SIMULATION REPORT CABO-TT NO 3

WINTER WHEAT EXPERIMENTS IN THE NETHERLANDS AND ITALY ANALYSED BY THE SUCROS MODEL

V. Marletto and H. van Keulen

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Contents

WINTER WHEAT EXPERIMENTS IN THE NETHERLANDS AND ITALY ANALYSED BY THE SUCROS MODEL

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A B S T R A C T

The results of two sets of experiments on winter wheat, performed in Rome from 1974 to 1976, and in Wageningen, 1983, have been analysed using the crop growth simulation model SUCROS. The model calculates crop production potential from current meteorological data, assuming non-limiting water and nitrogen supply (Level 1). An extended version of the model estimates water stress and its effect on dry matter production (Level 2). In Wageningen the evaporative demand was met thanks to capillary rise from the groundwater table, allowing the crop to attain potential production. A strongly limited assimilation in the 1974 Rome experiment resulted from a post-anthesis water stress, whereas the 1976 experiment was also affected by other growth limiting conditions; most likely the nitrogen supply was too low.

1. INTRODUCTION

After an initial period during which the senior author became acquainted with the philosophy underlying systems analysis and modelling of crop growth and development as conceived in Wageningen, he attempted to achieve a good command of the applications of such an approach.

Systems analysis is based on the concept that the state of a system at any particular point in time can be described quantitatively by state variables and that changes in the system can be expressed in mathematical terms, the rate variables. Such systems normally contain feedbacks as the state of the system at a certain moment depends on the rates in the preceding time, and the current rate is determined by the present state.

A practicle opportunity to apply systems analysis arose from the availability of the SUCROS (9) summary model and several sets of experimental data from different locations and environmental conditions collected with the aim of testing quantitative models of winter wheat growth

SUCROS is designated a summary model (12), which means that all the processes are presented in a simplified way. However, explanatory descriptions for some of the processes such as light interception, gross carbon assimilation, conversion efficiency for photosynthates into structural dry matter and the water balance of the soil are provided. These descriptions are based on a sound knowledge of the physical, physiological, geometrical and biochemical laws underlying these processes; thus these portions of the model never gave rise to problems.

On the other hand there are processes that must be part of the model because of the important role they play in plant behaviour and response to the environment although they are not as yet fully understood. They are included using semi-empirical relations. For instance, the influence of vernalization and photoperiod on pre-anthesis development rate in winter wheat are satisfactorily accounted for if the sowing date falls in early autumn; but the model induces delay in the anthesis date for winter sowings, hence the parameters describing phenology must be adapted for each experiment to match the measurements.

Another major problem is the allocation of dry matter to the various plant organs. In the present model distribution functions are introduced, with the phenological development stage of the crop as the independent variable. These functions are derived from experimental data that show a large variability. This is partly caused by inaccuracies in the data on both the partitioning factors and the development stage. Using these functions in some runs resulted in a simulated leaf area index (LAI) that was double the measured value, without obvious reason.

These remarks present a user's point of view. But a model is developed in order to be used and perhaps a way of judging its relevance and validity may be counting the number of times somebody has tried to use it.

In this study the model has been used as a theoretical "mirror", reflecting the sought-after image of production. This image can be of great value, as it indicates the presence of elements contraining growth, and so enables us to make an estimate of the extent of the damage incurred, comparing the original experiment with the "mirror".

2. THE MODEL

The model used in this study is an adapted version of SUCROS (9). The main difference from the former version is the introduction of three production levels (PL). At PL1, crop production is assumed to be governed by radiation and temperature only (potential production). It is essentially equal to the version presented in (9). The Porter model (13) of winter wheat pheonology has been included, as well as the partitioning factors as summarized by Van Keulen & Seligman (8) from literature data. These functions are presented in Fig. 1. Loss of photosynthetic area due to senescence is mimicked using a constant relative loss rate after anthesis.

At PL2 assimilation is linearly related to the ratio TRA/TRP (actual over potential transpiration). TRP is computed from climatic data using the Penman formula, and taking into account the current leaf area index of the crop. TRA then results from the moisture available to plants in the rooting zone.

To describe the water balance in the soil, the potential rooting zone is divided in three layers and for each layer a water balance is computed according to the following expression:

WLFLi - WLFLi+1 - EVSLi - TRAi + CRISEi (1)

This equation gives the daily rate of change in moisture content (mm d^{-1}) in the i-th layer.

WLFL1 is precipitation; for i=2,3,WLFLi is the water flux into the i-th layer from above; WLFLi > 0 when the influx of moisture would bring the volumetric soil moisture content of the layer above the soil's field capacity (FLD); WLFL4 is drainage. This description assumes instantaneous (within the time step of the model, that is one day) equilibrium of the moisture in the soil.

EVSLi, the contribution of the i-th layer to evaporation from the soil surface, decreases exponentially with depth. In the model evaporation is considered potential, i.e. determined by environmental conditions only on rainy days. Following a rainy day it is described as a linear function of the square root of the number of days since the last rain. Evaporation ceases when the volumetric soil moisture content of the first layer falls below the estimated value of soil moisture content at air dryness.

TRAi, the contribution of the layer to the actual transpiration is computed as follows:

TRAi = TRRM x RTLi x WSEi.

TRRM is potential transpiration per unit root length calculated via the Penman formula;

RTLi is the portion of the total root extension belonging to layeri;

WSEi is a root uptake coefficient derived from a nonlinear function of soil moisture in the wilting point - field capacity range as shown in Fig. 2. It assumes that water is readily available to roots in the upper half of the range, i.e. till about half of the soil moisture between field capacity and wilting point has been depleted. Uptake is progressively more hampered, when moisture gets close to WLT.

When soil moisture in a layer falls below wilting point no water can be taken up by roots (TRAi=0). If this holds for the complete root zone, no assimilation takes place. On the other hand, the ratio TRA/TRP is one when the root zone is at field capacity, resulting in potential assimilation.

The description of the water balance used in the model was developed for semi-arid conditions (16). However, in the area of the Wageningen experiment a relatively shallow water table was present, that contributed to available water in the root zone. To quantify this process a procedure was included to estimate capillary rise into the rooted zone, based on the work of Rijtema (14).

The rate of capillary rise from the ground water table to the layer where the root tip is located, is estimated on the basis of a set of tables referring to different soil texture classes. They can be found in (5) or

(14). The program transforms the tables in functions of pF and distance to the water table as illustrated for one soil type in Figure 3. It is assumed that capillary rise takes place to the layer in which the root tip is located, i.e. the distance is measured from the centre of the layer to the groundwater table. At each time step the layer's pF is estimated, so that CRISEi, the contribution of capillary rise to the water balance of the layer, is obtained by interpolation in the tables, graphically presented in Figure 3.

Production level 3, dealing with the effect of nitrogen on yield, has not been treated in this study.

3. THE EXPERIMENTS

During the 1982-83 growing season an experiment was performed at the experimental farm "De Bouwing" near Wageningen, as part of a study on the effect of nitrogen application regimes on final yield of winter wheat. The experiments and their results have been described in detail (10). The results obtained at the highest N application level (120 kg ha^{-1}) were used to test the performance of the model at Production Levels 1 and 2.

A similar series of field trials, carried out near Rome in the years 1973-76 (2) was considered, to evaluate the response of the model to different climatic conditions. However, great care had to be taken while checking the model output with Rome results, due to the likely occurrence of nitrogen shortage during the experiments.

Daily measurements of meteorological data not far from the fields were available for both sets of experiments. Rome weather data are part of a magnetic tape, compiled by the Deutscher Wetterdienst (3), originating from the "International experiment for the acquisition of crop-weather data" (W.M.O.).

4. RESULTS AND DISCUSSION

4.1 Production level 1: potential production

4.1.1 Dry matter accumulation and leaf area index

In Fig. 4 simulated total dry matter accumulation at PL1 is compared to measurements for both sets of experiments. The measurements refer to comparable sowing rates (90 kg ha^{-1} in Rome, 140 kg ha^{-1} in Wageningen) and to the highest nitrogen dressings. The different climatic characteristics at the two sites result in anthesis taking place some 45 days earlier in Rome than in Wageningen, though the crops were sown in mid-December and beginning of October, respectively.

The simulated dry matter accumulation rate is mainly the result of a positive feedback sequence (initial LAI $\rightarrow$ initial light interception $\rightarrow$ gross assimilation rate $\rightarrow$ dry matter production $\rightarrow$ increase in LAI), so that growth is essentially exponential. Hence, cumulative dry matter is very sensitive to the initial leaf area. That is a critical point because the LAI at emergence is usually estimated from the sowing rate, assuming a 50% loss of seed dry matter by respiration; roots and leaves evenly share in the seed reserves converted into structural dry matter. This procedure applied to the Wageningen experiment resulted in an overestimation of dry matter accumulation and leaf area development. The germination percentage was consequently estimated to be only 60%, presumably due to the high soil moisture content at sowing time. Introduction of a procedure estimating germination rate from environmental and soil data would avoid "guesstimation" and would lead to a more general applicability of the model.

For the Wageningen experiment the simulated dry matter accumulation is in close agreement with the measured values throughout, indicating that potential dry matter production was achieved in the field. As in the PL1 model production is determined only by temperature and radiation, these results indicate that water stress and nutrient shortages did not occur.

For Rome, the simulation at PL1 is far less satisfactory, simulated total dry matter production reaching up to 18.5 t ha^{-1}, slightly higher than in Wageningen, while in the field only 14.5 t ha^{-1} were actually harvested. Such a result could pinpoint to the fact that in Rome potential production was not achieved because of some limiting factor operative from anthesis onwards, roughly. Up to that moment model and experiment are in close agreement.

Fig. 5 is comparable to Fig. 4 but refers to leaf area index.

Simulation closely agrees with the experiments both for Wageningen and for Rome. At the latter site, however, leaf senescence begins very early, well before anthesis, so that even assuming in the model the onset of photosynthetic surface loss at DVS = 0.8 (rather than 1.0 as in the standard run), the decline in the simulated curve shows a 15-day delay.

Leaves have a limited life span, even under optimum growing conditions. However, the physiological principles governing plant morphogenesis are only partly understood and quantitative descriptions are generally lacking. Therefore, the model as such, provides no insight in the reasons leading to leaf and stem surface loss (stem photosynthetic surface consists of the leaf sheaths). In the present model, the process is descriptively taken into account by introducing a constant 2% relative rate of loss of photosynthetic tissue from anthesis (DVS = 1) onwards. The experimental data from Rome, however, suggest again, as indicated before, the presence of some stressing factor(s) that also influence(s) leaf senescence.

Application of the allocation functions used for the Wageningen simulation to the Rome data resulted in a very leafy crop, as already mentioned in the introduction. This result is likely to be attributed to the different temperature regime at the two sites. Temperature has a twofold effect in the model: on the one hand, it governs plant development, modified by photoperiod and vernalization requirements; on the other hand, it affects gross assimilation. However, the effects are not parallel. Allocation is a function of development stage only, and leaves have their highest share of assimilates up to DVS=0.5 (i.e. during winter).

In Wageningen, the low temperatures in the early growth stages reduce both the development rate and the assimilatory activity. In Rome, having higher temperatures, development is faster, but, because of photoperiodic effects, not fast enough to counterbalance the higher assimilation rate, resulting in a high simulated leaf area index. It could well be that the higher temperatures and the associated higher evaporative demand in Rome, affect the partitioning pattern in accordance with the functional balance principle, so as to promote a higher root to shoot ratio. That process would presumably be mediated through crop water status, but as that state variable is not included in the present version of the model, it is not possible to account for its effects directly.

However, to describe the process satisfactorily, it was suggested to reduce the fraction of assimilates allocated to the leaves in the early stages of the season (8). The adapted functions are shown in Table 1, both for Rome and Wageningen. The fraction not accounted for in the function used for Rome was added to the roots up to DVS=0.35 (end of ear initiation) and to the stem from then onwards.

4.1.2 Dry matter distribution

In Rome only total dry matter accumulation, LAI and final grain yield were recorded, so data are lacking to compare the above ground dry matter distribution as calculated, with measured values. However, an observation assessing the model validity is possible. Final grain yield in Rome was 4.9 t ha^{-1}, but total dry matter accumulation after anthesis as estimated from the data was not more than 2.5 t ha^{-1}. Hence, the remainder of the yield must have come from reserves accumulated before anthesis. In the model, total accumulated reserves at anthesist amount to 2.3 t ha^{-1}: agreement is thus very close if it is assumed that this reserve pool was totally available for the growing seeds.

Data on above ground dry matter distribution were regularly collected in Wageningen throughout the season (10). In particular chaff, stem and grain weight are available. Unfortunately, direct comparison with the model output is not possible, due to the structure of the allocation functions used (see Fig. 2). Model output provides values for stem + chaff structural weight and a separate variable takes into account accumulated reserves with no distinction regarding their location, although they will be primarily stored in the stem (up to anthesis) and subsequently be translocated to the seeds (during the grain filling stage). However, it is possible to make an estimate of the missing information. If no water stress occurs, as is presumably the case at PL1, the amount of reserves actually contributing to grain weight represents about 12-15% of the final grain weight (15). On the basis of that assumption, the following set of variables can be calculated: s, reserves remaining in the stem at maturity, g, reserves translocated to grains, w, final seed weight, by solving the following system of linear equations:

$$A = s + g; \quad R = s + w; \quad g = (.12)w,$$

where A and R are constant, being the amount of reserves present at anthesis and at maturity, respectively.

Solving these equations for the Wageningen situation, results in 7.2 t ha^{-1} of stem + chaff weight (7.5 were measured) and 8.2 t ha^{-1} of grain weight (7.7 measured).

4.1.3 Effects of different sowing rates

Fig. 6 shows a comparison of simulations and measurements for Rome, at three different sowing rates in the same year. The medium sowing rate has already been discussed above. In the model, these sowing rates were translated into intitial leaf dry weight values of 7, 20 and 60 kg ha^{-1}, respectively.

Both, simulated total dry matter accumulation (Fig. 6a) and LAI (leaf area index, Fig. 6b) show a distinctly linear response to the exponentially increasing sowing rates. Simulation of LAI can be considered satisfactory, recalling what was said about a stress factor resulting in accelerated loss of leaf photosynthetic tissue. At the lowest sowing rate that effect is absent and the model predictions are very accurate. Simulation at the densest sowing rate is the worst, probably because the model does not take into account competitive effects that could possibly affect both the distribution pattern and the specific leaf weight.

However, some doubt could be expressed about the very high value (LAI=12) reported for day 91, especially considering the fact that almost the same amount of dry matter was measured on that date at medium (M) and high (H) sowing rates. If specific leaf weight is maintained at a constant value at different densities, as in the model, that would imply that the two crops were at a different development stage. The high density crop, H, consisting completely of leaves and the medium density one, M, consisting for 50% of stem. That, however, seems highly unlikely. A combination of experimental error and low model sensitivity seems the best explanation for the poor quality of this simulation.

Although the simulation lines in Fig. 6a match with the first two measurements sets accurately enough, they are shifted downwards with respect to the two subsequent sets. The curves, indeed, show a distinct growth slowdown in the 100-120 day range reflecting a rainy spell well documented in the weather data set. The model seems thus more sensitive to bad weather than the actual crops! No explanation could be found for such a behaviour.

4.2 Production level 2

4.2.1 Wageningen

In the preceding section it was shown that for the Wageningen experiment the results of a simulation run, assuming no water or nitrogen stress, nearly coincided with the measured values of dry matter accumulation. Final dry matter distribution was also estimated with good accuracy. These results would indicate that in the field the crop grew under near optimum conditions of water and nutrient supply.

In order to test that hypothesis the PL2 model was run, where a water balance of the soil is included to assess the influence of possible moisture shortage on production. The first results were disappointing: in the model grain yield decreased tot 7.7 t ha^{-1}, due to the occurrence of water stress from anthesis onwards (up to anthesis the difference between the results of the PL1 and PL2 version was negligible).

However, measurements performed some years before in the field where the experiment was executed, indicated the presence of a groundwater table stabilizing at about 120 cm below the soil surface. The procedure mimicking capillary rise from the groundwater table was then added to the model.

In the model, water stress was then alleviated to a large extent, though the final results (16.3 t ha^{-1} dry matter, 8.9 t ha^{-1} grain yield) were about 1 t lower than in the PL1 version. That is presumably due to the procedure used, which takes into account only capillary rise to the soil layer in which the root tip is located. Thus, towards the end of the growing season capillary rise only contributes moisture to the third layer and the upper two layers are drying up too fast.

The estimated contribution of the water table to the soil water balance in the model adds up to about 70 mm throughout the growing season, 80% of which was being withdrawn during the last 35 days before maturity, to meet the transpirational demand of the crop, which over that period averaged 3 mm d^{-1}.

The result shows that under the experimental conditions in the field, capillary rise must have been a fundamental factor allowing the assimilation process to proceed unhampered throughout the grain filling phase.

4.2.2 Rome 1974

Because regular measurements of soil moisture content at several depths were carried out in Rome, it is possible to test the PL2 model performance, testing the accuracy of the simulated water balance. The discussion is limited to the 1973/74 growing season.

The presence of a stress factor reducing production during the grain filling phase had been deduced from the results of the PL1 runs with the Rome weather data (Section 3.1). With a reasonable degree of certainty it could be concluded that low moisture availability to the root system, from anthesis onwards, was indeed the limiting factor.

The estimates of grain yield and total dry matter production, resulting from the PL2 model runs are reasonably close to the measured values, although some of the features shown by the simulated crop do not agree with the measurements. In Fig. 4 in fact it is shown that simulated total dry matter production at anthesis is some two tons less than measured, and that the simulation "catches up" with reality during the grain filling period.

It should be stressed, however, that measured and simulated LAI are in close agreement, especially in the ascending part of the curve (Figure 5). This could suggest a possible underestimation of net CO_2 assimilation at the high radiation levels for the Italian variety used in the experiments. Fig. 7 shows a comparison between the simulated and measured soil moisture contents in the three soil layers. It shows that the agreement between simulation and field values is closer for the deeper layers (the measured peak values in the third layer must be attributed to experimental errors, as those values exceed by far the measured field capacity and "they cannot be explained by meteorological parameters" as stated in (4)).

The onset of a dry spell at anthesis is clearly visible in the data and is simulated reasonably accurately in the 20-60 and 60-120 cm layers. The simulated drying rate in the 0-20 cm layer is much slower than measured. The contribution of this layer to simulated transpiration in the last 20 days of the season, most likely caused the 1 t ha^{-1} overestimate of final dry matter and grain yield.

The PL2 results presented (Figure 8) were obtained by introducing in the model, from DVS=0.9 onwards, a 20-day delay between the moment leaf area is lost for photosynthesis and the moment it does not contribute any more to transpiration. Usually in the model, the contribution to transpiration of the drying power of the atmosphere is multiplied by a factor ALFA=0.5 to take into account the effect of stomatal closure at night. Reduced control of the stomata in older leaves could then be mimicked by setting ALFA=.75

from DVS=1.2 onwards. The results of these corrections are summarized in Table 2.
Running the PL2 model with the measured soil moisture values as a forcing function, instead of those resulting from the water balance simulation, shows a very good agreement between the simulation and the experiment: simulated total dry matter adds up to 14.3 t ha^{-1} and grain yield is 5.8 t ha^{-1}.

4.2.3 Rome 1975 and 1976

On the basis of the results discussed in the previous paragraph, it is possible to use the PL2 model to illustrate the existence of further constraints to growth in addition to water shortage.

Table 3 shows the negative trend in all measured crop parameters over the three years of the experiment which was carried out at the same field. This trend possibly reflects the existence of nitrogen shortage in the experiments due to the low fertilization rate. In the first year no fertilizer nitrogen was applied but soil fertility was quite high due to the plowing in of an N-fixing crop (alfalfa stubble) grown on the field previously (1). Indeed, the results obtained in the field in that first season could be fully explained on the basis of water shortage only as shown above.

During 1975 and 1976 the highest N application rate was 50 kg ha^{-1} (1/3 at sowing and 2/3 in March) which seems too low to ensure an adequate supply of nitrogen to the crop, considering that the estimated N content of the 1974 crop at harvest would be some 100 kg N ha^{-1}.
However, an attempt to make the existence of N shortage during the 1975 season plausible, failed. The first part of the growing season was very dry, restricting dry matter accumulation to a value as low as 8.5 t ha^{-1} at anthesis. The crop produced, however, some 3 t ha^{-1} during the post-anthesis phase. Soil moisture was sampled down to 1 m only, so that it was impossible to check the performance of the simulated soil water balance. Drought conditions are expected to induce a modification of the rooting system towards a less branched and deeper structure, and to increase the importance of the roots as a sink for assimilates (functional balance; 4).
In the model, however, dry matter allocation and root structure are regulated through fixed functions and parameters, so that a possible response of the rooting system to drought is not simulated.

A discussion about N-shortage in the situation described above would thus be mainly speculative.

Running the PL2 model for the 1976 season produced the results as shown in Figure 7. Simulated grain yield reached about 7 t ha^{-1}, which is almost twice that actually harvested. The same results were obtained running the model with the measured soil moisture contents as a forcing function. Weather conditions in that year were in fact more favourable than in the preceding years: during the grain filling stage total precipitation added up to 123 mm whereas only 11 mm fell in the same period in 1974 and 69 mm in 1975.

So, at least for the 1976 experiment there seems to be a good deal of evidence supporting the conclusion that a strong growth limiting factor was involved in addition to water shortage. Lack of nitrogen could be a likely cause, keeping LAI very low and inducing leaf area losses to begin as early as DVS=0.7, due to translocation of nitrogen from older tissue to young growing tissue.

5. CONCLUSIONS

All the difficulties encountered in the application of the SUCROS model to a practical case study are detailed in this report. The comparison of two sets of experiments carried out with two different varieties of winter wheat, at different locations with different climatic conditions, provided the possibility to point out the model rigidity and incompleteness in some respects. Indeed, modifications of the model structure and of some of its parameters were necessary to arrive at satisfactory descriptions of the real world behaviour.

However, it was also shown that thanks to this model the analysis of the experiments was easily performed with a depth and accuracy that could hardly have been obtained with techniques not involving modelling and by someone who is not an agronomist by training (VM). With the SUCROS dynamic model it was possible to follow the evolution of the crops under the influence of variable and fluctuating environmental conditions, enabling to explain, or at least to make plausible, a good deal of the experimental results.

This is largerly due to the structure of dynamic models: they present the basic plants processes from the point of view of their mutual interactions so that these models can be considered reliable computing and quantification tools.

complexity attainable by agricultural production models. It should be realised of course, that by their very nature, crop growth models are simplified representations of reality. However, they represent a consistent picture about somebody's view on the real world. Although the level of complexity that can be treated at the present state-of-the-art of modelling is limited, some of the existing models deal in great detail with specific aspects of the plant-environment interactions (6,7,15).

SUCROS, being advertised as a summary model deals with less detail with all the processes described in the comprehensive models, that present an explicit and complete picture of the crop. In that way a greater number of potential model users can be reached, increasing the impact of system analysis to agriculture. Such an approach seems the best for countries like Italy, where despite the fact that agricultural research is well developed, a multidisciplinary approach, involving plant physiologists, pathologists, soil scientists and agrometeorologists is still lacking.

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V. Marletto

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DVS	0.	0.2	0.35	0.4	0.5	0.6	0.7	0.8	0.9	1.	1.1	2.1
Wageningen	.475	.685	.785	.755	.515	.32	.22	.125	.07	.02	0.	0.
Rome	.35	.5	.6	.68	.48	.32	.22	.125	.07	.02	0.	0.

Table 1. Fraction of assimilates allocated to leaves, as a function of development stage for Wageningen and Rome.

	The "Standard" Model	Delay introduced	Delay + Stom. opening	Measurements
Final dry matter	16.2	15.5	14.2	14.6
Grain yield	7.3	6.5	5.0	4.9

Table 2. How model performance improved taking into account leaf senescence physiology (Section 3.2.2.).

		1975	1975	1976
Final dry matter	(t ha-1)	14.6	11.4	10.8
Grain Yield	(t ha-1)	4.9	4.4	3.8
Maximum LAI	(-)	5.9	3.5	3.3

Table 3. Measurements of the most important crop parameters in the three years of the Rome experiment.

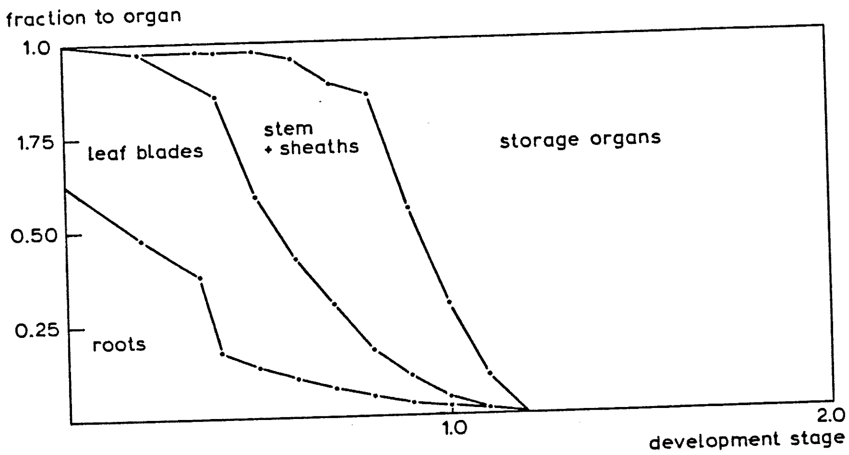

Figure 1. Cumulative partitioning pattern for various organs of winter wheat, as a function of the development stage.

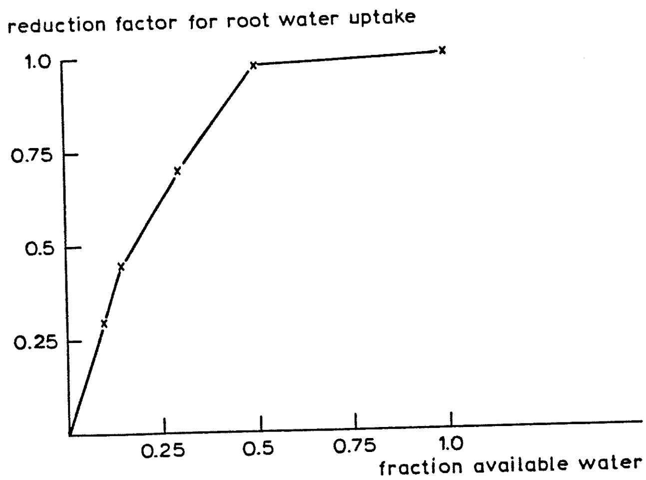

Figure 2. Reduction factor for root water uptake as a function of the fraction available water.

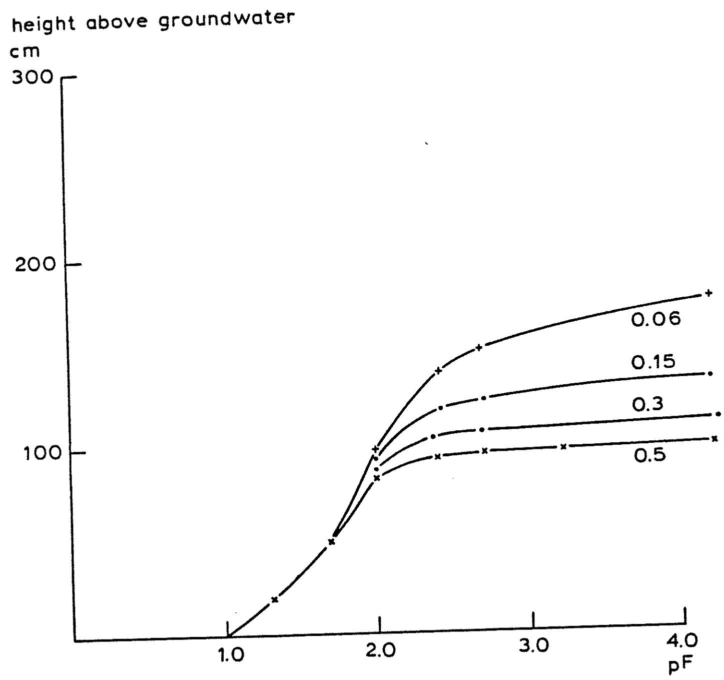

Figure 3. Rate of capillary rise (cm d^{-1}) from the groundwater table to the root zone, as a function of the height of the root zone above the groundwater table and the pF-value in the root zone.

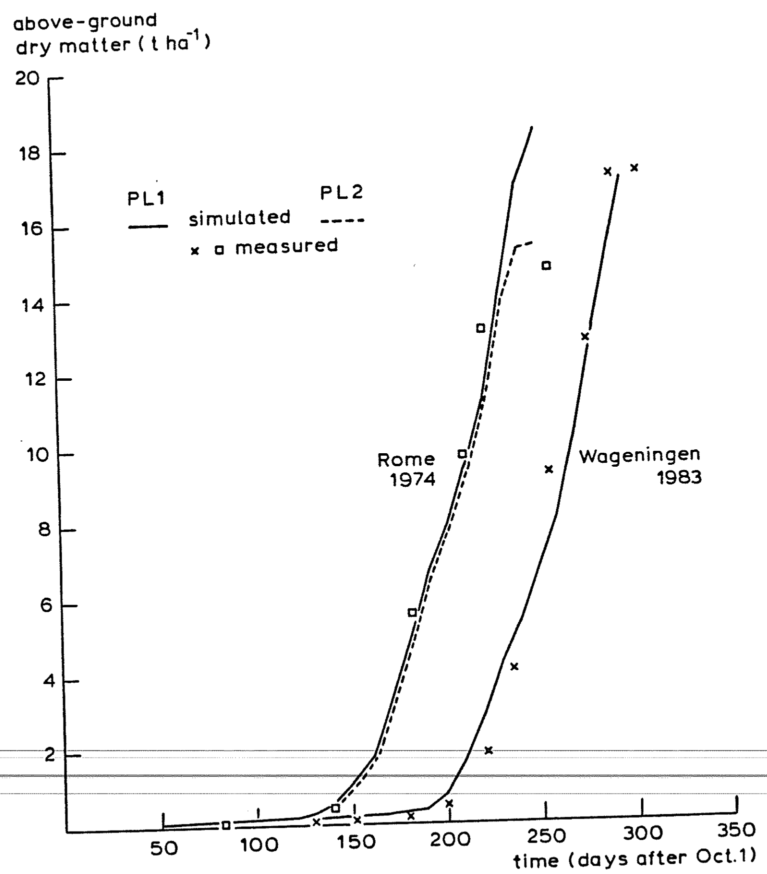

Figure 4. Measured and simulated cummulative dry matter production for winter wheat in Wageningen, the Netherlands and Rome, Italy. For Rome, the simulated values with the water balance are also included.

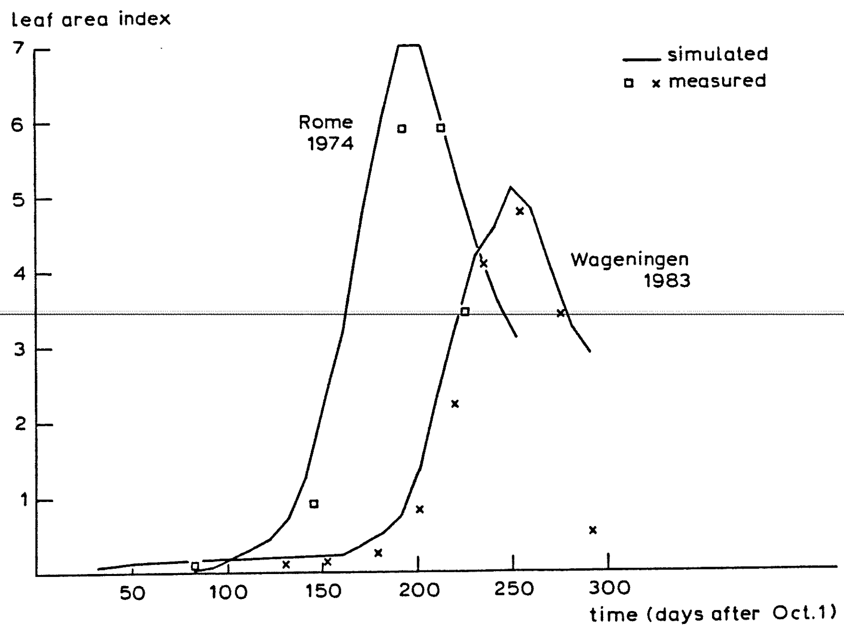

Figure 5. Measured and simulated time course of leaf area index for winter wheat in Wageningen, the Netherlands and Rome, Italy.

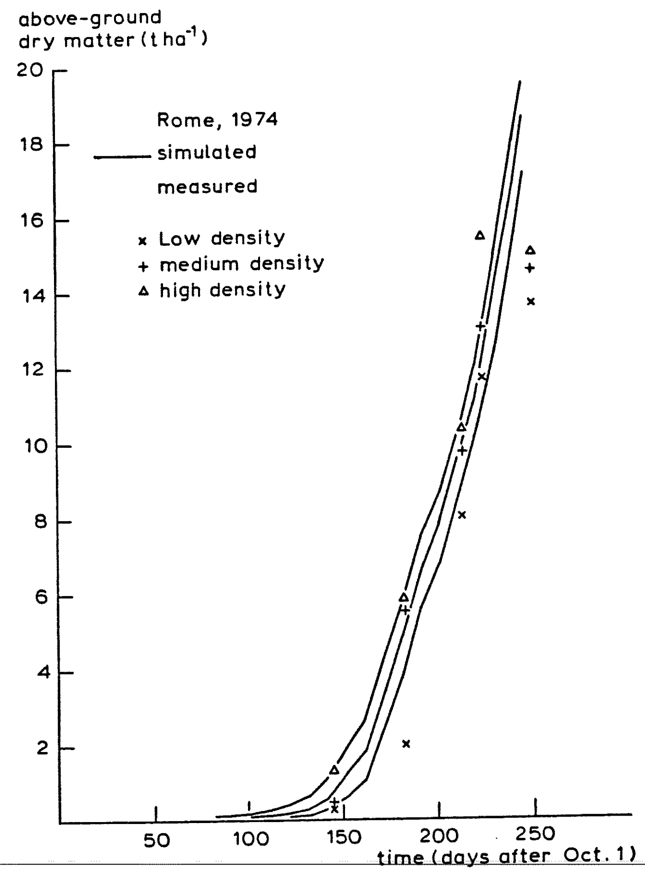

Figure 6a. Measured and simulated dry matter production for winter wheat in Rome, Italy, at three sowing densities.

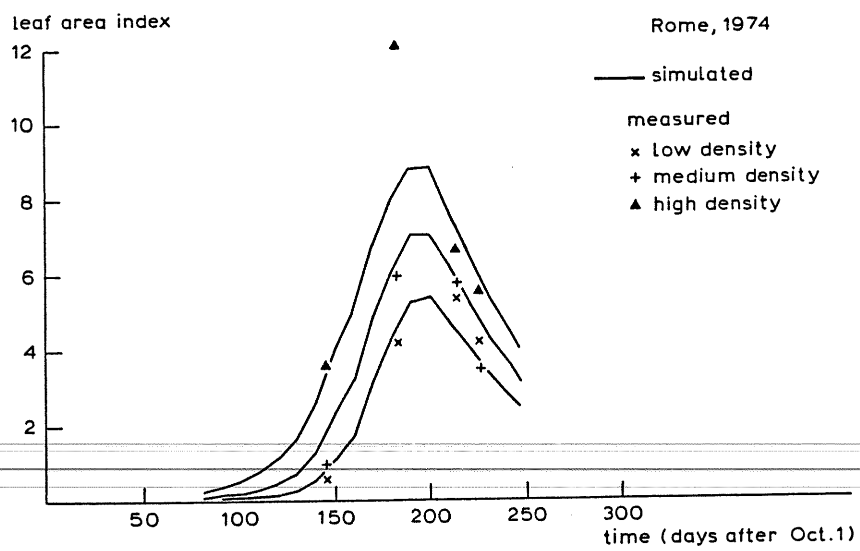

Figure 6b. Measured and simulated time course of leaf area index for winter wheat in Rome, at three sowing densities.

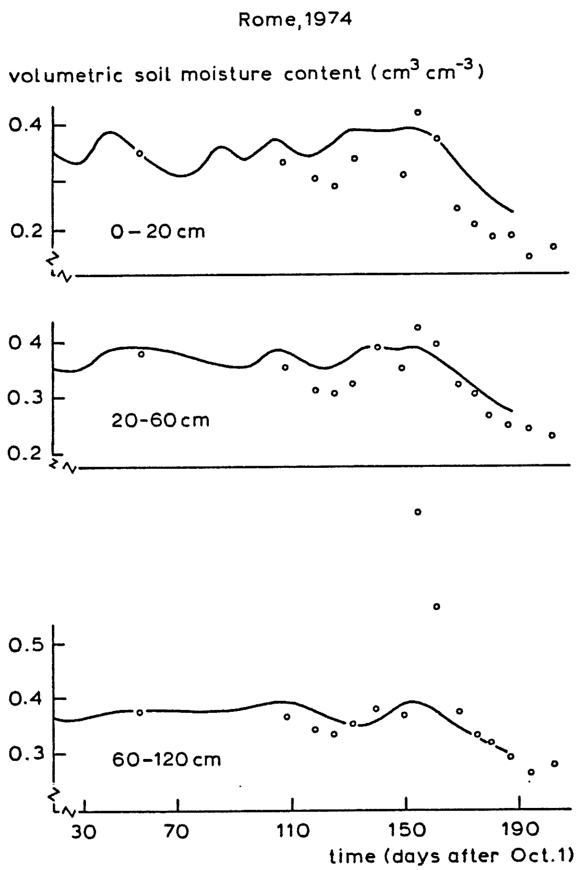

Figure 7. Measured and simulated time course of volumetric soil moisture content in three soil layers under winter wheat in Rome, Italy.

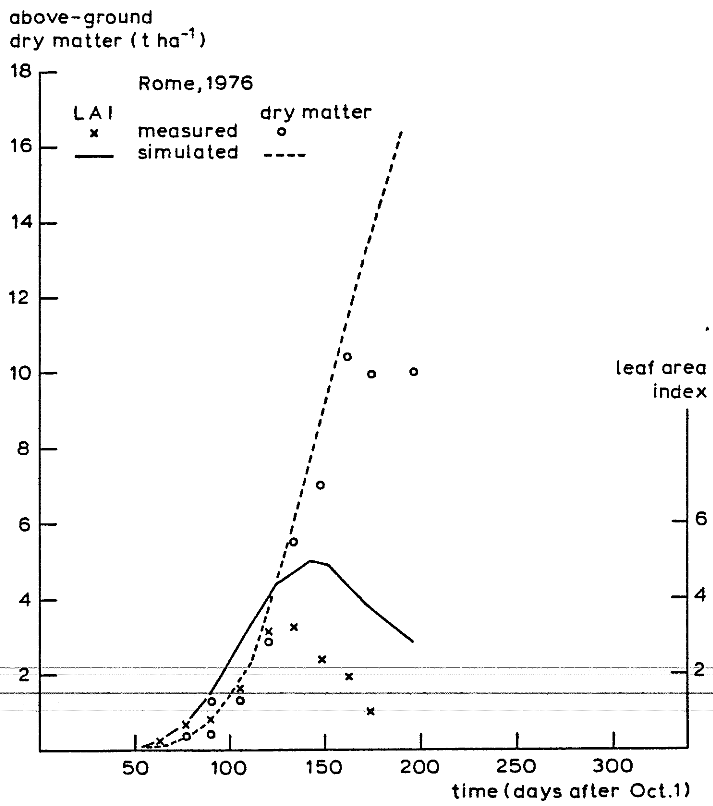

Figure 8. The effect of a delay in leaf senescence on simulated cumulative dry matter production and time course of leaf area index in comparison to the measurements for winter wheat in Rome, Italy.

```
TITLE SM.L1: PROGRAM SECTION LEVEL 1
*
INITIAL
      WRTI=WLVI
      WSTI=0.
      WSOI=0.
      ALVI=WLVI/(SLWC*0.5)
      NAGCR=1000.
*
DYNAMIC

      DATE=1+AMOD(TIME+DATAST+EMERG-1.,365.)
      DAY=TIME+EMERG

      WLV=INTGRL(WLVI,GLV-LLV)
      WST=INTGRL(WSTI,GST-CTST)
      WSO=INTGRL(WSOI,GSO)
      WRT=INTGRL(WRTI,GRT-LRT)
      WSS=WLV+WST+WSO
      WCR=WSS+WRT

      GLV=CAGLV*CFLV
      GST=CAGST*CFST
      GSO=CAGSO*CFSO
      GRT=CAGRT*CFRT

      CAGRT=CAGCR*AFGEN(CARTT,DVS)
      CAGLV=CAGCR*AFGEN(CALVT,DVS)
      CAGST=CAGCR*AFGEN(CASTT,DVS)
      CAGSO=CAGCR-CAGLV-CAGST-CAGRT

      CAGCR1=PCGA*30./44.-RMCR*30./44.+CTST*1.08
      PCGA=(PCGO*FOV+PCGC*(1.-FOV))*FTEMP
CAGCR=INSW(PCGA-RMCR,.001,CAGCR1)
FTEMP=AFGEN(PMXTT,ETMP)
ETMP=AFGEN(MXTT,DAY)-.25*(AFGEN(MXTT,DAY)-AFGEN(MNTT,DAY))
      PCGC,PCGO=PHOTO(PMAXP,PEA,ALV,RDTC,RDTO,DL,DLE,DEC,LAT)
      PCGAT=INTGRL(0.,PCGA-RMCR-RGCR)

      RCRT=INTGRL(0.,RMCR+RGCR)
      RCMR=RMLV+RMST+RMSO+RMRT
      RMLV=WLV*RMLVD*0.5*ETM
      RMST=WST*RMSTD*ETM
      RMSO=WSO*RMSOD*ETM
      RMRT=WRT*RMRTD*ETM
      ETM=Q10**((TMPA-TMPR)/10.)
      RGCR=RGLV+RGST+RGSO+RGRT
      RGLV=CAGLV*CPLV
      RGST=CAGST*CPST
      RGSO=CAGSO*CPSO
      RGRT=CAGRT*CPRT


      LLV=WLV*AFGEN(LLVT,DVS)
      CTST=WST*AFGEN(TSTT,DVS)
      LRT=WRT*AFGEN(LRTT,DVS)
      WLVD=INTGRL(0.,LLV)
      WRTD=INTGRL(0.,LRT)
      WSTT=INTGRL(0.,CTST)

      DVS=INTGRL(DVSI,DVR)
      DVR=DVRC*DVRET*DVREP*DVREV
```

```
       DVRC=INSW(DVS-1.,DVRC1,DVRC2)
       DVRET=LIMIT(0.,1.,(TMPA-TEMPB)/(TEMPO-TEMPB))
       TEMPB=INSW(DVS-1.,TEMPB1,TEMPB2)
       DVREP=INSW(DVS-0.,1.,...
             INSW(DVS-1.,LIMIT(0.,1.,(DLP-DLPB)/(DLPO-DLPB)),1.))
       DLPB=INSW(DVS-DBRDG,DLPB1,DLPB2)
       DVREV=INSW(DVS-0.,1.,...
             INSW(DVS-DBRDG,(VERND-VERNDB)/(VERNDO-VERNDB),1.))
       VERND=INTGRL(10.,VERNR)
       VERNR=INSW(DVS-DBRDG,AFGEN(VERNRT,TMPA),1.)
*

       ALV=PSST+INTGRL(ALVI,GLA-LLA)
      PSST=INTGRL(0.,GSA-LSA)
PARAM LSA=0.
       GLA=GLV/SLWA
       SLWA=SLWC*AFGEN(SLWT,DVS)
       LLA=LLV/SLWA
       GSA=GST/SSWC
LAI=ALV-PSST

       RDTC,RDTO,DEC,DL,DLE,DLP=ASTRO(DATE,LAT,INSP)
       FOV=(RDTC-RDTP)/(RDTC-RDTO)
       RDTP=RDTPF*RUCF*AFGEN(DTRT,DAY)
       RDTPF=0.5+0.1*(RDTC-0.5*RUCF*AFGEN(DTRT,DAY))/(RDTC-RDTO)
TMPA=(AFGEN(MXTT,DAY)+AFGEN(MNTT,DAY))/2.
             FLAI=AFGEN(MLAI,DAY)
             FDRYM=AFGEN(MDRYM,DAY)
TIMER TIME=1., DELT=1.,  PRDEL=10., OUTDEL=5., FINTIM=1000.
METHOD RECT
PRINT DATE,WCROP,WLV,WST,WSO,WRT,FTEMP,ALV,LAI,PCGA,TMPA,DVS
WCROP=WLV+WLVD+WST+WSO
OUTPUT WCROP,FDRYM
PAGE GROUP, NTAB=1
OUTPUT LAI,FLAI
PAGE GROUP, NTAB=1

TITLE SM.PWH: PLANT DATA FOR WHEAT
FUNCTION CRISIS
FUNCTION CRISIS
       PARAM TEMPB1=1., TEMPB2=9., TEMPO=35.
       PARAM DLPB1=0.,DLPB2=7.,DLPO=20.
       PARAM VERNDB=8., VERNDO=33.
PARAM RUCF=1.E4
PARAM LAT=52.
PARAM EMERG=31.
PARAM DVRC1=.0396,DVRC2=.1
PARAM DATAST=273.
PARAM DBRDG=.321
       FUNCTION VERNRT=-20.0,0.,-4.,0.,3.,1.,10.,1.,17.,0.,50.,0.
PARAM DVSI=0.0
*  REFLECTS WINTER WHEAT AT NOV. 1

PARAM WLVI=20.
FUNCTION CALVT=0.,.475,.2,.685,.35,.785,.4,.755,.5,.515,.6,.32,...
         .7,.22,.8,.125,.9,.07,1.,.02,1.1,0.,2.1,0.
FUNCTION CASTT=0.,0.,.35,0.,.4,.045,.5,.325,.6,.535,.7,.59,.8,.58,...
         .9,.45,1.,.25,1.1,.09,1.2,0.,2.1,0.
FUNCTION CARTT=0.,.5,.2,.29,.35,.19,.4,.175,.5,.135,.6,.1,.7,...
                .075,.8,.05,.9,.03,1.,.02,1.1,.01,1.2,0.,2.1,0.
PARAM PMAXP=40., PEA=0.5
FUNCTION PMXTT=-20.,0., -5.,0.01,5.,0.02,15.,0.8,20.,1.,...
25.,1., 30.,0.8, 37.,0.0
```

```
PARAM CFLV=0.73, CFST=0.73, CFSO=0.66, CFRT=0.73
PARAM CPLV=0.35, CPST=0.31, CPSO=0.28, CPRT=0.31
PARAM FCLV=0.42, FCST=0.43, FCSO=0.49, FCRT=0.43
PARAM INSP=-4.
PARAM Q10=2., TMPR=25.
PARAM RMLVD=0.03, RMSTD=0.015, RMSOD=0.005, RMRTD=0.01
FUNCTION LLVT=0.,0.,1.,0.,1.01,.02,2.1,0.02
FUNCTION TSTT=0.,0., 1.4,0., 2.1,0.0
FUNCTION LRTT=0.,0., 1.,0., 1.01,0.00, 2.1,0.00
PARAM DVRC=0.035
PARAM SLWC=450., SSWC=4000.
FUNCTION SLWT=0.,0.8, 0.5,1.1, 2.1,1.1
FUNCTION WSET=0.,0., 0.1,0.3, 0.15,0.45, 0.3,0.7, 0.5,0.975, 1.,1.
FUNCTION RTDT=0.,0., 800.,1., 3000.,2.
PARAM RS=160., RCCRV=0.25,ALFA=0.5,WDLV=0.02
FINISH DVS=2., CAGCR=0., NAGCR=0.
FUNCTION NCLVHT=0.,0.05, 1.0,0.04, 2.1,0.02
PARAM TCUNV=2.
PARAM NCSOH=0.018, NCSOL=0.015
FUNCTION PMXNT=0.,0., 0.8,1., 1.,1.
FUNCTION RMCRNT=0.,0.5, 1.,1.
FUNCTION TCRNT=0.,2., 0.5,5.,  1.,15., 2.,50.
FUNCTION WNUT=0.,0., 0.1,0.2, 0.5,0.8, 0.95,1., 1.,0., 1.1,0.

TITLE WINTERWHEAT, DE BOUWING 1982-1983

*     WEATHER TABLES START FROM OCTOBER 1


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238., 8.4,     239., 6.3,     240., 6.2,     241., 6.8,     242., 4.2,     ...
243.,11.1,     244.,14.7,     245., 9.9,     246., 9.4,     247.,12.4,     ...
248., 9.4,     249., 6.9,     250.,10.9,     251.,14.4,     252.,12.3,     ...
253.,12.0,     254.,11.3,     255.,12.4,     256., 9.8,     257., 8.4,     ...
258., 6.1,     259., 5.2,     260., 2.6,     261.,10.6,     262., 8.4,     ...
263.,11.7,     264.,12.5,     265.,13.9,     266.,15.2,     267.,13.7,     ...
268.,13.6,     269.,12.5,     270., 8.3,     271., 7.4,     272.,12.8,     ...
273.,11.2,     274., 9.7,     275.,10.6,     276., 9.7,     277., 8.6,     ...
278.,10.3,     279.,16.5,     280.,17.4,     281.,15.9,     282.,15.8,     ...
283.,15.3,     284.,15.2,     285.,16.2,     286.,13.7,     287.,13.2,     ...
288.,13.0,     289.,17.0,     290.,16.6,     291.,15.9,     292.,11.7,     ...
293., 9.4,     294., 8.4,     295.,11.3,     296.,15.4,     297.,13.7,     ...
298.,11.6,     299.,16.7,     300.,14.1,     301.,12.5,     302.,13.1,     ...
303.,12.0,     304.,16.9
FUNCTION VAPHTB     = ...
    1.,13.1,        2.,13.0,        3.,14.2,        4.,13.2,        5.,11.8,  ...
    6.,11.5,        7.,12.9,        8.,12.3,        9.,12.3,       10.,11.7,  ...
   11.,12.0,       12.,12.0,       13.,11.4,       14.,11.4,       15.,10.6,  ...
   16., 9.5,       17.,10.5,       18.,12.3,       19.,12.2,       20.,11.1,  ...
   21.,12.2,       22.,13.3,       23.,13.4,       24., 9.5,       25.,10.1,  ...
   26.,12.5,       27.,10.5,       28.,11.2,       29.,10.9,       30., 9.3,  ...
   31., 9.3,       32.,12.5,       33.,14.0,       34.,14.1,       35.,12.6,  ...
   36.,10.8,       37., 6.7,       38., 5.6,       39.,10.5,       40.,11.8,  ...
   41.,11.5,       42.,11.2,       43.,10.7,       44., 8.7,       45., 7.6,  ...
   46., 7.3,       47., 7.7,       48., 8.2,       49.,11.4,       50., 8.1,  ...
   51., 8.6,       52., 8.3,       53., 8.8,       54.,10.2,       55., 8.9,  ...
   56., 8.9,       57., 8.5,       58., 8.1,       59., 7.7,       60., 7.6,  ...
   61., 6.7,       62., 5.4,       63., 5.7,       64., 6.6,       65., 6.6,  ...
   66., 7.0,       67., 7.7,       68., 7.8,       69., 8.2,       70., 8.4,  ...
   71., 8.6,       72., 7.4,       73., 6.5,       74., 5.3,       75., 5.8,  ...
   76.,10.4,       77., 7.0,       78., 6.2,       79., 6.2,       80., 6.0,  ...
   81., 7.2,       82., 7.3,       83., 6.6,       84., 5.9,       85., 5.7,  ...
   86., 8.2,       87., 9.9,       88., 9.1,       89., 7.1,       90., 6.4,  ...
   91., 6.5,       92., 5.3,       93., 5.9,       94., 7.6,       95.,10.5,  ...
   96., 9.4,       97.,11.1,       98., 9.5,       99., 7.5,      100., 7.5,  ...
  101., 8.1,      102., 9.4,      103., 9.7,      104., 7.7,      105., 7.0,  ...
  106., 6.7,      107., 8.6,      108., 8.9,      109., 8.7,      110., 6.2,  ...
  111., 5.9,      112., 6.1,      113., 7.7,      114., 7.1,      115., 6.0,  ...
  116., 5.7,      117., 9.1,      118.,10.7,      119.,10.4,      120.,10.0,  ...
  121., 8.4,      122., 7.2,      123., 7.1,      124., 7.8,      125., 5.9,  ...
  126., 6.1,      127., 5.8,      128., 6.2,      129., 6.7,      130., 5.9,  ...
  131., 5.0,      132., 4.6,      133., 4.6,      134., 4.0,      135., 3.6,  ...
  136., 2.9,      137., 3.1,      138., 3.3,      139., 2.6,      140., 3.6,  ...
  141., 4.1,      142., 4.4,      143., 4.8,      144., 3.3,      145., 2.3,  ...
  146., 2.0,      147., 4.1,      148., 6.4,      149., 8.8,      150., 8.7,  ...
  151., 7.2,      152., 6.8,      153., 6.6,      154., 6.4,      155., 6.7,  ...
  156., 7.4,      157., 8.7,      158., 8.9,      159., 8.0,      160., 7.5,  ...
  161., 8.3,      162., 6.6,      163., 4.8,      164., 5.5,      165., 9.5,  ...
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166., 8.1,     167., 7.4,     168.,10.4,     169.,11.6,     170.,10.8,     ...
171., 9.2,     172., 7.4,     173., 6.1,     174., 8.2,     175., 7.3,     ...
176., 6.2,     177., 6.5,     178., 6.3,     179., 6.2,     180., 6.7,     ...
181., 7.5,     182., 8.1,     183., 8.5,     184., 7.9,     185., 6.4,     ...
186., 6.6,     187., 7.5,     188., 7.4,     189., 7.4,     190., 8.2,     ...
191., 7.2,     192.,10.1,     193., 8.8,     194., 7.5,     195., 6.9,     ...
196., 8.4,     197., 8.7,     198., 9.3,     199.,11.0,     200.,11.5,     ...
201., 9.5,     202., 8.5,     203.,10.0,     204., 9.7,     205.,11.0,     ...
206., 9.9,     207.,10.7,     208.,11.1,     209.,10.7,     210.,10.5,     ...
211.,10.2,     212., 9.8,     213.,11.6,     214., 9.2,     215., 9.7,     ...
216., 9.0,     217., 8.5,     218.,11.3,     219.,13.4,     220.,11.2,     ...
221.,10.9,     222., 8.7,     223., 9.6,     224.,10.0,     225.,10.5,     ...
226.,10.8,     227.,11.8,     228.,11.7,     229.,11.4,     230.,10.8,     ...
231.,10.8,     232.,11.3,     233.,12.5,     234.,10.6,     235., 9.9,     ...
236.,11.7,     237.,11.3,     238.,10.4,     239., 9.6,     240.,10.2,     ...
241.,10.5,     242.,10.8,     243.,11.9,     244.,15.1,     245.,13.5,     ...
246.,12.7,     247.,15.0,     248.,13.1,     249.,10.0,     250.,10.8,     ...
251.,15.5,     252.,14.9,     253.,12.4,     254.,12.8,     255.,13.8,     ...
256.,12.0,     257.,10.7,     258., 9.4,     259., 9.1,     260., 8.3,     ...
261.,11.5,     262.,12.9,     263.,12.7,     264.,13.5,     265.,15.2,     ...
266.,17.9,     267.,17.9,     268.,15.7,     269.,13.0,     270.,12.5,     ...
271.,11.0,     272.,15.5,     273.,14.5,     ...
274.,12.5,     275.,14.2,     276.,14.2,     277.,14.1,     278.,15.4,     ...
279.,18.5,     280.,19.4,     281.,20.5,     282.,21.3,     283.,18.1,     ...
284.,17.8,     285.,19.6,     286.,15.6,     287.,13.7,     288.,18.9,     ...
289.,19.6,     290.,18.8,     291.,18.7,     292.,15.7,     293.,11.0,     ...
294.,11.3,     295.,13.7,     296.,17.1,     297.,18.6,     298.,18.0,     ...
299.,20.4,     300.,19.5,     301.,16.3,     302.,17.1,     303.,17.1,     ...
304.,17.1
FUNCTION RAINT     = ...
  1., 0.0,       2., 0.0,       3., 0.0,       4., 0.0,       5., 0.8,     ...
  6., 0.0,       7.,16.0,       8., 4.8,       9., 4.2,      10.,14.3,     ...
 11., 2.1,      12., 2.3,      13., 5.1,      14., 5.4,      15.,14.1,     ...
 16., 0.1,      17., 1.0,      18., 6.8,      19., 0.3,      20., 0.0,     ...
 21., 0.1,      22., 0.0,      23., 5.0,      24., 0.5,      25., 0.1,     ...
 26., 0.0,      27., 0.0,      28., 0.0,      29., 0.0,      30., 0.0,     ...
 31., 0.0,      32., 0.0,      33., 0.1,      34., 0.0,      35., 0.1,     ...
 36., 0.0,      37., 0.0,      38., 0.1,      39., 3.1,      40., 0.1,     ...
 41., 0.2,      42., 0.0,      43., 6.9,      44., 1.9,      45., 2.9,     ...
 46.,13.5,      47., 4.1,      48., 9.7,      49., 8.2,      50., 1.5,     ...
 51., 0.4,      52., 0.0,      53., 7.1,      54., 1.6,      55., 0.3,     ...
 56., 0.7,      57., 3.3,      58., 0.0,      59., 0.0,      60., 0.0,     ...
 61., 0.0,      62., 0.0,      63., 0.0,      64., 0.0,      65., 0.0,     ...
 66., 3.7,      67., 1.3,      68., 3.9,      69., 1.0,      70., 6.2,     ...
 71., 9.3,      72., 7.7,      73., 0.0,      74., 0.0,      75., 0.1,     ...
 76., 1.3,      77., 5.3,      78., 2.3,      79., 0.4,      80., 2.7,     ...
 81., 5.2,      82., 6.1,      83., 1.3,      84., 0.0,      85., 0.0,     ...
 86., 0.0,      87., 0.0,      88., 0.1,      89., 1.4,      90., 0.0,     ...
 91., 0.0,      92., 0.0,      93., 1.5,      94., 0.1,      95.,18.6,     ...
 96.,10.7,      97., 2.4,      98., 2.2,      99., 0.1,     100., 0.1,     ...
101., 4.7,     102., 0.0,     103., 0.0,     104., 0.0,     105., 3.4,     ...
106., 6.9,     107., 3.3,     108., 0.1,     109., 0.0,     110., 1.4,     ...
111., 3.0,     112., 0.0,     113., 0.0,     114., 0.0,     115., 0.0,     ...
116., 0.0,     117., 3.3,     118., 0.4,     119., 0.5,     120., 3.2,     ...
121., 0.2,     122., 4.3,     123.,11.3,     124., 7.1,     125., 4.7,     ...
126., 3.3,     127., 0.0,     128.,10.8,     129., 1.6,     130., 0.5,     ...
131., 0.1,     132., 0.2,     133., 0.0,     134., 0.0,     135., 0.0,     ...
136., 0.0,     137., 0.0,     138., 0.0,     139., 0.0,     140., 0.0,     ...
141., 0.0,     142., 0.0,     143., 0.0,     144., 0.0,     145., 0.0,     ...
146., 0.0,     147., 0.0,     148., 0.3,     149., 2.2,     150., 5.3,     ...
151., 1.6,     152., 0.7,     153., 2.3,     154., 0.0,     155., 0.0,     ...
156., 0.0,     157., 0.0,     158., 0.0,     159., 0.0,     160., 0.0,     ...
161., 0.0,     162., 0.0,     163., 0.0,     164., 0.0,     165., 4.3,     ...
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166., 0.1,    167., 0.0,    168., 3.2,    169., 1.1,    170., 5.2,    ...
171., 3.7,    172., 4.6,    173., 1.6,    174.,11.3,    175., 0.2,    ...
176.,11.5,    177., 1.8,    178., 4.8,    179., 0.7,    180., 1.3,    ...
181., 5.0,    182., 3.5,    183., 2.4,    184., 0.0,    185., 0.4,    ...
186., 0.7,    187., 6.1,    188., 3.1,    189., 1.0,    190., 1.9,    ...
191., 0.0,    192., 5.1,    193., 1.5,    194., 8.6,    195., 0.0,    ...
196., 0.8,    197., 0.0,    198., 0.0,    199., 2.1,    200., 0.0,    ...
201., 0.5,    202., 0.0,    203.,16.8,    204., 0.0,    205., 2.4,    ...
206., 0.0,    207., 1.7,    208., 0.2,    209.,19.1,    210., 0.4,    ...
211., 5.6,    212., 0.0,    213.,18.9,    214., 4.0,    215., 5.1,    ...
216., 0.0,    217., 0.0,    218., 6.4,    219., 2.2,    220., 6.9,    ...
221., 2.5,    222., 1.1,    223., 4.4,    224., 5.4,    225., 1.2,    ...
226., 0.0,    227., 3.0,    228., 7.4,    229., 0.0,    230., 0.7,    ...
231., 1.0,    232., 8.0,    233., 9.5,    234., 0.1,    235., 0.0,    ...
236., 7.1,    237.,18.7,    238.,10.5,    239., 0.1,    240., 6.4,    ...
241., 0.9,    242., 0.0,    243., 0.6,    244., 0.6,    245.,14.3,    ...
246., 0.0,    247., 0.6,    248., 1.0,    249., 0.0,    250., 0.0,    ...
251.,12.5,    252., 0.1,    253., 0.0,    254., 0.0,    255., 3.6,    ...
256., 0.2,    257., 0.3,    258., 2.4,    259., 0.0,    260., 0.0,    ...
261., 0.0,    262., 0.0,    263., 0.0,    264., 0.0,    265., 0.0,    ...
266., 0.1,    267., 3.7,    268., 0.0,    269., 0.0,    270., 0.9,    ...
271., 0.0,    272., 6.7,    273., 5.4,    ...
274., 0.4,    275., 0.0,    276., 0.0,    277., 0.0,    278., 0.0,    ...
279., 0.4,    280., 2.0,    281., 0.0,    282., 0.0,    283., 0.0,    ...
284., 0.0,    285., 0.0,    286., 0.0,    287., 0.0,    288., 0.0,    ...
289., 0.0,    290., 0.0,    291., 0.0,    292., 0.0,    293., 0.0,    ...
294., 0.0,    295., 0.0,    296., 0.0,    297., 6.6,    298., 0.0,    ...
299., 0.0,    300., 2.3,    301., 0.0,    302., 0.0,    303., 0.0,    ...
304., 0.0
FUNCTION DTRT          = ...
  1., 857.,     2.,1048.,     3., 496.,     4., 701.,     5., 240.,   ...
  6., 624.,     7., 220.,     8., 374.,     9., 515.,    10., 452.,   ...
 11., 336.,    12., 402.,    13., 276.,    14., 358.,    15., 409.,   ...
 16., 702.,    17., 652.,    18., 641.,    19., 732.,    20., 610.,   ...
 21., 548.,    22., 699.,    23., 299.,    24., 735.,    25., 413.,   ...
 26., 232.,    27., 519.,    28., 448.,    29., 488.,    30.,  62.,   ...
 31., 336.,    32., 369.,    33.,  75.,    34., 214.,    35.,  79.,   ...
 36., 142.,    37., 553.,    38., 473.,    39., 279.,    40., 168.,   ...
 41., 229.,    42., 423.,    43., 316.,    44., 158.,    45., 418.,   ...
 46., 277.,    47.,  68.,    48., 216.,    49.,  52.,    50., 365.,   ...
 51., 364.,    52., 309.,    53., 177.,    54., 106.,    55., 199.,   ...
 56.,  35.,    57., 163.,    58., 226.,    59., 126.,    60., 112.,   ...
 61., 140.,    62., 327.,    63., 100.,    64.,  37.,    65.,  22.,   ...
 66., 205.,    67., 209.,    68., 108.,    69., 251.,    70.,  63.,   ...
 71., 107.,    72., 128.,    73., 149.,    74.,  83.,    75.,  53.,   ...
 76.,  22.,    77., 117.,    78.,  75.,    79., 243.,    80., 246.,   ...
 81., 119.,    82.,  82.,    83.,  92.,    84., 279.,    85.,  60.,   ...
 86.,  63.,    87.,  53.,    88., 191.,    89., 148.,    90., 269.,   ...
 91., 206.,    92., 131.,    93., 283.,    94.,  90.,    95.,  15.,   ...
 96.,  86.,    97.,  78.,    98.,  85.,    99., 290.,   100., 281.,   ...
101.,  47.,   102., 206.,   103., 154.,   104.,  60.,   105.,  38.,   ...
106.,  30.,   107., 103.,   108., 252.,   109.,  27.,   110., 369.,   ...
111., 263.,   112., 210.,   113., 106.,   114.,  97.,   115., 421.,   ...
116., 405.,   117.,  28.,   118., 209.,   119.,  50.,   120.,  70.,   ...
121., 356.,   122., 233.,   123., 262.,   124., 348.,   125., 439.,   ...
126., 334.,   127., 470.,   128., 323.,   129., 158.,   130., 152.,   ...
131., 273.,   132., 240.,   133., 143.,   134., 420.,   135., 439.,   ...
136., 748.,   137., 808.,   138., 665.,   139., 796.,   140., 768.,   ...
141., 830.,   142., 324.,   143., 497.,   144., 912.,   145., 952.,   ...
146., 949.,   147., 868.,   148., 431.,   149., 158.,   150., 150.,   ...
151., 404.,   152., 377.,   153., 890.,   154., 996.,   155., 819.,   ...
156., 907.,   157., 271.,   158., 526.,   159., 936.,   160., 237.,   ...
161., 521.,   162., 888.,   163.,1223.,   164.,1133.,   165., 610.,   ...
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166., 517.,   167., 881.,   168., 150.,   169., 274.,   170., 235.,   ...
171., 359.,   172., 579.,   173., 500.,   174., 587.,   175., 522.,   ...
176., 860.,   177.,1152.,   178., 985.,   179., 914.,   180., 947.,   ...
181., 809.,   182., 681.,   183., 879.,   184., 714.,   185.,1111.,   ...
186., 729.,   187., 876.,   188.,1197.,   189.,1364.,   190., 674.,   ...
191.,1478.,   192., 576.,   193., 640.,   194., 951.,   195.,1203.,   ...
196., 916.,   197.,1809.,   198.,1918.,   199., 624.,   200.,1421.,   ...
201., 501.,   202.,1524.,   203., 433.,   204.,1689.,   205.,1264.,   ...
206.,1892.,   207., 746.,   208.,1143.,   209., 893.,   210.,1230.,   ...
211.,1461.,   212.,2152.,   213., 829.,   214.,1546.,   215., 407.,   ...
216.,1246.,   217.,2208.,   218.,1133.,   219., 788.,   220.,1038.,   ...
221.,1120.,   222.,1978.,   223., 923.,   224., 850.,   225.,1514.,   ...
226.,1773.,   227.,1063.,   228., 476.,   229.,1396.,   230.,1558.,   ...
231.,1612.,   232.,1696.,   233., 384.,   234.,1281.,   235.,2027.,   ...
236., 258.,   237., 171.,   238., 187.,   239., 756.,   240., 787.,   ...
241., 751.,   242.,1686.,   243.,2444.,   244.,2103.,   245.,1418.,   ...
246.,2365.,   247.,1970.,   248.,2305.,   249.,2626.,   250.,2704.,   ...
251.,1376.,   252.,1649.,   253.,1867.,   254.,2031.,   255.,2325.,   ...
256.,1846.,   257.,1303.,   258.,1783.,   259.,1464.,   260.,2757.,   ...
261.,2112.,   262.,2726.,   263.,2727.,   264.,2651.,   265.,2510.,   ...
266.,1988.,   267.,1621.,   268.,1235.,   269.,2078.,   270.,1571.,   ...
271.,1497.,   272., 475.,   273., 856.,   274.,1846.,   275.,1355.,   ...
276.,2387.,   277.,2431.,   278.,2524.,   279.,1652.,   280.,1835.,   ...
281.,2157.,   282.,1992.,   283.,2265.,   284.,2320.,   285.,2509.,   ...
286.,1929.,   287.,2175.,   288.,2131.,   289.,2004.,   290.,2032.,   ...
291.,1990.,   292.,1544.,   293.,1819.,   294.,2515.,   295.,2430.,   ...
296.,1817.,   297.,1210.,   298.,2220.,   299.,1537.,   300.,1241.,   ...
301.,1183.,   302.,1591.,   303.,2076.,   304.,1801.
FUNCTION WSTB        = ...
  1., 1.5,      2., 1.8,      3., 1.3,      4., 2.2,      5., 2.8,    ...
  6., 1.5,      7., 2.0,      8., 2.4,      9., 3.4,     10., 3.2,    ...
 11., 2.0,     12., 2.4,     13., 4.0,     14., 4.2,     15., 4.6,    ...
 16., 3.2,     17., 3.8,     18., 3.4,     19., 3.8,     20., 4.3,    ...
 21., 2.5,     22., 2.4,     23., 2.1,     24., 2.0,     25., 3.2,    ...
 26., 3.0,     27., 0.8,     28., 1.4,     29., 2.4,     30., 1.7,    ...
 31., 2.7,     32., 3.1,     33., 1.7,     34., 1.1,     35., 1.7,    ...
 36., 2.7,     37., 4.6,     38., 4.5,     39., 5.2,     40., 3.8,    ...
 41., 4.6,     42., 3.3,     43., 5.4,     44., 3.4,     45., 3.7,    ...
 46., 1.4,     47., 4.3,     48., 4.9,     49., 6.3,     50., 6.8,    ...
 51., 4.8,     52., 4.9,     53., 4.4,     54., 4.0,     55., 6.0,    ...
 56., 5.8,     57., 3.0,     58., 1.8,     59., 2.9,     60., 1.7,    ...
 61., 3.0,     62., 3.4,     63., 0.9,     64., 1.0,     65., 2.3,    ...
 66., 3.9,     67., 1.0,     68., 2.9,     69., 4.0,     70., 5.6,    ...
 71., 7.0,     72., 5.5,     73., 2.3,     74., 1.7,     75., 4.0,    ...
 76., 8.8,     77., 6.7,     78., 2.5,     79., 2.0,     80., 6.7,    ...
 81., 5.8,     82., 6.5,     83., 1.8,     84., 1.4,     85., 4.5,    ...
 86., 2.2,     87., 3.8,     88., 5.4,     89., 4.1,     90., 1.2,    ...
 91., 2.0,     92., 2.9,     93., 4.2,     94., 3.7,     95., 5.7,    ...
 96., 7.0,     97., 6.2,     98., 6.6,     99., 5.9,    100., 3.8,    ...
101., 5.2,    102., 4.4,    103., 3.4,    104., 4.8,    105., 5.4,    ...
106., 6.0,    107., 6.7,    108., 6.2,    109., 7.2,    110., 8.5,    ...
111., 4.9,    112., 3.6,    113., 5.4,    114., 2.8,    115., 2.0,    ...
116., 2.8,    117., 3.3,    118., 4.3,    119., 6.6,    120., 7.0,    ...
121., 6.5,    122., 5.3,    123., 5.4,    124.,10.7,    125., 5.4,    ...
126., 3.5,    127., 2.4,    128., 5.4,    129., 2.3,    130., 3.2,    ...
131., 3.5,    132., 2.2,    133., 1.8,    134., 2.8,    135., 2.5,    ...
136., 2.9,    137., 4.1,    138., 4.0,    139., 3.3,    140., 3.3,    ...
141., 2.1,    142., 1.3,    143., 1.5,    144., 2.4,    145., 3.2,    ...
146., 4.5,    147., 3.2,    148., 3.1,    149., 2.5,    150., 3.7,    ...
151., 4.2,    152., 1.5,    153., 1.9,    154., 2.6,    155., 2.2,    ...
156., 4.1,    157., 4.8,    158., 3.8,    159., 3.3,    160., 2.9,    ...
161., 4.3,    162., 3.2,    163., 2.8,    164., 3.4,    165., 3.6,    ...
166., 1.2,    167., 1.8,    168., 3.4,    169., 3.6,    170., 4.4,    ...
```

```
171., 3.7,    172., 5.0,    173., 8.0,    174., 5.6,    175., 5.7,    ...
176., 5.6,    177., 4.5,    178., 3.5,    179., 1.9,    180., 3.3,    ...
181., 4.7,    182., 3.2,    183., 2.7,    184., 3.6,    185., 1.6,    ...
186., 3.7,    187., 3.7,    188., 5.4,    189., 4.1,    190., 3.9,    ...
191., 1.9,    192., 2.6,    193., 2.0,    194., 4.7,    195., 3.0,    ...
196., 3.7,    197., 2.9,    198., 2.9,    199., 3.8,    200., 2.9,    ...
201., 3.8,    202., 3.1,    203., 2.4,    204., 2.6,    205., 2.7,    ...
206., 1.7,    207., 3.0,    208., 1.6,    209., 4.6,    210., 2.5,    ...
211., 2.9,    212., 2.3,    213., 2.6,    214., 4.3,    215., 4.9,    ...
216., 1.7,    217., 2.2,    218., 2.9,    219., 1.7,    220., 2.2,    ...
221., 3.5,    222., 3.3,    223., 3.9,    224., 4.6,    225., 4.1,    ...
226., 2.5,    227., 2.5,    228., 2.3,    229., 1.9,    230., 2.7,    ...
231., 2.8,    232., 1.9,    233., 1.8,    234., 1.8,    235., 1.7,    ...
236., 3.2,    237., 4.0,    238., 4.4,    239., 3.1,    240., 2.8,    ...
241., 2.0,    242., 1.5,    243., 2.7,    244., 3.4,    245., 3.1,    ...
246., 1.9,    247., 3.0,    248., 2.0,    249., 3.4,    250., 3.3,    ...
251., 2.5,    252., 3.5,    253., 2.7,    254., 2.6,    255., 2.7,    ...
256., 1.5,    257., 3.0,    258., 3.2,    259., 2.0,    260., 2.7,    ...
261., 2.6,    262., 2.4,    263., 2.7,    264., 2.2,    265., 2.3,    ...
266., 1.5,    267., 1.3,    268., 1.8,    269., 1.4,    270., 3.0,    ...
271., 3.7,    272., 4.0,    273., 2.2,    ...
274., 1.4,    275., 2.7,    276., 1.6,    277., 1.1,    278., 1.9,    ...
279., 1.8,    280., 1.3,    281., 1.5,    282., 1.6,    283., 1.3,    ...
284., 1.4,    285., 2.2,    286., 2.4,    287., 1.0,    288., 2.8,    ...
289., 1.5,    290., 2.2,    291., 2.9,    292., 1.9,    293., 1.8,    ...
294., 1.4,    295., 2.4,    296., 2.2,    297., 1.2,    298., 1.5,    ...
299., 1.8,    300., 1.5,    301., 2.1,    302., 2.6,    303., 1.2,    ...
304., 2.4
TITLE SM.T1: TERMINAL WITH C BALANCE CHECK,  PHOTO AND ASTRO
TERMINAL
      HI=WSO/WSS

      CIN=(WLV-WLVI)*FCLV+(WST-WSTI)*FCST+(WSO-WSOI)*FCSO...
      +(WRT-WRTI)*FCRT
      CFL=PCGAT*12./44.-(WLVD*FCLV+WRTD*FCRT)
      CRD=(CIN-CFL)/(CIN+CFL)
      IF(ABS(CRD).GT.0.01) WRITE (6,1)
    1 FORMAT(10X,'* * *ERROR IN CARBON BALANCE, PLEASE CHECK* * *')
END
STOP
      SUBROUTINE PHOTO(PMAX,PEA,ALV,RDTC,RDTO,DL,DLE,DEC,LAT,PCGC,PCGO)
      REAL INSW,LAT
      PI=3.14159265
      SSLAE=SIN((90.+DEC-LAT)*PI/180.)
      X=ALOG(1.+0.45*RDTC/(DLE*3600.)*PEA/(SSLAE*PMAX))
      PHCH1=SSLAE*PMAX*DLE*X/(1.+X)
      Y=ALOG(1.+0.55*RDTC/(DLE*3600.)*PEA/((5.-SSLAE)*PMAX))
      PHCH2=(5.-SSLAE)*PMAX*DLE*Y/(1.+Y)
      PHCH=0.95*(PHCH1+PHCH2)+20.5
      PHC3=PHCH*(1.-EXP(-0.8*ALV))
      PHC4=DL*ALV*PMAX
      PHCL=AMIN1(PHC3,PHC4)*
     $(1.-EXP(-(AMAX1(PHC3,PHC4)/AMIN1(PHC3,PHC4))))
      Z=RDTO/(DLE*3600.)*PEA/(5.*PMAX)
      PHOH1=5.*PMAX*DLE*Z/(1.+Z)
      PHOH=0.9935*PHOH1+1.1
      PHO3=PHOH*(1.-EXP(-0.8*ALV))
      PHOL=AMIN1(PHO3,PHC4)*
     $(1.-EXP(-(AMAX1(PHO3,PHC4)/AMIN1(PHO3,PHC4))))
      PCGC=INSW(ALV-5.,PHCL,PHCH)
      PCGO=INSW(ALV-5.,PHOL,PHOH)
      RETURN
      END
```

```
SUBROUTINE ASTRO(DATE,LAT,INSP,RDTC,RDTO,DEC,DL,DLE,DLP)
REAL LAT,INSP
PI=3.14159265
DEC=-23.4*COS(2.*PI*(DATE+10.)/365.)
COSLD=COS(DEC*PI/180.)*COS(LAT*PI/180.)
SINLD=SIN(DEC*PI/180.)*SIN(LAT*PI/180.)
DL =12.*(PI+2.*ASIN(SINLD/COSLD))/PI
DLE=12.*(PI+2.*ASIN((-SIN(8.*PI/180.)+SINLD)/COSLD))/PI
DLP=12.*(PI+2.*ASIN((-SIN(INSP*PI/180.)+SINLD)/COSLD))/PI
RDN=3600.*(SINLD*DL+24./PI*COSLD*SQRT(1.-(SINLD/COSLD)**2))
RDTC=0.5*1300.*RDN*EXP(-0.1/(RDN/(DL*3600.)))
RDTO = 0.2*RDTC
RETURN
END
```

```
TITLE SM.L2: L1 PLUS A WATER BALANCE
*
* THE PROGRAM NOW PROVIDES AN ESTIMATE OF WATER CAPILLARY RISE
* FUNCTIONS OF PF AD HEIGHT ON THE WATER TABLE. HEIGHT IS COUNTED
* FROM THE SATURATED SOIL TO THE LAYER REACHED BY THE ROOT TIP.
*
* THE AMOUNT OF CAPILLARY RISE IS CALCULATED WITH THE AID OF
* TABLES WHICH CAN BE FOUND IN THE ANNEX OF CHAPTER IV OF
* THE WMO COURSE. THE TABLE REFERRING TO THE PROPER SOIL TEXTURE
* CLASS SHOULD BE COPIED IN THE FILE FOR20.DAT IN TEN LINES
* FORMATTED AS FOLLOWS: 8(3X,F5.1). THE NOSORT SECTION
* IN THE INITIAL PART OF THE PROGRAM TRANSFORMS THE TABLE IN
* FUNCTIONS OF PF AD HEIGHT ON THE WATER TABLE. HEIGHT IS COUNTED
* FROM THE CENTER OF THE LAYER INVOLVED.
* THE STATEMENT PSIX=...... CALCULATES THE WATER POTENTIAL OF THE
* LAYER. VALUES FOR GAMMA AND SMO CAN BE FOUND IN THE SAME CHAPTER
* OF THE COURSE, IF MEASUREMENTS ARE NOT AVAILABLE.
*
/          DIMENSION PF(10),PSI(10),CR(8),TH(10,8),H(14),TCR(14)
/       DATA PSI/20.,50.,100.,250.,500.,1000.,2500.,5000.,10000.,16000./
/          DATA CR/.5,.4,.3,.2,.15,.1,.06,.02/
/          DATA (H(I),I=1,7)/0.,10.,20.,30.,40.,50.,60./
/          DATA (H(I),I=8,14)/70.,80.,90.,100.,110.,120.,250./
*
INITIAL
      C1=TCK1/2.
      C2=TCK1+TCK2/2.
      C3=TCK1+TCK2+TCK3/2.
      WRTI=WLVI
      DSLRI=1.
*
* LAST RAINFALL ON DATE 50
*
      WSTI=0.
      WSOI=0.
      ALVI=WLVI/(SLWC*0.5)
      NAGCR=1000.

      WL1I=WVL1I*TCK1*1.E4
      WL2I=WVL2I*TCK2*1.E4
      WL3I=WVL3I*TCK3*1.E4
*
* IF NO CAPILLARY RISE ESTIMATE IS NEEDED, PLEASE INSERT A *
* BEFORE EACH OF THE FOLLOWING 29 STATEMENTS.
*
*FIXED I,J,JMAX,IMAX,P,M
*SYSTEM NPOINT=200,NFUN=20
*NOSORT

*       READ(20,1000) ((TH(I,J),J=1,8),I=1,10)
*       IMAX=14
*       JMAX=8
*
*    DO 200 P=1,10
*       PF(P)=ALOG10(PSI(P))
*       PPP=P
*       J=1
*       I=1
*100    IF(H(I)-TH(P,J)) 8,4,2
*8      IF(J-1) 3,3,9
*9      TCR(I)=CR(J-1)-(H(I)-T(P,J-1))/(TH(P,J)-TH(P,J-1))*...
```

```
*       (CR(J-1)-CR(J))
*       GOTO 6
*3      TCR(I)=.999
*       GOTO 6
*4      TCR(I)=CR(J)
*6      IF(I.EQ.IMAX) GOTO 200
*       I=I+1
*       GOTO 100
*2      IF(J-JMAX) 20,20,40
*20     J=J+1
*      GOTO 100
*40     DO 41 M=I,IMAX
*41     TCR(M)=0.
*200    CALL TVLOAD(CRISIS,H,TCR,IMAX,PPP,PF(PPP))
*1000   FORMAT (8(3X,F5.1))
*
DYNAMIC
      DATE=1.+AMOD(TIME+DATAST+EMERG-1.,365.)
      DAY=TIME+EMERG

      WLV=INTGRL(WLVI,GLV-LLV)
      WST=INTGRL(WSTI,GST-CTST)
      WSO=INTGRL(WSOI,GSO)
      WRT=INTGRL(WRTI,GRT-LRT)
      WSS=WLV+WST+WSO
      WCR=WSS+WRT

      GLV=CAGLV*CFLV
      GST=CAGST*CFST
      GSO=CAGSO*CFSO
      GRT=CAGRT*CFRT

      CAGRT=CAGCR*AFGEN(CARTT,DVS)
      CAGLV=CAGCR*AFGEN(CALVT,DVS)
      CAGST=CAGCR*AFGEN(CASTT,DVS)
      CAGSO=CAGCR-CAGRT-CAGLV-CAGST

      CAGCR1=PCGA*30./44.-RMCR*30./44.+CTST*1.08
      PCGP=PCGO*FOV+PCGC*(1.-FOV)
      PCGA=FTEMP*PCGP*TRA/TRP
      CAGCR=INSW(PCGA-RMCR,.001,CAGCR1)
      FTEMP=AFGEN(PMXTT,ETMP)
      ETMP=AFGEN(MXTT,DAY)-.25*(AFGEN(MXTT,DAY)-AFGEN(MNTT,DAY))
      PCGC,PCGO=PHOTO(PMAXP,PEA,ALV,RDTC,RDTO,DL,DLE,DEC,LAT)
      PCGAT=INTGRL(0.,PCGA-RMCR-RGCR)

      RCRT=INTGRL(0.,RMCR+RGCR)
      RMCR=RMLV+RMST+RMSO+RMRT
      RMLV=WLV*RMLVD*0.5*ETM
      RMST=WST*RMSTD*ETM
      RMSO=WSO*RMSOD*ETM
      RMRT=WRT*RMRTD*ETM
      ETM=Q10**((TMPA-TMPR)/10.)
      RGCR=RGLV+RGST+RGSO+RGRT
      RGLV=CAGLV*CPLV
      RGST=CAGST*CPST
      RGSO=CAGSO*CPSO
      RGRT=CAGRT*CPRT

      LLV=WLV*AFGEN(LLVT,DVS)
      CTST=WST*AFGEN(TSTT,DVS)
      LRT=WRT*AFGEN(LRTT,DVS)
      WLVD=INTGRL(0.,LLV)
```

```
WRTD=INTGRL(0.,LRT)
WSTT=INTGRL(0.,CTST)

ALV=INTGRL(ALVI,GLA-LLA+GSA)
LAI=INTGRL(ALVI,GLA-LLA)
GLA=GLV/SLWA
SLWA=SLWC*AFGEN(SLWT,DVS)
LLA=LLV/SLWA
GSA=GST/SSWC

RDTC,RDTO,DEC,DL,DLE,DLP=ASTRO(DATE,LAT,INSP)
FOV=(RDTC-RDTP)/(RDTC-RDTO)
RDTP=RDTPF*RUCF*AFGEN(DTRT,DAY)
RDTPF=0.5+0.1*(RDTC-0.5*RUCF*AFGEN(DTRT,DAY))/(RDTC-RDTO)
TMPA=(AFGEN(MNTT,DAY)+AFGEN(MXTT,DAY))/2.
WDS=AFGEN(WSTB,DAY)/3.6
HUAA=AFGEN(VAPHTB,DAY)

TRA=TRA1+TRA2+TRA3
TRA1=TRRM*RTL1*WSE1
TRA2=TRRM*RTL2*WSE2
TRA3=TRRM*RTL3*WSE3
TRRM=TRP/(RTL+NOT(RTL))
TRP=EVCR
EVCR=EVCRR*(1.-EXP(-0.5*ALV))+EVCRD*ALFA*ALV
EVCRR,EVCRD=EVATR(RDTM,FOV,DL,TMPA,HUAA,HUAD,WDS,WDLV,RS,RCCRV)
RDTM=RUCF*AFGEN(DTRT,DAY)

RTL=RTL1+RTL2+RTL3
RTL1=LIMIT(0.,TCK1,RTD)
RTL2=LIMIT(0.,TCK2,RTD-TCK1)
RTL3=LIMIT(0.,TCK3,RTD-TCK1-TCK2)
RTD=AMIN1(AFGEN(RTDT,WRT),TCK1+TCK2+TCK3)
WSE1=AFGEN(WSET,WVRL1)
WSE2=AFGEN(WSET,WVRL2)
WSE3=AFGEN(WSET,WVRL3)
WVRL1=LIMIT(0.,1.,(WVL1-WLP1)/(FLD1-WLP1))
WVRL2=LIMIT(0.,1.,(WVL2-WLP2)/(FLD2-WLP2))
WVRL3=LIMIT(0.,1.,(WVL3-WLP3)/(FLD3-WLP3))
WVL1=WL1/(TCK1*1.E4)
WVL2=WL2/(TCK2*1.E4)
WVL3=WL3/(TCK3*1.E4)

WL1=INTGRL(WL1I,(WLFL1-WLFL2-EVSL1-TRA1+CRISE1*10.)*10.)
WL2=INTGRL(WL2I,(WLFL2-WLFL3-EVSL2-TRA2+CRISE2*10.)*10.)
WL3=INTGRL(WL3I,(WLFL3-WLFL4-EVSL3-TRA3+CRISE3*10.)*10.)
WSLMM=(WL1+WL2+WL3)/10.
WLFL1=AFGEN(RAINT,DAY)*(1.-RNOF)
WLFL2=AMAX1(0.,WLFL1-(FLD1*TCK1*1000.-WL1*0.1)/DELT)
WLFL3=AMAX1(0.,WLFL2-(FLD2*TCK2*1000.-WL2*0.1)/DELT)
WLFL4=AMAX1(0.,WLFL3-(FLD3*TCK3*1000.-WL3*0.1)/DELT)
WDRT=INTGRL(0.,WLFL4)

EVSL1=EVSL*VAR1/(VAR1+VAR2+VAR3)
EVSL2=EVSL*VAR2/(VAR1+VAR2+VAR3)
EVSL3=EVSL*VAR3/(VAR1+VAR2+VAR3)
VAR1=AMAX1(WL1-WCL*TCK1*1.E4,0.)*EXP(-EESL*(0.25*TCK1))
VAR2=AMAX1(WL2-WCL*TCK1*1.E4,0.)*EXP(-EESL*(TCK1+0.25*TCK2))
VAR3=AMAX1(WL3-WCL*TCK3*1.E4,0.)*EXP(-EESL*(TCK1+TCK2+0.25*TCK3))

EVSL=INSW(DSLR-1.,EVSLP,EVSLW)
EVSLP=AMIN1(EVSLE,WLFL1+(WL1*1.E-4-WCL*TCK1)*1000.)
EVSLW=...
```

```
      INSW(DSLR-1.,0.,AMIN1(EVSLE,EVSLC*(SQRT(DSLR)-SQRT(DSLR-1.+...
          NOT(DSLR)))))
      EVSLE=EVSLR*EXP(-0.5*ALV)+EVSLD*EXP(-0.5*ALV)
      EVSLR,EVSLD=EVATR(RDTM,FOV,DL,TMPA,HUAA,HUAD,WDS,ERSL,0.,RCSLL)
      ERSL=WDLV
      WUC=TRP*1.E4/(PCGP+NOT(PCGP))
      DSLR=INTGRL(DSLRI,INSW(AFGEN(RAINT,DAY+1)-0.01,1.,-DSLR))
      WFL=INTGRL(0.,(CRISE*10.+WLFL1-EVSL-TRA-WLFL4)*10.)

TIMER TIME=1., DELT=1.,PRDEL=10.,OUTDEL=5.,FINTIM=1000.
METHOD RECT
PRINT DATE,RATIO,TRA,TRP,DVS,TRA1,TRA2,TRA3,TRRM,WSE1,WSE2,WSE3,...
WL1,WL2,WL3,WLFL1,WLFL2,WLFL3,WLFL4,WVRL1,WVRL2,WVRL3,...
EVSL1,EVSL2,EVSL3,RTD,PPF,CRISE,CTOT,...
WLVSO,WLV,WST,WSO,WRT,FTEMP,ALV,TMPA,PCGA,DATE
*OUTPUT LAI,FMLAI
PAGE GROUP,NTAB=1
*OUTPUT WLVSO,FMDRYM
PAGE GROUP,NTAB=1
*FMLAI=AFGEN(MLAI,DAY)
*FMDRYM=AFGEN(MDRYM,DAY)
OUTPUT WVL1,F1
PAGE GROUP,NTAB=1
*OUTPUT WVL2,F2
PAGE GROUP,NTAB=1
*OUTPUT WVL3,F3
PAGE GROUP,NTAB=1
*F1=AFGEN(VOLM1,DAY)
*F2=AFGEN(VOLM2,DAY)
*F3=AFGEN(VOLM3,DAY)

      RATIO=TRA/TRP
      WLVT=WLV+WLVD
      WLVST=WLVT+WST
      WLVSO=WLVST+WSO
      HI=WSO/WSS

      DVS=INTGRL(DVSI,DVR)
      DVR=DVRC*DVRET*DVREP*DVREV
      DVRC=INSW(DVS-1.,DVRC1,DVRC2)
      DVRET=LIMIT(0.,1.,(TMPA-TEMPB)/(TEMPO-TEMPB))
      TEMPB=INSW(DVS-1.,TEMPB1,TEMPB2)
      DVREP=INSW(DVS-0.,1.,...
            INSW(DVS-1.,LIMIT(0.,1.,(DLP-DLPB)/(DLPO-DLPB)),1.))
      DLPB=INSW(DVS-DBRDG,DLPB1,DLPB2)
      DVREV=INSW(DVS-0.,1.,...
            INSW(DVS-DBRDG,(VERND-VERNDB)/(VERNDO-VERNDB),1.))
      VERND=INTGRL(10.,VERNR)
      VERNR=INSW(DVS-DBRDG,AFGEN(VERNRT,TMPA),1.)
*
* IF NO CAPILLARY RISE ESTIMATE IS NEEDED, PLEASE INSERT A *
* BEFORE EACH OF THE FOLLOWING 12 STATEMENTS.
*
*WTABLE=AFGEN(FWTAB,DAY)
*DISTAN=(WTABLE-CL)*100.
*CL=INSW(0.-RTL3,C3,INSW(0.-RTL2,C2,C1))
*CRISE=TWOVAR(CRISIS,DISTAN,PPF)
*PPF=ALOG10(PSIX)
*PSIX=EXP((-1./GAMMA*ALOG(WVL/SMO))**.5)
*CRISE1=INSW(PSIX-20.,0.,INSW(0.-RTL3,0.,INSW(0.-RTL2,0.,CRISE)))
*CRISE2=INSW(PSIX-20.,0.,INSW(0.-RTL3,0.,INSW(0.-RTL2,CRISE,0.)))
*CRISE3=INSW(PSIX-20.,0.,INSW(0.-RTL3,CRISE,INSW(0.-RTL2,0.,0.)))
*WVL=INSW(0.-RTL3,WVL3,INSW(0.-RTL2,WVL2,WVL1))
```

```
*CTOT=INTGRL(0.,INSW(PSIX-20.,0.,CRISE)

TITLE SM.PWH: PLANT DATA FOR WHEAT
FUNCTION CRISIS
FUNCTION CRISIS
      PARAM TEMPB1=1., TEMPB2=9., TEMPO=35.
      PARAM DLPB1=0.,DLPB2=7.,DLPO=20.
      PARAM VERNDB=8., VERNDO=33.
PARAM RUCF=1.E4
PARAM LAT=52.
PARAM EMERG=31.
PARAM DVRC1=.0396,DVRC2=.1
PARAM DATAST=273.
PARAM DBRDG=.321
      FUNCTION VERNRT=-20.0,0.,-4.,0.,3.,1.,10.,1.,17.,0.,50.,0.
PARAM DVSI=0.0
*  REFLECTS WINTER WHEAT AT NOV. 1

PARAM WLVI=20.
FUNCTION CALVT=0.,.475,.2,.685,.35,.785,.4,.755,.5,.515,.6,.32,...
          .7,.22,.8,.125,.9,.07,1.,.02,1.1,0.,2.1,0.
FUNCTION CASTT=0.,0.,.35,0.,.4,.045,.5,.325,.6,.535,.7,.59,.8,.58,...
          .9,.45,1.,.25,1.1,.09,1.2,0.,2.1,0.
FUNCTION CARTT=0.,.5,.2,.29,.35,.19,.4,.175,.5,.135,.6,.1,.7,...
                 .075,.8,.05,.9,.03,1.,.02,1.1,.01,1.2,0.,2.1,0.
PARAM PMAXP=40., PEA=0.5
FUNCTION PMXTT=-20.,0., -5.,0.01,5.,0.02,15.,0.8,20.,1.,...
25.,1., 30.,0.8, 37.,0.0
PARAM CFLV=0.73, CFST=0.73, CFSO=0.66, CFRT=0.73
PARAM CPLV=0.35, CPST=0.31, CPSO=0.28, CPRT=0.31
PARAM FCLV=0.42, FCST=0.43, FCSO=0.49, FCRT=0.43
PARAM INSP=-4.
PARAM Q10=2., TMPR=25.
PARAM RMLVD=0.03, RMSTD=0.015, RMSOD=0.005, RMRTD=0.01
FUNCTION LLVT=0.,0.,1.,0.,1.01,.02,2.1,0.02
FUNCTION TSTT=0.,0., 1.4,0., 2.1,0.0
FUNCTION LRTT=0.,0., 1.,0., 1.01,0.00, 2.1,0.00
PARAM DVRC=0.035
PARAM SLWC=450., SSWC=4000.
FUNCTION SLWT=0.,0.8, 0.5,1.1, 2.1,1.1
FUNCTION WSET=0.,0., 0.1,0.3, 0.15,0.45, 0.3,0.7, 0.5,0.975, 1.,1.
FUNCTION RTDT=0.,0., 800.,1., 3000.,2.
PARAM RS=160., RCCRV=0.25,ALFA=0.5,WDLV=0.02
FINISH DVS=2., CAGCR=0., NAGCR=0.
FUNCTION NCLVHT=0.,0.05, 1.0,0.04, 2.1,0.02
PARAM TCUNV=2.
PARAM NCSOH=0.018, NCSOL=0.015
FUNCTION PMXNT=0.,0., 0.8,1., 1.,1.
FUNCTION RMCRNT=0.,0.5, 1.,1.
FUNCTION TCRNT=0.,2., 0.5,5.,  1.,15., 2.,50.
FUNCTION WNUT=0.,0., 0.1,0.2, 0.5,0.8, 0.95,1., 1.,0., 1.1,0.

TITLE WINTERWHEAT, DE BOUWING 1982-1983

*     WEATHER TABLES START FROM OCTOBER 1

FUNCTION MXTT        = ...
  1.,17.1,     2.,19.2,     3.,17.5,     4.,16.4,     5.,13.2,    ...
  6.,15.6,     7.,13.2,     8.,14.6,     9.,13.4,    10.,13.4,    ...
 11.,12.9,    12.,13.6,    13.,12.2,    14.,13.3,    15.,11.5,    ...
 16.,12.7,    17.,14.9,    18.,16.7,    19.,15.1,    20.,15.6,    ...
 21.,16.2,    22.,18.9,    23.,14.5,    24.,13.3,    25.,12.9,    ...
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  26.,13.7,    27.,14.9,    28.,15.4,    29.,12.8,    30., 9.3,    ...
  31.,10.4,    32.,16.5,    33.,13.2,    34.,14.4,    35.,12.8,    ...
  36.,11.5,    37., 9.9,    38., 9.0,    39.,16.1,    40.,13.2,    ...
  41.,11.7,    42.,13.7,    43.,14.4,    44., 8.6,    45., 7.5,    ...
  46., 6.5,    47., 7.4,    48., 8.4,    49.,11.7,    50.,10.3,    ...
  51.,10.4,    52., 9.2,    53., 8.7,    54.,12.8,    55.,13.7,    ...
  56., 8.7,    57., 8.2,    58., 7.4,    59., 5.2,    60., 4.4,    ...
  61., 4.1,    62., 2.5,    63., 1.8,    64., 3.0,    65., 3.5,    ...
  66., 6.4,    67., 6.4,    68.,10.6,    69.,11.6,    70., 9.2,    ...
  71.,11.7,    72., 6.0,    73., 3.9,    74., 0.4,    75., 2.2,    ...
  76.,12.6,    77.,11.8,    78., 3.5,    79., 2.9,    80., 6.6,    ...
  81., 6.8,    82., 5.3,    83., 3.7,    84., 2.3,    85., 2.6,    ...
  86., 5.8,    87., 8.7,    88., 9.3,    89., 6.7,    90., 3.2,    ...
  91., 4.1,    92., 1.1,    93., 2.4,    94., 4.4,    95.,10.9,    ...
  96.,11.8,    97.,12.9,    98.,13.0,    99., 7.6,   100., 7.6,    ...
 101., 8.4,   102., 9.4,   103., 9.5,   104., 7.1,   105., 6.7,    ...
 106., 6.5,   107., 9.5,   108., 9.4,   109., 8.6,   110., 8.4,    ...
 111., 5.0,   112., 4.6,   113., 7.0,   114., 6.1,   115., 5.1,    ...
 116., 5.2,   117., 8.5,   118.,11.0,   119.,12.4,   120.,10.0,    ...
 121.,10.4,   122., 8.0,   123.,10.3,   124.,10.7,   125., 6.2,    ...
 126., 3.9,   127., 5.0,   128., 5.7,   129., 3.5,   130., 1.3,    ...
 131., 0.8,   132.,-0.3,   133.,-1.4,   134., 0.0,   135., 0.0,    ...
 136.,-0.8,   137., 0.2,   138., 2.0,   139., 1.6,   140., 2.6,    ...
 141., 2.6,   142., 2.2,   143., 4.6,   144., 3.3,   145., 2.0,    ...
 146., 5.2,   147., 7.8,   148., 9.9,   149., 8.1,   150., 7.1,    ...
 151., 6.4,   152., 6.5,   153., 8.2,   154., 7.8,   155., 9.5,    ...
 156.,10.6,   157., 9.5,   158.,11.2,   159.,11.2,   160., 6.8,    ...
 161., 9.7,   162., 8.0,   163., 9.1,   164.,12.4,   165.,13.6,    ...
 166., 9.7,   167.,10.0,   168.,10.1,   169.,11.6,   170.,10.4,    ...
 171.,10.1,   172., 8.5,   173., 6.6,   174., 9.1,   175., 7.8,    ...
 176., 6.8,   177., 7.3,   178., 7.3,   179., 6.7,   180., 8.7,    ...
 181., 9.4,   182., 9.8,   183.,13.2,   184., 8.3,   185., 7.9,    ...
 186., 6.7,   187., 8.2,   188., 9.2,   189.,10.1,   190.,10.0,    ...
 191.,12.1,   192.,14.2,   193.,11.3,   194., 8.1,   195., 9.4,    ...
 196.,10.5,   197.,13.9,   198.,17.6,   199.,15.2,   200.,20.0,    ...
 201.,13.1,   202.,15.5,   203.,12.6,   204.,13.9,   205.,16.1,    ...
 206.,15.8,   207.,14.2,   208.,14.8,   209.,12.1,   210.,14.7,    ...
 211.,14.9,   212.,17.9,   213.,16.4,   214.,13.4,   215., 9.9,    ...
 216.,12.5,   217.,15.2,   218.,18.4,   219.,15.8,   220.,15.0,    ...
 221.,15.2,   222.,13.5,   223.,11.9,   224.,13.4,   225.,16.0,    ...
 226.,16.2,   227.,16.8,   228.,13.7,   229.,16.0,   230.,16.9,    ...
 231.,15.2,   232.,17.5,   233.,13.4,   234.,14.9,   235.,16.2,    ...
 236.,11.0,   237.,10.5,   238., 9.7,   239.,10.7,   240.,11.9,    ...
 241.,11.8,   242.,16.4,   243.,22.7,   244.,24.1,   245.,18.6,    ...
 246.,20.3,   247.,25.3,   248.,21.1,   249.,19.2,   250.,23.8,    ...
 251.,25.0,   252.,21.0,   253.,18.8,   254.,19.8,   255.,21.7,    ...
 256.,19.9,   257.,17.1,   258.,15.5,   259.,14.5,   260.,15.7,    ...
 261.,20.9,   262.,21.5,   263.,25.7,   264.,27.7,   265.,29.1,    ...
 266.,29.0,   267.,25.3,   268.,21.7,   269.,23.0,   270.,18.6,    ...
 271.,17.8,   272.,16.4,   273.,18.2,  ...
 274.,18.2,   275.,20.9,   276.,22.1,   277.,24.3,   278.,27.7,    ...
 279.,26.6,   280.,27.2,   281.,27.4,   282.,27.5,   283.,30.4,    ...
 284.,32.0,   285.,29.6,   286.,21.0,   287.,23.3,   288.,28.1,    ...
 289.,28.4,   290.,31.5,   291.,24.9,   292.,23.7,   293.,18.2,    ...
 294.,21.5,   295.,27.0,   296.,27.2,   297.,22.5,   298.,26.7,    ...
 299.,28.1,   300.,25.0,   301.,22.7,   302.,24.5,   303.,25.9,    ...
 304.,29.5
FUNCTION MNTT         = ...
   1., 9.5,     2., 7.6,     3., 7.5,     4., 8.8,     5., 8.6,    ...
   6., 4.0,     7., 8.3,     8., 9.4,     9.,10.2,    10., 9.7,    ...
  11., 9.6,    12., 8.5,    13., 8.0,    14., 9.2,    15., 8.5,    ...
  16., 5.2,    17., 9.1,    18., 9.5,    19., 9.5,    20.,10.0,    ...
  21.,10.9,    22., 8.1,    23., 9.7,    24., 5.3,    25., 5.1,    ...
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  26., 9.2,    27., 1.9,    28., 1.6,    29., 4.6,    30., 6.9,    ...
  31., 6.6,    32.,10.3,    33.,10.8,    34.,12.0,    35.,10.5,    ...
  36., 5.7,    37., 2.4,    38., 0.5,    39., 6.9,    40.,10.0,    ...
  41., 9.2,    42., 8.5,    43., 7.9,    44., 3.5,    45., 2.4,    ...
  46.,-0.6,    47.,-0.3,    48., 2.2,    49., 6.7,    50., 6.0,    ...
  51., 5.6,    52., 5.5,    53., 3.8,    54., 3.5,    55., 5.1,    ...
  56., 6.0,    57., 3.5,    58., 3.4,    59., 2.9,    60., 2.4,    ...
  61., 0.3,    62.,-0.6,    63.,-3.6,    64., 1.5,    65., 0.7,    ...
  66., 1.6,    67.,-0.7,    68., 0.1,    69., 3.6,    70., 3.1,    ...
  71., 4.0,    72., 1.8,    73., 0.1,    74.,-3.9,    75.,-2.4,    ...
  76., 1.7,    77., 2.9,    78., 0.2,    79.,-0.6,    80.,-1.0,    ...
  81., 3.9,    82., 3.2,    83.,-2.9,    84.,-3.5,    85.,-1.3,    ...
  86., 2.5,    87., 5.8,    88., 4.0,    89., 1.4,    90.,-3.3,    ...
  91.,-1.9,    92.,-1.6,    93.,-1.9,    94., 2.4,    95., 2.8,    ...
  96., 3.3,    97., 4.9,    98., 5.0,    99., 3.0,   100., 2.0,    ...
 101., 2.9,   102., 3.1,   103., 6.6,   104., 3.7,   105., 0.9,    ...
 106., 0.6,   107., 4.0,   108., 7.2,   109., 6.5,   110., 0.8,    ...
 111.,-0.1,   112.,-0.8,   113., 4.4,   114., 3.9,   115., 0.1,    ...
 116.,-1.4,   117., 3.6,   118., 6.5,   119., 9.0,   120., 7.6,    ...
 121., 4.2,   122., 0.4,   123., 0.9,   124., 2.1,   125., 0.2,    ...
 126.,-1.2,   127.,-1.6,   128., 0.4,   129., 1.0,   130., 0.3,    ...
 131.,-1.8,   132.,-3.0,   133.,-4.9,   134.,-4.7,   135.,-5.6,    ...
 136.,-6.3,   137.,-7.0,   138.,-3.8,   139.,-6.4,   140.,-3.5,    ...
 141.,-6.3,   142.,-1.4,   143.,-1.5,   144.,-2.6,   145.,-4.3,    ...
 146.,-4.9,   147.,-2.4,   148., 2.5,   149., 3.3,   150., 4.3,    ...
 151., 1.1,   152.,-0.5,   153.,-0.5,   154., 0.1,   155., 0.7,    ...
 156.,-1.4,   157., 5.1,   158., 5.9,   159., 2.0,   160., 1.9,    ...
 161., 2.1,   162.,-1.5,   163.,-3.9,   164., 0.8,   165., 6.3,    ...
 166., 0.5,   167., 0.5,   168., 5.2,   169., 8.7,   170., 6.5,    ...
 171., 5.8,   172., 2.3,   173., 2.1,   174., 1.3,   175., 0.3,    ...
 176., 0.3,   177., 0.7,   178., 0.7,   179.,-1.8,   180.,-1.4,    ...
 181., 3.6,   182., 3.8,   183., 4.5,   184., 0.6,   185.,-1.0,    ...
 186.,-0.8,   187., 1.4,   188., 2.5,   189., 3.0,   190., 4.1,    ...
 191., 1.1,   192., 3.3,   193., 6.7,   194., 2.5,   195., 1.2,    ...
 196., 5.6,   197., 3.5,   198., 1.2,   199.,11.0,   200., 9.0,    ...
 201., 2.5,   202., 1.7,   203., 7.0,   204., 5.5,   205., 8.0,    ...
 206., 5.2,   207., 8.5,   208., 6.4,   209., 5.2,   210., 6.4,    ...
 211., 7.0,   212., 5.5,   213., 9.4,   214., 7.3,   215., 7.4,    ...
 216., 1.8,   217.,-1.2,   218., 7.7,   219.,10.9,   220., 7.9,    ...
 221., 9.0,   222., 5.2,   223., 6.4,   224., 5.5,   225., 7.9,
 226., 7.8,   227., 6.6,   ...
 228., 9.9,   229., 8.6,   230., 8.5,   231., 8.9,   232., 8.1,    ...
 233., 8.6,   234., 6.2,   235., 5.6,   236., 9.6,   237., 8.8,    ...
 238., 8.4,   239., 6.3,   240., 6.2,   241., 6.8,   242., 4.2,    ...
 243.,11.1,   244.,14.7,   245., 9.9,   246., 9.4,   247.,12.4,    ...
 248., 9.4,   249., 6.9,   250.,10.9,   251.,14.4,   252.,12.3,    ...
 253.,12.0,   254.,11.3,   255.,12.4,   256., 9.8,   257., 8.4,    ...
 258., 6.1,   259., 5.2,   260., 2.6,   261.,10.6,   262., 8.4,    ...
 263.,11.7,   264.,12.5,   265.,13.9,   266.,15.2,   267.,13.7,    ...
 268.,13.6,   269.,12.5,   270., 8.3,   271., 7.4,   272.,12.8,    ...
 273.,11.2,   274., 9.7,   275.,10.6,   276., 9.7,   277., 8.6,    ...
 278.,10.3,   279.,16.5,   280.,17.4,   281.,15.9,   282.,15.8,    ...
 283.,15.3,   284.,15.2,   285.,16.2,   286.,13.7,   287.,13.2,    ...
 288.,13.0,   289.,17.0,   290.,16.6,   291.,15.9,   292.,11.7,    ...
 293., 9.4,   294., 8.4,   295.,11.3,   296.,15.4,   297.,13.7,    ...
 298.,11.6,   299.,16.7,   300.,14.1,   301.,12.5,   302.,13.1,    ...
 303.,12.0,   304.,16.9
FUNCTION VAPHTB     = ...
   1.,13.1,     2.,13.0,     3.,14.2,     4.,13.2,     5.,11.8,    ...
   6.,11.5,     7.,12.9,     8.,12.3,     9.,12.3,    10.,11.7,    ...
  11.,12.0,    12.,12.0,    13.,11.4,    14.,11.4,    15.,10.6,    ...
  16., 9.5,    17.,10.5,    18.,12.3,    19.,12.2,    20.,11.1,    ...
  21.,12.2,    22.,13.3,    23.,13.4,    24., 9.5,    25.,10.1,    ...
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  26.,12.5,     27.,10.5,     28.,11.2,     29.,10.9,     30., 9.3,    ...
  31., 9.3,     32.,12.5,     33.,14.0,     34.,14.1,     35.,12.6,    ...
  36.,10.8,     37., 6.7,     38., 5.6,     39.,10.5,     40.,11.8,    ...
  41.,11.5,     42.,11.2,     43.,10.7,     44., 8.7,     45., 7.6,    ...
  46., 7.3,     47., 7.7,     48., 8.2,     49.,11.4,     50., 8.1,    ...
  51., 8.6,     52., 8.3,     53., 8.8,     54.,10.2,     55., 8.9,    ...
  56., 8.9,     57., 8.5,     58., 8.1,     59., 7.7,     60., 7.6,    ...
  61., 6.7,     62., 5.4,     63., 5.7,     64., 6.6,     65., 6.6,    ...
  66., 7.0,     67., 7.7,     68., 7.8,     69., 8.2,     70., 8.4,    ...
  71., 8.6,     72., 7.4,     73., 6.5,     74., 5.3,     75., 5.8,    ...
  76.,10.4,     77., 7.0,     78., 6.2,     79., 6.2,     80., 6.0,    ...
  81., 7.2,     82., 7.3,     83., 6.6,     84., 5.9,     85., 5.7,    ...
  86., 8.2,     87., 9.9,     88., 9.1,     89., 7.1,     90., 6.4,    ...
  91., 6.5,     92., 5.3,     93., 5.9,     94., 7.6,     95.,10.5,    ...
  96., 9.4,     97.,11.1,     98., 9.5,     99., 7.5,    100., 7.5,    ...
 101., 8.1,    102., 9.4,    103., 9.7,    104., 7.7,    105., 7.0,    ...
 106., 6.7,    107., 8.6,    108., 8.9,    109., 8.7,    110., 6.2,    ...
 111., 5.9,    112., 6.1,    113., 7.7,    114., 7.1,    115., 6.0,    ...
 116., 5.7,    117., 9.1,    118.,10.7,    119.,10.4,    120.,10.0,    ...
 121., 8.4,    122., 7.2,    123., 7.1,    124., 7.8,    125., 5.9,    ...
 126., 6.1,    127., 5.8,    128., 6.2,    129., 6.7,    130., 5.9,    ...
 131., 5.0,    132., 4.6,    133., 4.6,    134., 4.0,    135., 3.6,    ...
 136., 2.9,    137., 3.1,    138., 3.3,    139., 2.6,    140., 3.6,    ...
 141., 4.1,    142., 4.4,    143., 4.8,    144., 3.3,    145., 2.3,    ...
 146., 2.0,    147., 4.1,    148., 6.4,    149., 8.8,    150., 8.7,    ...
 151., 7.2,    152., 6.8,    153., 6.6,    154., 6.4,    155., 6.7,    ...
 156., 7.4,    157., 8.7,    158., 8.9,    159., 8.0,    160., 7.5,    ...
 161., 8.3,    162., 6.6,    163., 4.8,    164., 5.5,    165., 9.5,    ...
 166., 8.1,    167., 7.4,    168.,10.4,    169.,11.6,    170.,10.8,    ...
 171., 9.2,    172., 7.4,    173., 6.1,    174., 8.2,    175., 7.3,    ...
 176., 6.2,    177., 6.5,    178., 6.3,    179., 6.2,    180., 6.7,    ...
 181., 7.5,    182., 8.1,    183., 8.5,    184., 7.9,    185., 6.4,    ...
 186., 6.6,    187., 7.5,    188., 7.4,    189., 7.4,    190., 8.2,    ...
 191., 7.2,    192.,10.1,    193., 8.8,    194., 7.5,    195., 6.9,    ...
 196., 8.4,    197., 8.7,    198., 9.3,    199.,11.0,    200.,11.5,    ...
 201., 9.5,    202., 8.5,    203.,10.0,    204., 9.7,    205.,11.0,    ...
 206., 9.9,    207.,10.7,    208.,11.1,    209.,10.7,    210.,10.5,    ...
 211.,10.2,    212., 9.8,    213.,11.6,    214., 9.2,    215., 9.7,    ...
 216., 9.0,    217., 8.5,    218.,11.3,    219.,13.4,    220.,11.2,    ...
 221.,10.9,    222., 8.7,    223., 9.6,    224.,10.0,    225.,10.5,    ...
 226.,10.8,    227.,11.8,    228.,11.7,    229.,11.4,    230.,10.8,    ...
 231.,10.8,    232.,11.3,    233.,12.5,    234.,10.6,    235., 9.9,    ...
 236.,11.7,    237.,11.3,    238.,10.4,    239., 9.6,    240.,10.2,    ...
 241.,10.5,    242.,10.8,    243.,11.9,    244.,15.1,    245.,13.5,    ...
 246.,12.7,    247.,15.0,    248.,13.1,    249.,10.0,    250.,10.8,    ...
 251.,15.5,    252.,14.9,    253.,12.4,    254.,12.8,    255.,13.8,    ...
 256.,12.0,    257.,10.7,    258., 9.4,    259., 9.1,    260., 8.3,    ...
 261.,11.5,    262.,12.9,    263.,12.7,    264.,13.5,    265.,15.2,    ...
 266.,17.9,    267.,17.9,    268.,15.7,    269.,13.0,    270.,12.5,    ...
 271.,11.0,    272.,15.5,    273.,14.5,    ...
 274.,12.5,    275.,14.2,    276.,14.2,    277.,14.1,    278.,15.4,    ...
 279.,18.5,    280.,19.4,    281.,20.5,    282.,21.3,    283.,18.1,    ...
 284.,17.8,    285.,19.6,    286.,15.6,    287.,13.7,    288.,18.9,    ...
 289.,19.6,    290.,18.8,    291.,18.7,    292.,15.7,    293.,11.0,    ...
 294.,11.3,    295.,13.7,    296.,17.1,    297.,18.6,    298.,18.0,    ...
 299.,20.4,    300.,19.5,    301.,16.3,    302.,17.1,    303.,17.1,    ...
 304.,17.1
 FUNCTION RAINT      = ...
   1., 0.0,      2., 0.0,      3., 0.0,      4., 0.0,      5., 0.8,    ...
   6., 0.0,      7.,16.0,      8., 4.8,      9., 4.2,     10.,14.3,    ...
  11., 2.1,     12., 2.3,     13., 5.1,     14., 5.4,     15.,14.1,    ...
  16., 0.1,     17., 1.0,     18., 6.8,     19., 0.3,     20., 0.0,    ...
  21., 0.1,     22., 0.0,     23., 5.0,     24., 0.5,     25., 0.1,    ...
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 26., 0.0,    27., 0.0,    28., 0.0,    29., 0.0,    30., 0.0,   ...
 31., 0.0,    32., 0.0,    33., 0.1,    34., 0.0,    35., 0.1,   ...
 36., 0.0,    37., 0.0,    38., 0.1,    39., 3.1,    40., 0.1,   ...
 41., 0.2,    42., 0.0,    43., 6.9,    44., 1.9,    45., 2.9,   ...
 46.,13.5,    47., 4.1,    48., 9.7,    49., 8.2,    50., 1.5,   ...
 51., 0.4,    52., 0.0,    53., 7.1,    54., 1.6,    55., 0.3,   ...
 56., 0.7,    57., 3.3,    58., 0.0,    59., 0.0,    60., 0.0,   ...
 61., 0.0,    62., 0.0,    63., 0.0,    64., 0.0,    65., 0.0,   ...
 66., 3.7,    67., 1.3,    68., 3.9,    69., 1.0,    70., 6.2,   ...
 71., 9.3,    72., 7.7,    73., 0.0,    74., 0.0,    75., 0.1,   ...
 76., 1.3,    77., 5.3,    78., 2.3,    79., 0.4,    80., 2.7,   ...
 81., 5.2,    82., 6.1,    83., 1.3,    84., 0.0,    85., 0.0,   ...
 86., 0.0,    87., 0.0,    88., 0.1,    89., 1.4,    90., 0.0,   ...
 91., 0.0,    92., 0.0,    93., 1.5,    94., 0.1,    95.,18.6,   ...
 96.,10.7,    97., 2.4,    98., 2.2,    99., 0.1,   100., 0.1,   ...
101., 4.7,   102., 0.0,   103., 0.0,   104., 0.0,   105., 3.4,   ...
106., 6.9,   107., 3.3,   108., 0.1,   109., 0.0,   110., 1.4,   ...
111., 3.0,   112., 0.0,   113., 0.0,   114., 0.0,   115., 0.0,   ...
116., 0.0,   117., 3.3,   118., 0.4,   119., 0.5,   120., 3.2,   ...
121., 0.2,   122., 4.3,   123.,11.3,   124., 7.1,   125., 4.7,   ...
126., 3.3,   127., 0.0,   128.,10.8,   129., 1.6,   130., 0.5,   ...
131., 0.1,   132., 0.2,   133., 0.0,   134., 0.0,   135., 0.0,   ...
136., 0.0,   137., 0.0,   138., 0.0,   139., 0.0,   140., 0.0,   ...
141., 0.0,   142., 0.0,   143., 0.0,   144., 0.0,   145., 0.0,   ...
146., 0.0,   147., 0.0,   148., 0.3,   149., 2.2,   150., 5.3,   ...
151., 1.6,   152., 0.7,   153., 2.3,   154., 0.0,   155., 0.0,   ...
156., 0.0,   157., 0.0,   158., 0.0,   159., 0.0,   160., 0.0,   ...
161., 0.0,   162., 0.0,   163., 0.0,   164., 0.0,   165., 4.3,   ...
166., 0.1,   167., 0.0,   168., 3.2,   169., 1.1,   170., 5.2,   ...
171., 3.7,   172., 4.6,   173., 1.6,   174.,11.3,   175., 0.2,   ...
176.,11.5,   177., 1.8,   178., 4.8,   179., 0.7,   180., 1.3,   ...
181., 5.0,   182., 3.5,   183., 2.4,   184., 0.0,   185., 0.4,   ...
186., 0.7,   187., 6.1,   188., 3.1,   189., 1.0,   190., 1.9,   ...
191., 0.0,   192., 5.1,   193., 1.5,   194., 8.6,   195., 0.0,   ...
196., 0.8,   197., 0.0,   198., 0.0,   199., 2.1,   200., 0.0,   ...
201., 0.5,   202., 0.0,   203.,16.8,   204., 0.0,   205., 2.4,   ...
206., 0.0,   207., 1.7,   208., 0.2,   209.,19.1,   210., 0.4,   ...
211., 5.6,   212., 0.0,   213.,18.9,   214., 4.0,   215., 5.1,   ...
216., 0.0,   217., 0.0,   218., 6.4,   219., 2.2,   220., 6.9,   ...
221., 2.5,   222., 1.1,   223., 4.4,   224., 5.4,   225., 1.2,   ...
226., 0.0,   227., 3.0,   228., 7.4,   229., 0.0,   230., 0.7,   ...
231., 1.0,   232., 8.0,   233., 9.5,   234., 0.1,   235., 0.0,   ...
236., 7.1,   237.,18.7,   238.,10.5,   239., 0.1,   240., 6.4,   ...
241., 0.9,   242., 0.0,   243., 0.6,   244., 0.6,   245.,14.3,   ...
246., 0.0,   247., 0.6,   248., 1.0,   249., 0.0,   250., 0.0,   ...
251.,12.5,   252., 0.1,   253., 0.0,   254., 0.0,   255., 3.6,   ...
256., 0.2,   257., 0.3,   258., 2.4,   259., 0.0,   260., 0.0,   ...
261., 0.0,   262., 0.0,   263., 0.0,   264., 0.0,   265., 0.0,   ...
266., 0.1,   267., 3.7,   268., 0.0,   269., 0.0,   270., 0.9,   ...
271., 0.0,   272., 6.7,   273., 5.4,   ...
274., 0.4,   275., 0.0,   276., 0.0,   277., 0.0,   278., 0.0,   ...
279., 0.4,   280., 2.0,   281., 0.0,   282., 0.0,   283., 0.0,   ...
284., 0.0,   285., 0.0,   286., 0.0,   287., 0.0,   288., 0.0,   ...
289., 0.0,   290., 0.0,   291., 0.0,   292., 0.0,   293., 0.0,   ...
294., 0.0,   295., 0.0,   296., 0.0,   297., 6.6,   298., 0.0,   ...
299., 0.0,   300., 2.3,   301., 0.0,   302., 0.0,   303., 0.0,   ...
304., 0.0
FUNCTION DTRT          = ...
  1., 857.,    2.,1048.,    3., 496.,    4., 701.,    5., 240.,   ...
  6., 624.,    7., 220.,    8., 374.,    9., 515.,   10., 452.,   ...
 11., 336.,   12., 402.,   13., 276.,   14., 358.,   15., 409.,   ...
 16., 702.,   17., 652.,   18., 641.,   19., 732.,   20., 610.,   ...
 21., 548.,   22., 699.,   23., 299.,   24., 735.,   25., 413.,   ...
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  26., 232.,     27., 519.,     28., 448.,     29., 488.,     30.,  62.,    ...
  31., 336.,     32., 369.,     33.,  75.,     34., 214.,     35.,  79.,    ...
  36., 142.,     37., 553.,     38., 473.,     39., 279.,     40., 168.,    ...
  41., 229.,     42., 423.,     43., 316.,     44., 158.,     45., 418.,    ...
  46., 277.,     47.,  68.,     48., 216.,     49.,  52.,     50., 365.,    ...
  51., 364.,     52., 309.,     53., 177.,     54., 106.,     55., 199.,    ...
  56.,  35.,     57., 163.,     58., 226.,     59., 126.,     60., 112.,    ...
  61., 140.,     62., 327.,     63., 100.,     64.,  37.,     65.,  22.,    ...
  66., 205.,     67., 209.,     68., 108.,     69., 251.,     70.,  63.,    ...
  71., 107.,     72., 128.,     73., 149.,     74.,  83.,     75.,  53.,    ...
  76.,  22.,     77., 117.,     78.,  75.,     79., 243.,     80., 246.,    ...
  81., 119.,     82.,  82.,     83.,  92.,     84., 279.,     85.,  60.,    ...
  86.,  63.,     87.,  53.,     88., 191.,     89., 148.,     90., 269.,    ...
  91., 206.,     92., 131.,     93., 283.,     94.,  90.,     95.,  15.,    ...
  96.,  86.,     97.,  78.,     98.,  85.,     99., 290.,    100., 281.,    ...
 101.,  47.,    102., 206.,    103., 154.,    104.,  60.,    105.,  38.,    ...
 106.,  30.,    107., 103.,    108., 252.,    109.,  27.,    110., 369.,    ...
 111., 263.,    112., 210.,    113., 106.,    114.,  97.,    115., 421.,    ...
 116., 405.,    117.,  28.,    118., 209.,    119.,  50.,    120.,  70.,    ...
 121., 356.,    122., 233.,    123., 262.,    124., 348.,    125., 439.,    ...
 126., 334.,    127., 470.,    128., 323.,    129., 158.,    130., 152.,    ...
 131., 273.,    132., 240.,    133., 143.,    134., 420.,    135., 439.,    ...
 136., 748.,    137., 808.,    138., 665.,    139., 796.,    140., 768.,    ...
 141., 830.,    142., 324.,    143., 497.,    144., 912.,    145., 952.,    ...
 146., 949.,    147., 868.,    148., 431.,    149., 158.,    150., 150.,    ...
 151., 404.,    152., 377.,    153., 890.,    154., 996.,    155., 819.,    ...
 156., 907.,    157., 271.,    158., 526.,    159., 936.,    160., 237.,    ...
 161., 521.,    162., 888.,    163.,1223.,    164.,1133.,    165., 610.,    ...
 166., 517.,    167., 881.,    168., 150.,    169., 274.,    170., 235.,    ...
 171., 359.,    172., 579.,    173., 500.,    174., 587.,    175., 522.,    ...
 176., 860.,    177.,1152.,    178., 985.,    179., 914.,    180., 947.,    ...
 181., 809.,    182., 681.,    183., 879.,    184., 714.,    185.,1111.,    ...
 186., 729.,    187., 876.,    188.,1197.,    189.,1364.,    190., 674.,    ...
 191.,1478.,    192., 576.,    193., 640.,    194., 951.,    195.,1203.,    ...
 196., 916.,    197.,1809.,    198.,1918.,    199., 624.,    200.,1421.,    ...
 201., 501.,    202.,1524.,    203., 433.,    204.,1689.,    205.,1264.,    ...
 206.,1892.,    207., 746.,    208.,1143.,    209., 893.,    210.,1230.,    ...
 211.,1461.,    212.,2152.,    213., 829.,    214.,1546.,    215., 407.,    ...
 216.,1246.,    217.,2208.,    218.,1133.,    219., 788.,    220.,1038.,    ...
 221.,1120.,    222.,1978.,    223., 923.,    224., 850.,    225.,1514.,    ...
 226.,1773.,    227.,1063.,    228., 476.,    229.,1396.,    230.,1558.,    ...
 231.,1612.,    232.,1696.,    233., 384.,    234.,1281.,    235.,2027.,    ...
 236., 258.,    237., 171.,    238., 187.,    239., 756.,    240., 787.,    ...
 241., 751.,    242.,1686.,    243.,2444.,    244.,2103.,    245.,1418.,    ...
 246.,2365.,    247.,1970.,    248.,2305.,    249.,2626.,    250.,2704.,    ...
 251.,1376.,    252.,1649.,    253.,1867.,    254.,2031.,    255.,2325.,    ...
 256.,1846.,    257.,1303.,    258.,1783.,    259.,1464.,    260.,2757.,    ...
 261.,2112.,    262.,2726.,    263.,2727.,    264.,2651.,    265.,2510.,    ...
 266.,1988.,    267.,1621.,    268.,1235.,    269.,2078.,    270.,1571.,    ...
 271.,1497.,    272., 475.,    273., 856.,    274.,1846.,    275.,1355.,    ...
 276.,2387.,    277.,2431.,    278.,2524.,    279.,1652.,    280.,1835.,    ...
 281.,2157.,    282.,1992.,    283.,2265.,    284.,2320.,    285.,2509.,    ...
 286.,1929.,    287.,2175.,    288.,2131.,    289.,2004.,    290.,2032.,    ...
 291.,1990.,    292.,1544.,    293.,1819.,    294.,2515.,    295.,2430.,    ...
 296.,1817.,    297.,1210.,    298.,2220.,    299.,1537.,    300.,1241.,    ...
 301.,1183.,    302.,1591.,    303.,2076.,    304.,1801.
FUNCTION WSTB         = ...
   1., 1.5,       2., 1.8,       3., 1.3,       4., 2.2,       5., 2.8,     ...
   6., 1.5,       7., 2.0,       8., 2.4,       9., 3.4,      10., 3.2,     ...
  11., 2.0,      12., 2.4,      13., 4.0,      14., 4.2,      15., 4.6,     ...
  16., 3.2,      17., 3.8,      18., 3.4,      19., 3.8,      20., 4.3,     ...
  21., 2.5,      22., 2.4,      23., 2.1,      24., 2.0,      25., 3.2,     ...
  26., 3.0,      27., 0.8,      28., 1.4,      29., 2.4,      30., 1.7,     ...
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  31., 2.7,    32., 3.1,    33., 1.7,    34., 1.1,    35., 1.7,    ...
  36., 2.7,    37., 4.6,    38., 4.5,    39., 5.2,    40., 3.8,    ...
  41., 4.6,    42., 3.3,    43., 5.4,    44., 3.4,    45., 3.7,    ...
  46., 1.4,    47., 4.3,    48., 4.9,    49., 6.3,    50., 6.8,    ...
  51., 4.8,    52., 4.9,    53., 4.4,    54., 4.0,    55., 6.0,    ...
  56., 5.8,    57., 3.0,    58., 1.8,    59., 2.9,    60., 1.7,    ...
  61., 3.0,    62., 3.4,    63., 0.9,    64., 1.0,    65., 2.3,    ...
  66., 3.9,    67., 1.0,    68., 2.9,    69., 4.0,    70., 5.6,    ...
  71., 7.0,    72., 5.5,    73., 2.3,    74., 1.7,    75., 4.0,    ...
  76., 8.8,    77., 6.7,    78., 2.5,    79., 2.0,    80., 6.7,    ...
  81., 5.8,    82., 6.5,    83., 1.8,    84., 1.4,    85., 4.5,    ...
  86., 2.2,    87., 3.8,    88., 5.4,    89., 4.1,    90., 1.2,    ...
  91., 2.0,    92., 2.9,    93., 4.2,    94., 3.7,    95., 5.7,    ...
  96., 7.0,    97., 6.2,    98., 6.6,    99., 5.9,   100., 3.8,    ...
 101., 5.2,   102., 4.4,   103., 3.4,   104., 4.8,   105., 5.4,    ...
 106., 6.0,   107., 6.7,   108., 6.2,   109., 7.2,   110., 8.5,    ...
 111., 4.9,   112., 3.6,   113., 5.4,   114., 2.8,   115., 2.0,    ...
 116., 2.8,   117., 3.3,   118., 4.3,   119., 6.6,   120., 7.0,    ...
 121., 6.5,   122., 5.3,   123., 5.4,   124.,10.7,   125., 5.4,    ...
 126., 3.5,   127., 2.4,   128., 5.4,   129., 2.3,   130., 3.2,    ...
 131., 3.5,   132., 2.2,   133., 1.8,   134., 2.8,   135., 2.5,    ...
 136., 2.9,   137., 4.1,   138., 4.0,   139., 3.3,   140., 3.3,    ...
 141., 2.1,   142., 1.3,   143., 1.5,   144., 2.4,   145., 3.2,    ...
 146., 4.5,   147., 3.2,   148., 3.1,   149., 2.5,   150., 3.7,    ...
 151., 4.2,   152., 1.5,   153., 1.9,   154., 2.6,   155., 2.2,    ...
 156., 4.1,   157., 4.8,   158., 3.8,   159., 3.3,   160., 2.9,    ...
 161., 4.3,   162., 3.2,   163., 2.8,   164., 3.4,   165., 3.6,    ...
 166., 1.2,   167., 1.8,   168., 3.4,   169., 3.6,   170., 4.4,    ...
 171., 3.7,   172., 5.0,   173., 8.0,   174., 5.6,   175., 5.7,    ...
 176., 5.6,   177., 4.5,   178., 3.5,   179., 1.9,   180., 3.3,    ...
 181., 4.7,   182., 3.2,   183., 2.7,   184., 3.6,   185., 1.6,    ...
 186., 3.7,   187., 3.7,   188., 5.4,   189., 4.1,   190., 3.9,    ...
 191., 1.9,   192., 2.6,   193., 2.0,   194., 4.7,   195., 3.0,    ...
 196., 3.7,   197., 2.9,   198., 2.9,   199., 3.8,   200., 2.9,    ...
 201., 3.8,   202., 3.1,   203., 2.4,   204., 2.6,   205., 2.7,    ...
 206., 1.7,   207., 3.0,   208., 1.6,   209., 4.6,   210., 2.5,    ...
 211., 2.9,   212., 2.3,   213., 2.6,   214., 4.3,   215., 4.9,    ...
 216., 1.7,   217., 2.2,   218., 2.9,   219., 1.7,   220., 2.2,    ...
 221., 3.5,   222., 3.3,   223., 3.9,   224., 4.6,   225., 4.1,    ...
 226., 2.5,   227., 2.5,   228., 2.3,   229., 1.9,   230., 2.7,    ...
 231., 2.8,   232., 1.9,   233., 1.8,   234., 1.8,   235., 1.7,    ...
 236., 3.2,   237., 4.0,   238., 4.4,   239., 3.1,   240., 2.8,    ...
 241., 2.0,   242., 1.5,   243., 2.7,   244., 3.4,   245., 3.1,    ...
 246., 1.9,   247., 3.0,   248., 2.0,   249., 3.4,   250., 3.3,    ...
 251., 2.5,   252., 3.5,   253., 2.7,   254., 2.6,   255., 2.7,    ...
 256., 1.5,   257., 3.0,   258., 3.2,   259., 2.0,   260., 2.7,    ...
 261., 2.6,   262., 2.4,   263., 2.7,   264., 2.2,   265., 2.3,    ...
 266., 1.5,   267., 1.3,   268., 1.8,   269., 1.4,   270., 3.0,    ...
 271., 3.7,   272., 4.0,   273., 2.2,   ...
 274., 1.4,   275., 2.7,   276., 1.6,   277., 1.1,   278., 1.9,    ...
 279., 1.8,   280., 1.3,   281., 1.5,   282., 1.6,   283., 1.3,    ...
 284., 1.4,   285., 2.2,   286., 2.4,   287., 1.0,   288., 2.8,    ...
 289., 1.5,   290., 2.2,   291., 2.9,   292., 1.9,   293., 1.8,    ...
 294., 1.4,   295., 2.4,   296., 2.2,   297., 1.2,   298., 1.5,    ...
 299., 1.8,   300., 1.5,   301., 2.1,   302., 2.6,   303., 1.2,    ...
 304., 2.4
**LINES WITH ASTERISK HAVE BEEN CHANGED TO COMPLY WITH VITT
FUNCTION FWTAB=0.,.9,100.,.9,160.,2.5,300.,2.5
PARAM GAMMA=.0042
*PARAM HUAD=3.
PARAM HUAD =4.
PARAM TCK1=0.2, TCK2=0.4, TCK3=0.6
*PARAM FLD1=.447,FLD2=.452,FLD3=.491,WLP=.25,WCL=.0833,SMO=.490
```

```
PARAM FLD1=0.375,FLD2=0.375,FLD3=0.420,WCL=0.0833,SM0=0.490
*PARAM WLP1=.25,WLP2=.26,WLP3=.31
PARAM WLP1=0.275,WLP2=0.275,WLP3=0.31
*INCON WVL1I=.358,WVL2I=.362,WVL3I=.393
INCON WVL1I=0.375,WVL2I=0.375,WVL3I=0.420
PARAM RNOF=0.
PARAM EVSLC=3.3, EESL=10.
PARAM RCSLL=0.20
PARAM NMR=0.3, NSIN=30., NREC=0.7
FUNCTION NMRWT=0.,0., 0.1,0.5, 0.3,1., 1.,1.
TITLE SM.T2: C AND H20 BALANCE CHECK, PHOTO AND ASTRO, EVATR AND VP
TERMINAL
       HI=WSO/WSS

       CIN=(WLV-WLVI)*FCLV+(WST-WSTI)*FCST+(WSO-WSOI)*FCSO...
       +(WRT-WRTI)*FCRT
       CFL=PCGAT*12./44.-(WLVD*FCLV+WRTD*FCRT)
       CRD=(CIN-CFL)/(CIN+CFL)
       IF(ABS(CRD).GT.0.01) WRITE (6,1)
     1 FORMAT(10X,'* * *ERROR IN CARBON BALANCE, PLEASE CHECK* * *')
       WRSL=WL1-WL1I+WL2-WL2I+WL3-WL3I
       WRD=(WRSL-WFL)/(WRSL+WFL)
       IF(ABS(WRD).GT.0.01) WRITE (6,22)
    22 FORMAT(10X,'* * * ERROR IN WATER BALANCE, PLEASE CHECK* * *')
END
STOP
       SUBROUTINE PHOTO(PMAX,PEA,ALV,RDTC,RDTO,DL,DLE,DEC,LAT,PCGC,PCGO)
       REAL INSW,LAT
       PI=3.14159265
       SSLAE=SIN((90.+DEC-LAT)*PI/180.)
       X=ALOG(1.+0.45*RDTC/(DLE*3600.)*PEA/(SSLAE*PMAX))
       PHCH1=SSLAE*PMAX*DLE*X/(1.+X)
       Y=ALOG(1.+0.55*RDTC/(DLE*3600.)*PEA/((5.-SSLAE)*PMAX))
       PHCH2=(5.-SSLAE)*PMAX*DLE*Y/(1.+Y)
       PHCH=0.95*(PHCH1+PHCH2)+20.5
       PHC3=PHCH*(1.-EXP(-0.8*ALV))
       PHC4=DL*ALV*PMAX
       PHCL=AMIN1(PHC3,PHC4)*
      $(1.-EXP(-(AMAX1(PHC3,PHC4)/AMIN1(PHC3,PHC4))))
       Z=RDTO/(DLE*3600.)*PEA/(5.*PMAX)
       PHOH1=5.*PMAX*DLE*Z/(1.+Z)
       PHOH=0.9935*PHOH1+1.1
       PHO3=PHOH*(1.-EXP(-0.8*ALV))
       PHOL=AMIN1(PHO3,PHC4)*
      $(1.-EXP(-(AMAX1(PHO3,PHC4)/AMIN1(PHO3,PHC4))))
       PCGC=INSW(ALV-5.,PHCL,PHCH)
       PCGO=INSW(ALV-5.,PHOL,PHOH)
       RETURN
       END
       SUBROUTINE ASTRO(DATE,LAT,INSP,RDTC,RDTO,DEC,DL,DLE,DLP)
       REAL LAT,INSP
       PI=3.14159265
       DEC=-23.4*COS(2.*PI*(DATE+10.)/365.)
       COSLD=COS(DEC*PI/180.)*COS(LAT*PI/180.)
       SINLD=SIN(DEC*PI/180.)*SIN(LAT*PI/180.)
       DL =12.*(PI+2.*ASIN(SINLD/COSLD))/PI
       DLE=12.*(PI+2.*ASIN((-SIN(8.*PI/180.)+SINLD)/COSLD))/PI
       DLP=12.*(PI+2.*ASIN((-SIN(INSP*PI/180.)+SINLD)/COSLD))/PI
       RDN=3600.*(SINLD*DL+24./PI*COSLD*SQRT(1.-(SINLD/COSLD)**2))
       RDTC=0.5*1300.*RDN*EXP(-0.1/(RDN/(DL*3600.)))
       RDTO=0.2*RDTC
       RETURN
       END
```

```
      SUBROUTINE EVATR(RDTM,FOV,DL,TMPA,HU,HD,WDS,WDLV,RS,RC,EVPR,EVPD)
      IF(HD.EQ.2.) VPA=VP(HU)-0.623*(TMPA-HU)
      IF(HD.EQ.3.) VPA=.01*HU*VP(TMPA)
      IF(HD.EQ.4.) VPA=HU
      IF(HD.EQ.0.) WRITE(6,5)
      RLW=4.9E-3*(TMPA+273.)**4*(0.56-0.080*SQRT(VPA))*(1.-.9*FOV)
       IF(RC.GT..21)       RLW=RLW*DL/24.
      RAN=RDTM*(1.-RC)-RLW
      SLOPE=4158.6*VP(TMPA)/(TMPA+239.)**2
      RA=89.5*SQRT(WDLV/(WDS*1.33))+63./(WDS*1.33)
      APSCH=0.63*(RA+RS)/RA
      EVPR=0.001*SLOPE*RAN/((SLOPE+APSCH)*2390.)
    5 FORMAT(10X,'DIMENSION OF HUAA NOT SPECIFIED')
      DRYP=(VP(TMPA)-VPA)*1200./RA
       IF(RC.GT..21)DRYP=DRYP*DL/24.
      EVPD=86400.*0.001*DRYP/((SLOPE+APSCH)*2390.)
      RETURN
      END
      FUNCTION VP(TMP)
      VP=6.11*EXP(17.47*TMP/(TMP+239.))
      RETURN
      END
ENDJOB
```

ABBREVIATIONS

USED IN a SERIES OF SIMULATION MODELS

DIMENSIONS BETWEEN PARENTHESES INDICATE THAT THESE, BUT ALSO OTHER DIMENSIONS CAN BE USED WHEN THE APPROPRIATE CONVERSION FACTORS ARE ADJUSTED.

NOTE: NOT ALL OF THESE VARIABLES ARE ACTUALLY USED IN THE PRESENT MODEL, AS THIS LIST PERTAINS ALSO TO THE MODEL LEVEL L3

ALFA	auxillary variable to reflect effect of stomatal control	-
ALV(I)	area leaves (initial)	ha ha-1
APSCH	apparent psychrometer constant	mbar K-1
ASTRO	subroutine to compute astronomical variables	-
C(1-3)	depth of centre of layer	m
CAGCR	carbohydrates available for growth of total crop	kg ha-1 d-1
CAGLV	carbohydrates available for growth of leaves	kg ha-1 d-1
CAGRT	carbohydrates available for growth of roots	kg ha-1 d-1
CAGSO	carbohydrates available for growth of storage organ	kg ha-1 d-1
CAGSS	carbohydrates available for growth of shoot plus storage organ	kg ha-1 d-1
CAGST	carbohydrates available for growth of stems	kg ha-1 d-1
CALVT	relation of CAGLV to DVS	-
CASST	relation of CAGSS to DVS	-
CASTT	relation of CAGST to DVS	-
CFL	carbon fluxes in crop, totaled	kg ha-1
CFDL	correction factor time interval to account for daylength	-
CIN	carbon present in crop	kg ha-1
CL	depth of the layer reached by the root tip	m

CPG	carbon dioxide production in growth in CO2/product	kg kg-1
CPGLV	CO2 production during formation of leaves with glucose	kg kg-1
CPGRT	CO2 production during formation of roots with glucose	kg kg-1
CPGSO	CO2 production during formation of storage organs w glucose	kg kg-1
CPGST	CO2 production during formation of stems with glucose	kg kg-1
CR	rate of capillary rise	cm d-1
CRD	relative difference between two carbon balances	-
CRG	relative carbohydrate requirement for growth (glucose/product)	kg kg-1
CRGLV	relative carbohydrate requirement for growth of leaves	kg kg-1
CRGST	relative carbohydrate requirement for growth of stem	kg kg-1
CRGSO	relative carbohydrates requirement for growth storage organ	kg kg-1
CRGRT	relative carbohydrate requirement for growth of roots	kg kg-1
~~CRISE(1-3)~~	~~tables defining capillary rise as function of H and PF~~	-
CRISIS	dummy TWOVAR name for CRISE	-
CTOT	cumulative capillary rise	cm
CUGCR	carbohydrate used for crop growth	kg ha-1 d-1
CUGLV	carbohydrates used for leaf growth	kg ha-1 d-1
CUGRT	carbohydrates used for root growth	kg ha 1 d-1
CUGSO	carbohydrates used for growth storage organs	kg ha-1 d-1
CUGSR	carbohydrates used for 'growth' of shielded reserves	kg ha-1 d-1
CUGST	carbohydrates used for stem growth	kg ha-1 d-1
DATAST	starting date of the data set	Julian day
DATE	julian date	-
DAY	days from emergence	d
DBRDG	double ridge stage	-
DEC	declination sun	degree
~~DF1~~	~~date of first fertilization~~	-
DF2	date of second fertilization	-

DISTAN	distance of the water table from CL	cm
DL	daylength, geophysical	h
DLE	daylength effective for photosynthesis	h
DLP	daylength effective for photoperiodism (in fact: nightlength)	h
DLPB	shortest day length for plant development	h
DLPO	optimum day length for plant development	h
DRYP	drying power air	J m-2 s-1
DSLR	number of days since last rain	-
DVR	development rate crop	d-1
DVRC	development rate constant	d-1
DVRC1	value of DVRC before anthesis	d-1
DVRC2	value of DVRC after anthesis	d-1
DVRDT	relation of DVRED to daylength	-
DVRED	effect of daylength on DVR	-
DVRET	effect of temperature on DVR	-
DVREV	effect of vernalization on DVR	-
DVREW	effect of water stress on DVR	-
DVRTT	relation of DVRET to temperature	-
DVRWT	relation of DVREW to stress level	-
DVS(I)	development stage crop (initial)	-
EESL	extinction coefficient of evaporation in soil	m-1
EMERG	days from DATAST to emergence	d
ERSL	evaporation resistance soil (leaf width analogue)	m
ETM	effect temperature on maintenance respiration	-
ETMP	estimate of day time temperature	degree C
EVATR	subroutine to compute evaporation of soil, crop and Penman	-
EVCR	equals TRP	mm d-1
EVCRD	transpiration canopy due to drying power air	mm d-1

EVCRR	transpiration canopy due to absorbed radiation	mm d-1
EVP	evaporation according to Penman	mm d-1
EVPD	drying power air part of EVP	mm d-1
EVPR	radiation part of EVP	mm d-1
EVSL	evaporation rate from the soil	mm d-1
EVSL(1-3)	EVSL for individual soil layers	mm d-1
EVSLC	constant to derive EVSLD	mm d-1
EVSLD	evaporation soil due to drying power air	mm d-1
EVSLE	evaporation rate soil as function of flux of absorbed energy	mm d-1
EVSLP	evaporation rate soil on rainy days	mm d-1
EVSLR	evaporation bare soil due to radiation	mm d-1
EVSLW	evaporation rate soil on days without rain	mm d-1
F(1-3)	measured volumetric soil moisture content per layer	cm3 cm-3
FCLV	fraction carbon in leaf dry matter	kg kg-1
FCRT	fraction carbon in root	kg kg-1
FCSO	fraction carbon in storage organ	kg kg-1
FCST	fraction carbon in stem	kg kg-1
FEP	fraction economic product in storage organ	kg kg-1
FLD	soil water content at field capacity	m3 m-3
FMDRYM	measured total dry matter	kg ha-1
FMLAI	measured LAI	ha ha-1
FPCT	fraction of clear day canopy photosynthesis (TWOVAR) 3	-
FTEMP	effect of temperature on gross assimilation	-
FWTAB	dummy name for WTABLE	-
GAMMA	soil texture constant	-
GCR	growth rate crop	kg ha-1 d-1
GLA	growth rate leaf area	ha ha-1 d-1
GLV	growth rate of leaves	kg ha-1 d-1

GLVM	maximum rate of GLV, absolute	kg ha-1 d-1
GLVRM	maximum rate of GLV, relative	kg kg-1 d-1
GRT	growth rate of roots	kg ha-1 d-1
GSO	growth rate of storage organ	kg ha-1 d-1
GSOM	maximum growth rate storage organ determined by its size	kg ha-1 d-1
GSON	growth rate storage organ as determined by N	kg ha-1 d-1
GSOP	growth rate storage organ as determined by carbohydrates	kg ha-1 d-1
GSA	growth rate photosynthetically active stem area	ha ha-1 d-1
GSR	growth rate of shielded reserves	kg ha-1 d-1
GSRP	potential rate of GSA determined by available reserves	kg ha-1 d-1
GST	growth rate of stems	kg ha-1 d-1
GSTM	maximum rate of GST, absolute	kg ha-1 d-1
~~GSTRM~~	~~maximum rate of GST, relative~~	~~kg kg-1 d-1~~
H	fixed values for distance to water table in CRISE	cm
HI	harvest index (based on above ground dry matter)	kg kg-1
HIN	harvest index (based on above ground N)	kg kg-1
HUAA	humidity of the air in units caracterized by HUAD	(variable)
HUAAT	table of values of HUAA during year	variable
HUAD	indicator of dimension of HUAA (1=dew point; 2=wet bulb, 3=relative humidity)	-
IDATE	integer value of DATE	-
IMAX	number of values of H in CRISE-tables	-
INSP	minimum inclination sun to trigger daylength effect	degree
JMAX	number of values of CR in CRISE-tables	-
LAT	latitude	degree
LLA	rate of loss of leaf area	ha ha-1 d-1
~~LLV~~	~~rate of loss of leaves~~	~~kg ha-1 d-1~~
LLVA	rate of loss of leaves due to aging	kg ha-1 d-1

LRLV	carbohydrate reserve level in leaves	kg kg-1
LRLVA	running average of LRLV	kg kg-1
LLVT	relation of relative loss rate to DVS	-
LRT	rate of loss of roots	kg ha-1 d-1
LRTA	rate of loss of roots due to aging	kg ha-1 d-1
LRTT	relation of relative loss rate due to aging to DVS	-
LSR	rate of loss of shielded reserves to WAR	kg ha-1 d-1
LSRM	maximum rate of LSR, absolute	kg ha-1 d-1
NAGCR	N available for growth of crop	kg ha-1
NCCR	average N concentration crop	kg kg-1
NCIN	inorganic N present in soil layers	kg ha-1
NCLV	actual N concentration leaves	kg kg-1
~~NCLVH~~	~~maximum N concentration leaves~~	~~kg kg-1~~
NCLVHT	relation of NCLVH to DVS	-
NCLVL	minimum N concentration leaves	kg kg-1
NCR	total amount of N in crop	kg ha-1
NCRCR	relative N concentration in crop	-
NCRD	relative difference between two N balances	-
NCRLV	relative N concentration in leaves	-
NCRT	actual N concentration roots	kg kg-1
NCRTH	maximum N concentration of roots	kg kg-1
NCRTL	minimum N concentration of roots	kg kg-1
NCSO	actual N concentration storage organs	kg kg-1
NCSOE	N concentration storage organs, equilibrium value	-
NCSOH	maximum N concentration storage organs	kg kg-1
NCSOL	minimum N concentration storage organs	kg kg-1
NCST	N concentration stems	kg kg-1
NCSTH	maximum N concentration stems	kg kg-1

NCSTL	minimum N concentration stems	kg kg-1
NDCR	N demand of crop	kg ha-1
NDLV	N demand of leaves	kg ha-1
NDRT	N demand of roots	kg ha-1
NDSO	N demand of storage organs	kg ha-1
NDST	N demand of stems	kg ha-1
NFL	fluxes of N in crop, totaled	kg ha-1
NFLS	fluxes of N in soil, totaled	kg ha-1
NFR(1-2)	intensities of N fertilization at two dates	kg ha-1
NFS(1-4)	fluxes of N into layers 1-3 and leaching	kg ha-1 d-1
NIGHT	variable to indicate day part: night (1) or day (Ø)	-
NLLV	N loss from leaves (leaf death)	kg ha-1 d-1
~~NLRT~~	~~N loss from roots (decay)~~	~~kg ha-1 d-1~~
NLV(I)	N in leaves (initial)	kg ha-1
NLVSO	sum of NLVT, NST and NSO	kg ha-1
NLVST	sum of NLVT and NST	kg ha-1
NLVT	sum of NLV and N in dead leaves	kg ha-1
NMR	rate of mineralization	kg ha-1 d-1
NMR(1-3)	rate of mineralization in soil layers 1-3	kg d-1 lr-1
NMRWT	relation of the rate of mineralization to water stress	-
NREC	recovery of fertilizer N	kg kg-1
NRT(I)	N in roots (initial)	kg ha-1
NSIN	inorganic N in soil (layers) at initialization	kg ha-1
NSI(1-3)(I)	inorganic N in soil layers 1-3 (initial)	kg ha-1
NSLA	N in soil available to plants	kg ha-1
NSO(I)	N in storage organs (initial)	kg ha-1
~~NSRD~~	~~relative difference between two soil N balances~~	~~-~~
NSS	N in shoots	kg ha-1

NST(I)	N in stems (initial)	kg ha-1
NTLV	N transfer from leaves	kg ha-1 d-1
NTLVP	N transfer from leaves, potential	kg ha-1 d-1
NTRT	N transfer from roots	kg ha-1 d-1
NTRTP	N transfer from roots, potential	kg ha-1 d-1
NTST	N transfer from stem	kg ha-1 d-1
NTSTP	N transfer from stem, potential	kg ha-1 d-1
NTVG	N transfer from vegetative parts	kg ha-1 d-1
NTVGT	NTVG totaled over time	kg ha-1
NUCR	rate of N uptake by crop	kg ha-1 d-1
NUCR(1-3)	rate of N uptake from soil layers 1-3	kg ha-1 d-1
NULV	rate of N incorporation in leaves	kg ha-1 d-1
NURT	rate of N incorporation in roots	kg ha-1 d-1
NUSO	rate of N incorporation in storage organs	kg ha-1 d-1
NUST	rate of N incorporation in stems	kg ha-1 d-1
NVCRH	maximum amount of N in vegetative crop parts	kg ha-1
NVCRL	minimum amount of N in vegetative crop parts	kg ha-1
PCG	rate of canopy photosynthesis, gross, without physiological corrections during daytime	kg CO2 ha-1
PCGA	photosynthesis canopy,gross, actual value (CO2) during daytime	kg ha-1
PCGD	PCGA expressed as rate per 24 h	kg ha-1 d-1
PCGT	gross canopy photosynthesis, totaled over time	kg ha-1
PCGC	photosynthesis canopy, daily total gross for clear sky	kg ha-1 d-1
PCGO	photosynthesis canopy, daily total gross, for overcast skies	kg ha-1 d-1
PCGP	photosynthesis canopy, unrestricted by water shortage	kg ha-1 d-1
PCNT	net canopy photosynthesis totaled over time	kg ha-1
PCRS	canopy photosynthesis reduced due to limited sink size	kg ha-1 d-1
PEITT	relation of PLEI to temperature	-

PF	soil water potential expressed in log	-
PLEA	PLEI, for absorbed light (CO2)	kg ha-1 h-1 (J m-2s-1)-1
PHOTO	subroutine to compute canopy photosynthesis	-
PLEI	initial efficiency of use of incident light by leaves	as PLEA
PLMX	maximum rate of photosynthesis of single leaves (CØ2) in current conditions	kg ha-1 h-1
PLMXP	PLMX for SLWC in optimal conditions	kg ha-1 h-1
PMDST	relation of PLMX to development stage	-
PMNTT	relation of PLMXP to N stress	-
PMWTT	relation of PLMXP to water stress	-
PMXTT	relation of PMAXP to temperature	-
PRTIM	time of printing, applicable if delt=Ø.5	h
PSI	soil water potential	cm
PSIX	equivalent to PSI	cm
Q1Ø	Q1Ø of maintenance respiration sensitivity to temperature	-
RA	resistance boundery layer	s m-1
RAINT	table of daily precipitation during year	-
RAN	radiation, absorbed net	J m-2 d-1
RC	reflection coefficient	-
RCCRV	reflection coefficient canopy for visible radiation	-
RCLVV	reflection coefficient leaves for visible radiation	-
RMCRNT	relation of maintenance respiration intensity to crop N level	-
RCMLV	maintenance respiration coefficient leaves	-
RCMRT	maintenance respiration coefficient roots	-
RCMSO	maintenance respiration coefficient storage organs	-
RCMST	maintenance respiration coefficient stems	-
RCRT	respiration crop, totaled (CO2)	kg ha-1

RCSLL	reflection coefficient soil for infrared radiation	-
RDTC	radiation, daily total global for standard clear sky	J m-2 d-1
RDTM	radiation, daily total global, as measured	J m-2 d-1
RDTMT	table of measured daily total global radiation during year	variable
RDTO	radiation, daily total for standard overcast sky	J m-2 d-1
RDTPC	photosynthetically active radiation, daily total,clear sky	J m-2 d-1
RDTPO	photosynthetically active radiation, daily total, overcast	J m-2 d-1
RDTPF	fraction PAR in total global radiation	-
RGCR	growth respiration crop (CO2)	kg ha-1 d-1
RGLV	growth respiration leaves	kg ha-1 d-1
RGRT	growth respiration roots	kg ha-1 d-1
RGSO	growth respiration storage organ	kg ha-1 d-1
RGSR	growth respiration shielded reserves	kg ha-1 d-1
RLSR	respiration caused by remoblization (loss) shielded reserves	kg ha-1 d-1
RGST	growth respiration stems	kg ha-1 d-1
RLW	radiation, long wave (thermal)	J m-2 d-1
RMCR	maintenance respiration crop (CO2)	kg ha-1 d-1
RMLV	maintenance respiration leaves	kg ha-1 d-1
RMLVD	RMLV in daytime	kg ha-1 d-1
RMLVN	RMLV in nightime	kg ha-1
RMSO	maintenance respiration storage organs	kg ha-1 d-1
RMST	maintenance respiration stems	kg ha-1 d-1
RMRT	maintenance respiration roots	kg ha-1 d-1
RTDT	relation of rooting depth to root weight	-
RNOF	fraction of precipitation that runs off	-
RS	resistance leaves	s m-1
RTD	rooting depth	m
RTL	root length in total profile	m

RTL(1-3)	RTL differentiated per layer	m
RTVG	respiration rate due to translocation of C and of N	kg ha-1 d-1
RUCF	radiation units conversion factor	variable
SLWA	specific leaf weight, actual value (eventually corrected for contribution stem area)	kg ha-1
SLWC	specific leaf weight constant	kg ha-1
SLWN	specific leaf weight constant for new leaves	kg ha-1
SLWT	relation of SLWA to DVS	-
SLOPE	slope of vapour pressure curve	mbar K-1
SMØ	total pore space of the soil	cm3 cm-3
SRRTM	maximum content of shielded reserves in structural dry matter of roots	kg kg-1
~~SRSTM~~	~~as SRRTM for stems~~	~~kg kg-1~~
SSWC	specific stem weight constant (SLWC analogy)	kg ha-1
TCK(1-3)	thickness soil layers 1-3	m
TCR	dummy name for CR	-
TCRN	time constant for N redistribution	d
TCRNT	relation of TCRN-equilibrium to relative availability of N	-
TCUN	time constant for N uptake	d
TCUNV	time constant for N uptake in vegetative phase	d
TH	dummy name for H	-
TMPAD	temperature air in daytime	degree c
TMPAN	temperature air in nighttime	degree C
TMPAV	temperature air, daily average	degree C
TMPHT	table of maximum temperatures during the year	degree C
TMPLT	table of minimum temperature during the year	degree C
~~TMPD~~	~~dew point temperature~~	~~degree C~~
TMPR	reference temperature for maintenance respiration	degree C

TRA	transpiration rate canopy, actual value	mm d-1
TRA(1-3)	TRA differentiated over individual layers	mm d-1
TRP	transpiration rate canopy, potential value	mm d-1
TRRM	transpiration rate expressed per unit root length	mm m-1
TST	rate of carbohydrate transfer from stem (see also CTST)	kg ha-1D-1
TSTT	TST totaled over time	kg ha-1
VAR(1-3)	auxillary variable for individual layers	m3 ha-1
VERND	number of vernalization days	d
VERNDB	beginning of vernalization	d
VERNDO	end of vernalization	d
VERNR	vernalization rate	-
VP	function quantifying saturation vapour pressure curve	-
~~WAR~~	~~weight of available carbohydrates in leaves~~	~~kg ha-1~~
WARI	initial value of WAR	kg ha-1
WCL	soil water content when air dry	m3 m-3
WCP	weight carbon present in total crop	kg ha-1
WCR	weight crop, including roots	kg ha-1
WDLV	width of leaves	m
WDRT	water drained from profile, totaled	mm
WDS	wind speed	m s-1
WDST	table of wind speed measurements during the year	-
WEP	weight economic part of storage organ	kg ha-1
WFL	total of water fluxes into and out of soil layers	m3 ha-1
WIR	weight increment of reserves since start, expressed in glucose	kg ha-1
WLFL(1-4)	fluxes of water into layers 1-3 and out of 3	mm d-1lr-1
WL(1-3)(I)	soil water content of individual soil layers (initial)	m3 ha-1
~~WLP~~	~~soil water content at wilting point~~	~~m3 m-3~~
WLMM	soil water content of the combined soil layers	mm

WLV(I)	weight leaves (initial)	kg ha-1
WLVD	weight dead leaves	kg ha-1
WLVSO	sum of WLV,WLVD, WST and WSO	kg ha-1
WLVST	sum of WLV, WLVD and WST	kg ha-1
WLVT	sum of WLV and WLVD	kg ha-1
WNU(1-3)	relative effect water content soil layers on N uptake	-
WRS	weight of shielded reserves in roots (or stem)	kg ha-1
WSRI	initial value of WSR	kg ha-1
WRD	relative difference between two water balance computations	-
WRSL	change in water content soil layers during simulation period	m3 ha-1
WNUT	relation of mineralization rate to soil water content	-
WRT(I)	weight roots (initial)	kg ha-1
WRTD	weight dead roots	kg ha-1
WSE(1-3)	effect of water stress on water uptake in individual layers	-
WSET	relation of relative root water uptake and water stress	-
WSLMM	total water in soil profile	mm
WSO(I)	weight storage organs (initial)	kg ha-1
WSS	weight shoot plus storage organs	kg ha-1
WST(I)	weight stems (initial)	kg ha-1
WTABLE	depth of the water table below soil surface	m
WUC	water use coefficient (water transpired per kg CO2 fixed)	kg kg-1
WVL(1-3)I	relative water content soil layers (volumetric)(initial)	m3 m-3
WVRL(1-3)	fraction of soil water per layer available to crop	-