRAMAT = 0.,1.,  0.5,1.,  1.,0.5

*   REDUCTION FACTOR OF AMAX ACCOUNTING
*   FOR THE EFFECT OF TEMPERATUR; VALUES AS FUNCITION OF
*   THE AVERAGE TEMPERATURE ( C) DURING DAYLIGHT PERIOD
FUNCTION TRAMAT = 0.,0.,  10.,1.,  25.,1.,  35.,0.01

*   AMAX (KG CO2 / HA / H) OF STEMS
TABLE SAMAX (1-12) = 12 * 20.

*   INITIAL LIGHT USE EFFICIENCY OF STEMS
*   (KG CO2 / HA / H /  (J/S/CM**2)
TABLE SEFF (1-12)  = 12 * 0.45

*   AMAX (KG CO2 / HA / H) OF EARS
TABLE EAMAX (1-12) = 12 * 20.

*   INITIAL LIGHT USE FFICIENCY OF EARS
*   (KG CO2 / HA / H /  (J/S/CM**2)
TABLE EEFF  (1-12) = 12 * 0.22

***  DEVELOPMENT OF THE EAR AREA  ***
*    EAR SURFACE AT ANTHESIS DIVIDED BY ABOVEGROUND BIOMASS AT
*    ANTHESIS (CM**2 / G)
*    (LARGE VALUES BELONG TO GENOTYPES WITH AWNS, SMALL TO
*    GENOTYPES WITHOUT AWNS)
TABLE EARSUR (1-12) = 8.64, 8.64, 15.98, 15.98, 8.64, 8.64,...
                      8.64, 8.64, 15.98,  8.64, 8.64, 8.64

*    GROWTH OF THE EAR AREA ( (EARSURFACE/PLANT) / (EARSURFACE/PLANT AT
*    ANTHESIS)  AS FUNCTION OF THE DEVELOPMENT STATE
FUNCTION EARGRT = 0.,0.,   0.4999,0.,  0.5,1.,  1.1,1.

*    THICKNESS OF THE EAR LAYER BELONGING
*    TO A SINGLE GENOTYPE (CM)
PARAM VEEL = 20.

***  GREEN FRACTION OF THE EAR AREA  ***

*   VALUES AS FUNCTION OF THE NUMBER OF DAYS AFTER EMERGENCE
FUNCTION GFET,  1.= 0.,1.,   67.,1.000,  103.,0.200,  107.,0.125, ...
                            112.,0.050,  117.,0.025,  130.,0.,  131.,0.
FUNCTION GFET,  2.= 0.,1.,   65.,1.000,  103.,0.250,  107.,0.138, ...
                            112.,0.050,  117.,0.000,  130.,0.,  131.,0.
FUNCTION GFET,  3.= 0.,1.,   64.,1.000,  103.,0.327,  107.,0.319, ...
                            112.,0.029,  117.,0.014,  130.,0.,  131.,0.
FUNCTION GFET,  4.= 0.,1.,   68.,1.000,  103.,0.422,  107.,0.352, ...
                            112.,0.205,  117.,0.000,  130.,0.,  131.,0.
```

```
FUNCTION GFET,  5.= 0.,1.,   66.,1.000,  103.,0.263,  107.,0.163, ...
                            112.,0.050,  117.,0.050,  130.,0.,  131.,0.
FUNCTION GFET,  6.= 0.,1.,   69.,1.000,  103.,0.200,  107.,0.150,...
                            112.,0.050,  117.,0.000,  130.,0.,  131.,0.
FUNCTION GFET,  7.= 0.,1.,   67.,1.000,  103.,0.200,  107.,0.138, ...
                            112.,0.050,  117.,0.000,  130.,0.,  131.,0.
FUNCTION GFET,  8.= 0.,1.,   70.,1.000,  103.,0.225,  107.,0.150, ...
                            112.,0.050,  117.,0.000,  130.,0.,  131.,0.
FUNCTION GFET,  9.= 0.,1.,   70.,1.000,  103.,0.509,  107.,0.375, ...
                            112.,0.118,  117.,0.007,  130.,0.,  131.,0.
FUNCTION GFET, 10.= 0.,1.,   71.,1.000,  103.,0.288,  107.,0.188, ...
                            112.,0.113,  117.,0.000,  130.,0.,  131.,0.
FUNCTION GFET, 11.= 0.,1.,   71.,1.000,  103.,0.375,  107.,0.213, ...
                            112.,0.075,  117.,0.000,  130.,0.,  131.,0.
FUNCTION GFET, 12.= 0.,1.,   69.,1.000,  103.,0.238,  107.,0.163, ...
                            112.,0.100,  117.,0.000,  130.,0.,  131.,0.

***  RELATIVE DYING RATES OF LEAVES  ***
*  VALUES AS FUNCTION OF THE NUMBER OF DAYS AFTER EMERGENCE
FUNCTION DRLVTB,  1.= 0.,0.,  66.,0.,  67.,0.024,  102.,0.024, ...
         103.,0.038,  106.,0.038,  107.,0.197,  111.,0.197, ...
         112.,0.392,  116.,0.392,  117.,0.452,  131.,0.452
FUNCTION DRLVTB,  2.= 0.,0.,  64.,0.,  65.,0.033,  102.,0.033, ...
         103.,0.092,  106.,0.092,  107.,0.234,  111.,0.234, ...
         112.,0.818,  116.,0.818,  117.,0.818,  131.,0.818
FUNCTION DRLVTB,  3.= 0.,0.,  63.,0.,  64.,0.045,  102.,0.045, ...
         103.,0.045,  106.,0.045,  107.,0.156,  111.,0.156, ...
         112.,0.197,  116.,0.197,  117.,0.443,  131.,0.443
FUNCTION DRLVTB,  4.= 0.,0.,  67.,0.,  68.,0.038,  102.,0.038, ...
         103.,0.075,  106.,0.075,  107.,0.139,  111.,0.139, ...
         112.,0.838,  116.,0.838,  117.,0.838,  131.,0.838
FUNCTION DRLVTB,  5.= 0.,0.,  65.,0.,  66.,0.030,  102.,0.030, ...
         103.,0.077,  106.,0.077,  107.,0.178,  111.,0.178, ...
         112.,0.356,  116.,0.356,  117.,0.412,  131.,0.412
FUNCTION DRLVTB,  6.= 0.,0.,  68.,0.,  69.,0.033,  102.,0.033, ...
         103.,0.111,  106.,0.111,  107.,0.189,  111.,0.189, ...
         112.,0.830,  116.,0.830,  117.,0.830,  131.,0.830
FUNCTION DRLVTB,  7.= 0.,0.,  66.,0.,  67.,0.038,  102.,0.038, ...
         103.,0.168,  106.,0.168,  107.,0.197,  111.,0.197, ...
         112.,0.810,  116.,0.810,  117.,0.810,  131.,0.810
FUNCTION DRLVTB,  8.= 0.,0.,  69.,0.,  70.,0.033,  102.,0.033, ...
         103.,0.118,  106.,0.118,  107.,0.189,  111.,0.189, ...
         112.,0.830,  116.,0.830,  117.,0.830,  131.,0.830
FUNCTION DRLVTB,  9.= 0.,0.,  69.,0.,  70.,0.022,  102.,0.022, ...
         103.,0.134,  106.,0.134,  107.,0.164,  111.,0.164, ...
         112.,0.381,  116.,0.381,  117.,0.412,  131.,0.412
FUNCTION DRLVTB, 10.= 0.,0.,  70.,0.,  71.,0.024,  102.,0.024, ...
         103.,0.087,  106.,0.087,  107.,0.165,  111.,0.165, ...
         112.,0.850,  116.,0.850,  117.,0.850,  131.,0.850
FUNCTION DRLVTB, 11.= 0.,0.,  70.,0.,  71.,0.027,  102.,0.027, ...
         103.,0.105,  106.,0.105,  107.,0.140,  111.,0.140, ...
         112.,0.140,  116.,0.140,  117.,0.488,  131.,0.488
FUNCTION DRLVTB, 12.= 0.,0.,  68.,0.,  69.,0.030,  102.,0.030, ...
         103.,0.148,  106.,0.148,  107.,0.234,  111.,0.234, ...
         112.,0.818,  116.,0.818,  117.,0.818,  131.,0.818

***  RELATIVE DYING RATE OF ROOTS  ***
*  VALUES AS FUNCTION OF THE NUMBER OF DAYS AFTER EMERGENCE
FUNCTION DRRTB =  0.,0.,        67.,0.,        68.,0.0061, 102.,0.0061,...
                103.,0.0206,  106.,0.0206,  107.,0.037,  111.,0.037, ...
                112.,0.073,   131.,0.073

***  RELATIVE DYING RATE OF STEMS  ***
*  VALUES AS FUNCTION OF THE NUMBER OF DAYS AFTER EMERGENCE
FUNCTION DRSTTB=  0.,0.,        67.,0.,        68.,0.0076, 102.,0.0076,...
                103.,0.0258,  106.,0.0258,  107.,0.047,  111.,0.047, ...
                112.,0.091,   131.,0.091
```

```
*** DEVELOPMENT OF PLANT HEIGHT ***
*   VALUES AS FUNCTION OF THE NUMBER OF DAYS AFTER EMERGENCE
FUNCTION HEITB,  1. = 0., 5.,  40.,34.,  55.,64.,  72.,89.,  130.,73.
FUNCTION HEITB,  2. = 0., 5.,  40.,30.,  55.,56.,  72.,81.,  130.,63.
FUNCTION HEITB,  3. = 0., 5.,  40.,37.,  55.,66.,  72.,91.,  130.,78.
FUNCTION HEITB,  4. = 0., 5.,  40.,32.,  55.,54.,  72.,81.,  130.,66.
FUNCTION HEITB,  5. = 0., 5.,  40.,32.,  55.,58.,  72.,81.,  130.,70.
FUNCTION HEITB,  6. = 0., 5.,  40.,31.,  55.,58.,  72.,97.,  130.,82.
FUNCTION HEITB,  7. = 0., 5.,  40.,34.,  55.,58.,  72.,82.,  130.,70.
FUNCTION HEITB,  8. = 0., 5.,  40.,26.,  55.,55.,  72.,92.,  130.,74.
FUNCTION HEITB,  9. = 0., 5.,  40.,34.,  55.,57.,  72.,88.,  130.,74.
FUNCTION HEITB, 10. = 0., 5.,  40.,30.,  55.,55.,  72.,89.,  130.,69.
FUNCTION HEITB, 11. = 0., 5.,  40.,28.,  55.,59.,  72.,94.,  130.,77.
FUNCTION HEITB, 12. = 0., 5.,  40.,27.,  55.,58.,  72.,93.,  130.,79.

*** MAINTENANCE RESPIRATION ***

*   "Q10-PARAMTER"
PARAM Q10 = 2.

*** RELATIVE RESPIRATION RATES OF LEAVES, STEMS, ROOTS, GRAINS ***

PARAM BMRCLV = 0.03, BMRCST = 0.015, BMRCRT = 0.01, BMRCGR = 0.01

*   REDUCTION FACTOR ACCOUNTING FOR THE EFFECT OF SENESCENCE ON THE
*   RESPIRATION RATE OF LEAVES; VALUES AS FUNCTION OF THE
*   DEVELOPMENTAL STATE
FUNCTION LVRRT  = 0.,1.,  0.5,1.,  0.5001,0.5,  1.1,0.5

*** GROWTH EFFICIENCY ***

PARAM EFCLVS = 0.68, EFCST  = 0.66, EFCRT  = 0.69, EFCGR  = 0.70

*** DRY MATTER ALLOCATION  ***

*   FRACTION OF NET ASSIMILATION ALLOCATED TO THE  L E A V E S,
*   DIVIDED BY THE FRACTION ALLOCATED TO THE SHOOT
*   VALUES AS FUNCTION OF THE DEVELOPMENTAL STATE
FUNCTION FLVST, 1.=  0.,0.61,  0.10671,0.61,  ...
      0.10672,0.65,  0.14981,0.65,  0.14982,0.54,  0.22581,0.54, ...
      0.22582,0.47,  0.26921,0.47,  0.26922,0.32,  0.31265,0.32, ...
      0.40000,0.04,  0.50001,0.,    1.,0.
FUNCTION FLVST, 2.=  0.,0.65,  0.11041,0.65, ...
      0.11042,0.66,  0.15501,0.66,  0.15502,0.56,  0.23361,0.56, ...
      0.23362,0.42,  0.27851,0.42,  0.27852,0.32,  0.32350,0.32, ...
      0.40000,0.04,  0.50001,0.,    1.,0.
FUNCTION FLVST, 3.=  0.,0.64,  0.11241,0.64,  ...
      0.11242,0.58,  0.15781,0.58,  0.15782,0.54,  0.23781,0.54, ...
      0.23782,0.42,  0.28361,0.42,  0.28362,0.32,  0.32394,0.32, ...
      0.40000,0.04,  0.50001,0.,    1.,0.
FUNCTION FLVST, 4.=  0.,0.59,  0.10511,0.59,  ...
      0.10512,0.65,  0.14741,0.65,  0.14742,0.56,  0.22221,0.56, ...
      0.22222,0.55,  0.26501,0.55,  0.26502,0.32,  0.30774,0.32, ...
      0.40000,0.04,  0.50001,0.,    1.,0.
FUNCTION FLVST, 5.=  0.,0.62,  0.10861,0.62,  ...
      0.10862,0.63,  0.15241,0.63,  0.15242,0.53,  0.22971,0.53, ...
      0.22972,0.42,  0.27391,0.42,  0.27392,0.32,  0.31810,0.32, ...
      0.40000,0.04,  0.50001,0.,    1.,0.
FUNCTION FLVST, 6.=  0.,0.60, 0.10331,0.60,  ...
      0.10332,0.65,  0.14501,0.65,  0.14502,0.54,  0.21851,0.54, ...
      0.21852,0.44,  0.26061,0.44,  0.26062,0.32,  0.30265,0.32, ...
      0.40000,0.04,  0.50001,0.,    1.,0.
```

```
FUNCTION FLVST, 7.= 0.,0.60,  0.10671,0.60,  ...
      0.10672,0.62,  0.14981,0.62,  0.14982,0.51,  0.22581,0.51, ...
      0.22582,0.57,  0.26921,0.57,  0.26922,0.32,  0.31265,0.32, ...
      0.40000,0.04,  0.50001,0.,    1.,0.
FUNCTION FLVST, 8.= 0.,0.65,  0.10171,0.65,  ...
      0.10172,0.68,  0.14271,0.68,  0.14272,0.59,  0.21511,0.59, ...
      0.21512,0.53,  0.25651,0.53,  0.25652,0.32,  0.29792,0.32, ...
      0.40000,0.04,  0.50001,0.,   1.,0.
FUNCTION FLVST, 9.= 0.,0.64,  0.10171,0.64,  ...
      0.10172,0.64,  0.14271,0.64,  0.14272,0.55,  0.21511,0.55, ...
      0.21512,0.36,  0.25651,0.36,  0.25652,0.32,  0.29792,0.32, ...
      0.40000,0.04,  0.50001,0.,   1.,0.
FUNCTION FLVST,10.= 0.,0.65,  0.10011,0.65,  ...
      0.10012,0.70,  0.14051,0.70,  0.14052,0.61,  0.21181,0.61, ...
      0.21182,0.46,  0.25261,0.46,  0.25262,0.32,  0.29334,0.32, ...
      0.40000,0.04,  0.50001,0.,   1.,0.
FUNCTION FLVST,11.= 0.,0.62,  0.10011,0.62,  ...
      0.10012,0.71,  0.14051,0.71,  0.14052,0.61,  0.21181,0.61, ...
      0.21182,0.48,  0.25261,0.48,  0.25262,0.32,  0.29334,0.32, ...
      0.40000,0.04,  0.50001,0.,   1.,0.
FUNCTION FLVST,12.= 0.,0.64,  0.10331,0.64,  ...
      0.10332,0.67,  0.14501,0.67,  0.14502,0.57,  0.21851,0.57, ...
      0.21852,0.43,  0.26061,0.43,  0.26062,0.32,  0.30265,0.32, ...
      0.40000,0.04,  0.50001,0.,   1.,0.

*   FRACTION OF NET ASSIMILATION ALLOCATED TO THE   S T E M S,
*   DIVIDED BY THE FRACTION ALLOCATED TO THE SHOOT
*   VALUES AS FUNCTION OF THE DEVELOPMENTAL STATE
FUNCTION FSTT,  1.= 0.,0.39,  0.10671,0.39,  ...
      0.10672,0.35,  0.14981,0.35,  0.14982,0.46,  0.22581,0.46, ...
      0.22582,0.53,  0.26921,0.53,  0.26922,0.68,  0.31265,0.68, ...
      0.40000,0.96,  0.50001,0.,    1.,0.
FUNCTION FSTT,  2.= 0.,0.35,  0.11041,0.35, ...
      0.11042,0.34,  0.15501,0.34,  0.15502,0.44,  0.23361,0.44, ...
      0.23362,0.58,  0.27851,0.58,  0.27852,0.68,  0.32350,0.68, ...
      0.40000,0.96,  0.50001,0.,    1.,0.
FUNCTION FSTT,  3.= 0.,0.36,  0.11241,0.36,  ...
      0.11242,0.42,  0.15781,0.42,  0.15782,0.46,  0.23781,0.46, ...
      0.23782,0.58,  0.28361,0.58,  0.28362,0.68,  0.32394,0.68, ...
      0.40000,0.96,  0.50001,0.,    1.,0.
FUNCTION FSTT,  4.= 0.,0.41,  0.10511,0.41,  ...
      0.10512,0.35,  0.14741,0.35,  0.14742,0.44,  0.22221,0.44, ...
      0.22222,0.45,  0.26501,0.45,  0.26502,0.68,  0.30774,0.68, ...
      0.40000,0.96,  0.50001,0.,    1.,0.
FUNCTION FSTT,  5.= 0.,0.38,  0.10861,0.38,  ...
      0.10862,0.37,  0.15241,0.37,  0.15242,0.47,  0.22971,0.47, ...
      0.22972,0.58,  0.27391,0.58,  0.27392,0.68,  0.31810,0.68, ...
      0.40000,0.96,  0.50001,0.,    1.,0.
FUNCTION FSTT,  6.= 0.,0.40, 0.10331,0.40,  ...
      0.10332,0.35,  0.14501,0.35,  0.14502,0.46,  0.21851,0.46, ...
      0.21852,0.56,  0.26061,0.56,  0.26062,0.68,  0.30265,0.68, ...
      0.40000,0.96,  0.50001,0.,    1.,0.
FUNCTION FSTT,  7.= 0.,0.40,  0.10671,0.40,  ...
      0.10672,0.38,  0.14981,0.38,  0.14982,0.49,  0.22581,0.49, ...
      0.22582,0.43,  0.26921,0.43,  0.26922,0.68,  0.31265,0.68, ...
      0.40000,0.96,  0.50001,0.,    1.,0.
FUNCTION FSTT,  8.= 0.,0.35,  0.10171,0.35,  ...
      0.10172,0.32,  0.14271,0.32,  0.14272,0.41,  0.21511,0.41, ...
      0.21512,0.47,  0.25651,0.47,  0.25652,0.68,  0.29792,0.68, ...
      0.40000,0.96,  0.50001,0.,   1.,0.
FUNCTION FSTT,  9.= 0.,0.36,  0.10171,0.36,  ...
      0.10172,0.36,  0.14271,0.36,  0.14272,0.45,  0.21511,0.45, ...
      0.21512,0.64,  0.25651,0.64,  0.25652,0.68,  0.29792,0.68, ...
      0.40000,0.96,  0.50001,0.,   1.,0.
FUNCTION FSTT, 10.= 0.,0.35,  0.10011,0.35,  ...
      0.10012,0.30,  0.14051,0.30,  0.14052,0.39,  0.21181,0.39, ...
      0.21182,0.54,  0.25261,0.54,  0.25262,0.68,  0.29334,0.68, ...
      0.40000,0.96,  0.50001,0.,   1.,0.
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FUNCTION FSTT, 11.=  0.,0.38,  0.10011,0.38,  ...
      0.10012,0.29,  0.14051,0.29,  0.14052,0.39,  0.21181,0.39, ...
      0.21182,0.52,  0.25261,0.52,  0.25262,0.68,  0.29334,0.68, ...
      0.40000,0.96,  0.50001,0.,   1.,0.
FUNCTION FSTT ,12.=  0.,0.36,  0.10331,0.36,  ...
      0.10332,0.33,  0.14501,0.33,  0.14502,0.43,  0.21851,0.43, ...
      0.21852,0.57,  0.26061,0.57,  0.26062,0.68,  0.30265,0.68, ...
      0.40000,0.96,  0.50001,0.,   1.,0.

*   FRACTION OF NET ASSIMILATION ALLOCATED TO THE SHOOT,
*   DEPENDENT ON THE DEVELOPMENTAL STATE
FUNCTION FSHTB, 1.=  0.,0.5,  0.25,0.8,  0.5,1.,  1.,1.
FUNCTION FSHTB,12.=  0.,0.5,  0.25,0.8,  0.5,1.,  1.,1.

***  SPECIFIC LEAF AREA  ***
*   VALUES AS FUNCTION OF THE DEVELOPMENTAL STATE
*    (M**2 / KG)
FUNCTION SLATB, 1.= 0.,21.570,  1.,     21.570
FUNCTION SLATB, 2.= 0.,21.848,  1.,     21.848
FUNCTION SLATB, 3.= 0.,20.786,  1.,     20.786
FUNCTION SLATB, 4.= 0.,23.348,  1.,     23.348
FUNCTION SLATB, 5.= 0.,22.227,  1.,     22.227
FUNCTION SLATB, 6.= 0.,21.459,  1.,     21.459
FUNCTION SLATB, 7.= 0.,22.457,  1.,     22.457
FUNCTION SLATB, 8.= 0.,22.041,  1.,     22.041
FUNCTION SLATB, 9.= 0.,20.396,  1.,     20.396
FUNCTION SLATB,10.= 0.,21.478,  1.,     21.478
FUNCTION SLATB,11.= 0.,21.124,  1.,     21.124
FUNCTION SLATB,12.= 0.,22.758,  1.,     22.758

***  SPECIFIC STEM AREA  ***
*    ( M**2 / KG )
PARAM SSTA = 2.5

METHOD RECT

**********************************************************************
*              W E A T H E R        D A T A                          *
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*   DAILY GLOBAL RADIATION (J/CM**2/D)
FUNCTION DTRT=  ...
              96.,1873., 97.,1593., 98., 834., 99., 902.,100.,   0.,...
             101.,   0.,102.,   0.,103.,2165.,104.,2124.,105.,2083.,...
             106.,2070.,107.,1928.,108.,1894.,109., 411.,110.,1166.,...
             111.,1631.,112.,2159.,113., 959.,114.,2097.,115.,1341.,...
             116., 314.,117., 877.,118.,1847.,119., 367.,120., 629.,...
             121.,2105.,122.,2132.,123.,2345.,124.,1979.,125.,2227.,...
             126.,2589.,127.,1696.,128.,1363.,129., 957.,130.,2486.,...
             131.,2774.,132.,2701.,133.,2627.,134.,2691.,135.,2767.,...
             136.,2656.,137.,2089.,138.,2233.,139.,1998.,140.,2601.,...
             141.,2004.,142.,2567.,143.,2778.,144.,1943.,145., 833.,...
             146.,1580.,147.,2040.,148.,1671.,149.,1623.,150.,1326.,...
             151.,2310.,152.,1336.,153.,1319.,154.,2324.,155., 628.,...
             156.,1737.,157.,2798.,158.,2594.,159., 970.,160.,1885.,...
             161.,2365.,162., 949.,163.,2053.,164.,2584.,165.,2214.,...
             166.,1707.,167.,1485.,168., 870.,169.,1383.,170.,1147.,...
             171., 667.,172.,1521.,173.,1369.,174.,1398.,175.,1543.,...
             176.,1355.,177.,1892.,178.,1720.,179.,1735.,180., 799.,...
             181.,1573.,182.,2212.,183.,1065.,184.,1542.,185.,1652.,...
             186., 878.,187.,1329.,188.,2219.,189.,1007.,190., 635.,...
             191., 779.,192., 428.,193., 618.,194.,1194.,195.,1348.,...
             196.,1017.,197.,1735.,198.,1031.,199.,1263.,200., 753.,...
             201., 389.,202., 655.,203., 540.,204.,2615.,205.,2592.,...
             206.,2141.,207.,2414.,208.,2153.,209.,1667.,210.,1700.,...
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        211.,2282.,212., 556.,213.,2290.,214.,2044.,215.,2073.,...
        216.,1507.,217.,1480.,218.,1393.,219.,1296.,220.,1455.,...
        221.,1799.,222.,1814.,223.,1563.,224.,1264.,225.,1238.,...
        226.,1164.,227., 724.,228.,1989.,229., 928.,230.,1705.,...
        231.,1045.,232.,1372.,233.,1115.,234.,1364.,235.,1229.,...
        236.,1073.,237., 579.,238.,1895.,239.,2087.,240.,1819.,...
        241., 704.,242., 928.,243., 820.,244., 779.,245.,1572.

*   DAILY TEMPERATUR MAXIMA ( C)
FUNCTION MXTT=      ...
         96.,10.9, 97.,11.8, 98., 8.0, 99., 7.4,100., 7.9 ,     ...WAG1980
        101., 9.3,102.,13.2,103.,15.8,104.,19.3,105.,21.6 ,     ...WAG1980
        106.,22.3,107.,22.3,108.,18.6,109., 9.5,110.,10.1 ,     ...WAG1980
        111., 9.1,112.,10.8,113., 8.5,114.,11.1,115.,12.1 ,     ...WAG1980
        116., 7.8,117.,12.5,118.,14.1,119., 9.1,120.,10.1 ,     ...WAG1980
        121.,12.1,122.,19.5,123.,14.9,124.,13.9,125.,14.1 ,     ...WAG1980
        126.,13.1,127.,16.7,128.,13.1,129.,10.0,130.,14.9 ,     ...WAG1980
        131.,17.9,132.,21.0,133.,23.6,134.,21.1,135.,20.1 ,     ...WAG1980
        136.,19.3,137.,18.4,138.,20.5,139.,22.9,140.,24.6 ,     ...WAG1980
        141.,24.2,142.,22.6,143.,15.1,144.,14.1,145.,13.2 ,     ...WAG1980
        146.,15.7,147.,18.8,148.,20.7,149.,19.6,150.,17.8 ,     ...WAG1980
        151.,15.7,152.,17.2,153.,18.6,154.,19.5,155.,18.6 ,     ...WAG1980
        156.,23.5,157.,27.0,158.,27.2,159.,17.8,160.,19.5 ,     ...WAG1980
        161.,24.1,162.,20.0,163.,22.3,164.,23.5,165.,26.9 ,     ...WAG1980
        166.,28.4,167.,20.8,168.,19.8,169.,19.3,170.,18.2 ,     ...WAG1980
        171.,17.7,172.,16.3,173.,17.1,174.,15.9,175.,17.2 ,     ...WAG1980
        176.,15.8,177.,17.8,178.,17.7,179.,16.7,180.,13.6 ,     ...WAG1980
        181.,16.4,182.,17.7,183.,18.3,184.,18.8,185.,18.4 ,     ...WAG1980
        186.,16.1,187.,17.9,188.,20.9,189.,18.0,190.,16.4 ,     ...WAG1980
        191.,16.0,192.,16.5,193.,14.0,194.,16.2,195.,16.8 ,     ...WAG1980
        196.,18.0,197.,17.7,198.,15.0,199.,16.4,200.,17.3 ,     ...WAG1980
        201.,16.5,202.,17.6,203.,14.5,204.,20.0,205.,23.9 ,     ...WAG1980
        206.,22.8,207.,26.9,208.,29.1,209.,24.8,210.,24.5 ,     ...WAG1980
        211.,26.5,212.,20.4,213.,23.9,214.,25.7,215.,28.3 ,     ...WAG1980
        216.,28.8,217.,23.5,218.,21.1,219.,21.4,220.,23.0 ,     ...WAG1980
        221.,21.9,222.,20.0,223.,21.1,224.,23.9,225.,18.0 ,     ...WAG1980
        226.,18.9,227.,21.3,228.,26.5,229.,22.7,230.,23.3 ,     ...WAG1980
        231.,22.5,232.,21.0,233.,22.5,234.,19.4,235.,16.9 ,     ...WAG1980
        236.,15.1,237.,13.8,238.,18.6,239.,22.2,240.,24.0 ,     ...WAG1980
        241.,18.8,242.,21.7,243.,18.4,244.,17.3,245.,19.1 ,     ...WAG1980
        246.,20.4,247.,22.3,248.,17.6,249.,18.6,250.,20.7

*   DAILY TEMPERATURE MINIMA ( C)
FUNCTION MNTT=      ...
         96.,-3.5, 97.,-2.2, 98.,-1.4, 99., 1.5,100., 1.8 ,     ...WAG1980
        101., 1.9,102.,-2.2,103., 3.1,104., 7.0,105., 8.8 ,     ...WAG1980
        106., 3.1,107., 3.2,108., 4.9,109., 1.3,110., 1.8 ,     ...WAG1980
        111., 0.9,112., 0.5,113., 0.0,114.,-2.4,115., 4.5 ,     ...WAG1980
        116., 4.2,117., 0.6,118.,-0.8,119., 2.5,120., 2.8 ,     ...WAG1980
        121., 4.4,122., 7.9,123., 6.8,124., 3.7,125., 2.9 ,     ...WAG1980
        126., 3.7,127., 3.2,128., 4.7,129., 1.4,130., 0.9 ,     ...WAG1980
        131., 2.9,132., 1.9,133.,10.1,134.,10.4,135., 9.3 ,     ...WAG1980
        136., 5.6,137., 2.0,138., 2.9,139., 7.4,140., 4.7 ,     ...WAG1980
        141., 5.6,142., 8.0,143., 5.5,144., 0.8,145., 8.7 ,     ...WAG1980
        146., 6.4,147., 5.8,148., 6.7,149., 6.8,150., 5.3 ,     ...WAG1980
        151., 3.8,152., 4.0,153., 5.5,154., 4.2,155., 7.1 ,     ...WAG1980
        156.,13.0,157., 7.1,158., 9.2,159., 7.7,160., 5.4 ,     ...WAG1980
        161., 9.4,162.,14.2,163.,12.1,164.,10.8,165.,16.5 ,     ...WAG1980
        166.,15.4,167.,12.8,168.,11.5,169.,11.1,170.,10.3 ,     ...WAG1980
        171., 9.2,172., 9.5,173., 9.8,174., 9.3,175., 9.6 ,     ...WAG1980
        176.,10.0,177., 7.9,178., 4.0,179., 7.3,180., 8.6 ,     ...WAG1980
        181., 9.5,182.,11.2,183.,11.0,184.,12.3,185.,12.2 ,     ...WAG1980
        186., 8.3,187.,10.6,188.,11.2,189.,14.3,190.,12.6 ,     ...WAG1980
        191.,11.8,192.,12.9,193.,11.8,194.,10.8,195.,10.5 ,     ...WAG1980
        196.,11.2,197.,10.8,198., 7.3,199., 7.2,200.,12.7 ,     ...WAG1980
        201.,14.0,202.,12.0,203., 7.7,204., 7.1,205.,12.2 ,     ...WAG1980
        206.,10.9,207.,11.2,208.,17.0,209.,14.1,210.,14.2 ,     ...WAG1980
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          211.,17.0,212.,13.4,213.,12.5,214.,16.0,215.,12.6 ,     ...WAG1980
          216.,15.6,217.,13.7,218.,17.5,219.,15.8,220.,14.2 ,     ...WAG1980
          221.,11.2,222., 6.8,223.,10.6,224.,14.3,225.,15.1 ,     ...WAG1980
          226.,12.8,227.,16.0,228.,15.1,229.,15.5,230.,16.4 ,     ...WAG1980
          231.,14.4,232.,13.2,233.,13.8,234.,12.9,235.,11.1 ,     ...WAG1980
          236., 9.4,237., 7.0,238., 3.0,239., 4.3,240., 6.4 ,     ...WAG1980
          241.,10.5,242.,14.6,243.,13.3,244., 9.2,245., 7.0 ,     ...WAG1980
          246., 6.6,247.,10.5,248.,11.5,249.,11.5,250.,11.7

*********************************************************************
***************  OUTPUT AND RUN CONTROL  ***************************
*********************************************************************
NOSORT
TIMER FINTIM = 231., TIME = 126., DELT=1., PRDEL=1., OUTDEL=1.
PRINT OGBMPP(1-12)
END
STOP


*********************************************************************
*****          SUBROUTINES CALLED FROM   DYNAMIC               *****
*********************************************************************

      SUBROUTINE STRATA (MAXHEI,NCL,ULCL)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C     SUBROUTINE CALCULATING THE BOUNDARY HEIGHTS SEPERATING THE          C
C             CANOPY LAYERS; THE LAYERS HAVE EQUAL THICKNESS              C
C                     INPUT PARAMETERS:                                   C
C     MAXHEI  :  CANOPY HEIGHT                                       [CM] C
C     NCL     :  NUMBER OF CANOPY LAYERS                                  C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                     OUTPUT PARAMETERS:                                  C
C     ULCL    :  UPPER LIMITS OF CANOPY LAYERS                       [CM] C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL(A-Z)
      INTEGER NCL,K
      DIMENSION ULCL (NCL+1)
      THK = MAXHEI / NCL
         DO 10 K = 1,NCL
         ULCL(K) = MAXHEI - (K-1) * THK
 10      CONTINUE
      ULCL(NCL+1) = 0.
      RETURN
      END

      SUBROUTINE VPRE1 (DNSP,A,C,Z,DISPA,DUM)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C    SUBROUTINE WRITING AN ARRAY CONTAINING PARAMETERS AND/OR AUXILIARY   C
C      VARIABLES USED FOR THE VERTICAL DISTRIBUTON OF A SURFACE TYPE;     C
C    THE ARRAY PRODUCED BY "VPRE1" REFLECTS THE SITUATION THAT FOR ALL    C
C    DESCRIBED GENOTYPES THE VERTICAL AREA DENSITY FUNCTION OF THE        C
C    SURFACE IS GIVEN BY                                                  C
C         Y  =  ( A * X**Z  + A  +  C) / NORMALIZATION CONSTANT           C
C     AND THAT ITS 3 PARAMETERS (A,C,Z) ARE IDENTICAL FOR ALL GENOTYPES   C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                     INPUT PARAMETERS:                                   C
C     DNSP    :  DESCRIBED NUMBER OF GENOTYPES                            C
C     A,C,Z   :  PARAMETERS CHARACTERIZING THE VERTICAL AREA DENSITY      C
C                FUNCTION                                                 C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                     OUTPUT PARAMETERS:                                  C
C     DISPA   :  ARRAY CONTAINING PARAMETERSAND/OR AUXILIARY VARIABLES    C
C                USED FOR THE VERTICAL DISTRIBUTION OF A SURFACE TYPE     C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
```

```
      IMPLICIT REAL (A-Z)
      INTEGER   DNSP,A,G,COUNT
      DIMENSION DISPA (72)
      DIMENSION X (6)
      X(1)  = 0.
      X(2)  = 1. +  C/A
      X(3)  = 1. / (Z+1.)
      X(4)  = X(2) - X(3)
      X(5)  = Z + 1.
      X(6)  = 0.
      COUNT = 0
         DO 15251 A = 1,DNSP
            DO 15252 G = 1,6
            COUNT = COUNT + 1
            DISPA(COUNT) = X(G)
15252       CONTINUE
15251    CONTINUE
      RETURN
      END

      SUBROUTINE VPRE2 (DNSP,D,DISPA,DUM)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C    SUBROUTINE WRITING AN ARRAY CONTAINING PARAMETERS AND/OR AUXILIARY   C
C      VARIABLES USED FOR THE VERTICAL DISTRIBUTON OF A SURFACE TYPE;     C
C    THE ARRAY PRODUCED BY "VPRE2" REFLECTS THE SITUATION THAT FOR ALL    C
C    DESCRIBED GENOTYPES THE VERTICAL AREA DENSITY FUNCTION OF THE        C
C    SURFACE IS GIVEN BY                                                  C
C                 1 / D ,   1-D  `=  X  `=  1                              C
C         Y  =                                                            C
C                 0        ,  OTHERWIZE                                   C
C    AND THAT ITS  PARAMETER (D) IS IDENTICAL FOR ALL GENOTYPES   C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                         INPUT PARAMETERS:                                C
C     DNSP    :  DESCRIBED NUMBER OF GENOTYPES                             C
C     D       :  PARAMETER CHARACTERIZING THE VERTICAL AREA DENSITY        C
C                FUNCTION                                                  C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                         OUTPUT PARAMETERS:                               C
C     DISPA   :  ARRAY CONTAINING PARAMETERSAND/OR AUXILIARY VARIABLES     C
C                USED FOR THE VERTICAL DISTRIBUTION OF A SURFACE TYPE      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL (A-Z)
      INTEGER A,G,COUNT,DNSP
      DIMENSION X(6)
      DIMENSION DISPA (72)
      X(1) = 1.
      X(2) = D
         DO 128 G = 3,6
         X(G) = 0.
128      CONTINUE
      COUNT = 0
         DO 698 A = 1,DNSP
            DO 699 G = 1,6
            COUNT = COUNT + 1
            DISPA(COUNT) = X(G)
699         CONTINUE
698      CONTINUE
      RETURN
      END
```

```
      SUBROUTINE CLFRAC (DISPA,L,LOWLIM,UPLIM,HEIGHT,TAI,CLAI)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C      SUBROUTINE CALCULATING THE AREA INDEX OF THAT FRACTION OF A       C
C            SURFACE TYPE WHICH IS POSITIONED IN A CANOPY LAYER          C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                           INPUT PARAMETERS:                            C
C      DISPA  :  ARRAY CONTAINING PARAMETERS AND/OR AUXILIARY VARIABLES  C
C                USED FOR DESCRIBING THE VERTICAL DISTRIBUTION OF A      C
C                SURFACE TYPE                                            C
C      L      :  LIBRARY REFERENCE OF THE GENOTYPE                       C
C      LOWLIM :  LOWER BOUNDARY HEIGHT OF THE CONSIDERED CANOPY LAYER [CM]C
C      UPLIM  :  UPPER BOUNDARY HEIGHT OF THE CONSIDERED CANOPY LAYER [CM]C
C      HEIGHT :  PLANT HEIGHT OF THE GENOTYPE                            C
C      TAI    :  TOTAL AREA INDEX OF THE SURFACE TYPE                    C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                           OUTPUT PARAMETERS:                           C
C      CLAI   :  AREA INDEX OF THAT FRACTION OF THE SURFACE TYPE WHICH   C
C                IS POSITIONED IN THE CANOPY LAYER                       C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL(A-Z)
      INTEGER L,XADRES,XFUNC
      DIMENSION DISPA (72)
C     CHOOSE THE DISTRIBUTION FUNCTION
      XADRES = (L-1) * 6 + 1
      XFUNC  = DISPA(XADRES)
      IF (XFUNC.EQ.1)  GOTO 88877
C     DISTRIBUTION FUNCTION :
C     Y = A - A * X**Z + C
      LOW = AMAX1 (0.,LOWLIM / HEIGHT)
      UP  = AMIN1 (1.,UPLIM  / HEIGHT)
      IF (LOWLIM.GE.HEIGHT.  OR.
     1   UP.    LE.1.E-5    )  THEN
         CLAI = 0.
      ELSE
         X0 = DISPA(XADRES+4)
         X1 = DISPA(XADRES+1) * (UP-LOW)
         X2 = DISPA(XADRES+2) * ( UP ** X0   -   LOW ** X0 )
         CLAI = (X1 - X2) / DISPA(XADRES+3)   * TAI
      ENDIF
      GOTO 90909
88877 CONTINUE
C     DISTRIBUTION FUNCTION :
C
C                 1 / D ,   1-D  `=  X  `=  1
C         Y  =
C                 0         ,  OTHERWIZE
C
      LIM1 = AMAX1 (0.,HEIGHT - DISPA (XADRES+1))
      LIM2 = AMAX1 (0.,HEIGHT - DISPA (XADRES+2))
      THICK = LIM2 - LIM1
      IF (TAI.  LE. 1.E-6.  OR.
     1    THICK.LE. 1.E-6.  OR.
     1    UPLIM.LE. LIM1.   OR.
     1    LOWLIM.GE.LIM2)       THEN
         CLAI = 0.
      ELSE
         XU = AMIN1 (UPLIM, LIM2)
         XL = AMAX1 (LOWLIM,LIM1)
         CLAI = (XU - XL) / THICK * TAI
      ENDIF
90909 CONTINUE
      RETURN
      END

      SUBROUTINE VERDI2 (NSP,DNSP,V,EXIST,
     1                   NCL,HEI,ULCL,
     1                   AI,ECOF,DISPA,
     1                   AID,LAIL,ECDIF,
     1                   CHECK1,CHECK2,CHECK3)
```

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C   SUBROUTINE DISTRIBUTING THE AREA INDEX OF A SURFACE TYPE OVER THE     C
C   CANOPY LAYERS; FOR EACH CANOPY LAYER, THE EXTINCTION CAPACITY AND     C
C      THE TOTAL AREA INDEX OF ALL CONTAINED SURFACES IS ENHANCED         C
C       CORRESPONDINGLY TO THE CONTRIBUTION OF THIS SURFACE TYPE          C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                         INPUT PARAMETERS:                               C
C     NSP     :  NUMBER OF GENOTYPES                                      C
C     DNSP    :  DESCRIBED NUMBER OF GENOTYPES                            C
C     V       :  ARRAY LINKING THE ACTUAL REFERENCES OF THE GENOTYPES     C
C                TO THEIR LIBRARY REFERENCES                              C
C     NCL     :  NUMBER OF CANOPY LAYERS                                  C
C     HEI     :  PLANT HEIGHTS OF THE GENOTYPES                           C
C     ULCL    :  BOUNDARY HEIGHTS SEPRERATING THE CANOPY LAYERS           C
C     AI      :  AREA INDICES OF THE VARIOUS GENOTYPES                    C
C     ECOF    :  EXTINCTION COEFFICIENTS OF THIS SURFACE TYPE BELONGING   C
C                TO THE VARIOUS GENOTYPES                                 C
C     DISPA   :  ARRAY CONTAINING PARAMETERSAND/OR AUXILIARY VARIABLES    C
C                USED FOR THE VERTICAL DISTRIBUTION OF A SURFACE TYPE     C
C     LAIL    :  CONTAINS FOR EACH OF THE NCL CANOPY LAYERS THE           C
C                SUM OF AREA INDICES BELONGING TO ABSORBING SURFACES      C
C                (LEAVES, STEMS, EARS...) POSITIONED IN IT       [HA/HA]  C
C     ECDIF   :  AS LAIL, BUT THE CONTRIBUTING AREA INDICES ARE           C
C                MULTIPLIED BY THE CORRESPONDING EXTINCTION               C
C                COEFFICIENTS FOR DIFFUSE LIGHT                  [HA/HA]  C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                         OUTPUT PARAMETERS:                              C
C     AID     :  DISTRIBUTION OF THE TOTAL AREA INDEX OF THE CONSIDERED   C
C                SURFACE TYPE OVER CANOPY LAYERS AND COMPETITORS          C
C     LAIL    :  CONTAINS FOR EACH OF THE NCL CANOPY LAYERS THE           C
C                SUM OF AREA INDICES BELONGING TO ABSORBING SURFACES      C
C                (LEAVES, STEMS, EARS...) POSITIONED IN IT       [HA/HA]  C
C     ECDIF   :  AS LAIL, BUT THE CONTRIBUTING AREA INDICES ARE           C
C                MULTIPLIED BY THE CORRESPONDING EXTINCTION               C
C                COEFFICIENTS FOR DIFFUSE LIGHT                  [HA/HA]  C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL (A-Z)
      INTEGER V,K,A,C,NSP,DNSP,NCL,L
      DIMENSION V     (NSP)
      DIMENSION EXIST (NSP)
      DIMENSION HEI   (NSP)
      DIMENSION ULCL  (NCL+1)
      DIMENSION AI    (NSP)
      DIMENSION ECOF  (DNSP)
      DIMENSION DISPA (72)
      DIMENSION AID   (NSP*NCL)
      DIMENSION LAIL  (NCL)
      DIMENSION ECDIF (NCL)
      C = 0
      CHECK1 = 0.
         DO 565 K = 1,NCL
         LOWLIM = ULCL(K+1)
         UPLIM  = ULCL(K)
            DO 566 A = 1,NSP
            C  = C + 1
            L  = V(A)
            XAI = AI(A)
            XHEI= HEI(A)
            CALL CLFRAC (DISPA,L,LOWLIM,UPLIM,XHEI,XAI,CLAI)
            CHECK1  = CHECK1 + CLAI
            AID (C)  = CLAI
            LAIL  (K)= LAIL  (K) + CLAI
            ECDIF (K)= ECDIF (K) + CLAI * ECOF(L)
566         CONTINUE
565      CONTINUE
      CHECK2 = 0.
         DO 1729 A = 1,NSP
         CHECK2 = CHECK2 + AI(A)
1729     CONTINUE
```

```
C      CHECKING THE CORRECT DISTRIBUTION
      IF (CHECK2.LT.1.E-5)  THEN
         CHECK3 = CHECK1
      ELSE
         CHECK3 = ABS(CHECK1-CHECK2) / CHECK2
      ENDIF
      IF (CHECK3.GT.0.01)      TYPE 88661
88661 FORMAT (' INCORRECT DISTRIBUTION ALGORITHM ')
      RETURN
      END

      SUBROUTINE YELDI1 (NSP,NCL,AI,GAID,YFRAC)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C   SUBROUTINE DERIVING THE DISTRIBUTION OF THE GREEN FRACTION OF A       C
C       SURFACE TYPE OVER CANOPY LAYERS AND COMPETITORS FROM THE          C
C          CORRESPONDING DISTRIBUTION OF THE TOTAL SURFACE AREA;          C
C   THE DERIVATION REFLECTS THE SITUATION THAT THE TOTAL GREEN FRACTION   C
C               IS POSITIONED ABOVE THE TOTAL YELLOW FRACTION             C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                          INPUT PARAMETERS:                              C
C     NSP     :  NUMBER OF GENOTYPES                                      C
C     NCL     :  NUMBER OF CANOPY LAYERS                                  C
C     AI      :  TOTAL AREA INDICES OF THE VARIOUS GENOTYPES              C
C     YFRAC   :  YELLOW FRACTIONS OF THE TOTAL AREA INDICES               C
C                BELONGING TO THE VARIOUS GENOTYPES                       C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                          OUTPUT PARAMETERS:                             C
C     GAID    :  DISTRIBUTION OF THE GREEN AREA INDEX OF THE CONSIDERED   C
C                SURFACE TYPE OVER CANOPY LAYERS AND COMPETITORS          C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL (A-Z)
      INTEGER NSP,NCL,A,K
      DIMENSION AI    (NSP)
      DIMENSION GAID  (NSP*NCL)
      DIMENSION YFRAC (NSP)
         DO 1914 A = 1,NSP
         XCUMGR = 0.
         XGRAI  = AI(A) * (1.-YFRAC(A))
            DO 1915 K = A, (NCL-1) * NSP + A, NSP
            GAID (K) = LIMIT (0.,GAID(K), XGRAI - XCUMGR)
            XCUMGR  = XCUMGR + GAID(K)
1915        CONTINUE
1914     CONTINUE
      RETURN
      END

      SUBROUTINE YELDI2 (NSP,NCL,GAID,YFRAC)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C   SUBROUTINE DERIVING THE DISTRIBUTION OF THE GREEN FRACTION OF A       C
C       SURFACE TYPE OVER CANOPY LAYERS AND COMPETITORS FROM THE          C
C          CORRESPONDING DISTRIBUTION OF THE TOTAL SURFACE AREA;          C
C   THE DERIVATION REFLECTS THE SITUATION THAT THE GREEN FRACTION         C
C         IS DISTRIBUTED UNIFORMLY FROM GROUND TO PLANT TOP               C
C               IS POSITIONED ABOVE THE TOTAL YELLOW FRACTION             C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                          INPUT PARAMETERS:                              C
C     NSP     :  NUMBER OF GENOTYPES                                      C
C     NCL     :  NUMBER OF CANOPY LAYERS                                  C
C     YFRAC   :  YELLOW FRACTIONS OF THE TOTAL AREA INDICES               C
C                BELONGING TO THE VARIOUS GENOTYPES                       C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                          OUTPUT PARAMETERS:                             C
C     GAID    :  DISTRIBUTION OF THE GREEN AREA INDEX OF THE CONSIDERED   C
C                SURFACE TYPE OVER CANOPY LAYERS AND COMPETITORS          C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
```

```
      IMPLICIT REAL (A-Z)
      INTEGER NSP,NCL,A,K
      DIMENSION GAID (NSP * NCL)
      DIMENSION YFRAC (NSP)
         DO 8001 A = 1,NSP
            DO 8002 K = A, (NCL-1) * NSP + A, NSP
            GAID (K) = GAID (K) * (1. - YFRAC(A))
8002        CONTINUE
8001     CONTINUE
      RETURN
      END

      SUBROUTINE ASTRO(DAY,LAT,DTR,DAYL,SININT,
     $                 SINLD,COSLD)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C     SUBROUTINE CALCULATING THE DAYLENGTH [H] AND 3 AUXILIARY VARIABLES  C
C     NEEDED FOR DESCRIBING THE INSTANTANEOUS RADIATION FOR A GIVEN       C
C                      TIMEPOINT OF THE DAY                               C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                     INPUT PARAMETERS:                                   C
C      DAY    :  NUMBER OF CALENDAR DAY                                   C
C      LAT    :  LATITUDE OF LOCATION                                     C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                     OUTPUT PARAMETERS:                                  C
C     DAYL    :  DAYLENGTH                                            [H] C
C     SINLD   :  AUXILIARY VARIABLE                                       C
C     COSLD   :  AUXILIARY VARIABLE                                       C
C     SININT  ;  AIXILIARY VARIABLE                                       C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL(A-Z)
      PI=3.1415926
      RAD=PI/180.
      DEC=-23.45*COS(2*PI*(DAY+10.)/365.)
      SINLD=SIN(RAD*LAT)*SIN(RAD*DEC)
      COSLD=COS(RAD*LAT)*COS(RAD*DEC)
      AOB=SINLD/COSLD
      DAYL=12.0*(1.0+2.0*ASIN(AOB)/PI)
      SININT=DAYL*(SINLD+0.4*(SINLD*SINLD+COSLD*COSLD*0.5) ) +
     $12.0*COSLD*(2.0+3.0*0.4*SINLD)*SQRT(1.0-AOB*AOB)/PI
      RETURN
      END

      SUBROUTINE FRADIF (DAY,DTR,DAYL,SINLD,COSLD,FRDFD)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C     SUBROUTINE CALCULATING THE DIFFUSE FRACTION OF DAILY VISIBLE        C
C                             RADIATION                                   C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                     INPUT PARAMETERS:                                   C
C      DAY    :  NUMBER OF CALENDAR DAY                                   C
C      DTR    :  DAILY GLOBAL RADIATION                         [J/M**2/D] C
C      DAYL   :  DAYLENGTH                                            [H] C
C      SINLD  :  AUXILIARY VARIABLE                                       C
C      COSLD  :  AUXILIARY VARIABLE                                       C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                     OUTPUT PARAMETERS:                                  C
C      FRDFD  :  DIFFUSE FRACTION OF DAILY VISIBLE RADIATION              C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL(A-Z)
      PI=3.1415926
C     SOLAR CONSTANT (J/M**2/S)
      SC = 1370.
      SCACT = SC * (1. + 0.033 * COS(360.*DAY/365.))
C     AVERAGE SINE OF SOLAR ALTITUDE
      INTBET= 3600. * (DAYL * SINLD + 24./PI * COSLD *
     $          SQRT(1.- (SINLD/COSLD)**2))
C     EXTRATERRESTRIAL IRRADIATION (J/M**2/D)
      EXTEIR= INTBET * SCACT
C     ATMOSPHERIC TRANSMISSION ON DAY BASIS
      ATD    = DTR / EXTEIR
```

```
C     FRACTION DIFFUSE LIGHT ON DAY BASIS
      IF (ATD.GE.0.35)  FRDF = 1.33 - 1.46 * ATD
      IF (ATD.LT.0.35)  FRDF = 1.   - 2.3  * (ATD-0.07)**2
      FRDFD  =  LIMIT(0.23,1.,FRDF)
      RETURN
      END

       SUBROUTINE INSTIR (DAYL,HOUR,DTR,FRDFD,SINLD,COSLD,SININT,
     $                    IRR,SINB,FRDR)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C     SUBROUTINE CALCULATING THE SINE OF SUN HEIGHT AND THE INTENSITY    C
C     [J/M**2/S]    AND DIRECT FRACTION OF INSTANTANEOUS VISIBLE         C
C                         RADIATION                                      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                     INPUT PARAMETERS:                                  C
C      DAYL   :  DAYLENGTH                                           [H] C
C      HOUR   :  ACTUAL HOUR OF THE DAY                                  C
C      DTR    :  DAILY GLOBAL RADIATION                       [J/M**2/D] C
C      FRDFD  :  DIFFUSE FRACTION OF DAILY VISIBLE RADIATION             C
C      SINLD  :  AUXILIARY VARIABLE                                      C
C      COSLD  :  AUXILIARY VARIABLE                                      C
C      SININT :  AUXILIARY VARIABLE                                      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                     OUTPUT PARAMETERS:                                 C
C      IRR    :   INTENSITY OF INSTANTANEOUS VISIBLE RADIATION [J/M**2/S] C
C      FRDR   :   DIRECT FRACTION OF VISIBLE RADIATION                   C
C      SINB   :   SINE OF SUN HEIGHT                                     C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL (A-Z)
      PI = 3.1415926
         SINB = AMAX1(0.,SINLD + COSLD * COS(2. *
     1             PI * (HOUR+12.)/24.))
         SFF = SINB * (1. + 0.4 * SINB)
         IRR = SFF * DTR * 0.5 / (SININT * 3600.)
         AUXFRD= (1. - FRDFD)  *   (1.08 - 0.0095 *
     $               EXP (4.6 * (HOUR-12.) / (0.5*DAYL)))
         FRDR = LIMIT(0.,1.,AUXFRD)
3000     CONTINUE
      RETURN
      END

      SUBROUTINE PHOTOC (NCL, NSP, DNSP, V, STESWI, EARSWI,
     1                   LAIFIX,SAIFIX, EAIFIX,  LAIL, ECDIF,
     1                   KL, KLSTEM, KLEAR,
     1                   AMAX,SAMAX,EAMAX, EFF, SEFF, EEFF,
     1                   IRR, FRDR, SINB, PROD)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                       SUBROUTINE CALCULATING                           C
C       I N S T A N T A N E O U S   RATES OF GROSS ASSIMILATION [KG/HA/H] C
C     OF NSP COMPETITORS FORMING A CANOPY DESCRIBED IN TERMS OF NCL      C
C     CANOPY LAYERS; OPTIONALLY, THE PHOTOSYNTHESIS OF STEMS AND EARS    C
C     CAN BE INCLUDED                                                    C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                     INPUT PARAMETERS:                                  C
C      IRR    :  INTENSITY OF VISIBLE RADIATION               [J/M**2/S] C
C      FRDR   :  DIRECT FRACTION OF VISIBLE RADIATION                    C
C      SINB   :  SINUS OF SUN HEIGHT                                     C
C                                                                        C
C      THE OTHER INPUT PARAMETERS ARE EXPLAINED IN THE HEAD PART OF      C
C                       THE SUBROUTINE    D A Y A S S                    C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                     OUTPUT PARAMETERS:                                 C
C     PROD    :  INSTANTANEOUS ASSIMILATION RATES OF THE NSP SPECIES     C
C                                                           [KG/HA/H]  C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
```

```
      IMPLICIT REAL (A-Z)
      INTEGER G,K,A,DNSP,NSP,V,NCL,C,STESWI,EARSWI
      DIMENSION LAIFIX  (NCL*NSP)
      DIMENSION SAIFIX  (NCL*NSP)
      DIMENSION EAIFIX  (NCL*NSP)
      DIMENSION LAIL    (NCL)
      DIMENSION ECDIF   (NCL)
      DIMENSION V       (NSP)
      DIMENSION KL      (DNSP)
      DIMENSION KLSTEM  (DNSP)
      DIMENSION KLEAR   (DNSP)
      DIMENSION AMAX    (DNSP)
      DIMENSION SAMAX   (DNSP)
      DIMENSION EAMAX   (DNSP)
      DIMENSION EFF     (DNSP)
      DIMENSION SEFF    (DNSP)
      DIMENSION EEFF    (DNSP)
      DIMENSION PROD    (NSP)
C     SCATTERING COEFFICIENT (ASSUMED TO BE EQUAL FOR ALL LIGHT
C     ABSORBING STRUCTURES
      SCV = 0.2
C     AN AUXILIARY VARIABLE ("SQV")
      SQV = SQRT (1. - SCV)
C     REFLECTION COEFFICIENT OF THE CANOPY
      REFLC = (1. - SQV) / (1. + SQV)
C     INTENSITIES (J/CM**2/S) OF DIRECT LIGHT ("DIR") AND OF INDIRECT
C     LIGHT ("DIF") ABOVE THE CANOPY AT THE CONSIDERED TIMEPOINT
         DIF = IRR * (1.- FRDR)  *   (1. - REFLC)
         DIR = IRR * FRDR
            DO 4 A = 1,NSP
            PROD(A) = 0.
4           CONTINUE
C     MULTIPLICATION FACTORS FOR CONVERTING THE EXTINCTION OF DIFFUSE
C     LIGHT  INTO THE EXTINCTION OF LIGHT INTENSITY WHEN THE INCOMING
C     RADIATION IS DIRECT ("CONDRF") AND INTO THE EXTINCTION OF
C     THE DIRECT COMPONENT OF INCOMING DIRECT RADIATION ("CONDIR")
C     (CONDRF = KDRF/KDIR, CONDIR = KDIR/KDIF)
         CONDIR = 0.5 / (SINB * SQV * 0.8)
         CONDRF = CONDIR * SQV
C     FRACTION OF LIGHT ENTERING THE CANOPY
         DIFOUT = 1.
C     LOOP ACCOUNTING FOR THE DIFFERENT LEAF LAYERS
            DO 2 K = 1,NCL
C     KDIF AND KDIR OF THE COMPOSITE LEAF LAYER, OBTAINED BY
C     AVERAGING THE LAI-WEIGHTED VALUES OF THE CONTRIBUTING
C     SPECIES (USED FOR CALCULATING THE SUNLIT LEAF AREA)
      IF (LAIL(K).LT.1.E-4)   THEN
         TYPE 5011,K
5011     FORMAT (' CANOPY LAYER ',I5,' WITH LAIL = 0 ')
         GOTO 2
      ENDIF
      IF (ECDIF(K).LT.1.E-4)  THEN
          TYPE 5012,K
5012      FORMAT (' CANOPY LAYER',I5,' WITH ECDIF = 0 ')
          GOTO 2
      ENDIF
            KDIF = ECDIF(K) / LAIL(K)
            KDIR = KDIF * CONDIR
C     FRACTIONS  OF DIFFUSE LIGHT ENTERING (DIFIN) AND LEAVING
C     (DIFOUT) THE CONSIDERED LEAF LAYER
            DIFIN  = DIFOUT
            DIFOUT = DIFIN * EXP(-ECDIF(K))
C     FRACTION OF DIFFUSE LIGHT ABSORBED IN THE LAYER ("ADIF"),
C     OF DIRECT LIGHT ABSORBED IN THE LAYER AS DIRECT LIGHT ("ADDIR")
C     AND OF DIRECT LIGHT ABSORBED IN THE LAYER AS DIRECT OR
```

```
C     INDIRECT LIGHT ("ATDIR")  (1/S)
           ADIF  = DIFIN           -  DIFOUT
           EDDIR = DIFIN**CONDIR   -  DIFOUT**CONDIR
           ADDIR = EDDIR  * (1.-SCV)
           ATDIR = (DIFIN**CONDRF  -  DIFOUT**CONDRF) * (1.-REFLC)
C     FRACTION OF SUNLIT LEAF AREA IN THE LAYER
           SLLA  = EDDIR / (KDIR*LAIL(K)) * KDIF/SQV/0.8
           IF (SLLA.LT.1.E-10)  THEN
              TYPE 5020
5020          FORMAT (' SLLA = 0 ')
              GOTO 2
           ENDIF
C     ABSORPTION RATE (J/S) OF THE SUNLIT PART OF THE LEAF LAYER ("SUNA")
C     AND OF THE SHADOWED PART ("SHAA") (1/S)
           SUMDIF = DIF * ADIF  + DIR * (ATDIR-ADDIR)
           SHAA   = SUMDIF * (1. - SLLA)
           SUNA   = SLLA * SUMDIF  + DIR * ADDIR

C      ***    ASSIMILATION PERFORMED BY LEAVES    ***
              DO 3 A = 1,NSP
              L = V(A)
              C = (K-1) * NSP + A
              LEAFAR  =  LAIFIX (C)
C     ABSORPTION RATE (J/CM**2 LEAF/S) OF SUNLIT LEAVES ("ABSDIR")
C     AND OF SHADED LEAVES ("ABSDIF")
             ABSDIR = SUNA * KL(L)/(ECDIF(K)  *   SLLA)
             ABSDIF = SHAA * KL(L)/(ECDIF(K)  * (1. - SLLA))
C      THE ASSIMILATION OF SUNLIT AND SHADED LEAFAREA IS
C      ADDED TO THE OVERALL PRODUCTION OF THE SPECIES WITHIN
C      THE CONSIDERED LEAF LAYER
             IF (AMAX(L).LT.1.E-3)   THEN
                TYPE 5014,L
5014            FORMAT (' SPECIES ',I5,' WITH AMAX = 0 ! ')
                GOTO 3
             ENDIF
             PROD1  = AMAX(L) * (1. - EXP(-EFF(L)*ABSDIF/AMAX(L)))
             PROD2  = AMAX(L) * (1. - EXP(-EFF(L)*ABSDIR/AMAX(L)))
             PROD(A)= PROD(A) + LEAFAR *
     $                  (SLLA*PROD2 + (1. - SLLA) * PROD1)
3            CONTINUE
         IF (STESWI.EQ.0)   GOTO 80
C      ***    ASSIMILATION PERFORMED BY STEMS     ***
C      ABSORPTION RATE (J/CM**2 STEM/S) OF SUNLIT STEMAREA ("STADIR")
C      AND OF SHADED STEMAREA ("STADIF")
           STADIR =  SUNA * KLSTEM(L)/(ECDIF(K) * SLLA)
           STADIF =  SHAA * KLSTEM(L)/(ECDIF(K) * (1. - SLLA))
C      THE ASSIMILATION OF SUNLIT AND SHADED STEMAREA IS
C      ADDED TO THE OVERALL PRODUCTION OF THE SPECIES WITHIN
C      THE CONSIDERED LEAF LAYER
              DO 70 A = 1,NSP
              L = V(A)
              C = (K-1) * NSP + A
              STEMAR  =  SAIFIX (C)
             IF (SAMAX(L).LT.1.E-3)   THEN
                TYPE 5015,L
5015            FORMAT (' SPECIES ',I5,' WITH SAMAX = 0 ! ')
                GOTO 70
             ENDIF
              PROD1 = SAMAX(L)*(1.- EXP(-SEFF(L) * STADIF/SAMAX(L)))
              PROD2 = SAMAX(L)*(1.- EXP(-SEFF(L) * STADIR/SAMAX(L)))
              PROD(A)   =   PROD(A) + STEMAR *
     1                    (SLLA * PROD2 + (1. - SLLA) * PROD1)
70            CONTINUE
80         IF (EARSWI.EQ.0)  GOTO  2
```

```
C     INDIRECT LIGHT ("ATDIR")  (1/S)
            ADIF  = DIFIN          -  DIFOUT
            EDDIR = DIFIN**CONDIR   -  DIFOUT**CONDIR
            ADDIR = EDDIR  * (1.-SCV)
            ATDIR = (DIFIN**CONDRF  -  DIFOUT**CONDRF) * (1.-REFLC)
C     FRACTION OF SUNLIT LEAF AREA IN THE LAYER
            SLLA  = EDDIR / (KDIR*LAIL(K)) * KDIF/SQV/0.8
            IF (SLLA.LT.1.E-10)  THEN
               TYPE 5020
5020           FORMAT (' SLLA = 0 ')
               GOTO 2
            ENDIF
C     ABSORPTION RATE (J/S) OF THE SUNLIT PART OF THE LEAF LAYER ("SUNA")
C     AND OF THE SHADOWED PART ("SHAA") (1/S)
            SUMDIF = DIF * ADIF  + DIR * (ATDIR-ADDIR)
            SHAA   = SUMDIF * (1. - SLLA)
            SUNA   = SLLA * SUMDIF  + DIR * ADDIR

C      ***    ASSIMILATION PERFORMED BY LEAVES    ***
              DO 3 A = 1,NSP
              L = V(A)
              C = (K-1) * NSP + A
              LEAFAR  =  LAIFIX (C)
C     ABSORPTION RATE (J/CM**2 LEAF/S) OF SUNLIT LEAVES ("ABSDIR")
C     AND OF SHADED LEAVES ("ABSDIF")
              ABSDIR = SUNA * KL(L)/(ECDIF(K)  *   SLLA)
              ABSDIF = SHAA * KL(L)/(ECDIF(K)  * (1. - SLLA))
C      THE ASSIMILATION OF SUNLIT AND SHADED LEAFAREA IS
C      ADDED TO THE OVERALL PRODUCTION OF THE SPECIES WITHIN
C      THE CONSIDERED LEAF LAYER
              IF (AMAX(L).LT.1.E-3)   THEN
                 TYPE 5014,L
5014             FORMAT (' SPECIES ',I5,' WITH AMAX = 0 ! ')
                 GOTO 3
              ENDIF
              PROD1  = AMAX(L) * (1. - EXP(-EFF(L)*ABSDIF/AMAX(L)))
              PROD2  = AMAX(L) * (1. - EXP(-EFF(L)*ABSDIR/AMAX(L)))
              PROD(A)= PROD(A) + LEAFAR *
     $                   (SLLA*PROD2 + (1. - SLLA) * PROD1)
3             CONTINUE
         IF (STESWI.EQ.0)   GOTO 80
C      ***    ASSIMILATION PERFORMED BY STEMS     ***
C      ABSORPTION RATE (J/CM**2 STEM/S) OF SUNLIT STEMAREA ("STADIR")
C      AND OF SHADED STEMAREA ("STADIF")
            STADIR =  SUNA * KLSTEM(L)/(ECDIF(K) * SLLA)
            STADIF =  SHAA * KLSTEM(L)/(ECDIF(K) * (1. - SLLA))
C      THE ASSIMILATION OF SUNLIT AND SHADED STEMAREA IS
C      ADDED TO THE OVERALL PRODUCTION OF THE SPECIES WITHIN
C      THE CONSIDERED LEAF LAYER
              DO 70 A = 1,NSP
              L = V(A)
              C = (K-1) * NSP + A
              STEMAR  =  SAIFIX (C)
              IF (SAMAX(L).LT.1.E-3)   THEN
                 TYPE 5015,L
5015             FORMAT (' SPECIES ',I5,' WITH SAMAX = 0 ! ')
                 GOTO 70
              ENDIF
              PROD1 = SAMAX(L)*(1.- EXP(-SEFF(L) * STADIF/SAMAX(L)))
              PROD2 = SAMAX(L)*(1.- EXP(-SEFF(L) * STADIR/SAMAX(L)))
              PROD(A)   =   PROD(A) + STEMAR *
     1                   (SLLA * PROD2 + (1. - SLLA) * PROD1)
70            CONTINUE
80          IF (EARSWI.EQ.0)  GOTO  2
```

```
C     INDIRECT LIGHT ("ATDIR")  (1/S)
            ADIF  = DIFIN          -  DIFOUT
            EDDIR = DIFIN**CONDIR   -  DIFOUT**CONDIR
            ADDIR = EDDIR  * (1.-SCV)
            ATDIR = (DIFIN**CONDRF  -  DIFOUT**CONDRF) * (1.-REFLC)
C     FRACTION OF SUNLIT LEAF AREA IN THE LAYER
            SLLA  = EDDIR / (KDIR*LAIL(K)) * KDIF/SQV/0.8
            IF (SLLA.LT.1.E-10)  THEN
               TYPE 5020
5020           FORMAT (' SLLA = 0 ')
               GOTO 2
            ENDIF
C     ABSORPTION RATE (J/S) OF THE SUNLIT PART OF THE LEAF LAYER ("SUNA")
C     AND OF THE SHADOWED PART ("SHAA") (1/S)
            SUMDIF = DIF * ADIF  + DIR * (ATDIR-ADDIR)
            SHAA   = SUMDIF * (1. - SLLA)
            SUNA   = SLLA * SUMDIF  + DIR * ADDIR

C      ***    ASSIMILATION PERFORMED BY LEAVES    ***
               DO 3 A = 1,NSP
               L = V(A)
               C = (K-1) * NSP + A
               LEAFAR  =  LAIFIX (C)
C     ABSORPTION RATE (J/CM**2 LEAF/S) OF SUNLIT LEAVES ("ABSDIR")
C     AND OF SHADED LEAVES ("ABSDIF")
              ABSDIR = SUNA * KL(L)/(ECDIF(K)  *   SLLA)
              ABSDIF = SHAA * KL(L)/(ECDIF(K)  * (1. - SLLA))
C      THE ASSIMILATION OF SUNLIT AND SHADED LEAFAREA IS
C      ADDED TO THE OVERALL PRODUCTION OF THE SPECIES WITHIN
C      THE CONSIDERED LEAF LAYER
              IF (AMAX(L).LT.1.E-3)   THEN
                 TYPE 5014,L
5014             FORMAT (' SPECIES ',I5,' WITH AMAX = 0 ! ')
                 GOTO 3
              ENDIF
              PROD1  = AMAX(L) * (1. - EXP(-EFF(L)*ABSDIF/AMAX(L)))
              PROD2  = AMAX(L) * (1. - EXP(-EFF(L)*ABSDIR/AMAX(L)))
              PROD(A)= PROD(A) + LEAFAR *
     $                   (SLLA*PROD2 + (1. - SLLA) * PROD1)
3             CONTINUE
         IF (STESWI.EQ.0)   GOTO 80
C      ***      ASSIMILATION PERFORMED BY STEMS      ***
C      ABSORPTION RATE (J/CM**2 STEM/S) OF SUNLIT STEMAREA ("STADIR")
C      AND OF SHADED STEMAREA ("STADIF")
            STADIR =  SUNA * KLSTEM(L)/(ECDIF(K) * SLLA)
            STADIF =  SHAA * KLSTEM(L)/(ECDIF(K) * (1. - SLLA))
C      THE ASSIMILATION OF SUNLIT AND SHADED STEMAREA IS
C      ADDED TO THE OVERALL PRODUCTION OF THE SPECIES WITHIN
C      THE CONSIDERED LEAF LAYER
               DO 70 A = 1,NSP
               L = V(A)
               C = (K-1) * NSP + A
               STEMAR  =  SAIFIX (C)
              IF (SAMAX(L).LT.1.E-3)   THEN
                 TYPE 5015,L
5015             FORMAT (' SPECIES ',I5,' WITH SAMAX = 0 ! ')
                 GOTO 70
              ENDIF
               PROD1 = SAMAX(L)*(1.- EXP(-SEFF(L) * STADIF/SAMAX(L)))
               PROD2 = SAMAX(L)*(1.- EXP(-SEFF(L) * STADIR/SAMAX(L)))
               PROD(A)  =  PROD(A) + STEMAR *
     1                      (SLLA * PROD2 + (1. - SLLA) * PROD1)
70             CONTINUE
80          IF (EARSWI.EQ.0)  GOTO  2
```

```
      SUBROUTINE LNDCAL (NSP,OGBMPP,PROB,LNDVBM,DUM)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C           SUBROUTINE  CALCULATING  DELTA - LN - VALUES                 C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                     INPUT PARAMETERS:                                  C
C     NSP     :  NUMBER OF GENOTYPES                                     C
C     OBBMPP  :  ABOVE GROUND BIOMASS PER PLANT                      [G] C
C     PROB    :  FREQUENCIES OF THE GENOTYPES                            C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                     OUTPUT PARAMETERS:                                 C
C     LNDBVBM :  DELTA - LN - VALUES                                     C
C     DUM     :  DUMMY VARIABLE                                          C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL (A-Z)
      INTEGER NSP,A
      DIMENSION OGBMPP(NSP)
      DIMENSION PROB  (NSP)
      DIMENSION LNDVBM(NSP)
      IF (NSP.EQ.1) GOTO 7020
      SUMLN = 0.
         DO 851 A = 1,NSP
         IF   (OGBMPP(A).LT.1.E-3)   GOTO 851
         SUMLN = SUMLN + ALOG(OGBMPP(A)) * PROB(A)
851      CONTINUE
      AVLN = SUMLN
         DO 852 A = 1,NSP
         LNDVBM(A) = ALOG(AMAX1(6.73795E-3, OGBMPP(A))) - AVLN
852      CONTINUE
7020  CONTINUE
      RETURN
      END
ENDJOB
```

```
C      CALCULATE INSTANTANEOUS ASSIMILATION RATES OF THE NSP COMPETITORS
C      (KG CHO / HA / HA)
          CALL PHOTOC (NCL,NSP,DNSP,V,STESWI,EARSWI,LAID,SAID,EAID,
     1          LAIL,ECDIF,KL,KLSTEM,KLEAR,AMAX,SAMAX,EAMAX,EFF,SEFF,
     1          EEFF,IRR,FRDR,SINB,
     1                INSTAS)
          INST1 = INSTAS(1)
C       WEIGHTED SUMMATION OF INSTANTANEOUS ASSIMILATION RATES
             DO 5 A = 1,NSP
             GASSP(A) = GASSP(A) + INSTAS(A) * WEIGHT(G)
5            CONTINUE
6000      CONTINUE
       WRITE (20,2620) FRDFD,DIR(1),DIR(2),DIR(3),INTENS(1),
     1                  INTENS(2),INTENS(3),SNUS(1),SNUS(2),SNUS(3)
2620   FORMAT (10(F11.5))
C       FINISHING THE INTEGRATION PROCEDURE
          DO 6 A=1,NSP
          GASSP(A) = GASSP(A) / 3.6 * DAYL
6         CONTINUE
       RETURN
       END

       SUBROUTINE EVAL1 (DIM,ARR,PROB,EXVA,VAR,CV)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C    SUBROUTINE  CALCULATING EXPECTION VALUE, VARIACE AND THE COEFFICIENT  C
C                      OF VARIATION OF A CHANCE VARIABLE                   C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                        INPUT PARAMETERS:                                 C
C      DIM     :  NUMBER OF VALUES OF THE CHANCE VARIABLE                  C
C      ARR     :  VALUES OF THE CHANCE VARIABLE                            C
C      PROB    :  PROBABILITIES ASSOCIATED WITH THE VALUES                 C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                        OUTPUT PARAMETERS:                                C
C      EXVA    :  EXPECTATION VALUE                                        C
C      VAR     :  VARIANCE                                                 C
C      CV      :  COEFFICIENT OF VARIATION                                 C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
       IMPLICIT REAL (A-Z)
       INTEGER DIM,J
       DIMENSION ARR (DIM)
       DIMENSION PROB(DIM)
       IF (DIM.EQ.1 )  THEN
          EXVA = ARR(1)
          VAR  = 0.
       ELSE
          SUMX = 0.
          SUMXX = 0.
             DO 851 J = 1,DIM
             SUMX  = SUMX   +  ARR(J)      * PROB(J)
             SUMXX = SUMXX  +  ARR(J)**2   * PROB(J)
851          CONTINUE
          EXVA = SUMX
          VAR  = SUMXX - SUMX**2
       ENDIF
       IF (EXVA.LT.1.E-8)  GOTO 9013
       IF (VAR. LT.1.E-8)   THEN
          CV = 0.
       ELSE
          CV = SQRT(VAR) / EXVA
       ENDIF
9013   CONTINUE
       RETURN
       END
```

```
C       ***    ASSIMILATION PERFORMED BY EARS    ***
C       ABSORPTION RATE  (J/CM**2 EAR/S) OF SUNLIT EARARE ("EARDIR")
C       AND OF SHADED EARARE ("EARDIF")
             EARDIR =  SUNA * KLEAR(L) / (ECDIF(K) *       SLLA)
             EARDIF =  SHAA * KLEAR(L) / (ECDIF(K) * (1. - SLLA))
C       THE ASSIMILATION OF SUNLIT AND SHADED EARAREA IS
C       ADDED TO THE OVERALL PRODUCTION OF THE SPECIES WITHIN
C       THE CONSIDERED LEAF LAYER
                  DO 75 A = 1,NSP
                  L = V(A)
                  C = (K-1) * NSP + A
                  EARAR  =  EAIFIX  (C)
               IF (EAMAX(L).LT.1.E-3)   THEN
                  TYPE 5016,L
5016              FORMAT (' SPECIES ',I5,' WITH EAMAX = 0 ! ')
                  GOTO 75
               ENDIF
                  PROD1 = EAMAX(L)*(1.-EXP(-EEFF(L)* EARDIF/EAMAX(L)))
                  PROD2 = EAMAX(L)*(1.-EXP(-EEFF(L)* EARDIR/EAMAX(L)))
                  PROD(A)  =  PROD(A) + EARAR *
     1                        (SLLA * PROD2 + (1. - SLLA) * PROD1)
75                CONTINUE
2           CONTINUE
C       NOW THE LOOP HAS GONE THROUGH ALL LEAF LAYERS AND ALL COMPETITORS
          DO 85 A = 1,NSP
          PROD(A) = PROD(A) * 30. / 44.
85        CONTINUE
      RETURN
      END

      SUBROUTINE DAYASS (DAY,DTR,LAT,NCL,NSP,DNSP,V,STESWI,EARSWI,
     $                   LAID,SAID,EAID,LAIL,ECDIF,
     $                   KL,KLSTEM,KLEAR,
     $                   AMAX,SAMAX,EAMAX,EFF,SEFF,EEFF,
     $                   GASSP,DUM,DAYL,IRR,INST1,FRDFD,FRDR)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                 SUBROUTINE CALCULATING THE                          C
C               D A I L Y   GROSS ASSIMILATION        [KG/HA/D]       C
C     OF NSP COMPETITORS FORMING A CANOPY DESCRIBED IN TERMS OF NCL   C
C     CANOPY LAYERS; OPTIONALLY, THE PHOTOSYNTHESIS OF STEMS AND EARS C
C     CAN BE INCLUDED                                                 C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                     INPUT PARAMETERS:                               C
C      DAY    :  NUMBER OF CALENDAR DAY                               C
C      DTR    :  DAILY GLOBAL RADIATION                   [J/M**2/D]  C
C      LAT    :  LATITUDE OF LOCATION                                 C
C      NCL    :  NUMBER OF DESCRIBED CANOPY LAYERS                    C
C      NSP    :  NUMBER OF SPECIES MODELLED IN THE PRESENT CASE       C
C      DNSP   :  NUMBER OF SPECIES DESCRIBED IN THE PARAMETER         C
C                SECTION OF THE MAIN PROGRAMM                         C
C      V      :  ARRAY RELATING THE NUMBER USED TO DENOTE             C
C                A SPECIES IN THE PARAMETER SECTION OF THE MAIN       C
C                PROGRAM TO THE NUMBER USED IN THE ACTUAL RUN         C
C      STESWI,                                                        C
C      EARSWI :  SWITCH PARAMETERS DETERMINING IF PHOTOSYNTHESIS OF   C
C             :  STEMS (EARS) IS TO BE INCLUDED                       C
C      LAID   :  DISTRIBUTION OF LAI (GREEN LEAVES ONLY) OVER SPECIES C
C                AND LAEF LAYER                                [HA/HA] C
C      SAID   :                                                       C
C      EAID   :  AS LAIFIX, BUT FOR GREEN STEM AND GREEN              C
C                EAR AREA                                      [HA/HA] C
C                (IF PHOTOSYNTHESIS OF STEMS (EARS) IS TO BE NEGLECTED, C
C                SAIFIX (EAIFIX) MAY BE ANY DUMMY ARRAY WITH A DIMENSION C
C                GREATER OR EQUAL "NSP*NCL" (THUS FOR EXAMPLE "LAIFIX") C
C      LAIL   :  CONTAINS FOR EACH OF THE NCL CANOPY LAYERS THE       C
C                SUM OF AREA INDICES BELONGING TO ABSORBING SURFACES  C
C                (LEAVES, STEMS, EARS...) POSITIONED IN IT     [HA/HA] C
C      ECDIF  :  AS LAIL, BUT THE CONTRIBUTING AREA INDICES ARE       C
C                MULTIPLIED BY THE CORRESPONDING EXTINCTION           C
C                COEFFICIENTS FOR DIFFUSE LIGHT                [HA/HA] C
```

```
C       KL,                                                             C
C       KLSTEM,                                                         C
C       KLEAR  :  EXTINCTION COEFFICIENTS FOR DIFFUSE LIGHT OF LEAVES  C
C                 STEMS, EARS                                           C
C       AMAX,                                                           C
C       SAMAX,                                                          C
C       EAMAX  :  AMAX VALUES OF LEAVES, STEMS, EARS          [KG/HA/D] C
C       EFF,                                                            C
C       SEFF,                                                           C
C       EEFF   :  LIGHT USE EFFICIENCY OF LEAVES,STEMS,EARS            C
C                                              [KG/HA/D/(J/S/M**2)]    C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                    OUTPUT PARAMETERS:                                 C
C      GASSP  :  GROSS ASSIMILATION OF THE NSP SPECIES        [KG/HA/D] C
C      DUM    :  DUMMY PARAMETER                                        C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
      IMPLICIT REAL (A-Z)
      INTEGER G,K,A,DNSP,NSP,V,NCL,C,STESWI,EARSWI
      DIMENSION LAID  (NCL*NSP)
      DIMENSION SAID  (NCL*NSP)
      DIMENSION EAID  (NCL*NSP)
      DIMENSION LAIL    (NCL)
      DIMENSION ECDIF   (NCL)
      DIMENSION V       (NSP)
      DIMENSION KL      (DNSP)
      DIMENSION KLSTEM  (DNSP)
      DIMENSION KLEAR   (DNSP)
      DIMENSION AMAX    (DNSP)
      DIMENSION SAMAX   (DNSP)
      DIMENSION EAMAX   (DNSP)
      DIMENSION EFF     (DNSP)
      DIMENSION SEFF    (DNSP)
      DIMENSION EEFF    (DNSP)
      DIMENSION GASSP   (NSP)
      DIMENSION INSTAS  (27)
      DIMENSION WEIGHT  (3)
      DIMENSION DIR     (3)
      DIMENSION INTENS  (3)
      DIMENSION SNUS   (3)
C     CALCULATE DAYLENGTH AND 3 AUXILIARY VARIABLES WHICH
C     ARE NEEDED FOR DESCRIBING INSTANTANEOUS IRRADIATION
      CALL ASTRO (DAY,LAT,DTR,
     1            DAYL,SININT,SINLD,COSLD)
C     CALCULATE THE DIFFUSE FRACTION OF DAILY IRRADIATION
      CALL FRADIF(DAY,DTR,DAYL,SINLD,COSLD,
     1            FRDFD)
C     WEIGHTING FACTORS USED IN THE 3-POINT GAUSS INTEGRATION
      WEIGHT(1) = 1.
      WEIGHT(2) = 1.6
      WEIGHT(3) = 1.
      XGAUS = SQRT (0.15)
         DO 445 A = 1,NSP
         GASSP(A) = 0.
445      CONTINUE
         DO 6000 G=1,3
C     SELECT TIMEPOINT DURING THE DAY
         HOUR = 12. + DAYL * 0.5 * (0.5 + (G-2.) * XGAUS)
C     DESCRIBE INSTANTANEOUS IRRADIATION (INTENSITY, DIRECT
C     FRACTION AND SINUS OF SUN HEIGHT)
         CALL INSTIR (DAYL,HOUR,DTR,FRDFD,SINLD,COSLD,SININT,
     1                IRR,SINB,FRDR)
         DIR(G)    = FRDR
         INTENS(G) = IRR
         SNUS (G)  = SINB
```