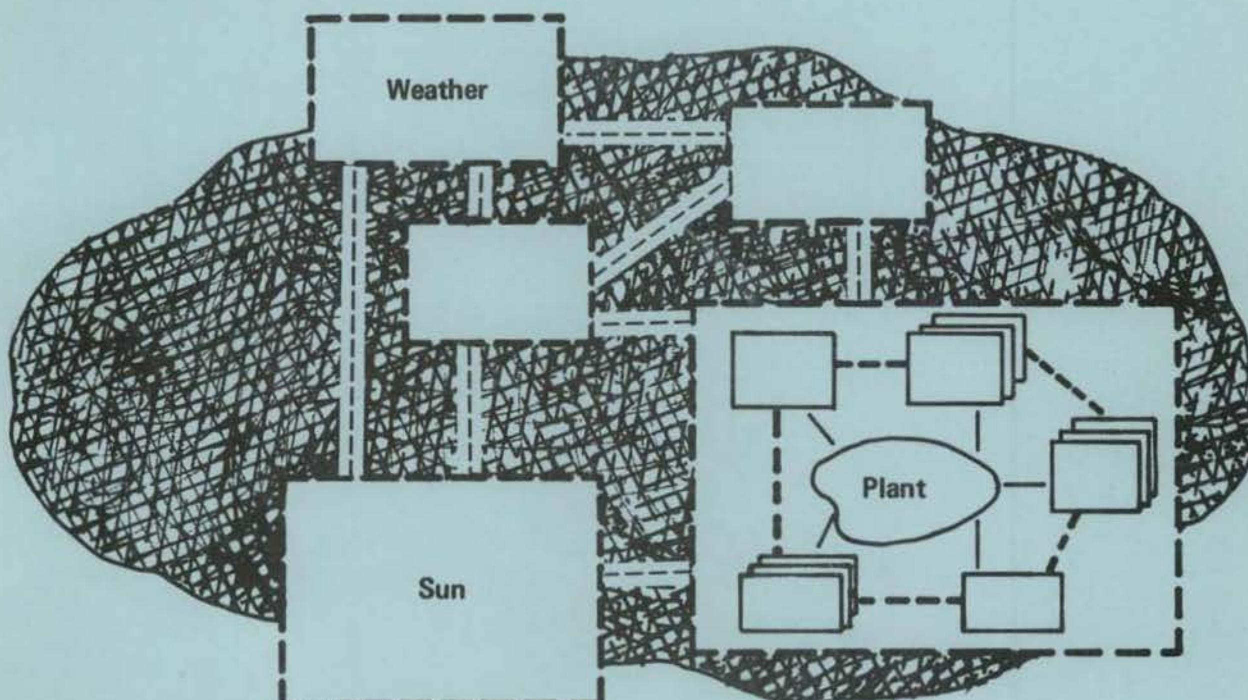
Bulletin No. 635

The POTATO Model

A Physiological Simulation Computer Model



R. K. Steinhorst, G. E. Kleinkopf, M. J. Grube and R. B. Dwelle

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About the Authors

R. Kirk Steinhorst is a professor of statistics in the University of Idaho Agricultural Communications Center, Moscow. Gale E. Kleinkopf is a professor of plant science at the UI Research and Extension Center, Kimberly. Michael J. Grube is a programmer/analyst in the ACC at Moscow. Robert B. Dwelle is an associate professor of plant physiology at the UI Research and Extension Center, Aberdeen.

Published and distributed by the
Idaho Agricultural Experiment Station
R. J. Miller, Director

University of Idaho College of Agriculture
Moscow 83843

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Introduction

Even though computer simulation of crop growth has increased our understanding of plant adaptation and physiology, a continuing need exists for community level crop modeling efforts to help expand our knowledge base of plant-environment interactions. POTATO was developed to fulfill some of those needs for potato production. The primary objective for POTATO was to develop a research tool for investigation of integrative potato physiology as affected by biotic and abiotic conditions.

POTATO is a result of a cooperative agreement among the University of California at Davis, the University of Idaho and the U.S. Department of Agriculture. Ed Ng and Bob Loomis at UCD produced the model that closely followed the format of the sugarbeet model (Fick et al. 1975). Data on potato growth and development was supplied by cooperating scientists at several locations.

Objectives for POTATO were to provide a tool for investigations of potato-climate interactions and to establish a better understanding of potato growth physiology. A secondary goal was that management strategies could be evaluated including varietal selections. The initial model was purposely limited in scope to provide a basic plant model free from water, nutrient, disease or insect stresses. The initial model was also developed to simulate growth of the Russet Burbank potato cultivar under normal growing conditions. A working model of potato crop growth is described in detail in this publication.

The model consists of a set of nonlinear differential equations driven by temperature, solar radiation, dewpoint and wind. When several variables affect a change of state of a variable (flow), it is generally assumed that one is most limiting. The solution is found using an Euler approximation with one hour time steps. Each leaf, internode and tuber is accounted for separately as a state variable, and others account for roots, carbohydrate reserves and mother tuber as well. Plant state variables are either area, biomass, phenological age or counts of leaves, internodes, branches or tubers.

At the start of a typical run, just a few state variables have flows. As leaves, branches, internodes and tubers are initiated, more state variables become active. For example by day 50, 200 state variables might be operational. The model is organized in five major components (Fig. 1). A typical potato plant is simulated by growing main stem and branch internodes, main stem and branch leaves, roots and tubers. The growth of each of these organs depends on carbohydrate reserves, water availability and the influence of temperature.

The calculations for the numerous distinct organs are organized around a single set of physiological equations that represent a "canonical" organ (Fig. 2). This canonical organ can represent a leaf or stem or root or tuber by selecting different values for the parameters of the equations describing growth. For example, roots respire but do not photosynthesize, so in this case, the respiration coefficient would be positive, but the photosynthesis parameter would be zero. Branches, leaves and so forth are similarly distinguished by the values of the controlling parameters of the canonical equations.

Values for the model parameters and forms of flow functions were derived both from the literature and from data collected at the University of Idaho Agricultural Research and Experiment Stations at Kimberly and Aberdeen. Basic photosynthesis follows the Duncan model (Duncan et al. 1967) used in the sugarbeet model developed by Loomis and others (Fick et al. 1975).

The transfer of carbohydrate from the reserve pool (RES) to tissue dryweight (DW) is controlled by growth rate (GR) that is affected by temperature (T), water (W) and available reserves (RES). This growth is applied to the fraction of the biomass capable of growing (FCG). The fraction capable of growth is dependent on the physiological age (PA) of the organ and its current dryweight. Reserves are affected by respiration (RESP), the rate of photosynthesis (PS) and the mobilization rate (MR) of reserves from the mother tuber (MT). This rate is dependent on the developmental state of the plant as a whole.

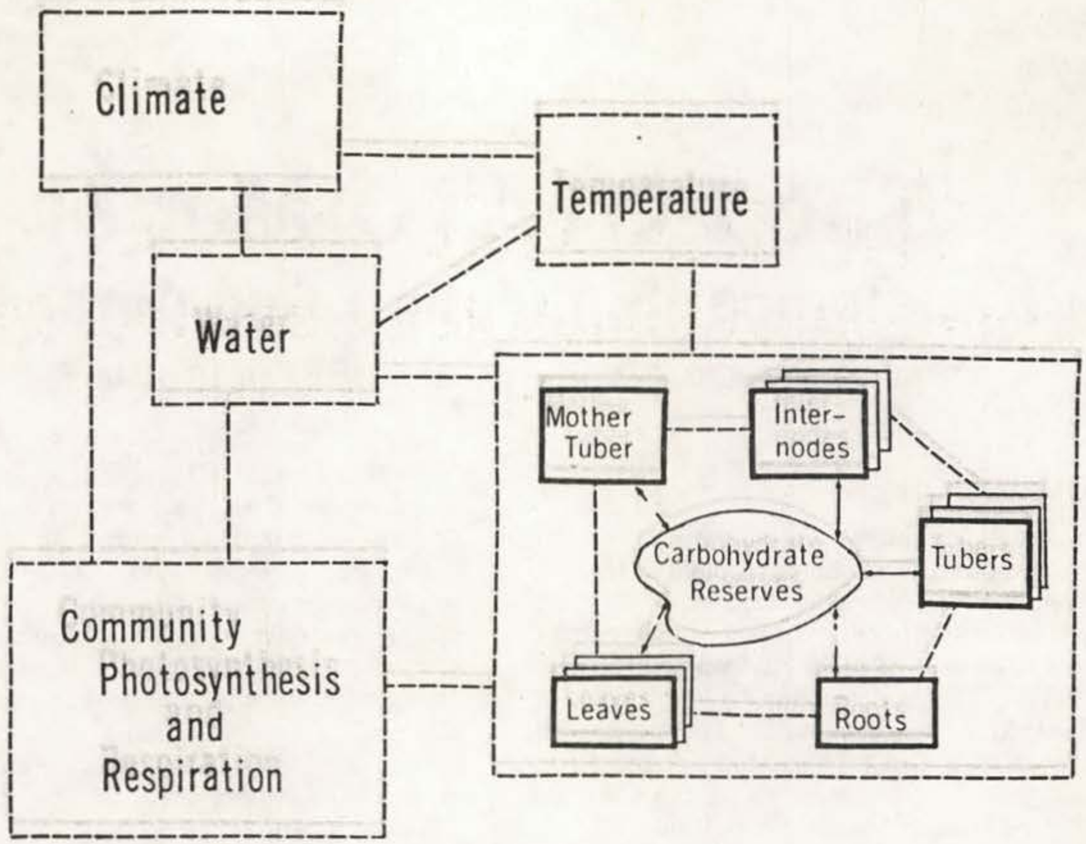

Fig. 1. The POTATO model.

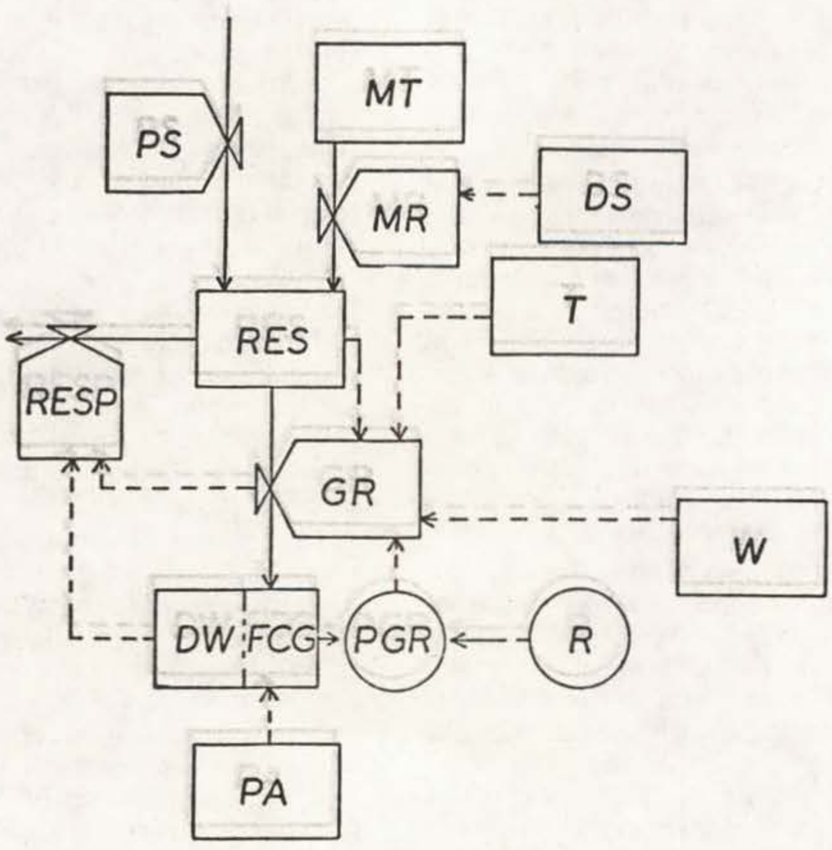

Fig. 2. Canonical plant organ.

POTATO Growth

Photosynthesis

Gross photosynthesis rates (g $CH_2O/m^2/hr$) are calculated from the elevation angle of the sun and the current leaf area index (LAI) (Duncan et al. 1967). Photosynthesis rates are different for four states: (1) untuberized plants, clear skies; (2) untuberized plants, overcast skies; (3) tuberized plants, clear skies and (4) tuberized plants, overcast skies. Tuberized plants can produce as much as twice the photosynthate as untuberized plants under similar conditions (Ku et al. 1977).

The sun angle, LAI and photosynthesis functional relationships for the four states are shown in Tables 1 and 2. For given values of the sun angle and LAI,

Table 1. Photosynthesis rates (g $CH_2O/m^2/hr$) figured on the basis of leaf area index (LAI) and the sine of the height of the sun for untuberized plants. Values in the second line correspond to overcast conditions.

	SNHSUN										
LAI	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.29	0.73	1.17	1.45	1.76	2.15	2.55	2.87	3.00	3.13
	0.00	0.06	0.26	0.44	0.61	0.75	0.88	0.97	1.03	1.05	1.07
2	0.00	0.41	0.96	1.65	2.14	2.60	3.20	3.73	4.01	4.05	4.10
	0.00	0.09	0.37	0.62	0.86	1.06	1.23	1.37	1.45	1.48	1.50
3	0.00	0.47	1.06	1.85	2.48	3.07	3.78	4.38	4.70	4.75	4.84
	0.00	0.10	0.42	0.71	0.98	1.21	1.41	1.56	1.66	1.69	1.71
4	0.00	0.49	1.09	1.93	2.62	3.26	4.06	4.69	4.91	4.86	4.92
	0.00	0.10	0.44	0.74	1.03	1.27	1.48	1.64	1.74	1.78	1.80
5	0.00	0.50	1.11	1.96	2.69	3.38	4.22	4.87	5.10	5.05	5.11
	0.00	0.10	0.45	0.76	1.05	1.30	1.52	1.68	1.79	1.83	1.85
6	0.00	0.50	1.11	1.98	2.73	3.44	4.29	4.96	5.19	5.15	5.20
	0.00	0.10	0.45	0.76	1.06	1.32	1.54	1.70	1.81	1.85	1.87
7	0.00	0.51	1.12	1.98	2.74	3.47	4.33	5.00	5.24	5.20	5.25
	0.00	0.10	0.45	0.77	1.07	1.32	1.54	1.71	1.82	1.86	1.88
8	0.00	0.51	1.12	1.99	2.75	3.48	4.35	5.03	5.27	5.22	5.28
	0.00	0.10	0.45	0.77	1.07	1.32	1.55	1.71	1.82	1.86	1.88
9	0.00	0.50	1.12	1.99	2.75	3.49	4.36	5.04	5.28	5.23	5.29
	0.00	0.10	0.45	0.77	1.07	1.32	1.55	1.72	1.82	1.86	1.88
10	0.00	0.50	1.12	1.98	2.75	3.49	4.36	5.04	5.28	5.24	5.29
	0.00	0.10	0.45	0.77	1.07	1.32	1.55	1.71	1.82	1.86	1.88

Table 2. Photosynthesis rates (g $CH_2O/m^2/hr$) figured on the basis of leaf area index (LAI) and the sine of the height of the sun for tuberized plants. Values in the second line correspond to overcast conditions.

	SNHSUN										
LAI	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.43	1.04	1.65	2.16	2.71	3.16	3.44	3.60	3.67	3.68
	0.00	0.09	0.39	0.65	0.90	1.10	1.26	1.39	1.46	1.49	1.51
2	0.00	0.60	1.38	2.34	3.18	3.99	4.75	5.25	5.55	5.67	5.70
	0.00	0.13	0.54	0.91	1.27	1.55	1.79	1.97	2.09	2.13	2.15
3	0.00	0.68	1.51	2.62	3.68	4.70	5.61	6.22	6.58	6.73	6.77
	0.00	0.14	0.61	1.04	1.44	1.77	2.04	2.25	2.39	2.43	2.46
4	0.00	0.71	1.56	2.73	3.88	5.00	6.05	6.77	7.21	7.39	7.44
	0.00	0.15	0.64	1.08	1.51	1.85	2.15	2.37	2.51	2.56	2.59
5	0.00	0.73	1.58	2.78	3.99	5.18	6.28	7.04	7.49	7.69	7.74
	0.00	0.15	0.65	1.11	1.54	1.90	2.20	2.43	2.57	2.63	2.66
6	0.00	0.74	1.59	2.80	4.04	5.27	6.39	7.17	7.64	7.84	7.89
	0.00	0.15	0.66	1.12	1.56	1.92	2.23	2.46	2.61	2.66	2.69
7	0.00	0.74	1.60	2.81	4.06	5.32	6.45	7.24	7.71	7.91	7.97
	0.00	0.15	0.66	1.13	1.57	1.93	2.24	2.47	2.62	2.68	2.70
8	0.00	0.74	1.60	2.82	4.07	5.34	6.48	7.28	7.75	7.95	8.01
	0.00	0.15	0.67	1.13	1.58	1.94	2.25	2.48	2.63	2.68	2.71
9	0.00	0.74	1.60	2.82	4.08	5.35	6.49	7.29	7.77	7.97	8.03
	0.00	0.15	0.67	1.13	1.58	1.94	2.25	2.48	2.63	2.69	2.72
10	0.00	0.74	1.60	2.82	4.08	5.36	6.50	7.30	7.78	7.98	8.04
	0.00	0.15	0.67	1.13	1.58	1.94	2.25	2.49	2.63	2.69	2.72

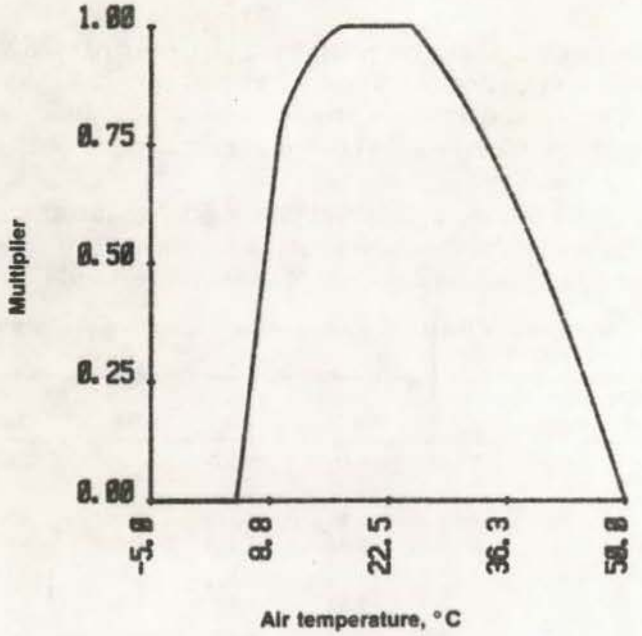

Fig. 3. Temperature-dependent multiplier for photosynthesis (unitless).

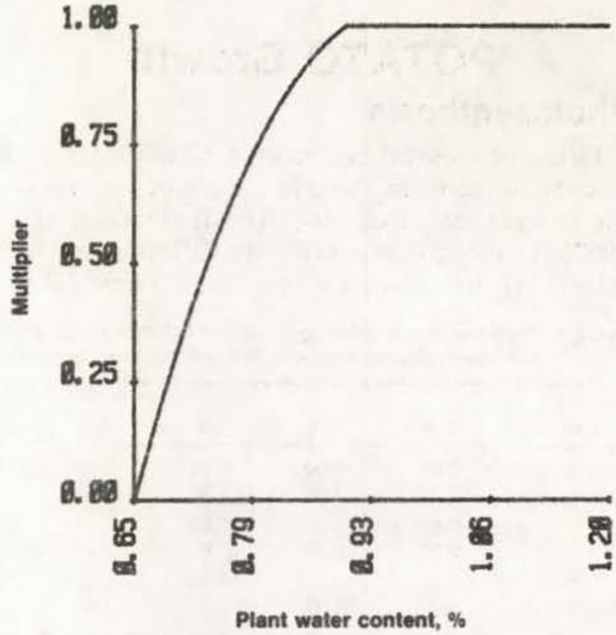

Fig. 4. Water-dependent multiplier for photosynthesis (unitless).

the photosynthesis values for clear skies are combined in proportion to the translocation of assimilate to the tubers. The proportion (EFBPS) is calculated from the average daily transfer of assimilate to the tubers (AVDTRN). That is:

PHOTO (clear) = (1-EFBPS) × PHOTO (clear, untuberized) + (EFBPS) × PHOTO (clear, tuberized)

with a similar formula for photosynthesis under overcast skies.

The maximum rate of photosynthesis under given sky conditions is calculated as PHOTO = (1-p) × PHOTO (clear) + p × PHOTO (ovrcst), where p is the proportion of cloud cover and PHOTO (clear) and PHOTO (ovrcst) are from the clear and overcast calculations above. Actual photosynthesis for a given hour is calculated as maximum photosynthesis times a multiplier that depends on temperature, water and the age of the leaf tissue:

photosynthesis = PHOTO × effect of age × min (effect of temp and water)

See Figs. 3 and 4. The amount of photosynthate produced for a given plant is found by dividing the photosynthate per m^2 by the number of plants per m^2 (plant density).

Main Stems

Each hill typically has three to five main stems growing from a single seed piece. The actual number depends primarily on the size, shape and physiological age of the seed piece. These main stems develop in parallel without any one of them attaining apical dominance.

In the model, the average number of main stems per hill is input as a model parameter. The calculations for growth, development and formation of branches are carried along in tandem. The model run is started with several below ground and several above ground internodes, generally coincident with emergence. From that point, internode initiation rate is calculated as a function of carbohydrate reserves and mother tuber reserves (depending on leaf area) (Figs. 5 and 6).

The phenological ages of the main stems are characterized by main stem "developmental age." Likewise, each internode has an age state variable. Each elapsed hour is modified by a temperature dependent multiplier (Fig. 7) and then accumulated as developmental age for the main stems and each internode. Thus, the ages of the main stems and each internode are functionally related to the temperature regime since their emergence or initiation. Above ground or below ground temperature is used for above ground or below ground internodes, respectively.

Internode initiation is controlled by reserves and temperature. The change in number of internodes per unit time is given by:

$$\frac{d\,(\#\text{internodes})}{dt} = k \times \min\,(\text{temperature effect, reserve effect})$$

where the temperature effect follows from Fig. 7, and the reserves effect is calculated as the maximum of the effect of mother tuber reserves and the effect of the general reserve pool (Figs. 5 and 6). The number of internodes is rounded down to the nearest integer, so that new internodes appear one at a time.

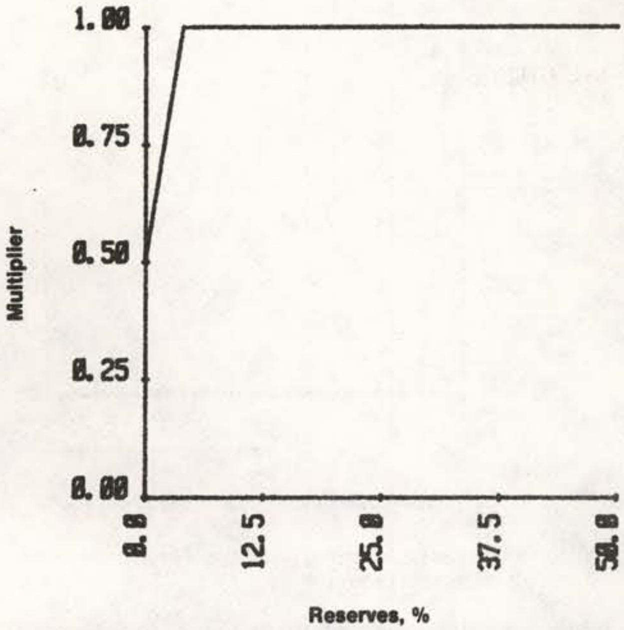

Fig. 5. Multiplier for organ initiation rate, dependent on plant reserves (unitless).

The growth of each internode in each unit of time is a function of reserves, temperature, water availability and internode age. Reserves, temperature and water enter in a "most limiting" calculation:

limit = min (effects of temperature, water and the maximum of reserves and MT reserves)

See Figs. 8 and 9. The water limiter is calculated in the water subsection. The age effect is entered as a multiplicative factor (Fig. 10) so that the change in dryweight per unit time is given as:

$$\frac{d\,[\text{wt of internode (i)}]}{dt} = k \times \text{effect of age} \times \text{limit} \times \text{current internode weight}$$

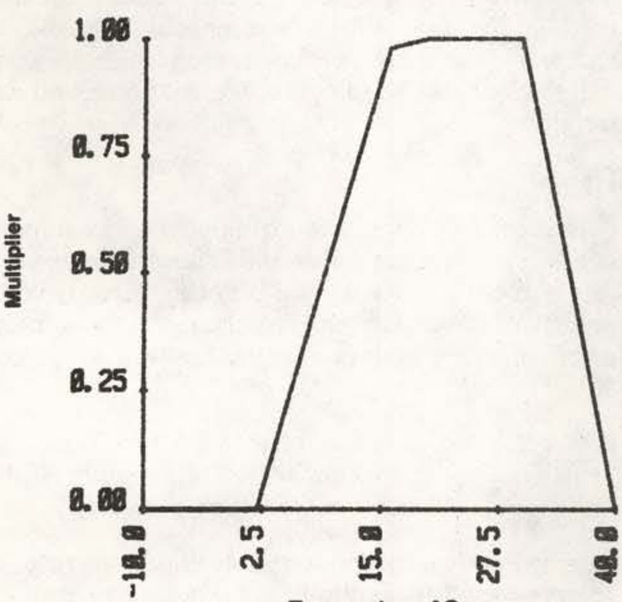

Fig. 7. Temperature-dependent multiplier for organ development rate (unitless).

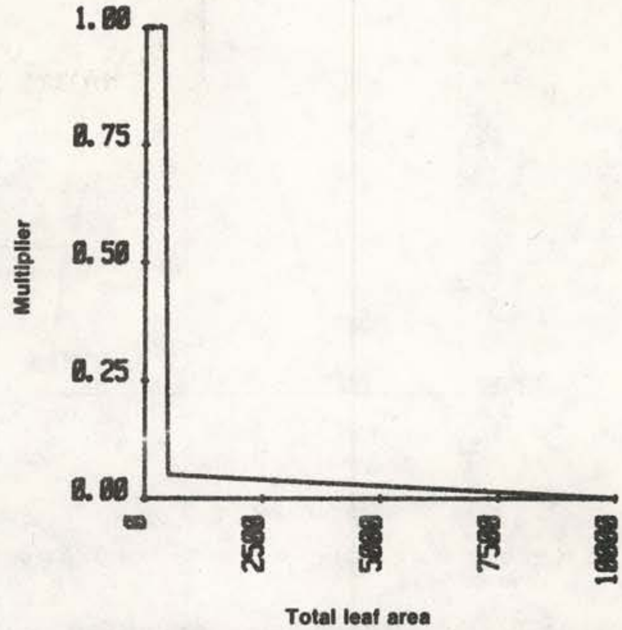

Fig. 6. Leaf area-dependent multiplier for the effect of mother tuber reserves (unitless).

In this equation, k is the maximal growth rate; the effect of age and the limit defined above are unitless modifiers taking values between 0 and 1. These are multiplied together with the current internode dryweight to determine the change of the internode's weight for this time period. This formulation follows the general format of all of the first order differential equations used to describe the system written as:

$$\frac{dX}{dt} = f\,(X, P, Z, t)$$

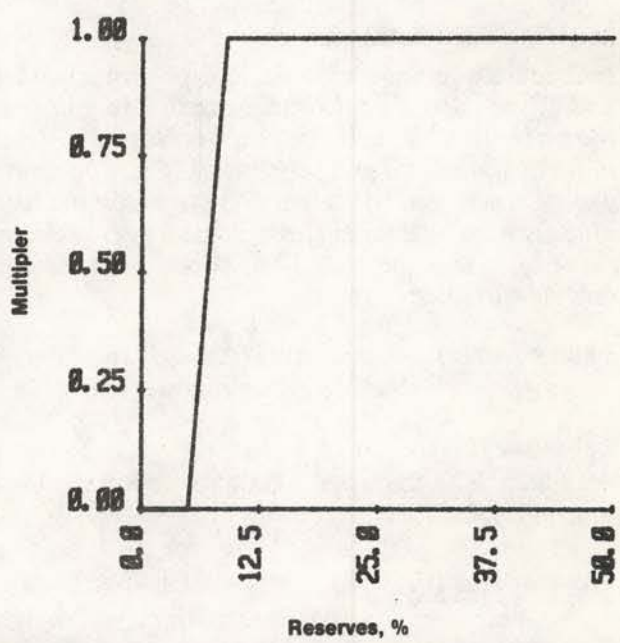

Fig. 8. Reserve-dependent multiplier for internode growth (unitless).

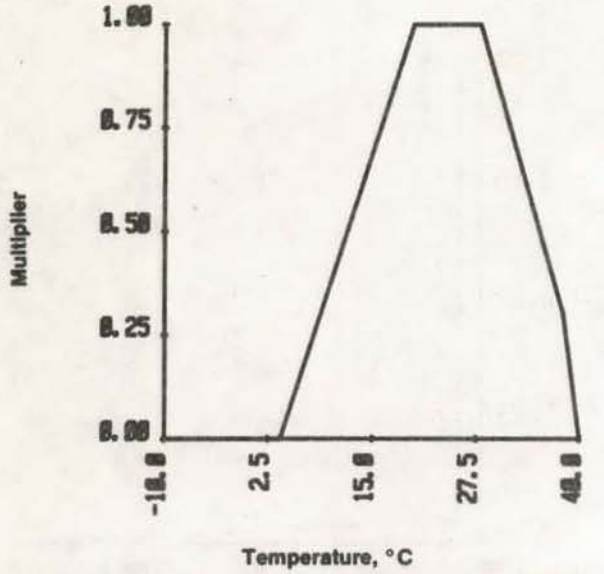

Fig. 9. Temperature-dependent multiplier for internode growth (unitless).

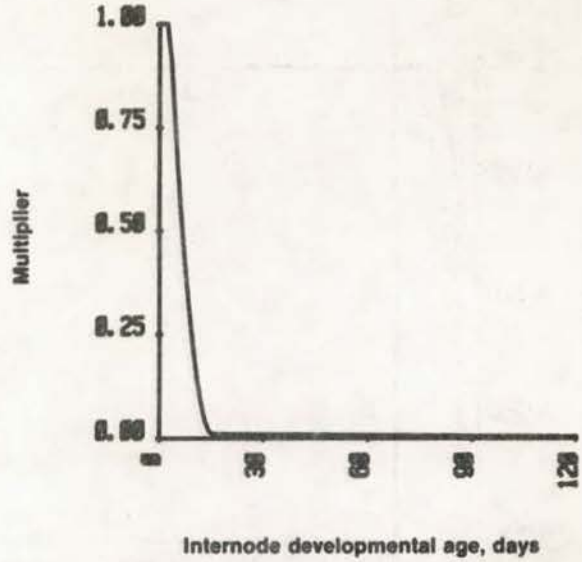

Fig. 10. Multiplier for internode growth, dependent on internode development (age) (unitless).

where X is the vector of state variables, P is a vector of parameters, Z is a vector of driving variables (see Abiotic Processes section on page 14) and t is time. These equations are solved using an Euler approximation with dt = 1 hour. Initial conditions, X(o), are input as values of the state variables at emergence. In this notation, if X_1 is the first main stem internode, then:

f_1 (X, P, Z, t) = k × effect of age × limit × X_1

where k is from P, effect of age depends on X and P, and the limit depends on Z and P.

In summary, main stems have state variables and differential equations describing their change per unit time for numbers of internodes and internode weights. This also applies to the physiological ages of the main stems and each internode.

Main Stem Leaves

Calculations for leaf initiation, phenological age and growth are similar to main stems. In addition, the main stem leaf section has calculations to determine leaf area and leaf senescence. Developmental age of each leaf is calculated as a temperature modification to elapsed chronological age. Initiation rate of leaves is calculated as a function of reserves and development rate:

$$\frac{d\ (\#\text{ms leaves})}{dt} = k \times \min\ (\text{AG dev rate } {*}24,\ \text{effect of reserves})$$

See Fig. 5. The change in weight of a main stem leaf in a unit of time is:

$$\frac{d\ [\text{wt of leaf (i)}]}{dt} = k \times \text{effect of leaf age} \times \text{limiter} \times \text{current leaf weight}$$

where the limiter is given as (Figs. 9, 11 and 12):

limiter = min (effects of temp, water and the max of reserves and MT reserves)

The effect of water is calculated in the plant water section. The effect of mother tuber (MT) reserves is the same as calculated for main stem internodes. Leaf area is started as 2.75 cm^2. The change in leaf area is proportional to the change in leaf weight and is calculated each hour as (Figs. 13 and 14):

$$\frac{d\ [\text{area of leaf(i)}]}{dt} = k \times [d\ (\text{wt of leaf (i)})] \times \text{effect of leaf age} \times \text{effect of solar radiation}$$

The expected life of a leaf is 55 developmental days for the first leaves and decreases for leaves initiated as the season progresses (Fig. 15). Leaves actively grow early in their life and eventually lose half of their biomass before they senesce (Fig. 16). In summary, then, once initiated, each leaf has a state variable for its phenological age, leaf area and dry weight.

Branches

In the model, branches are initiated under suitable conditions of reserve availability and development rate if there are not several branches already competing for these reserves. The change in the number of branches per hour is calculated as (Figs. 7, 17 and 18):

$$\frac{d\ (\#\text{ branches})}{dt} = k \times \text{effect of \# previous branches} \times \min\ (\text{effect of dev rate, effect of reserves})$$

which implies that either development rate or reserves is most limiting but not both, and the number of previous branches enters multiplicatively.

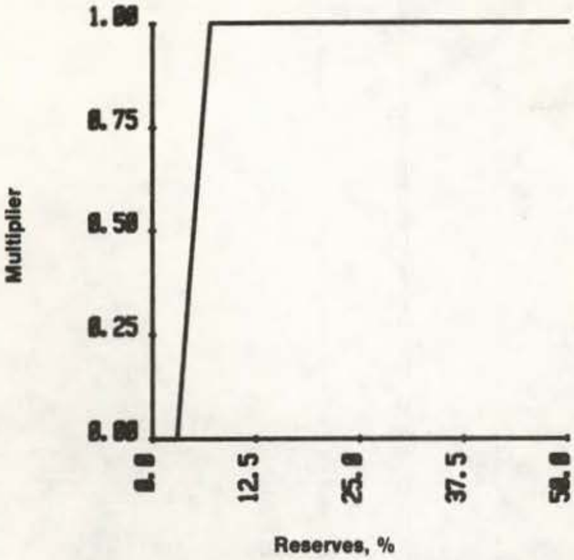

Fig. 11. Reserve-dependent multiplier for leaf growth (unitless)

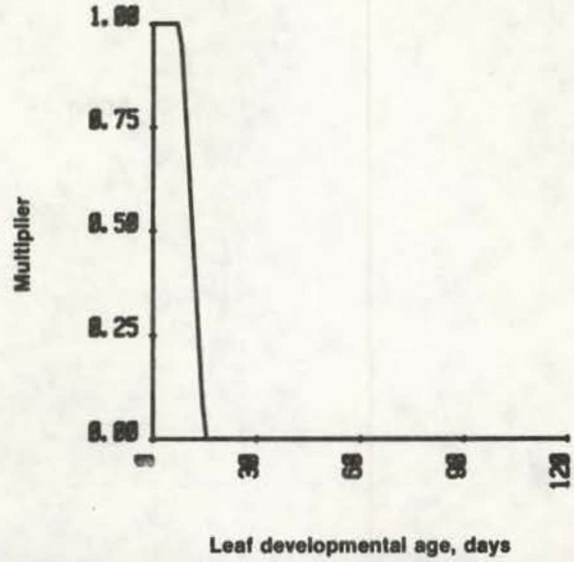

Fig. 12. Multiplier for leaf growth, dependent on leaf development (age) (unitless).

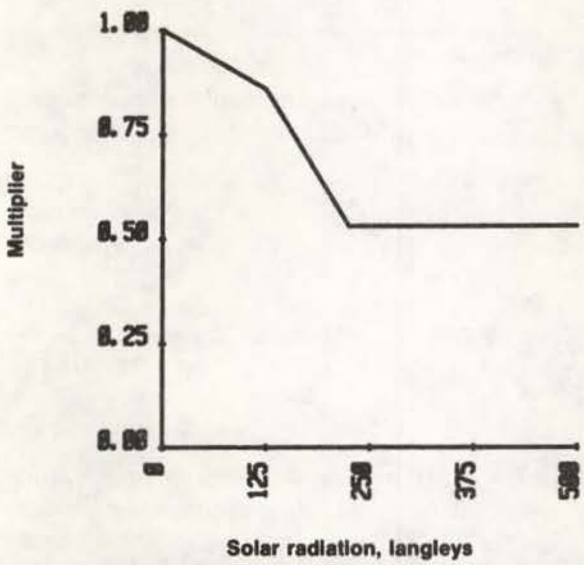

Fig. 13. Solar radiation-dependent multiplier for specific leaf area (unitless).

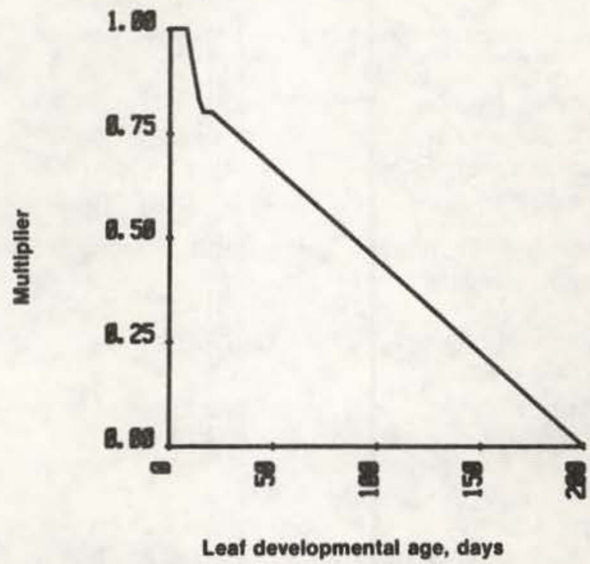

Fig. 14. Multiplier for leaf area growth, dependent on leaf development (age) (unitless).

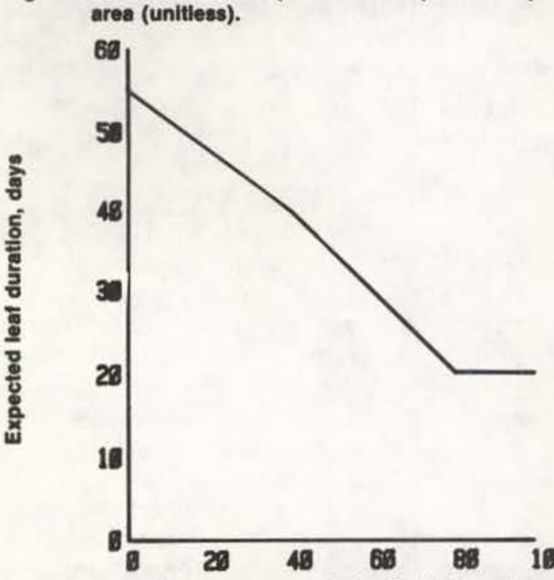

Fig. 15. Leaf life as a function of initiation period.

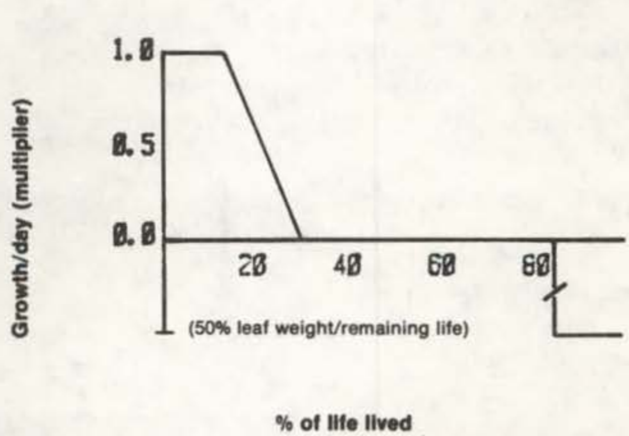

Fig. 16. Leaf activity as a function of percent of life lived.

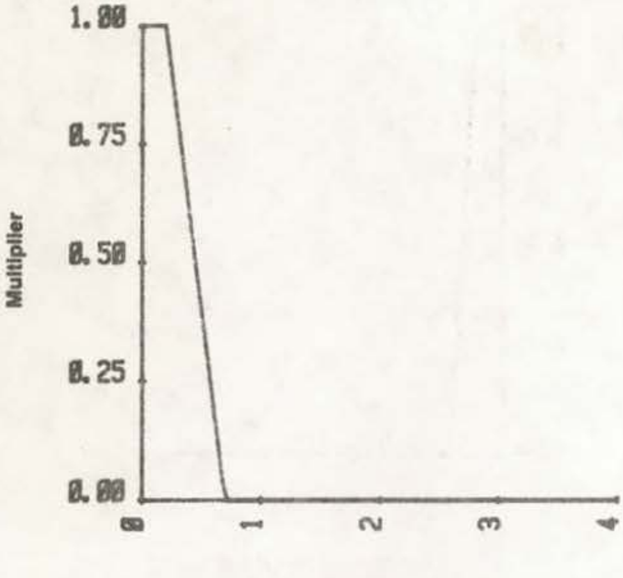

Fig. 17. Multiplier for branch initiation rate, dependent on the number of previous branches (unitless).

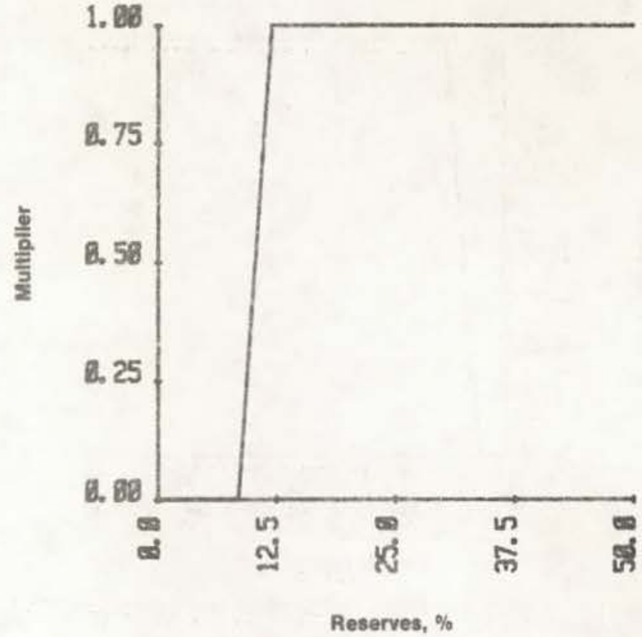

Fig. 18. Reserve-dependent multiplier for the branch initiation rate (unitless).

For each branch, internode initiation is calculated as a function of above ground development rate and percent reserves. The change in number of internodes on a given branch is calculated as (Figs. 5 and 7):

$$\frac{d\,(\#\text{ branch internodes})}{dt} = k \times \min\,(\text{effect of dev rate, effect of reserves})$$

The development rate of a branch is taken as the current above ground development rate.

Once initiated, branch internode growth increments are calculated as (Figs. 8, 9 and 10):

$$\frac{d\,[\text{wt of branch internode (i)}]}{dt} =$$

$$k \times \text{effect of age x min (effects of reserves, temp, water) x current internode weight}$$

The effect of plant water is calculated in the water subsection.

Branch Leaves

Branch leaves grow in a manner parallel to main stem leaves but perhaps at differing rates. To summarize:

$$\frac{d\,(\#\text{ branch leaves})}{dt} = k \times \min\,(\text{effect of dev age, effect of reserves})$$

See Figs. 5 and 7.

$$\frac{d\,[\text{wt of branch leaf (i)}]}{dt} = k \times \text{effect of age} \times \min\,(\text{effects of reserves, temp, water}) \times \text{current leaf dry weight}$$

See Figs. 9, 11 and 12. The effect of water on branch leaf weight increment is calculated in the plant water section.

$$\frac{d\,[\text{area of branch leaf (i)}]}{dt} = k \times [d\,(\text{wt of branch leaf (i))}] \times \text{effect of branch leaf age}$$

See Figs. 13 and 14. Branch leaves senesce in the same manner as main stem leaves (Figs. 15 and 16).

Tubers

Tuber initiation and growth is a three step process. Tubers are initiated into a preliminary "induction" state under suitable photoperiod conditions. They remain "induced but not growing" until they experience a sufficient number of hours under favorable carbohydrate reserve availability. They then become growing tubers.

The change in the number of tuber starts is (Fig. 19):

$$\frac{d\,(\#\text{ tuber starts})}{dt} = \frac{\text{effective photoperiod}}{\#\text{ hours required of photoperiod} < \text{critical}}$$

Tubers are initiated in groups of three. To determine if these "tuber starts" begin to develop, the proportion of total hours under favorable reserve conditions is monitored. When this figure reaches one, then a tuber is released for growth (Fig. 20):

$$\frac{d\,(\text{proportion for release})}{dt} = \frac{\text{effective time under suitable reserve conditions}}{\#\text{ of hours needed}}$$

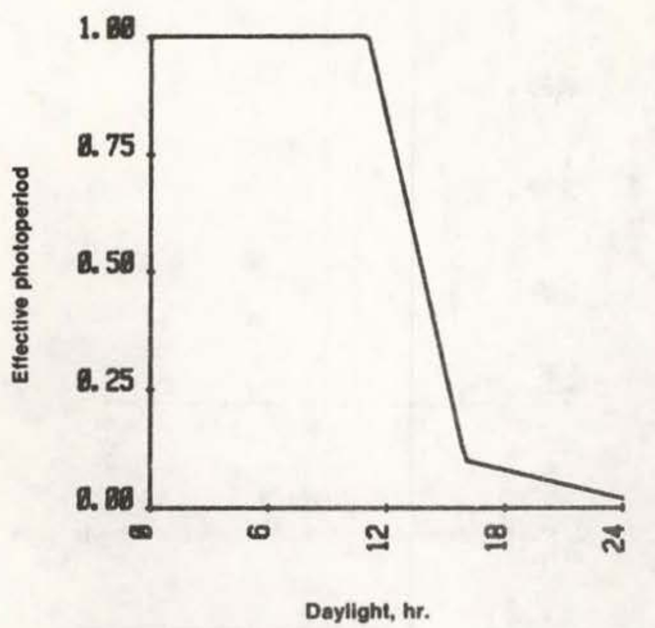

Fig. 19. Effective photoperiod as a function of hours of daylight.

Tuber growth is regulated by soil temperature, percent reserves, available water, developmental age and the current dry weight (Figs. 21, 22 and 23):

$$\frac{d\,[\text{wt of tuber (i)}]}{dt} = k \times \text{effect of tuber age} \times \min(\text{effects of temp, reserves, water}) \times \text{current tuber dry weight}$$

The effect of plant water is calculated in the water subsection.

Roots

The process of root growth involves the continuous increase of fibrous root material through growth and the continuous decrease of fibrous roots through suberization. The growth rate and the rate of suberization must be monitored. In addition, since water uptake is associated with the fibrous root surface, the length of fibrous root material available must be known. Consequently, state variables are modeled for total root biomass, total root length that results from the elongation of adventicious roots and suberized root length. The current unsuberized root length is merely the total length minus the suberized root length.

Root growth is controlled by reserves, soil temperature, water availability and the amount of existing root material (Figs. 9, 24 and 25):

$$\frac{d\,(\text{wt fibrous roots})}{dt} = k \times \text{effect of existing root wt} \times \min(\text{effects of MT and general reserves, temp and water}) \times \text{current dry wt of roots}$$

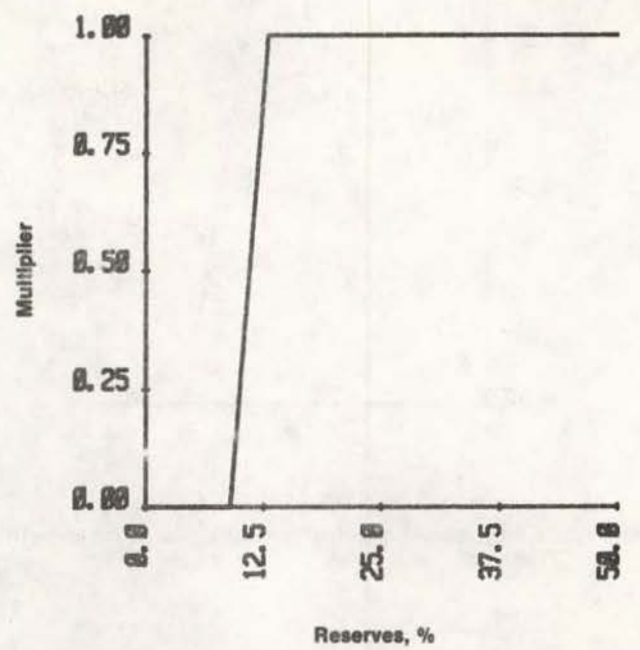

Fig. 20. Reserve-dependent multiplier for parallel tuber initiation rates (unitless).

The effect of plant water is calculated in the water subsection.

The change in total root length is a function of current growth and soil temperature (Fig. 26):

$$\frac{d\,(\text{root length})}{dt} = k \times [d\,(\text{wt of fibrous roots})] \times \text{effect of temperature}$$

Suberization is a function of soil temperature and reserves. In each unit of time a proportion of the current fibrous root length is converted to suberized material according to (Figs. 24 and 27):

$$\frac{d\,(\text{suberized length})}{dt} = k \times \text{effect of temperature} \times \text{effect of reserves} \times \text{current length of fibrous roots}$$

Carbohydrate Reserves

The reserve pool consists of carbohydrates associated with the labile carbon available to all plant parts. Initially, the pool has reserves from the growing plant and the mother tuber. As the plant grows, the mother tuber disappears, and the reserve pool becomes merely the plant part carbohydrates. The reserves decrease with translocation to nonlabile dry weight and with respiration and increase with photosynthesis and translocation from dying leaves. The change in mother tuber reserves is a fraction of the total translocation in a unit time:

$$\frac{d\,(\text{MT reserves})}{dt} = -\ \text{total translocation of reserves} \times \text{effect of MT reserve}$$

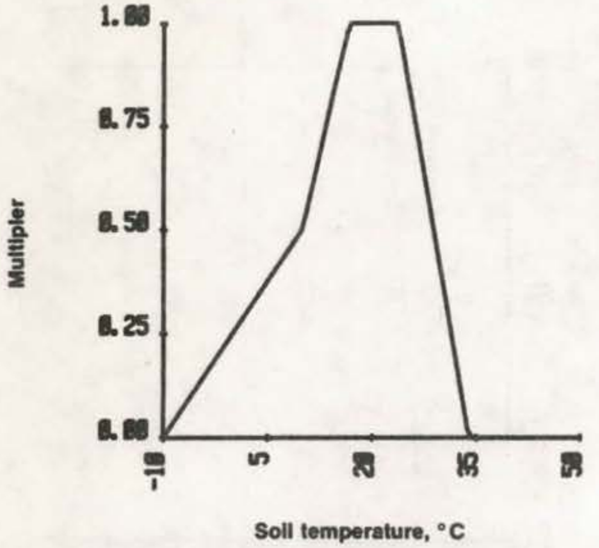

Fig. 21. Temperature-dependent multiplier for tuber growth (unitless).

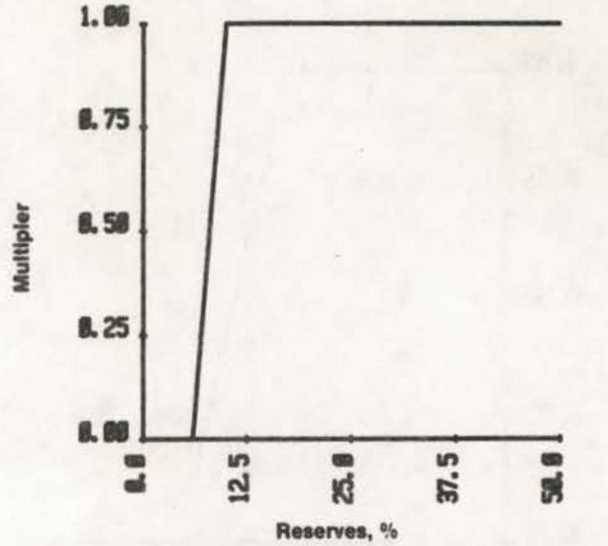

Fig. 22. Reserve-dependent multiplier for tuber growth (unitless).

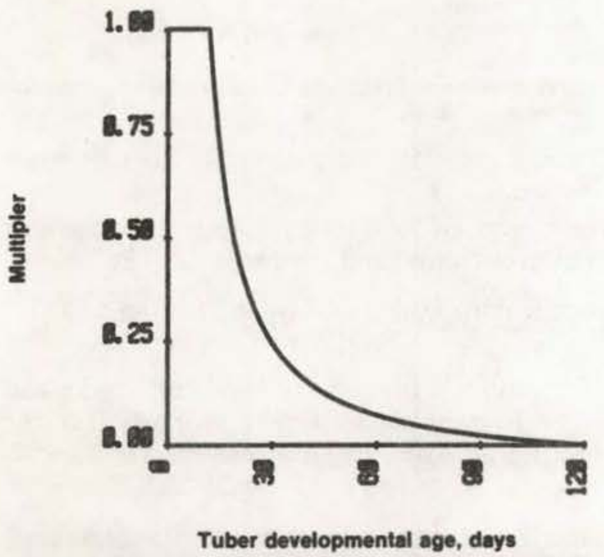

Fig. 23. Multiplier for tuber growth, dependent on tuber development (age) (unitless).

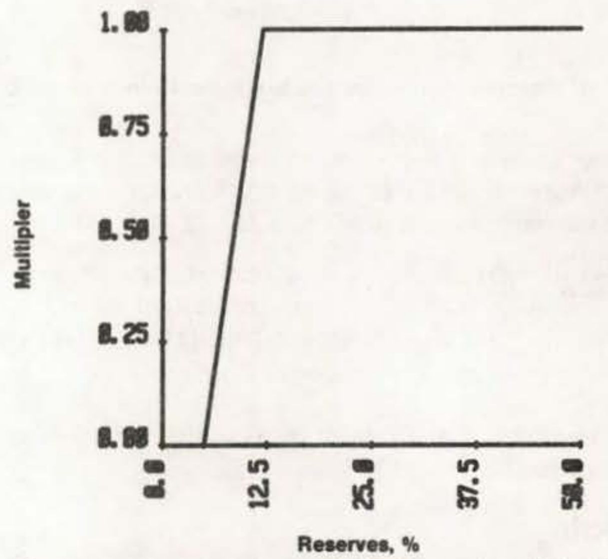

Fig. 24. Reserve-dependent multiplier for root growth (unitless).

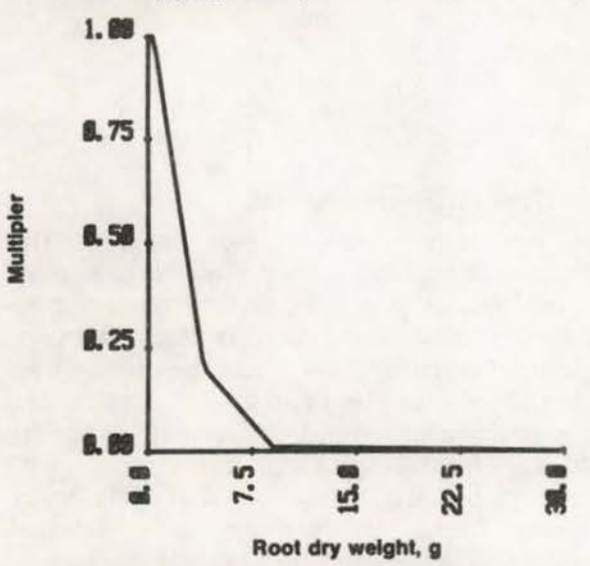

Fig. 25. Multiplier for root growth, dependent on root dry weight (unitless).

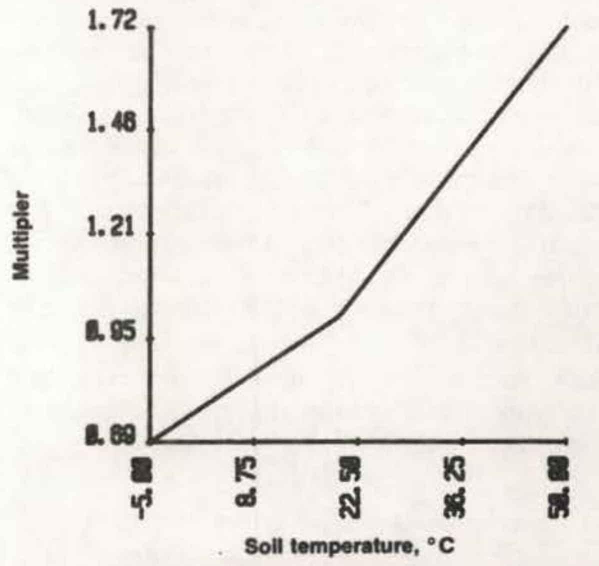

Fig. 26. Temperature-dependent multiplier for root length growth (unitless).

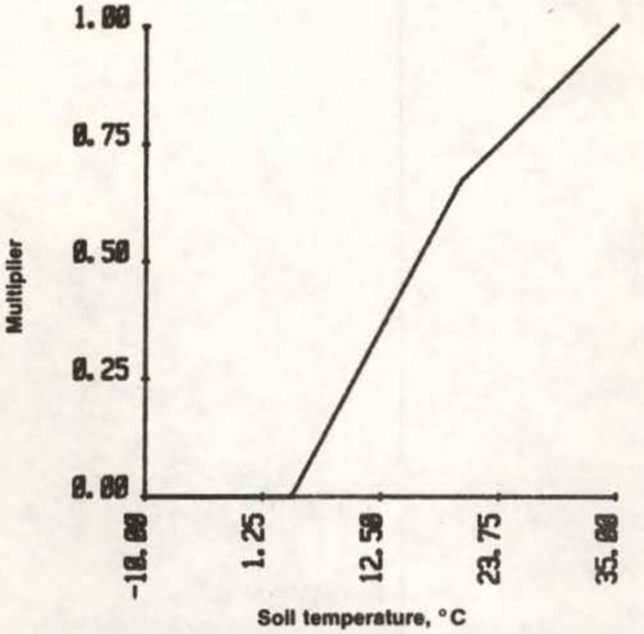

Fig. 27. Temperature-dependent multiplier for root suberization (unitless).

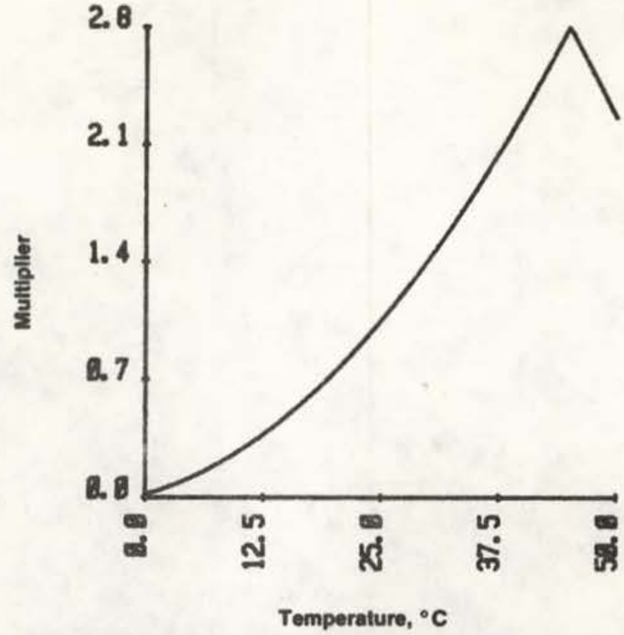

Fig. 28. Temperature-dependent multiplier for maintenance respiration (unitless).

The change in the overall reserve pool is calculated as:

$$\frac{d\,(\text{reserves})}{dt} = \text{photosynthesis} + \text{return from dying leaves} + d\,(\text{MT reserves}) - \text{total translocation}$$

where total translocation is translocation to below ground internodes, main stem internodes, main stem leaves, branch internodes, branch leaves, tubers, roots and losses caused by maintenance respiration and growth respiration. The maintenance respiration rate for the various organs is calculated as (Figs. 28, 29 and 30):

below ground internodes =
(1-f) drywt of BG internodes × effect of temperature × base resp rate for internodes

above ground internodes =
(1-f) drywt AG internodes × effect of temperature × base resp rate for internodes

branch internodes =
(1-f) drywt branch internodes × effect of temperature × base resp rate for internodes

roots =
(1-f) drywt roots × effect of temperature × base resp rate for roots

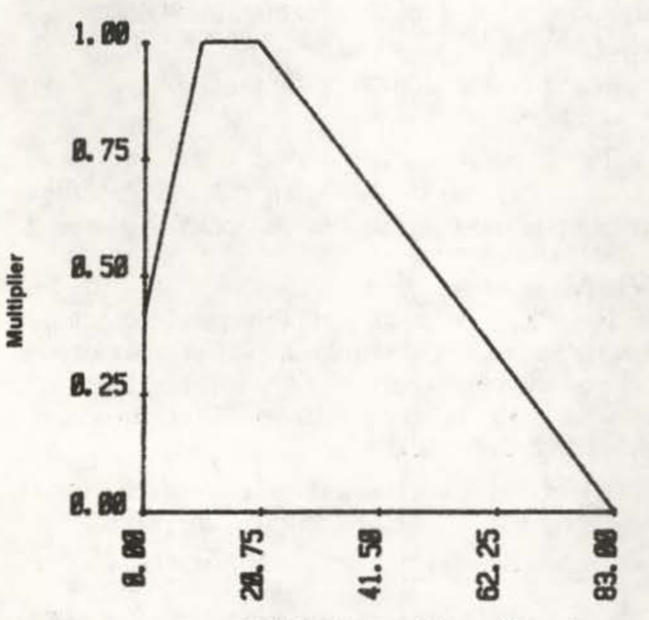

Fig. 29. Multiplier for maintenance respiration of leaves, dependent on leaf development (age) (unitless).

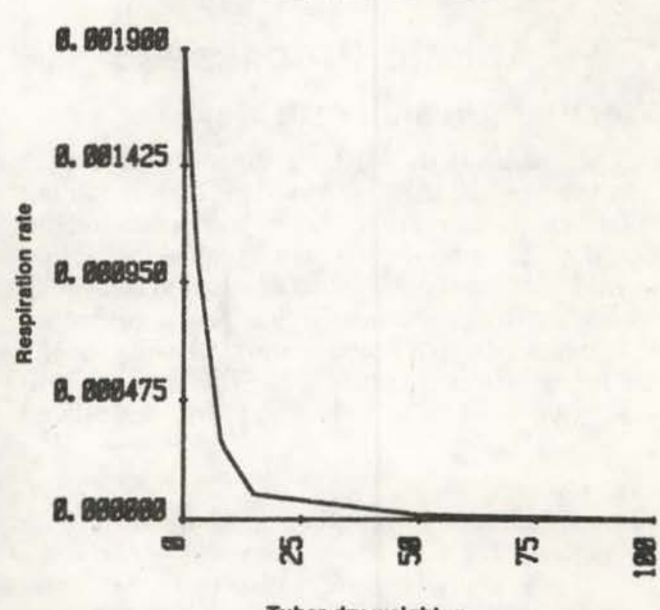

Fig. 30. Effective tuber base maintenance respiration rate as a function of individual tuber dry weight.

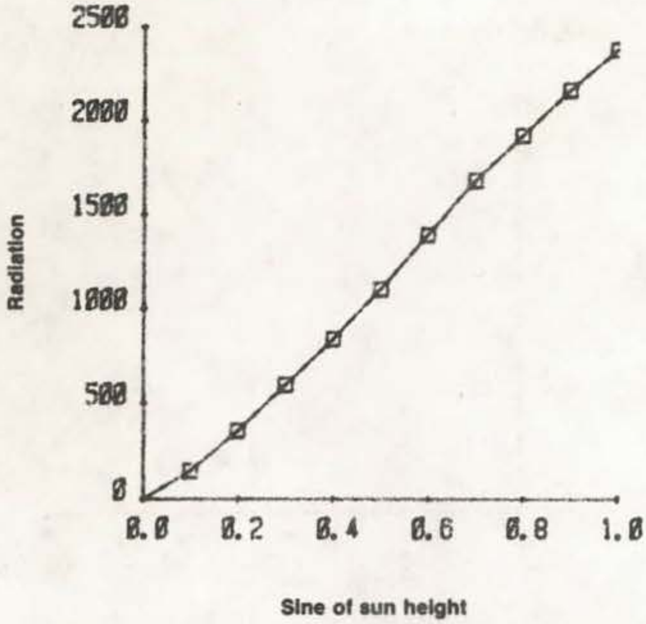

Fig. 31. Potential clear sky radiation as a function of sun height.

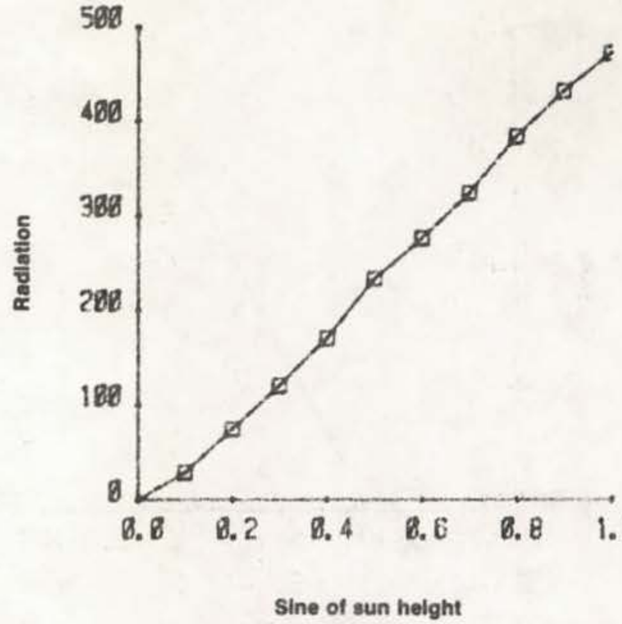

Fig. 32. Potential overcast sky radiation as a function of sun height.

main stem leaves =
(1-f) drywt MS leaves × effect of temperature × effect of age × base resp rate for leaves

branch leaves =
(1-f) drywt branch leaves × effect of temperature × effect of age × base resp rate for leaves

for **each** tuber =
tuber drywt × effect of temperature × base resp rate for tubers (dependent on the tuber dw)

where f is the fraction of the plant in reserves. Growth respiration is proportional to translocation. For each organ the calculation is:

growth resp of organ (i) = k × translocation rate (i)

Abiotic Processes

Weather (Driving Variables)

The model is driven by temperature (average temperature and daily fluctuation), daily incoming solar radiation, average daily dewpoint and wind run per day. Hourly air temperatures are generated assuming a sinusoidal, diurnal fluctuation coinciding with the two temperature inputs. Soil temperature is calculated from air temperature allowing for the buffering effect of the soil. The average soil temperature is a 48-hour moving average calculated each hour as:

avg. soil temp =
previous average daily soil temp + the difference between the current air temp and previous avg. soil temperature divided by 48

Soil temperature is assumed to have a sinusoidal, diurnal pattern just like air temperature except it lags air temperature by 4 hours, and the amplitude is dampened. Photoperiod is calculated as:

photoperiod = k × arccos [- tan (latitude) × tan (declination)]

where k[1] is a constant.

The current hourly radiation is calculated for clear and overcast skies as a function (Figs. 31 and 32) of the sine of the height of the sun (from Photosynthesis section on page 5). These two figures are accumulated for each 24-hour period to use in the fraction clear sky computation for the following day — DRCP and DROP, respectively.

The fraction clear sky is calculated once a day as:

$$\text{fraction clear sky} = \frac{\text{current daily radiation - DROP}}{\text{DRCP - DROP}}$$

In addition, actual radiation for the current hour is computed as:

radiation = p × current clear sky radiation + (1 - p) × current overcast radiation

where p is the fraction clear sky calculated above.

Plant Water

The relative water content of the plant is calculated hourly and used to determine the effect of water content on the parts of the plant: stems and branches, fibrous roots, tubers and leaves. These effects are calculated individually by:

effect of water content = k + l × relative water content of plant

where l is dependent on the specific organ.

[1]The letters k, l and m are used in this section to denote constants in the equations, and not a specific constant among the different equations.

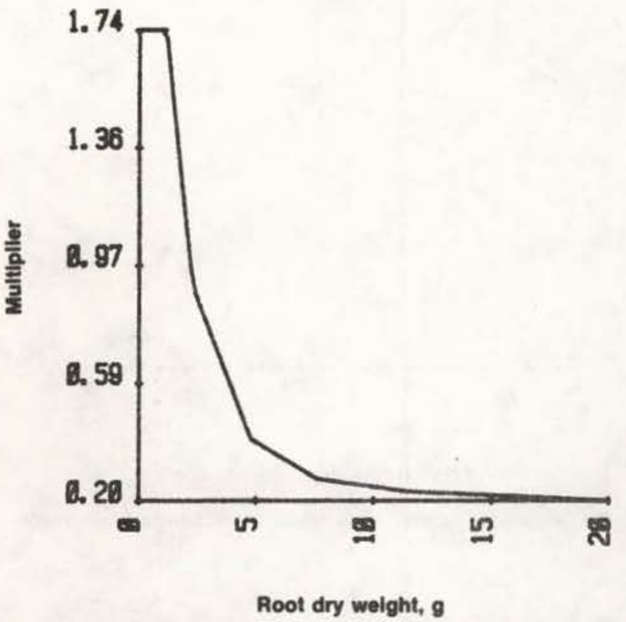

Fig. 33. Multiplier for root water uptake ability, dependent on root dry weight (unitless).

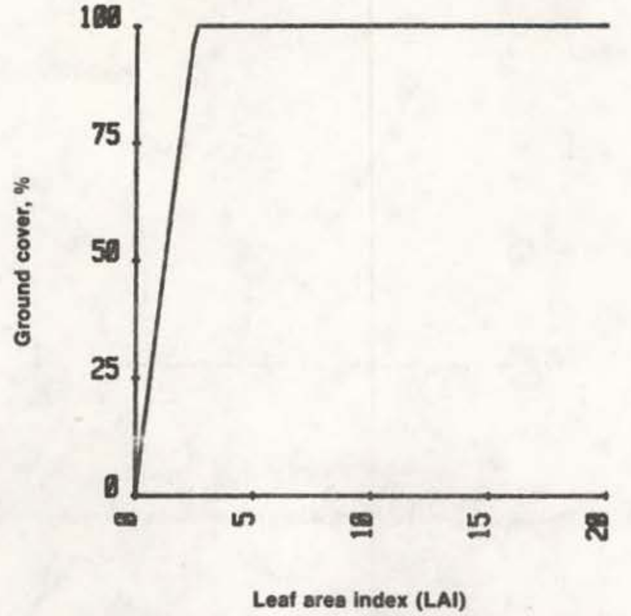

Fig. 34. Percent ground cover as a function of leaf area index (LAI).

The effect of water on photosynthesis is also calculated using the relative water content (see Photosynthesis section on page 5). The relative water content is figured as a percent of the plant's total weight, calculated as:

$$\text{relative water content} = \frac{\text{total water weight of plant}}{\left[\dfrac{\text{total dry weight of the plant}}{\text{dry matter fraction of the plant}} - \text{total dry weight of plant}\right]}$$

where the dry matter fraction of the plant is figured as:

$$\text{dry matter fraction of plant} = \frac{\Sigma\left[\text{dry weight of each organ} \times \text{its dry matter fraction}\right]}{\text{plant's total dry weight}}$$

The total water weight of the plant is a state variable that is updated each hour by the change in weight of the water:

$$\frac{d\,(\text{water weight of plant})}{dt} = \text{water weight taken up by roots} - \text{water weight lost to transpiration}$$

The water uptake of the plant is assumed to be the lesser of (a) the capacity of the root system and (b) the amount needed to bring the relative water content to 100 percent, including the amount necessary to cover transpiration. The capacity of the root system is figured as (Fig. 33):

root water uptake possible =

k × effect of soil temperature and water potential × effect of root dry weight × available root length

The calculations for the amount of water lost each hour to transpiration are considerably more complex (Rijtema 1965). The calculation for transpiration uses a set of preliminary calculations using the driving variables and the current state of the plant (Figs. 34, 35 and 36):

Saturation vapor pressure = f (air temperature)

Actual vapor pressure = f [minimum (air temperature, dewpoint)]

Slope of vapor pressure curve = f (air temperature)

Longwave radiation = f (fraction of clear skies, actual vapor pressure, air temperature)

Net radiation = f (crop albedo, actual current radiation, longwave radiation)

Diffusion resistance = f (actual current radiation, amount of plant cover)

Given these values, the potential evapotranspiration is figured in several steps. First a sub calculation gives (Figs. 37 and 38):

EAP = f (windspeed) × f (plant height) × windspeed × (saturation vapor pressure - actual vapor pressure)

This value for EAP is used to help construct the numerator of the final equation for potential evapotranspiration:

$$\text{TOP} = \frac{\text{slope of vapor pressure curve} \times \text{net radiation}}{k} + (m \times \text{EAP})$$

The denominator for the expression is found as

DENOM = slope of vapor pressure curve + 1 + f (windspeed) × f (plant height) × windspeed × diffusion resistance × 24

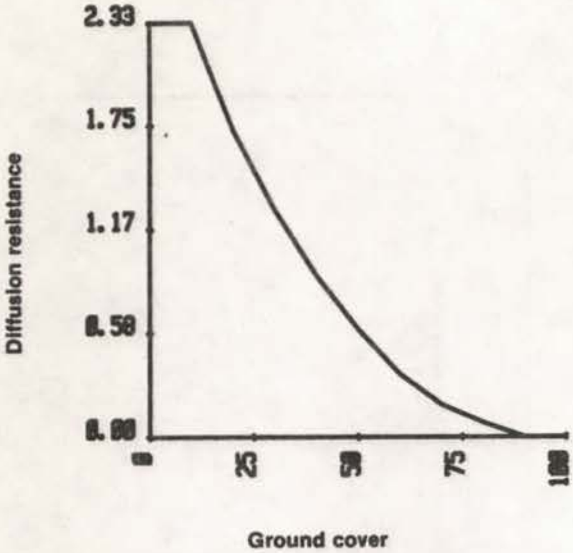

Fig. 35. Partial diffusion resistance as a function of ground cover.

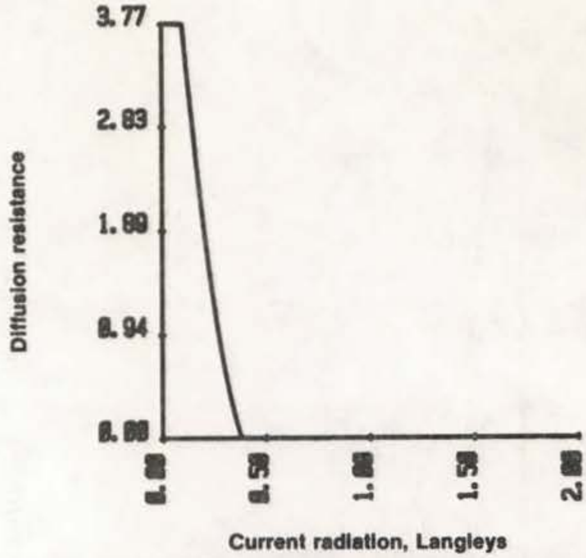

Fig. 36. Partial diffusion resistance as a function of current radiation.

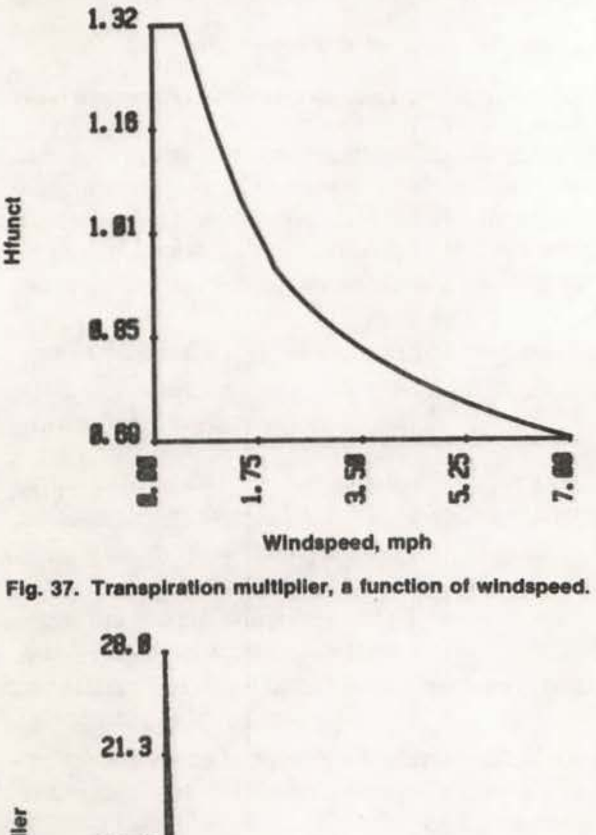

Fig. 37. Transpiration multiplier, a function of windspeed.

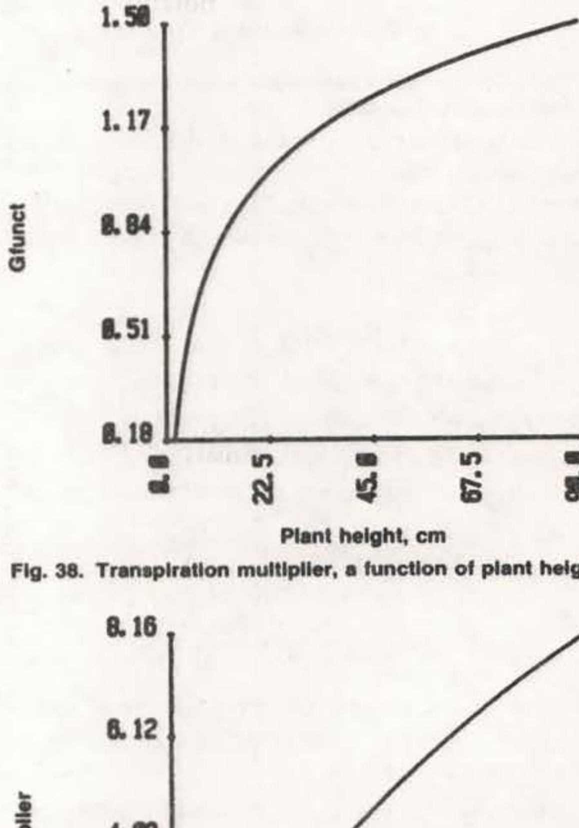

Fig. 38. Transpiration multiplier, a function of plant height.

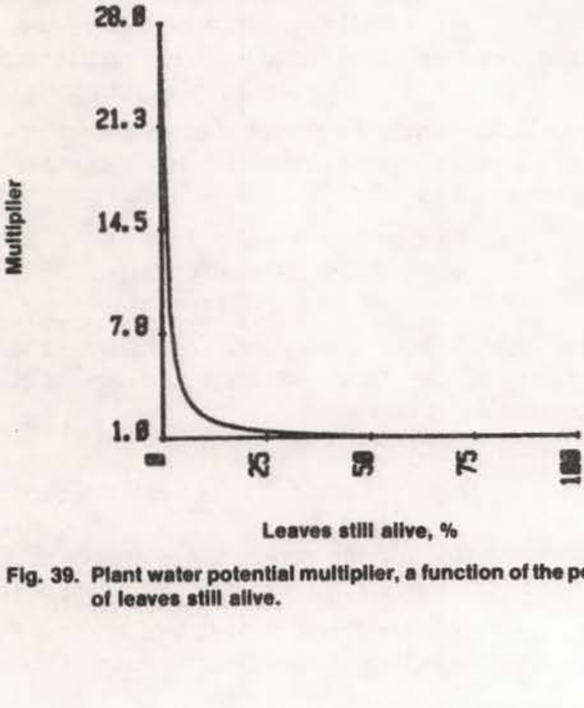

Fig. 39. Plant water potential multiplier, a function of the percent of leaves still alive.

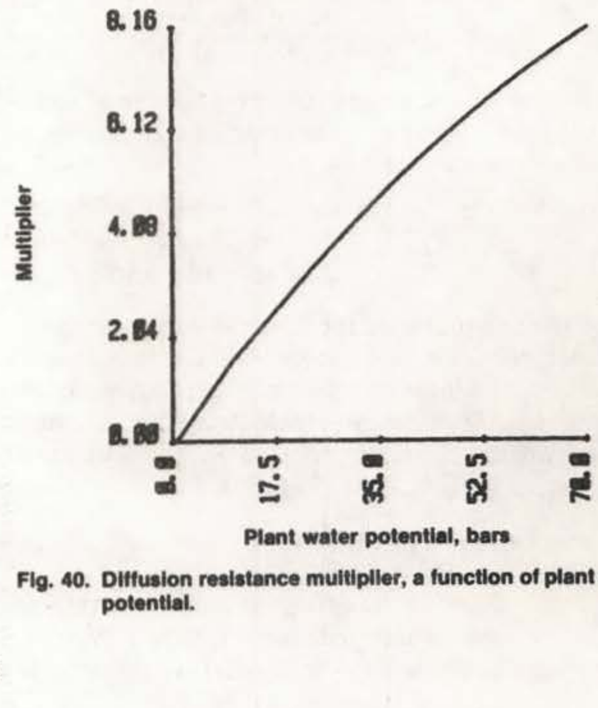

Fig. 40. Diffusion resistance multiplier, a function of plant water potential.

The potential evapotranspiration is then figured as:

$$\text{potential evapotranspiration} = \frac{\text{TOP}}{\text{DENOM}}$$

This value must be modified to take into account factors that are leaf- and soil-related. The hydraulic conductivity of the soil is determined, a value which is dependent on the soil type (Willis 1960) (Figs. 39 and 40).

$$\text{plant water potential} = \text{potential evapotranspiration} \times \left[\frac{\text{diffusion resistance dependent on percent live leaves}}{\text{hydraulic conductivity}}\right] + (m \times \text{soil water potential})$$

The diffusion resistance modifier is figured as a function of this plant water potential. The denominator of the evapotranspiration equation is then modified by adding the new modifier to the previous diffusion resistance value, and the actual evapotranspiration is figured using this new denominator (DENOM2):

$$\text{evapotranspiration} = \frac{\text{TOP}}{\text{DENOM2}}$$

This figure is multiplied by the community leaf area index if the index is less than one, to provide a crop evapotranspiration figure. The transpiration for the single model plant is:

$$\text{transpiration} = \frac{k \times \text{evapotranspiration}}{\text{planting density}}$$

This is the transpiration figure used for the water content calculations.

Input and Output

Input to and output from the model are functions handled to a large extent independently from the main flow of calculations for the growth of the potato plant. Most input is handled in the calling (MAIN) section of the model, while input pertaining to desired output, as well as the output itself, is handled in the "Output" subsection.

Input

Input to the POTATO model consists of an ordered deck of card data. In this guide, "card" and "deck" are used to refer to 80-byte card-image data which may or may not be actual physical punchcards. This deck is referred to internally as file 5 (FT05F001). An example of an input deck may be found in Appendix B. A typical input deck consists of (a) run and input/output control, (b) a parameter namelist, (c) two table namelists, (d) an initial condition namelist and (e) driving variables. Those data which have defaults are entered in the five namelist groups. A variable which can be included in a namelist may be omitted, in which case the default value for the variable is used. Other data, which are (normally) required, are read from the deck on cards with formatted fields.

The first cards of the deck comprise the first namelist that is the run control group. The variables in this group control the simulation run itself. These variables are NDAYS, the number of days for the run; IDAST, the Julian date of the first day of the run; IOUTPT, the number of variables to be printed in tabular form; IPLOTN, the number of plots to be printed; and IHEADR, to control the amount of information in the output header. Default values for namelisted variables may be found in the output listing in Appendix B.

When either IOUTPUT and IPLOT is not zero, cards describing the requirements for the output immediately follow the run control namelist. If there are any variables (up to 12) to be printed in tabular form, the first card (or two, if necessary) will provide the variable names and the hour of day for which each variable is requested. If there are any plots to be output (up to 10), the following cards will have information on each plot.

For each plot, a card details the variables (up to five) to be included with the hour of day for each variable. If column 51 of the card is nonzero, then another card is included immediately following to force the maximums and minimums of the x and y axes of the plot. Otherwise, these will be determined by the range of values of the variables included. Field specifications for these cards may be found in Appendix B.

The second namelist, which is for modification of parameter values, follows at this point in the deck. As with the other namelists, any or all of these variables may be omitted if the default is acceptable.

The third and fourth namelists are included for modification of function values in the model. These are variables that are of the TxLx or TxPx form.

The final namelist is for modification of initial conditions of the parts of the plant. In most cases, the simulation run begins at emergence so that the various weights and measurements of the plant at that time must be known. Appendix B contains the variables in each of the five namelists.

The second half of the input deck consists of the driving weather variables. The first of these cards provides an identifier for the weather deck, WHEAD. Each variable in the weather deck is read in its entirety for the given calendar year, day 1 to day 365, even though only those days to be actually used in the model need to be valid. The calendar year data for each of the following variables are read in order: average daily air temperature in degrees Fahrenheit, average daily air temperature amplitude (= .5 × range) in degrees Fahrenheit, daily total radiation in Langleys, average daily dewpoint in degrees Fahrenheit and wind run in miles per day.

Output

Two major output files can be produced during a simulation run. One is temporary for saving plot data, and the other is the printed output from the run.

The temporary disk file is used to retain values of those variables which are to be plotted at the end of the run. The size of this file must be sufficient to contain a record for each day of the run, and each record must be of a length to contain the total number of variables to be plotted, multiplied by 12 (length of file in characters = 12 × number of variables × number of days).

The header of the output file that is normally sent to the printer is controlled by the variable IHEADR. The sections of header available for output include a listing of all weather data, a listing of all parameter and function parameter values and a listing of some initial conditions.

The tabular portion of the output follows the header. It provides those variables requested once for each day of the run, along with the run day number. These variables are specified on the run control cards at the beginning of the run. This is the first major portion of the permanent output.

The other section of permanent output consists of the requested plots. These follow the tabular output and are designed to be "drawn" by the printer, one per page. Each plot is identified as is each of the variables on the plot. On each plot the × axis shows the number of days elapsed since the first day of the run. Appendix B contains the output from a run of 10 days.

Sensitivity Analysis

Since POTATO is a physiological model, it has many parameters describing organ growth potentials, abiotic effects, respiration rates, etc. These were obtained largely from the literature, but some were estimated empirically. A sensitivity analysis was performed on the model to see how sensitive the model is to parameter perturbations. If a parameter perturbation has little effect, that parameter need not be known as precisely as one which is sensitive. Further, if it is known how such a change affects the real system, then information is obtained on model adequacy based on the simulation model's response.

Too many parameters exist to perturb each of them (even singly), so the fractional factorial perturbation technique of Steinhorst, Hunt, Innis and Haydock was used (1978). Two sensitivity analyses were run — one for the abiotic and photosynthesis portions of the model and one for the plant growth portion. Single parameters and groups of parameters defining a single effect curve were combined in logical groups as macroparameters. Each was perturbed 5 percent unless otherwise indicated. The direction of perturbation was selected randomly for each macroparameter. All parameters within the macroparameter were perturbed in a manner consistent with this randomly selected direction.

Six sensitivity indicator variables were selected: (1) total dry weights of the plant (TDW) and (2) tubers (TUBER) at harvest, (3) maximum Leaf Area Index (LAI), (4) maximum percent reserves (Rmax), (5) minimum percent reserves (Rmin) and (6) minimum relative water content of the plant (WC). The latter three variables were taken from midday readings.

Abiotic and Photosynthesis Sensitivities

Five macroparameters were defined for the abiotic and photosynthesis portions of the model (Table 3). A modifies the effects of incoming solar radiation. B modifies the effects of water balance on photosynthesis and growth. C deals with water uptake. D affects actual photosynthesis rates. E changes the evapotranspiration calculations.

A one-half fraction of a 2^5 factorial perturbation was run. Table 4 shows the model responses. The first line, (1), is the control run. The letter codes of subsequent lines show which macroparameters were perturbed in that run. The plant harvest dry weight ranges from 339 g pl^{-1} to 417 g pl^{-1}. The nominal value is 392 g pl^{-1}. Tuber harvest dry weight echoes the same pattern. In the control run, the LAI rose to 2.74; in the other runs, it ranged from 2.25 to 2.84. The maximum (minimum) percent reserves range from 29.89 to 35.96 (5.39 to 5.56). The nominal minimum for the portion of the plant that is water is .89. The range over all 16 runs was from .87 to .94.

The normalized mean squares from the analysis of variance provide an index of sensitivity (Table 5). The nonsignificance of the various two- and three-way effects implies that line 2 expresses sensitivity to B rather than ACDE. B decreased total dry weight by an average of 47 g. It likewise reduced tuber biomass, LAI and Rmax while increasing the relative water content of the plant. Rmin was not affected by B. Rmin, however, was increased by A which increased the effect of radiation. Perturbing B effectively reduced plant growth by making less water available.

The model was not particularly sensitive to macroparameters C, D, E and (except for Rmin) A. From this, you would conclude that in the Abiotic and Photosynthesis sections of the model, you must be able to estimate the parameters dealing with the interaction of water availability with photosynthesis and growth quite well.

Table 3. Macroparameter definitions.

Macroparameters	Default	Perturbed
A. Incoming radiation		
PHCCOR	1.05	1.10
CROT	table	×1.05
CRCT	table	×1.05
B. Effect of water balance		
EWPH	function	×0.95
YINT	table	×0.95
C. Water uptake		
WURINT	0.16	0.152
EFLFLR	function	×0.95
D. Temperature and radiation effects on evapo transpiration (et) and photosynthesis		
ETPH	function	×1.05
TRNFCI	1.22	1.28
ACRDV	60.0	63.0
E. Evapotranspiration		
RPSI	function	×1.05
RC	function	×1.05
HFUNCT	function	×1.05
F. Initiation of leaves and stems		
PBLIR	0.017	0.01615
PNIR	0.017	0.01615
PBNINR	0.017	0.01615
PBLIR	0.017	0.01615
G. Leaf area		
SLAP	350.	332.5
ERASLA	function	×0.95
EAGEAG, EABLAG	function	×0.95
H. Global		
DEVRAG, DEVRBG	function	×1.05
ETAGIG, ETMSLG, ETBRIG, ETBLG, ETRFG	function	×1.05
EFBPST	function	×1.05
J. Internode growth		
RINOD	0.0215	0.02043
STINRT	0.01	0.0095
ERMSG, ERBRIG	function	×0.95
K. Tuber growth		
RTUB	0.02083	0.0219
STTBRT	0.06	0.063
ETTUBG	function	×1.05
L. Leaf senescence		
RSLOSS	0.02083	0.02187
DAGEmL, dagebl	function	×1.05
M. Leaf growth		
RMSL	0.02083	0.0198
RBL	0.02083	0.0198
STLFRT	0.005	0.00475
ERMSLG, ERBLG	function	×0.95
N. Initiation of branches, tubers		
CF	0.55	0.5775
PBRIR	0.04	0.038
DAMNTU	8.	8.4
PTUBIR	0.014	0.0133
EPPTUB	function	×0.95
P. Root growth		
SFRW	290.	304.5
BSUBR	0.01562	0.0148
ERFRG	function	×1.05
EDWFRG	function	×1.05
Q. Respiration		
SGRPIN	0.39	0.4095
SGRPTU	0.22	0.231
BMRPTU	0.0002	0.00019
ETAMRP, ETSMRP	function	×0.95

Plant Growth

The macroparameters were defined using parameters from the various organ growth routines.

Parameter	Effect of perturbation
F	decreases leaf and internode initiation.
G	decreases leaf area.
H	increases overall plant growth by increasing organ development rates, increasing the effect of temperature on growth and increasing photosynthesis with tuberization.
J	decreases internode growth.
K	increases tuber growth.
L	deals with leaf senescence. It increases the amount of carbohydrate translocated back to the plant upon senescence and increases leaf longevity.
M	depresses leaf growth.
N	decreases branch initiation and tuberization.
P	increases root growth.
Q	increases organ maintenance costs and respiration.

The $1/2^5$ fraction of the 2^{10} factorial produced 32 runs (Table 6). Plant harvest dry weight ranged from 274 g pl^{-1} to 436 g pl^{-1}. The tuber harvest dry weights were maximum (392 g pl^{-1}) and minimum (229 g pl^{-1}) for the same runs as were the LAI figures (3.24 and 1.56, respectively). The noontime maximum and minimum percent reserve values ranged from 18.30 to 43.32 and 4.32 to 5.79, respectively. The minimum relative water content varied from .85 to .99.

The principal sensitivities were for the main effects of M, L and G in that order (Table 7). The 16 runs with M perturbed had a mean total dry weight of 317.4 g pl^{-1} while the unperturbed runs averaged 376.1. M decreases leaf growth and hence photosynthesis. L increases the translocation of carbohydrates from the leaves to reserves and prolongs

Table 4. Responses to abiotic and photosynthesis perturbation.

	TDW	TUBER	LAI	WC	Rmax	Rmin
(1)	392	347	2.74	0.89	32.64	5.44
ACDE	408	364	2.73	0.89	35.96	5.56
ABDE	369	326	2.37	0.94	31.86	5.52
ABCE	346	305	2.28	0.92	31.33	5.48
ABCD	357	316	2.27	0.92	31.86	5.52
BCDE	354	313	2.29	0.92	31.19	5.43
AB	353	311	2.34	0.94	31.33	5.48
AC	387	344	2.65	0.87	34.19	5.53
AD	417	372	2.84	0.91	35.96	5.56
AE	403	358	2.83	0.91	34.19	5.53
BC	339	298	2.25	0.92	29.89	5.39
BD	361	318	2.34	0.94	31.19	5.43
BE	350	307	2.34	0.95	29.89	5.39
CD	397	353	2.66	0.87	34.39	5.48
CE	385	340	2.65	0.87	32.64	5.44
DE	412	367	2.84	0.91	34.39	5.48

Table 5. Sensitivity of abiotic and photosynthesis parameters and interactions.

Line number	Main effect	Aliases	TDW	Tuber	LAI	WC	Rmax	Rmin
1	incoming rad	A,BCDE	0.02	.02	—	—	.16	1.00
2	water eff.	B,ACDE	1.00	1.00	1.00	1.00	1.00	.29
12		AB,CDE	—	—	—	.02	.01	—
3	water uptake	C,ABDE	.05	.04	.06	.35	—	—
13		AC,BDE	—	—	—	—	—	—
23		BC,ADE	—	—	.01	.02	—	—
123		ABC,DE	—	—	—	—	—	—
4	temp and rad. eff.	D,ABCE	.10	.11	.01	.01	.17	.18
14		AD,BCE	—	—	—	—	—	—
24		BD,ACE	—	—	—	.02	.02	—
124		ABD,CE	—	—	—	—	—	—
34		CD,ABE	—	—	—	—	—	—
134		ACD,BE	—	—	—	—	—	—
234		BCD,AE	—	—	—	—	—	—
1234	et calc. fns.	E,ABCD	—	—	—	.03	—	—

Table 6. Responses to plant growth perturbations.

	TDW	TUBER	LAI	WC	Rmax	Rmin		TDW	TUBER	LAI	WC	Rmax	Rmin
(1)	392	347	2.74	.891	32.64	5.44	FGMNP	274	229	1.56	.992	19.59	4.32
PQ	399	353	2.84	.925	32.70	5.36	FGMNQ	276	231	1.57	.992	20.71	4.61
GJLM	351	309	2.28	.936	19.77	4.76	FJLNP	436	392	3.24	.954	42.16	5.31
GJLMPQ	351	309	2.29	.959	19.69	4.52	FJLNQ	428	385	3.08	.922	43.32	5.42
GJKNP	347	307	2.16	.956	24.61	4.67	FJKM	334	297	2.00	.947	28.98	5.87
GJKNQ	346	306	2.16	.932	25.69	4.89	FJKMPQ	336	299	2.00	.966	27.88	5.79
KLMNP	362	315	2.26	.957	29.07	5.56	FGKL	390	341	2.74	.886	27.79	4.98
KLMNQ	361	315	2.26	.934	30.28	5.68	FGKLPQ	394	344	2.81	.912	19.69	4.54
HJMN	301	265	1.74	.992	34.66	5.78	FGHJP	329	293	2.16	.967	25.35	4.91
HJMNPQ	295	259	1.74	.992	33.31	5.58	FGHJQ	329	293	2.16	.950	26.45	5.05
GHLN	351	306	2.43	.962	27.40	4.62	FHLMP	343	300	2.29	.970	29.81	5.40
GHLNPQ	354	309	2.47	.982	26.40	4.49	FHLMQ	342	300	2.29	.946	30.97	5.60
GHKMP	288	246	1.76	.991	18.30	4.39	FHKN	344	304	2.18	.954	38.84	5.69
GHKMQ	278	236	1.66	.991	18.54	4.88	FHKNPQ	345	305	2.18	.967	37.68	5.63
HJKLP	422	385	3.18	.876	36.53	5.66	FGHJKLMN	294	257	1.73	.992	23.57	5.01
HJKLQ	412	376	3.02	.855	37.79	5.69	FGHJKLMNPQ	293	256	1.73	.991	22.49	4.78

Table 7. Sensitivity to plant growth parameters and interactions.

Line number	Main effect	Low order aliases	TDW	TUBER	LAI	WC	Rmax	Rmin
1	leaf, node initiation	F,GHJ,GKL,GMN,HKN,JLN,JKM,HLM,KPQ	.02	.02	.01	.07	.01	—
2	dev. rate, temp eff.	H,FGJ,JKL,JMN,FKN,GLN,GKM,FLM,NPQ	.24	.18	.10	.23	.02	.01
12		FH,GJ,KN,LM,JLPQ	—	—	.02	—	.01	.01
3	tuber growth	K,FGL,HJL,LMN,FHN,GJN,GHM,FJM,FPQ	—	—	.01	.12	.01	.03
13		FK,GL,HN,JM,PQ	—	—	.01	.01	—	—
23		HK,JL,FN,GM,FGJK	.01	.01	.02	.01	.01	.02
123	br initiation, tuberization	N,GKL,FJL,GJLMN,FGM,HJM,KLM,HPQ,FHK	.09	.10	.13	.59	.07	—
4	leaf senescence	L,FGK,HJK,KMN,GHN,FJN,FHM,GJM,GPQ	.51	.46	.52	.32	.01	—
14		FL,GK,JN,HM,HJPQ,MNPQ	—	—	—	.01	—	—
24		HL,JK,GN,CM,GKLM	.01	—	—	.02	.01	—
124	leaf growth	M,FHL,GJL,GHK,FJK,KLN,FGM,JPQ,HMNPQ	1.00	1.00	1.00	1.00	.30	—
34		KL,FG,HJ,MN,HMPQ	—	—	—	.12	—	.01
134	leaf area	G,FKL,FHJ,FMN,HLN,JKN,JLM,HKM,LPQ,HJKPQ	.42	.46	.27	.27	1.00	1.00
234	internode growth	J,HKL,HMN,GLM,FKM	.01	.05	—	.01	.03	.03
1234		LN,GH,FJ,FHKL,GJMN	—	—	—	.10	—	—
5	respiration	Q,FKP,GLP,HNP	—	—	—	—	—	—
15		FQ,KP,GHJQ,GKLQ,GMNQ	—	—	—	—	—	—
25		HQ,NP,JMNQ	—	—	—	.01	—	—
125		FHQ,JLP,GMP,HKP	—	—	—	—	—	—
35		KQ,FP,GHJP,FGLQ	—	—	—	—	—	—
135	root growth	P,FKQ,GLQ,HNQ,JMQ	—	—	—	.18	.02	.05
235		HKQ,HJP,JLQ,FNQ,KNQ	—	—	—	—	—	—
1235		NQ,HP,FHKQ,JMNP,FGMQ	—	—	—	.02	—	—
45		LQ,GP,FHJP,HKMP	—	—	—	.01	—	.01
145		FLQ,HJP,GKQ,JNQ,HMQ,FGP	—	—	—	—	—	—
245		HLQ,FJP,JKQ,GNQ,FMQ,LNP	—	—	—	—	—	—
1245		JP,MQ,FHLQ,GJLQ	—	—	—	—	—	—
345		KLQ,JNP,FGQ,HJQ,MNQ,FLP	—	—	—	—	—	—
1345		LP,FKLQ,GHNP,FHJQ	—	—	—	.01	—	—
2345		MP,JQ,HKLQ,HMNQ	—	—	—	.02	—	—
12345		GNP,LNQ,HLP,FHKLQ	—	—	—	—	—	—

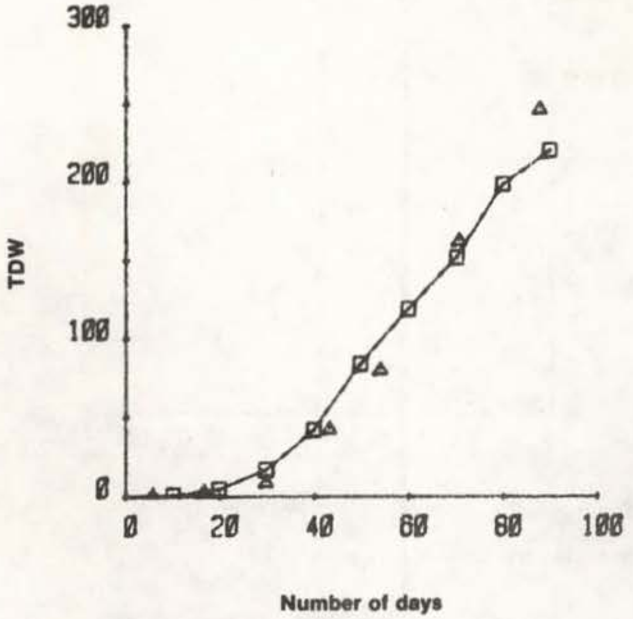

Fig. 41. Ng and Loomis validation on total dry weight.

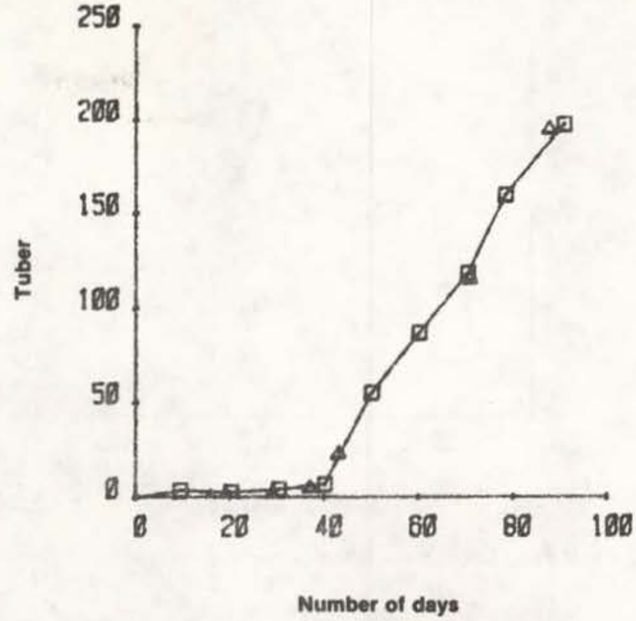

Fig. 42. Ng and Loomis validation on tuber dry weight.

leaf life thus increasing photosynthesis slightly. The combined effects of these changes increases plant growth in terms of total dry weight, tuber weight and LAI. The relative water content of the plant is decreased. G decreases leaf area and hence photosynthesis and growth. The relative water content of the plant also responded to macroparameter N that decreases branch initiation and tuberization. Maximum and minimum percent reserves were sensitive to two of the same macroparameters as TDW, TUBER and LAI, namely G and M; however, the order of importance is reversed. The model is not particularly sensitive to macroparameters F, H, J, K, P and Q.

These analyses show that for both abiotic and biotic parameters, the interaction of macroparameters is not of any particular importance. This implies that the macroparameters each deal with fairly distinct parts of the model. In the first analysis, macroparameter B is the most sensitive, and macroparameter A is less so. In the second analysis, macroparameters M, L and G are all sensitive, and all deal with some aspect of the leaves.

Overall, then, parameters dealing with the availability of water for photosynthesis and growth and those dealing with leaves must be well estimated. The sensitivity to water availability is not surprising. The importance of leaf development and growth confirms the tenet that potato plants are source limited. Without sufficient leaf area, photosynthesis will be decreased and eventually translocation of carbohydrate to the tuber will be diminished.

Validation

Ng and Loomis (1979)[2] performed a validation analysis for Aberdeen using 1978 data. They found that leaf area index (LAI) was underestimated by the model, numbers of tubers were overestimated early in the season and total dryweight and tuber dryweight were similar to field observation (Figs. 41 to 44).

The data used by Ng and Loomis were used in part for model development. Some tuning of the model to account for unknown initial conditions and parameters was done. To provide another test of model validation, we compared model simulation with field data collected by Gale Kleinkopf at two locations at Kimberly in 1981. Weather data were obtained from the Kimberly weather station.

Total dry weight, tuber dryweight and the dryweights of internodes, leaves and roots were selected for comparison. Total dryweight and tuber dryweight simulations parallel dryweight accumulation seen in the field (Figs. 45 and 46). The tuber bulking curve for the model starts out higher than that observed in the field, but the final weight is quite close.

Tuber dryweight makes up most of the total dryweight of the plant after tubers begin to grow. At the end of the growing season, the other plant parts amount to only 60 g pl^{-1} out of a total of 387

[2]E. Ng and R. Loomis, personal communication, 1979. Final report on potato model development.

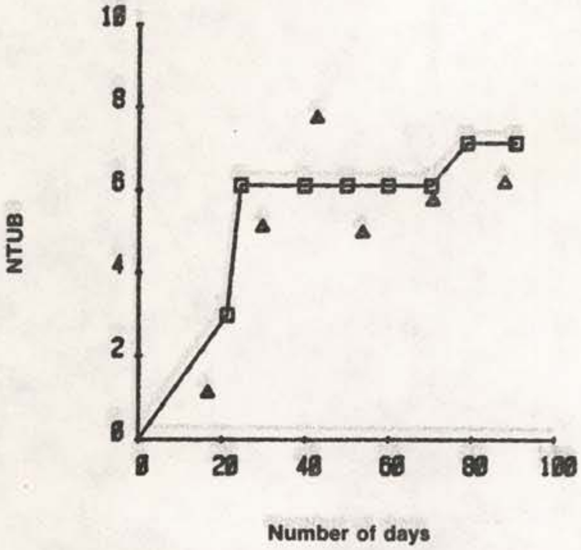

Fig. 43. Ng and Loomis validation on number of tubers.

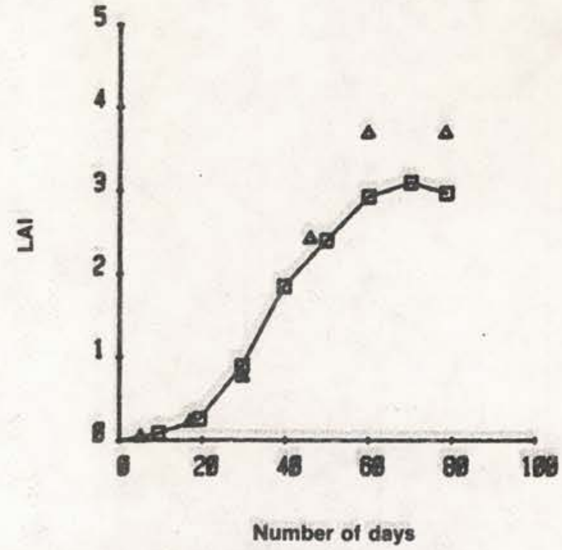

Fig. 44. Ng and Loomis validation on LAI.

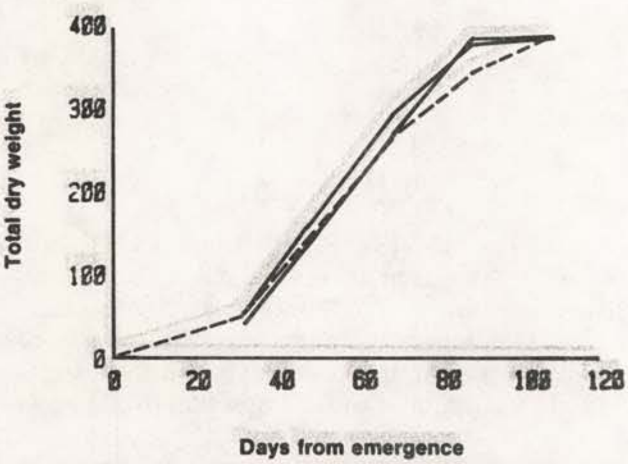

Fig. 45. POTATO total dry weight with points for Kimberly 1981 sites 1 and 2.

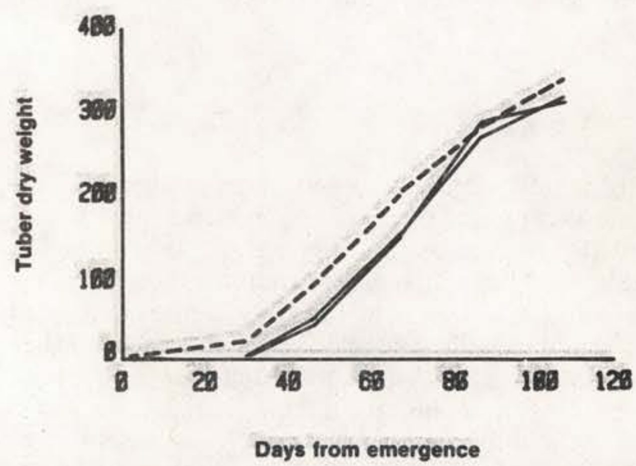

Fig. 46. POTATO tuber dry weight with points for Kimberly 1981 sites 1 and 2.

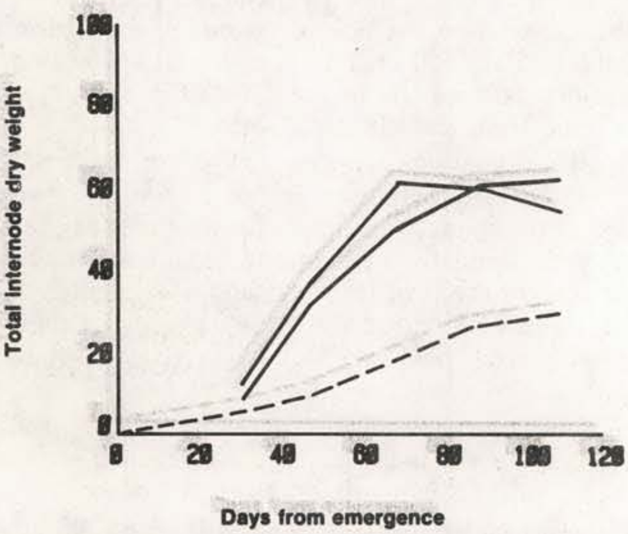

Fig. 47. POTATO stem internode dry weight with Kimberly 1981 sites 1 and 2.

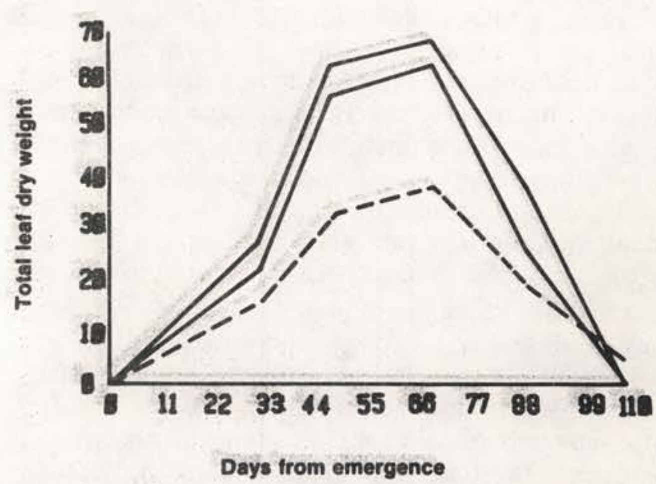

Fig. 48. POTATO leaf dry weight with Kimberly 1981 sites 1 and 2.

g pl^{-1}. Stem dryweight never got to the level seen in the field (Fig. 47). Leaf dryweight has the correct dynamics, but the magnitude is 50 percent too low through most of the season (Fig. 48). The simulated root biomass agrees quite well with the observed field data until the end of the growing season when the field data biomass drops off. We attribute this to a problem of root recovery in the field and not to a problem in simulating root growth.

Overall, the model agrees very well with observed field data. The fact that the linear phase of the bulking curve starts too soon may be caused in part by poor estimates of the weights of the various plant parts at emergence. In the vegetative parts of the model, roots are modeled more accurately than stems and leaves.

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Appendix A — Model Dictionary

This appendix provides a dictionary of the variables used within the POTATO model. Parentheses ( ) following a variable name indicate that the variable name covers an array of values. Subroutine names in parentheses indicate where the variable is to be found if it is not available through a common block. The unit "days" refers to temperature-dependent developmental "age."

ABLIR ( ) = Actual initiation rates of branch leaves, lf/br
ABNIR ( ) = Actual initiation rates of branch internodes, int/br
ABRIR = Actual branch initiation rate, br
ACR = Actual current radiation, Langleys
ACVP = Actual vapor pressure (PLWAT), mm hg
ADEWPT ( ) = Daily average dewpoint, degr F
MAFRL = Length of unsuberized root (FIBRTG, PLWAT, COMMUN), cm
AGBRIN ( ) = Ages of branch internodes, days
AGEBL ( ) = Ages of branch leaves, days
AGEBR ( ) = Ages of branches, days
AGEFR = Age of fibrous roots, days
AGEIN ( ) = Ages of main stem internodes, days
AGEMS = Age of main stem, days
AGEMSL ( ) = Age of main stem leaves, days
AGETUB ( ) = Ages of tubers, days
AGLFST = Age of leaf when growth stops - constant (MSLEAF, BRLFGR), days
ALBEDO = Reflection coefficient of plant - constant (PLWAT)
ALIML = Area growth limiter of main stem leaves (MSLEAF)
AMLINR ( ) = Actual initiation rates of main stem leaves, lf
ANINR = Actual main stem internode initiation rate, int
ANPNRA = Actual to possible branch node initiation rate ratio
ARBL ( ) = Areas of branch leaves, cm-sq
AREALV = Area of leaves, total, cm-sq
ARMSL ( ) = Areas of main stem leaves, cm-sq
AVAMP ( ) = Daily average amplitude of air temperature, degr F
AVDTMP ( ) = Hourly reserve use of tubers in last 24 hours
AVDTRN = Average hourly tuber use of reserves
AVSLA = Total specific leaf area (COMMUN), cm-sq/g
AVTEMP ( ) = Daily average air temperature, degr F
AVTS = Buffered 48-hour average soil temperature (WEATHR), degr C
B = Root physiology factor - constant (PLWAT), cm
BLGLIM = Growth limiter for branch leaves (BRLFGR)
BLILIM = Branch leaf initiation rate limiter (BRLFGR)
BMRPFR = Base maintenance respiration rate for fibrous roots - constant (RPRES), g
BMRPIN = Base maintenance respiration rate for internodes - constant (RPRES), g
BMRPL = Base maintenance respiration rate for leaves - constant (RPRES), g
BMRPTU = Base maintenance respiration rate for tubers - constant (RPRES), g
BNILIM = Branch internode initiation rate limiter (BRANGR)
BSUBR = Base rate for suberization - constant (FIBRTG), cm
CARBL ( ) = Changes in areas of branch leaves, cm-sq
CARMSL ( ) = Changes in areas of main stem leaves, cm-sq
CDWMT = Change in dry weight of mother tuber from previous day (MAIN), g
CGR = Community growth rate, g/m-sq
CLFR = Change in length of fibrous roots, cm
CMBLAR = Community branch leaf area (COMMUN), cm-sq/m-sq
CMLAI = Community leaf area index, m-sq/m-sq
CMLAR = Community leaf area (COMMUN), cm-sq/m-sq
CMMLAR = Community main stem leaf area (COMMUN), cm-sq/m-sq

CRC	=	Current radiation for clear skies, Langleys
CRES	=	Change in reserves from previous day (MAIN), g
CRO	=	Current radiation for overcast skies, Langleys
CROPET	=	Crop evapotranspiration (PLWAT), mm/m-sq
CSUBFR	=	Change in length of suberized roots, cm
CTDW	=	Change in total dry weight from previous day (MAIN), g
CWATPL	=	Change in plant water content, g
CWBL ( )	=	Changes in weights of branch leaves, g
CWBRIN ( )	=	Changes in weights of branch internodes, g
CWDEDL	=	Change in weight of dead leaves, g
CWFR	=	Change in weight of fibrous roots, g
CWINOD ( )	=	Changes in weights of main stem internodes, g
CWMSL ( )	=	Changes in weights of main stem leaves, g
CWRES	=	Change in weight of reserves, g
CWTUB ( )	=	Changes in weights of tubers, g
DAGEBL	=	Death age of branch leaves (BRLFGR), days
DAGEML	=	Death age of main stem leaves (MSLEAF), days
DAMNTU	=	Minimum number of days with photperiod × critical - constant (TUBER)
DAYHRS	=	Hours of daylight, hr
DAYRAD	=	Day's radiation, Langleys
DCGR	=	Day's community growth, g
DEC	=	Declination of the sun
DEDMLT	=	Percentage of carbohydrate returned to the plant from dying leaves - constant (RPRES)
DELTA	=	Model time step, hr
DENOM	=	Partial calculation for POTET (PLWAT)
DENOM2	=	Partial calculation for ET (PLWAT)
DENS	=	Planting density, plts/m-sq
DEVBRI ( )	=	Developmental rates of branch internodes, days
DEVRAG	=	Developmental rate above ground, days
DEVRBG	=	Developmental rate below ground, days
DEVRBL ( )	=	Developmental rates of branch leaves, days
DEVRBR ( )	=	Developmental rates of branches, days
DEVRFR	=	Developmental rate of fibrous roots, days
DEVRIN ( )	=	Developmental rates of main stem internodes, days
DEVRML ( )	=	Developmental rates of main stem leaves, days
DEVRMS	=	Developmental rate of main stem, days
DEVTUB( )	=	Developmental rates of tubers, days
DEWPT	=	Daily average dewpoint, degr C
DGRPBI	=	Day's below ground internode growth respiration, g
DGRPBL	=	Day's branch leaf growth respiration, g
DGRPBR	=	Day's branch internode growth respiration, g
DGRPFR	=	Day's fibrous root growth respiration, g
DGRPMI	=	Day's main stem internode growth respiration, g
DGRPML	=	Day's main stem leaf growth respiration, g
DGRPTU	=	Day's tuber growth respiration, g
DLAT	=	Latitude of the geographical area
DMFFR	=	Dry matter fraction for fibrous roots - constant (MAIN, PLWAT)
DMFIN	=	Dry matter fraction for internodes - constant (MAIN, PLWAT)
DMFLV	=	Dry matter fraction for leaves - constant (MAIN, PLWAT)
DMFTUB	=	Dry matter fraction for tubers - constant (MAIN, PLWAT)
DMFPL	=	Dry matter fraction of the plant (MAIN, PLWAT)
DMRPBI	=	Day's below ground internode maintenance respiration, g
DMRPBL	=	Day's branch leaf maintenance respiration, g

DMRPBR	=	Day's branch internode maintenance respiration, g
DMRPFR	=	Day's fibrous root maintenance respiration, g
DMRPML	=	Day's main stem leaf maintenance respiration, g
DMRPMS	=	Day's main stem internode maintenance respiration, g
DMRPTU	=	Day's tuber maintenance respiration, g
DPHPP	=	Day's photosynthesis per plant, g
DRC	=	Day's total possible radiation for clear skies, Langleys
DRCP	=	Previous day's total possible radiation for clear skies, Langleys
DRO	=	Day's total possible radiation for overcast skies, Langleys
DROP	=	Previous day's total possible radiation for overcast skies, Langleys
DTGRP	=	Day's total growth respiration, g
DTMRP	=	Day's total maintenance respiration, g
DTRAD ( )	=	Daily solar radiation, Langleys
DTRANS	=	Day's total transpiration, g
DTRP	=	Day's total respiration, g
DWBL ( )	=	Dry weights of branch leaves, g
DWBRIN ( )	=	Dry weights of branch internodes, g
DWDEDL	=	Dry weight of dead leaves, g
DWFR	=	Dry weight of fibrous roots, g
DWINOD ( )	=	Dry weights of main stem internodes, g
DWMSL ( )	=	Dry weights of main stem leaves, g
DWMT	=	Dry weight of mother tuber, g
DWTUB ( )	=	Dry weights of tubers, g
EABLAG	=	Effect of age on branch leaf area growth (BRLFGR)
EABLIR	=	Effect of age on branch leaf initiation rate (BRLFGR)
EABNIR	=	Effect of age on branch internode initiation rate (BRANGR)
EABRIG	=	Effect of age on branch internode growth (BRANGR)
EAGBLG	=	Effect of age on branch leaf growth (BRLFGR)
EAGE	=	Partial effect of leaf age on maintenance respiration (RPRES)
EAGEAG	=	Effect of age on main stem leaf area growth (MSLEAF)
EAGEIG	=	Effect of age on main stem internode growth (MSTEM)
EAGELG	=	Effect of age on main stem leaf growth (MSLEAF)
EAGPSL	=	Effect of leaf age on photosynthesis
EAGRBL	=	Effect of branch leaf age on maintenance respiration (RPRES)
EAGRML	=	Effect of main stem leaf age on maintenance respiration (RPRES)
EAP	=	Partial calculation for ET (PLWAT)
EATUBG	=	Effect of age on tuber growth (TUBER)
EBRAC	=	Effect of previous branching on branch initiation (BRANGR)
EDWFRG	=	Effect of dry weight on fibrous root growth (FIBRTG)
EFBPS	=	Percentage of photosynthesis affected by tuberization
EFBPST	=	Table for determining EFBPS
EFLFLR	=	Effect of suberization on root water uptake (PLWAT)
ELNFR	=	Effective length of fibrous roots (PLWAT)
EMTRES	=	Effect of mother tuber reserves
EPPTUB	=	Effect of photoperiod on tuberization stimulation (TUBER)
ERASLA	=	Effect of radiation on specific leaf area (MSLEAF, BRLFGR)
ERBLG	=	Effect of reserves on branch leaf growth (BRLFGR)
ERBLIR	=	Effect of reserves on branch leaf initiation rate (BRLFGR)
ERBNIR	=	Effect of reserves on branch internode initiation rate (BRANGR)
ERBRIG	=	Effect of reserves on branch internode growth (BRANGR)
ERBRIR	=	Effect of reserves on branch initiation rate (BRANGR)
ERFRG	=	Effect of reserves on fibrous root growth (FIBRTG)
ERING	=	Effect of reserves on main stem internode growth (MSTEM)
ERINR	=	Effect of all reserves on internode initiation rate (MSTEM)

ERIR = Effect of all reserves on tuber initiation (TUBER)
ERLINR = Effect of reserves on main stem leaf initiation rate (MSLEAF)
ERLIR = Effect of all reserves on leaf initiation rate (MSLEAF)
ERMLG = Effect of all reserves on main stem leaf growth (MSLEAF)
ERMSG = Effect of reserves on main stem growth (MSTEM)
ERMSLG = Effect of reserves on main stem leaf growth (MSLEAF)
ERNINR = Effect of reserves on main stem internode initiation rate (MSTEM)
ERSFRG = Effect of all reserves on fibrous root growth (FIBRTG)
ERTIR = Effect of reserves on tuber initiation rate (TUBER)
ERTUBG = Effect of reserves on tuber growth (TUBER)
ET = Evapotranspiration (PLWAT), mm/m-sq
ETAGIG = Effect of air temperature on internode growth (MSTEM)
ETAMRP = Effect of air temperature on maintenance respiration (RPRES)
ETBGIG = Effect of soil temperature on internode growth (MSTEM)
ETBLG = Effect of temperature on branch leaf growth (BRLFGR)
ETBLIR = Effect of temperature on branch leaf initiation rate (BRLFGR)
ETBNIR = Effect of temperature on branch internode initiation rate (BRANGR)
ETBRIG = Effect of temperature on branch internode growth (BRANGR)
ETBRIR = Effect of temperature on branch initiation rate (BRANGR)
ETFRG = Effect of temperature on fibrous root growth (FIBRTG)
ETLINR = Effect of temperature on main stem leaf initiation rate (MSLEAF)
ETMSLG = Effect of temperature on main stem leaf growth (MSLEAF)
ETNINR = Effect of temperature on main stem internode initiation rate (MSTEM)
ETPH = Effect of temperature on photosynthesis (PHOTOS)
ETSFRW = Effect of soil temperature on fibrous root length growth (FIBRTG)
ETSLA = Effect of temperature on specific leaf area (MSLEAF)
ETSMRP = Effect of soil temperature on maintenance respiration (RPRES)
ETSUBR = Effect of temperature on suberization rate (FIBRTG)
ETTUBG = Effect of temperature on tuber growth (TUBER)
EWFRG = Effect of water content on fibrous root growth
EWLFG = Effect of water content on leaf growth
EWPH = Effect of water content on photosynthesis
EWSTG = Effect of water content on stem growth
EWTUBG = Effect of water content on tuber growth
FCL = Fraction of skies clear
FOV = Fraction of skies overcast
FRCRES = Fraction of total weight in reserves
FRGLIM = Fibrous root growth limiter (FIBRTG)
FRL = Fibrous root length, cm
FRSUBL = Suberized root length, cm
GFUNCT = Effect of plant height on ET (PLWAT)
GLIMBI = Growth limiter for branch internodes (BRANGR)
GLIML = Growth limiter for main stem leaves (MSLEAF)
GLIMMS = Growth limiter for main stem (MSTEM)
GLIMT = Growth limiter for tubers (TUBER)
GR = Growth factor for a plant organ, g
GRRBGI = Growth respiration rate for below ground internodes, g
GRRBRI = Growth respiration rate for branch internodes, g
GRRBRL = Growth respiration rate for branch leaves, g
GRRFR = Growth respiration rate for fibrous roots, g
GRRMSI = Growth respiration rate for main stem internodes, g
GRRMSL = Growth respiration rate for main stem leaves, g
GRRTUB = Growth respiration rate for tubers, g
GRTPP = Growth per plant (COMMUN), g

HEIGHT	=	Height of plant (PLWAT), cm
HFUNCT	=	Effect of wind speed on ET (PLWAT)
HLVAP	=	Heat of vaporization - constant (PLWAT)
HTINT	=	Average internode height - constant (PLWAT), cm
IDACNT	=	Days since last output header
IDAOUT	=	Counter for days between header outputs
IDAST	=	Starting date of the run in Julian (MAIN)
IDATE	=	Julian day of the year
IDAY	=	Days from start of the run
IHEADR	=	Control for the output listing headers
IHOUR	=	Hour of the day
IOFLAG	=	Internal subroutine flag (OUTPUT)
IOUTPT	=	Number of variables to be outputted per day
MTSTOP	=	Day on which mother tuber ceases to have an effect - constant (MSTEM)
NBGIN	=	Number of below ground internodes
NBL	=	Number of branch leaves per branch (BRLFGR)
NBLT	=	Number of branch leaves total
NBR	=	Number of branches
NBRIN	=	Number of branch internodes per branch (BRANGR)
NBRIT	=	Number of branch internodes total
NDAYS	=	Number of days for the complete run (MAIN)
NDEDL	=	Number of dead leaves
NINTOT	=	Number of main stem internodes total
NLVTOT	=	Number of live leaves (PLWAT)
NMSIN	=	Number of above ground main stem internodes
NMSL	=	Number of main stem leaves
NMST	=	Number of main stems
NTADD	=	Number of tuber initials that may be developing at one time - constant (TUBER)
NTUB	=	Number of tubers
NTUBM	=	Number of last tuber initial (TUBER)
NTUBP	=	Maximum number of tubers possible constant (TUBER)
NTUB1	=	Number of first tube initial (TUBER)
OLDWMT	=	Previous day's dry weight of mother tuber, g
OLRES	=	Previous day's reserves, g
OLTDW	=	Previous day's total dry weight, g
PBLIR	=	Potential rate for branch leaf initiation - constant (BRLFGR), lf/br
PBNINR	=	Potential rate for branch internode initiation - constant (BRANGR), int/br
PBRIR	=	Potential rate for branch initiation - constant (BRANGR), br
PC	=	Psychrometric constant (PLWAT)
PCOVER	=	Percent soil cover (PLWAT)
PCTBL	=	Percent of life lived for branch leaf (BRLFGR)
PCTMSL	=	Percent of life lived for main stem leaf (MSLEAF)
PHC1	=	Potential photos. for clear skies (untuberized), g
PHC2	=	Potential photos. for clear skies (tuberized), g
PHCCOR	=	Photosynthesis correction factor - constant (PHOTOS)
PHCR	=	Photosynthesis rate (PHOTOS), g
PHCRPP	=	Photosynthesis rate per plant, g
PHCT ( )	=	Photosynthesis table for clear skies (untuberized)
PHCT2 ( )	=	Photosynthesis table for clear skies (tuberized)
PHO1	=	Potential photos. for overcast skies (untuberized), g
PHO2	=	Potential photos. for overcast skies (tuberized), g
PHOT ( )	=	Photosynthesis table for overcast skies (untuberized)
PHOT2 ( )	=	Photosynthesis table for overcast skies (tuberized)
PLINR	=	Partial main stem leaf initiation rate calculation (MSLEAF), lf

PLIVLV = Percent of leaves alive (PLWAT)
PMLINR = Potential main stem leaf initiation rate - constant (MSLEAF), lf
PNINR = Partial main stem internode initiation rate - constant (MSTEM), int
PNIR = Potential rate of internode initiation - constant (MSTEM), int
POTET = Potential evapotranspiration (PLWAT), mm/m-sq
PRES = Reserves as percent of total plant weight
PSINRM = Normal soil water potential under irrigation conditions - constant (PLWAT), cm H_2O
PSIPLT = Plant water potential (PLWAT), atm
PSISOL = Soil water potential (PLWAT), cm H_2O
PSLIM = Photosynthesis limiter (PHOTOS)
PTUBIR = Potential tube initiation rate - constant (TUBER), tub
RBL = Base rate for branch leaf growth - constant (BRLFGR), g
RC = Effect of plant cover on diffusion resistance (PLWAT)
RES = Reserves in the plant, g
RFR = Base rate for fibrous root growth - constant (FIBRTG), g
RINOD = Base rate of internode growth - constant (MSTEM, BRANGR), g
RL = Effect of actual radiation on diffusion resistance (PLWAT)
RMRPBI = Maintenance respiration rate for below ground internodes, g
RMRPBL = Maintenance respiration rate for branch leaves, g
RMRPBR = Maintenance respiration rate for branch internodes, g
RMRPFR = Maintenance respiration rate for fibrous roots, g
RMRPML = Maintenance respiration rate for main stem leaves, g
RMRPMS = Maintenance respiration rate for main stem internodes, g
RMRPTU = Maintenance respiration rate for tubers, g
RMSL = Base main stem leaf growth rate - constant (MSLEAF), g
RNBL ( ) = Numbers of branch leaves per branch
RNBR = Number of branches
RNBRIN ( ) = Numbers of branch internodes
RNET = Net radiation (PLWAT), Langleys
RNMSIN = Number of main stem internodes
RNMSL = Number of main stem leaves
RPL = Effect of percent live leaves on plant water potential (PLWAT)
RPMTUB = Base maintenance respiration rate per tuber weight (RPRES), g
RPSI = Effect of plant water potential on diffusion resistance (PLWAT)
RSLOSS = Potential translocation by senescing leaves - constant
RSPBGI = Percent of reserves in below ground internodes (COMMUN)
RSPBRI = Percent of reserves in branch internodes (COMMUN)
RSPBRL = Percent of reserves in branch leaves (COMMUN)
RSPFR = Percent of reserves in fibrous roots (COMMUN)
RSPGRP = Percent of reserves for growth respiration (COMMUN)
RSPMRP = Percent of reserves for maintenance respiration (COMMUN)
RSPMSI = Percent of reserves in main stem internodes (COMMUN)
RSPMSL = Percent of reserves in main stem leaves (COMMUN)
RSPRP = Percent of reserves for respiration (COMMUN)
RSPTUB = Percent of reserves in tubers (COMMUN)
RSTBGI = Reserve status of below ground internodes, g
RSTBL = Reserve status of branch leaves, g
RSTBRI = Reserve status of branch internodes, g
RSTFR = Reserve status of fibrous roots, g
RSTGRP = Reserve status for growth respiration, g
RSTMRP = Reserve status for maintenance respiration, g
RSTMSI = Reserve status of main stem internodes, g
RSTMSL = Reserve status of main stem leaves, g
RSTTUB = Reserve status of tubers, g

RTBGIN = Change in reserves in below ground internodes, g
RTBL = Change in reserves in branch leaves, g
RTBRIN = Change in reserves in branch internodes, g
RTFDLV = Rate of translocation of reserves from dead leaves (RPRES), g
RTFR = Change in reserves in fibrous roots, g
RTGRP = Change in reserves to growth respiration, g
RTMRP = Change in reserves to maintenance respiration, g
RTMSIN = Change in reserves in main stem internodes, g
RTMSL = Change in reserves in main stem leaves, g
RTTUB = Change in reserves in tubers, g
RTUB = Base rate for tuber growth constant (TUBER), g
RUPLIM = Limiting multiplier for root uptake constant (PLWAT)
RUPT = Maximum soil water uptake (PLWAT), g
RWCMLT = Multiplier for effect of plant water on plant organs - constant (PLWAT)
RWCPL = Relative water content of the plant by weight
SATVPA = Saturation vapor pressure of the air (PLWAT)
SFRW = Potential rate for fibrous root length growth - constant (FIBRTG), cm
SGRPFR = Growth respiration coefficient for fibrous roots - constant (RPRES)
SGRPIN = Growth respiration coefficient for internodes - constant (RPRES)
SGRPML = Growth respiration coefficient for leaves - constant (RPRES)
SGRPTU = Growth respiration coefficient for tubers - constant (RPRES)
SLA = Specific leaf area (MSLEAF, BRLFGR), cm-sq/g
SLABL = Specific leaf area of branch leaves (BRLFGR), cm-sq/g
SLAP = Specific leaf area possible - constant (MSLEAF, BRLFGR), cm-sq/g
SLOPE = Partial calculation for net radiation (PLWAT)
SNHSUN = Sine of the height of the sun
STINRT = New internode growth rate - constant (MSTEM, BRANGR), g
STLFRT = New leaf growth rate - constant (MSLEAF, BRLFGR), g
STTBRT = New tuber growth rate - constant (TUBER), g
T++L++ = Function limiting values
T++P++ = Function curve parameters
TAHOFF = Air temperature sine wave hour offset - constant (WEATHR)
TAIR = Temperature of the air, degr C
TARBL = Total area of branch leaves (COMMUN), cm-sq
TARMSL = Total area of main stem leaves (COMMUN), cm-sq
TCWBL = Total change in weight of branch leaves, g
TCWBRI = Total change in weight of branch internodes, g
TCWFR = Total change in weight of fibrous roots, g
TCWIN = Total change in weight of main stem internodes, g
TCWMSL = Total change in weight of main stem leaves, g
TCWTUB = Total change in weight of tubers, g
TDW = Total dry weight of the plant
TDWBGI = Total dry weight of below ground internodes, g
TDWBRI = Total dry weight of branch internodes, g
TDWBRL = Total dry weight of branch leaves, g
TDWFR = Total dry weight of fibrous roots, g
TDWMSI = Total dry weight of main stem internodes, g
TDWMSL = Total dry weight of main stem leaves, g
TDWTUB = Total dry weight of tubers, g
TFRL = Total fibrous root length (COMMUN), cm
TFRSUB = Total suberized root length (COMMUN), cm
TGRPBI = Total growth respiration for below ground internodes, g
TGRPBL = Total growth respiration for branch leaves, g
TGRPBR = Total growth respiration for branch internodes, g

TGRPFR = Total growth respiration for fibrous roots, g
TGRPMI = Total growth respiration for main stem internodes, g
TGRPML = Total growth respiration for main stem leaves, g
TGRPTU = Total growth respiration for tubers, g
TMRPBI = Total maintenance respiration for below ground tubers, g
TMRPBL = Total maintenance respiration for branch leaves, g
TMRPBR = Total maintenance respiration for branch internodes, g
TMRPFR = Total maintenance respiration for fibrous roots, g
TMRPML = Total maintenance respiration for main stem leaves, g
TMRPMS = Total maintenance respiration for main stem internodes, g
TMRPTU = Total maintenance respiration for tubers, g
TOP = Partial calculation for POTET and ET (PLWAT)
TPDEF = Transpiration deficiency (PLWAT), g
TPHPP = Total photosynthesis per plant, cc (=g)
TRANSP = Transpiration rate (PLWAT), g
TRESFL = Total plant reserves (COMMUN), g
TRGRP = Total growth respiration rate, g
TRMRP = Total maintenance respiration rate, g
TRNET = Longwave radiation (PLWAT), Langleys
TRRP = Total respiration rate, g
TRTRAN = Total translocation of reserves (RPRES), g
TSOIL = Temperature of soil, degr C
TTGRP = Total growth respiration, g
TTMRP = Total maintenance respiration, g
TTRANS = Total transpiration, g
TTRP = Total respiration, g
TUBIR = Tuber initiation rate (TUBER), tub
TUBIS ( ) = Individual tuber initiation status
TUBISR ( ) = Changes in initiation rates of individual tubers
TUBSTR = Tuberization stimulation rate (TUBER)
TUBSTS = Tuberization stimulation status (TUBER)
UPTAKE = Water uptake of the plant (PLWAT), cc (=g)
WATDEF = Water deficiency (PLWAT), g
WATMAX = Maximum water content possible (PLWAT), g
WATPL = Plant water content, g
WERR = Weight error, g
WHEAD = Driving variable deck identifier
WIND ( ) = Wind run, mi/day
WINDSP = Wind speed, m/sec
WNDMIN = Minimum wind speed for advection effect (PLWAT), m/sec
WUR = Soil water uptake rate (PLWAT), g
XK = Hydraulic conductivity of the soil (PLWAT), mm/day
YINT ( ) = Y-intercepts for water effect curves - constants (PLWAT)

Appendix B — Input and Output Examples

Input

This section provides an example of an input deck that is necessary for a typical POTATO model run. The numbered notes refer to the numbers found with the listing of the deck and provide details on the formation of the input deck. The lines of asterisks (*) are not part of the input deck but are provided only to delineate the different components of the deck for the appendix, as are the words in parentheses.

1. Namelists — The variables within the five namelists have defaults and may therefore be omitted from the input in which case the defaults occur. A list of the variables for each of the namelists, with their defaults, may be found in the output section of this appendix as part of the output listing. Even if all variables in a given namelist are defaulted, however, the header and trailer cards for the namelist must still be included in the deck. The header card contains a blank in column 1, an ampersand (&) in column 2 and the name of the namelist immediately following. The trailer card contains the blank and the ampersand immediately followed by the word "end." Cards containing new variable values for a given namelist always contain a blank in column 1, followed by "variable name = value" for each variable to be modified. The entries in a namelist are separated by commas, and as many cards as are necessary may be used to include all variables to be modified. These cards are inserted between the header and trailer cards.

2. Tabular Printout Requests — Variables to be printed in tabular form follow the CNTRL namelist as many as are designated by the variable IOUTPT. Each variable input takes up a field of 10 characters; the field begins with the variable name (8 characters) and ends with the hour of day for the reading (1 to 24). If no hour is specified, 12 is assumed. Up to seven variable names and times may be entered on the first card with up to five more on a second card if more than seven are requested.

3. Plotting Output Requests — Information on plotting requests, if any are indicated by the number of plots IPLOTN, follow the tabular printout requests. All of the variables for one plot (up to five) are entered on a single card in the same fashion as those for tabular output. The maximum number of plots for one run is 10. If there is a nonzero entry in column 51 of any plot card, another card will be read for that plot. This card contains four decimal fields of 10 characters each that have the requested x-minimum, x-maximum, y-minimum and y-maximum for the plot. Any or all of these may be omitted for the default values that will be determined by the plotting routine from the ranges of the variables to be plotted.

```
*************************************************************************************
 &CNTRL
 IPLOTN=1,IOUTPT=5,IDAST=148,NDAYS=10,IHEADR=15
 &END                                                                            (1)
*************************************************************************************
TDW       TDWTUB    CMLAI     PRES      RWCPL                                    (2)
*************************************************************************************
TDW       TDWTUB                                                                 (3)
*************************************************************************************
 &PARS
  SLAP=350.0,PHCCOR=1.05,CF=.55,
  RINOD=.0215 ,RMSL=.0207,RBL=.0207,
  PNIR=.017,PMLINR=.017,PBNINR=.017,PBLIR=.017,
 &END
 &FUN1
  T12L1=150.,T12L2=150.,
 &END
 &FUN2
 &END
 &INCOND
  DENS=3.56,DLAT=42.6
 &END                                                                            (1)
*************************************************************************************
(CONT)
```

4. Weather Deck Identifier — The card that begins the driving variable portion of the input deck contains the weather deck identifier at the beginning of the card; it may have up to eight characters. This identifier will be printed in the output along with the driving variable listing if that header listing is requested.

5. Driving Variables — Each of the component decks that comprise the complete driving variable deck is similar to the others. Each contains values for each day of the calendar year (1 to 365). All of these values will be read, although only those which are required by the run will actually be used. Blank cards may suffice for unused dates. Each card is read as 16 fields of length five, in decimal format. Note that radiation and wind run are read as f5.0, while temperature, temperature amplitude and dewpoint are read as f5.1. The order of variables that the program expects to see is (a) daily average air temperature, (b) daily average air temperature amplitude, (c) daily incoming solar radiation, (d) daily average dewpoint and (e) daily wind run.

```
********************************************************************************
KMBRLY81                                                                     (4)
********************************************************************************
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  (5,TEMPERATURE)0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0 65.0 53.5 46.0 51.5 44.5 41.0 41.0 41.0
 48.5 52.5 48.0 45.5 45.5 52.0 45.5 46.5 51.5 53.0 52.5 52.5 52.0 53.5 57.0 60.5
 57.0 60.0 60.0 58.0 62.0 61.0 56.5 59.0 59.5 59.5 61.0 65.5 65.0 62.0 59.5 58.0
 58.0 63.0 53.0 45.5 47.5 54.0 62.0 56.5 63.0 64.0 63.5 63.0 67.0 65.5 65.5 73.5
 72.0 65.0 61.0 64.0 72.0 72.0 70.5 71.5 73.5 77.0 69.5 56.0 56.0 69.0 73.0 68.5
 68.0 65.0 62.0 62.0 69.5 72.5 71.0 67.5 68.5 68.5 68.5 68.0 68.0 67.5 64.0 69.0
 72.0 72.0 66.0 68.5 69.5 67.0 65.5 66.5 66.5 69.0 72.0 72.5 75.5 73.5 69.5 69.5
 73.0 73.5 72.0 69.5 72.0 72.0 74.0 72.0 67.0 66.5 70.5 77.5 74.5 74.5 74.5 69.5
 73.0 62.5 58.0 62.0 60.5 60.5 62.0 65.5 62.5 64.0 66.5 66.0 66.0 66.5 66.0 67.0
 66.5 64.5 68.0 68.0 68.0 61.5 56.5 53.0 49.0 49.0 58.5 58.5 48.5 59.5 56.5 48.0
 47.0 50.0 57.0 43.5 41.5 44.5 55.0 57.0 57.0 50.5 51.5 51.5 51.5 51.5 51.5 51.5
 47.0 50.0 49.5 50.0 50.0 42.0 42.0 43.0 46.5 47.0 50.0 50.5 51.0 51.0 38.5 43.5
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
********************************************************************************
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  (5,TEMPERATURE AMPL)0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0 17.0  6.5 13.0 14.5 12.5  9.0  9.0  9.0
 17.5 14.5 10.0 11.5 11.5  9.0  9.5 11.5 12.5 12.0 10.5 10.5  5.0  7.5 13.0 13.5
  6.0  8.0  8.0 15.0 17.0 15.0 10.5 18.0  3.5  3.5 14.0 17.5  9.0 10.0  9.5  8.0
  8.0 13.0 13.0  9.5 11.5 16.0 22.0  7.5 13.0 11.0 12.5 11.0 19.0  9.5  9.5 21.5
 12.0 12.0 15.0 18.0 20.0 20.0 16.5 17.5 19.5 20.0 12.5  6.0  6.0 24.0 13.0 13.5
 18.0 11.0 16.0 16.0 21.5 17.5 16.0 16.5 18.5 15.5 15.5 18.0 20.0 15.5 14.0 16.0
 21.0 21.0 14.0 20.5 21.5 15.0 18.5 18.5 18.5 19.0 20.0 17.5 20.5 20.5 19.5 19.5
```

```
17.0 17.5 18.0 19.5 21.0 21.0 16.0 15.0 16.0 18.5 22.5 14.5 18.5 18.5 18.5 19.5
15.0  8.5 16.0 22.0 11.5 11.5 18.0 12.5 16.5 18.0 17.5 18.0 18.0 19.5 18.0 18.0
16.5 21.5 20.0 20.0 20.0 11.5 18.5 13.0 15.0 15.0 12.5 12.5 14.5 17.5 10.5  8.0
13.0 20.0 17.0  6.5 12.5 17.5 21.0 10.0 10.0  9.5  6.5  6.5  6.5  6.5  6.5  6.5
11.0 11.0 16.5 16.0 13.0 12.0 12.0 15.0 10.5 14.0 12.0 12.5 14.0 14.0  8.5 12.5
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
********************************************************************************
  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   (5,SOLAR RADIATION) 0.   0.
  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
  0.   0.   0.   0.   0.   0.   0.   0. 484. 564. 661. 613. 508. 392. 623.   0.
230. 322. 610. 561. 663. 215. 427. 394. 682. 333. 334. 438. 269. 277. 619. 499.
251. 398. 679. 693. 674. 371. 704. 681. 705. 702. 658. 693. 554. 404. 303. 657.
492. 722. 567. 676. 718. 760. 584. 660. 681. 733. 734. 750. 758. 761. 767. 601.
748. 680. 771. 757. 572. 626. 734. 741. 739. 487. 588. 673. 756. 749. 725. 708.
748. 747. 750. 755. 596. 716. 719. 717. 729. 707. 719. 714. 647. 646. 704. 710.
687. 668. 698. 701. 701. 677. 691. 688. 688. 691. 678. 679. 580. 651. 664. 629.
389. 591. 610. 644. 639. 497. 376. 527. 611. 619. 620. 581. 612. 597. 588. 531.
568. 564. 590. 538. 587. 578. 517. 483. 553. 540. 540. 532. 529. 533. 540. 525.
526. 519. 514. 505. 489. 466. 462. 496. 461. 339. 353. 325. 246. 399. 423. 173.
451.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
********************************************************************************
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0(5,DEWPOINT)0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0 41.7 34.6 25.6 31.3 26.6 23.7 23.7 23.7
25.8 30.2 32.6 33.7 33.7 34.9 40.6 39.9 32.2 36.4 45.1 45.1 44.7 40.8 46.9 51.2
45.0 54.0 54.0 34.2 33.3 41.9 44.5 36.9 47.2 47.2 48.3 51.4 51.5 47.9 49.1 46.2
46.2 44.7 34.4 31.2 31.3 32.8 37.7 38.1 35.1 41.2 43.4 36.2 42.0 45.5 45.5 49.6
42.8 32.3 28.1 30.8 46.9 46.9 42.3 48.7 46.2 52.1 49.5 39.8 39.8 54.7 47.8 45.8
49.6 41.0 38.7 38.7 46.8 55.7 55.5 43.6 44.1 43.7 43.7 49.1 43.8 48.3 44.5 54.0
52.2 52.2 41.2 45.7 41.5 40.1 41.8 41.1 41.1 48.0 46.4 43.3 54.2 50.8 48.3 48.3
58.4 59.5 57.9 51.9 51.2 51.2 53.4 60.2 47.7 45.7 49.5 54.4 55.1 55.1 55.1 55.5
55.5 41.4 44.2 48.0 44.1 44.1 48.3 43.8 47.6 53.8 57.0 56.8 56.8 50.7 49.0 45.4
41.6 40.7 42.7 42.7 42.7 35.3 39.8 36.2 33.5 33.5 40.6 40.6 39.5 47.1 44.5 37.3
35.8 38.0 40.2 40.7 31.9 30.1 43.9 23.4 23.4 39.3 49.8 49.8 49.8 49.8 49.8 49.8
38.9 38.5 41.2 41.2 32.9 24.8 24.8 29.3 22.5 36.6 31.8 32.2 22.2 22.2 29.4 28.1
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
 0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
********************************************************************************
```

```
   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.(5,WIND RUN) 0.   0.
   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
   0.   0.   0.   0.   0.   0.   0.   0. 113. 320. 240. 220. 192. 346. 339. 344.
 115. 199. 460. 156. 208. 146. 219. 318. 221. 165. 126. 165. 434. 254.  82. 110.
 147. 116. 149. 152.  89. 165. 225. 100. 144. 271. 172. 144. 223. 113. 134. 165.
  84. 136. 306. 328. 336. 118. 298. 277. 120. 234. 216. 242. 104. 244. 101. 161.
 164.   0.   0.   0. 166. 203. 129. 125. 107. 145. 156. 315. 108.  97. 128. 139.
 132. 213. 142.  94. 179. 104. 154. 148. 125. 161. 132. 153. 101. 138. 165. 129.
 101. 151. 176. 105. 123. 164. 143. 154. 142. 122. 133. 143. 191. 159. 114. 101.
 119. 123. 141. 114. 109. 131. 123. 105.  95. 122. 124. 151.  99. 112. 114. 101.
 152. 294. 104. 128. 199.  95. 133. 189. 118. 158. 134.  77. 200. 108. 131. 152.
 174. 129. 149. 152. 123. 258. 125. 186. 147.  90. 143. 210. 120. 129. 172. 115.
 117.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
*******************************************************************************
(END OF INPUT)
```

Output

The second half of this appendix contains a typical output listing from a single run. For purposes of space, the run encompassed only 10 days from the date of emergence (day 1). The normal default is for a run of 100 days.

Driving Variable Listing — When requested by the variable IHEADR, the output listing will begin with a listing of the input driving variables for the run identified by the weather deck identifier. The information is provided for every day of the calendar year identified by Julian date. For this listing, add four to IHEADR.

Namelist Listings — When requested through IHEADR, the variables of the CNTRL, PARAM, FUN1 and FUN2 namelists will be listed with the variable values that were current for the run. For this listing, add two to IHEADR.

Initial Conditions Listing — When requested through IHEADR, some of the initial conditions for the run will be listed; this is not, however, a listing of the initial conditions namelist. For this listing, add one to IHEADR.

Simulation Results — The actual output of the run begins under this heading. The tabular output appears first, with each data column titled every 20 days by variable name and hour of reading. The leftmost data column provides the current day number.

Plots — Each requested plot is printed on a separate page titled with a plot number and identifiers for the variables included on the plot. The range for the x-axis of the plot will default to the number of days of the run, and the range of the y-axis will default to the range of the values to be plotted unless either is overridden on input.

Following is a listing of the namelist INCOND that is not provided in the output listing because of its length. This listing of the variables of INCOND and their defaults has been modified to decrease the length of the listing. The ellipses in the listing indicate a repetition of the last previous value shown, for the extent of the array.

```
&INCOND
TDWMSL=.0181, TDWBRL=0.0, TDWBGI=.3333, TDWMSI=.069, TDWBRI=0.0,
TDWFR=.0121, TDWTUB=0.0, AREALV=4.05, PRES=10.0, DWMT=20.0,
DLAT=43.60, DENS=3.6, NINTOT=0,
AGEIN=12.0, 11.0, 10.0, 9.0, 8.0, 7.0, 6.0, 5.0, 4.0, 2.0, 0.0,...,
DWINOD=.063, .058, .053, .045, .043, .035, .033, .028, .023, .018,
  0.0,...,
AGEMS=3.0, NBGIN=7, RNMSIN=3.0,
AGEMSL=.7, .6, .5, 999.99,...,
DWMSL=.0062, .0060, .0059, 999.99,...,
ARMSL=1.4, 1.35, 1.30, 999.99,...,
RNMSL=3.0,
AGEBR=999.99,...,
RNBRIN=999.99,...,
DWBRIN=999.99,...,
AGBRIN=999.99,...,
RNBR=0.0,
RNBL=999.99,...,
AGEBL=999.99,...,
DWBL=999.99,...,
ARBL=999.99,...,
DWTUB=999.99,...,
AGETUB=999.99,...,
NTUB=0, AGEFR=8.0, DWFR=.01214, FRL=3.520, FRSUBL=1.760
&END
```

Following is the listing of an output from a run of 10 days. The defaults of all namelists except INCOND, above, may be seen in the listing header.

POTATO GROWTH MODEL PRINTOUT

****

TEST SITE WEATHER : IDENTIFIER = KMBRLY81

JULDAY	AVTEMPF	AVAMPF	DTRAD	AVDEWPTF	WINDMD	JULDAY	AVTEMPF	AVAMPF	DTRAD	AVDEWPTF	WINDMD	JULDAY	AVTEMPF	AVAMPF	DTRAD	AVDEWPTF	WINDMD
1	0.0	0.0	0.0	0.0	0.0	123	46.0	13.0	661.0	25.6	240.0	245	60.5	11.5	587.0	44.1	199.0
2	0.0	0.0	0.0	0.0	0.0	124	51.5	14.5	613.0	31.3	220.0	246	60.5	11.5	578.0	44.1	95.0
3	0.0	0.0	0.0	0.0	0.0	125	44.5	12.5	508.0	26.6	192.0	247	62.0	18.0	517.0	48.3	133.0
4	0.0	0.0	0.0	0.0	0.0	126	41.0	9.0	392.0	23.7	346.0	248	65.5	12.5	483.0	43.8	189.0
5	0.0	0.0	0.0	0.0	0.0	127	41.0	9.0	623.0	23.7	339.0	249	62.5	16.5	553.0	47.6	118.0
6	0.0	0.0	0.0	0.0	0.0	128	41.0	9.0	0.0	23.7	344.0	250	64.0	18.0	540.0	53.8	158.0
7	0.0	0.0	0.0	0.0	0.0	129	48.5	17.5	230.0	25.8	115.0	251	66.5	17.5	540.0	57.0	134.0
8	0.0	0.0	0.0	0.0	0.0	130	52.5	14.5	322.0	30.2	199.0	252	66.0	18.0	532.0	56.8	77.0
9	0.0	0.0	0.0	0.0	0.0	131	48.0	10.0	610.0	32.6	460.0	253	66.0	18.0	529.0	56.8	200.0
10	0.0	0.0	0.0	0.0	0.0	132	45.5	11.5	561.0	33.7	156.0	254	66.5	19.5	533.0	50.7	108.0
11	0.0	0.0	0.0	0.0	0.0	133	45.5	11.5	663.0	33.7	208.0	255	66.0	18.0	540.0	49.0	131.0
12	0.0	0.0	0.0	0.0	0.0	134	52.0	9.0	215.0	34.9	146.0	256	67.0	18.0	525.0	45.4	152.0
13	0.0	0.0	0.0	0.0	0.0	135	45.5	9.5	427.0	40.6	219.0	257	66.5	16.5	526.0	41.6	174.0
14	0.0	0.0	0.0	0.0	0.0	136	46.5	11.5	394.0	39.9	318.0	258	64.5	21.5	519.0	40.7	129.0
15	0.0	0.0	0.0	0.0	0.0	137	51.5	12.5	682.0	32.2	221.0	259	68.0	20.0	514.0	42.7	149.0
16	0.0	0.0	0.0	0.0	0.0	138	53.0	12.0	333.0	36.4	165.0	260	68.0	20.0	505.0	42.7	152.0
17	0.0	0.0	0.0	0.0	0.0	139	52.5	10.5	334.0	45.1	126.0	261	68.0	20.0	489.0	42.7	123.0
18	0.0	0.0	0.0	0.0	0.0	140	52.5	10.5	438.0	45.1	165.0	262	61.5	11.5	466.0	35.3	258.0
19	0.0	0.0	0.0	0.0	0.0	141	52.0	5.0	269.0	44.7	434.0	263	56.5	18.5	462.0	39.8	125.0
20	0.0	0.0	0.0	0.0	0.0	142	53.5	7.5	277.0	40.8	254.0	264	53.0	13.0	496.0	36.2	186.0
21	0.0	0.0	0.0	0.0	0.0	143	57.0	13.0	619.0	46.9	82.0	265	49.0	15.0	461.0	33.5	147.0
22	0.0	0.0	0.0	0.0	0.0	144	60.5	13.5	499.0	51.2	110.0	266	49.0	15.0	339.0	33.5	90.0
23	0.0	0.0	0.0	0.0	0.0	145	57.0	6.0	251.0	45.0	147.0	267	58.5	12.5	353.0	40.6	143.0
24	0.0	0.0	0.0	0.0	0.0	146	60.0	8.0	398.0	54.0	116.0	268	58.5	12.5	325.0	40.6	210.0
25	0.0	0.0	0.0	0.0	0.0	147	60.0	8.0	679.0	54.0	149.0	269	48.5	14.5	246.0	39.5	120.0
26	0.0	0.0	0.0	0.0	0.0	148	58.0	15.0	693.0	34.2	152.0	270	59.5	17.5	399.0	47.1	129.0
27	0.0	0.0	0.0	0.0	0.0	149	62.0	17.0	674.0	33.3	89.0	271	56.5	10.5	423.0	44.5	172.0
28	0.0	0.0	0.0	0.0	0.0	150	61.0	15.0	371.0	41.9	165.0	272	48.0	8.0	173.0	37.3	115.0
29	0.0	0.0	0.0	0.0	0.0	151	56.5	10.5	704.0	44.5	225.0	273	47.0	13.0	451.0	35.8	117.0
30	0.0	0.0	0.0	0.0	0.0	152	59.0	18.0	681.0	36.9	100.0	274	50.0	20.0	0.0	38.0	0.0
31	0.0	0.0	0.0	0.0	0.0	153	59.5	3.5	705.0	47.2	144.0	275	57.0	17.0	0.0	40.2	0.0
32	0.0	0.0	0.0	0.0	0.0	154	59.5	3.5	702.0	47.2	271.0	276	43.5	6.5	0.0	40.7	0.0
33	0.0	0.0	0.0	0.0	0.0	155	61.0	14.0	658.0	48.3	172.0	277	41.5	12.5	0.0	31.9	0.0
34	0.0	0.0	0.0	0.0	0.0	156	65.5	17.5	693.0	51.4	144.0	278	44.5	17.5	0.0	30.1	0.0
35	0.0	0.0	0.0	0.0	0.0	157	65.0	9.0	554.0	51.5	223.0	279	55.0	21.0	0.0	43.9	0.0
36	0.0	0.0	0.0	0.0	0.0	158	62.0	10.0	404.0	47.9	113.0	280	57.0	10.0	0.0	23.4	0.0
37	0.0	0.0	0.0	0.0	0.0	159	59.5	9.5	303.0	49.1	134.0	281	57.0	10.0	0.0	23.4	0.0
38	0.0	0.0	0.0	0.0	0.0	160	58.0	8.0	657.0	46.2	165.0	282	50.5	9.5	0.0	39.3	0.0
39	0.0	0.0	0.0	0.0	0.0	161	58.0	8.0	492.0	46.2	84.0	283	51.5	6.5	0.0	49.8	0.0
40	0.0	0.0	0.0	0.0	0.0	162	63.0	13.0	722.0	44.7	136.0	284	51.5	6.5	0.0	49.8	0.0
41	0.0	0.0	0.0	0.0	0.0	163	53.0	13.0	567.0	34.4	306.0	285	51.5	6.5	0.0	49.8	0.0
42	0.0	0.0	0.0	0.0	0.0	164	45.5	9.5	676.0	31.2	328.0	286	51.5	6.5	0.0	49.8	0.0
43	0.0	0.0	0.0	0.0	0.0	165	47.5	11.5	718.0	31.3	336.0	287	51.5	6.5	0.0	49.8	0.0

JULDAY	AVTEMPF	AVAMPF	DTRAD	AVDEWPTF	WINDMD	JULDAY	AVTEMPF	AVAMPF	DTRAD	AVDEWPTF	WINDMD	JULDAY	AVTEMPF	AVAMPF	DTRAD	AVDEWPTF	WINDMD
44	0.0	0.0	0.0	0.0	0.0	166	54.0	16.0	760.0	32.8	118.0	288	51.5	6.5	0.0	49.8	0.0
45	0.0	0.0	0.0	0.0	0.0	167	62.0	22.0	584.0	37.7	298.0	289	47.0	11.0	0.0	38.9	0.0
46	0.0	0.0	0.0	0.0	0.0	168	56.5	7.5	660.0	38.1	277.0	290	50.0	11.0	0.0	38.5	0.0
47	0.0	0.0	0.0	0.0	0.0	169	63.0	13.0	681.0	35.1	120.0	291	49.5	16.5	0.0	41.2	0.0
48	0.0	0.0	0.0	0.0	0.0	170	64.0	11.0	733.0	41.2	234.0	292	50.0	16.0	0.0	41.2	0.0
49	0.0	0.0	0.0	0.0	0.0	171	63.5	12.5	734.0	43.4	216.0	293	50.0	13.0	0.0	32.9	0.0
50	0.0	0.0	0.0	0.0	0.0	172	63.0	11.0	750.0	36.2	242.0	294	42.0	12.0	0.0	24.8	0.0
51	0.0	0.0	0.0	0.0	0.0	173	67.0	19.0	758.0	42.0	104.0	295	42.0	12.0	0.0	24.8	0.0
52	0.0	0.0	0.0	0.0	0.0	174	65.5	9.5	761.0	45.5	244.0	296	43.0	15.0	0.0	29.3	0.0
53	0.0	0.0	0.0	0.0	0.0	175	65.5	9.5	767.0	45.5	101.0	297	46.5	10.5	0.0	22.5	0.0
54	0.0	0.0	0.0	0.0	0.0	176	73.5	21.5	601.0	49.6	161.0	298	47.0	14.0	0.0	36.6	0.0
55	0.0	0.0	0.0	0.0	0.0	177	72.0	12.0	748.0	42.8	164.0	299	50.0	12.0	0.0	31.8	0.0
56	0.0	0.0	0.0	0.0	0.0	178	65.0	12.0	680.0	32.3	0.0	300	50.5	12.5	0.0	32.2	0.0
57	0.0	0.0	0.0	0.0	0.0	179	61.0	15.0	771.0	28.1	0.0	301	51.0	14.0	0.0	22.2	0.0
58	0.0	0.0	0.0	0.0	0.0	180	64.0	18.0	757.0	30.8	0.0	302	51.0	14.0	0.0	22.2	0.0
59	0.0	0.0	0.0	0.0	0.0	181	72.0	20.0	572.0	46.9	166.0	303	38.5	8.5	0.0	29.4	0.0
60	0.0	0.0	0.0	0.0	0.0	182	72.0	20.0	626.0	46.9	203.0	304	43.5	12.5	0.0	28.1	0.0
61	0.0	0.0	0.0	0.0	0.0	183	70.5	16.5	734.0	42.3	129.0	305	0.0	0.0	0.0	0.0	0.0
62	0.0	0.0	0.0	0.0	0.0	184	71.5	17.5	741.0	48.7	125.0	306	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0	0.0	185	73.5	19.5	739.0	46.2	107.0	307	0.0	0.0	0.0	0.0	0.0
64	0.0	0.0	0.0	0.0	0.0	186	77.0	20.0	487.0	52.1	145.0	308	0.0	0.0	0.0	0.0	0.0
65	0.0	0.0	0.0	0.0	0.0	187	69.5	12.5	588.0	49.5	156.0	309	0.0	0.0	0.0	0.0	0.0
66	0.0	0.0	0.0	0.0	0.0	188	56.0	6.0	673.0	39.8	315.0	310	0.0	0.0	0.0	0.0	0.0
67	0.0	0.0	0.0	0.0	0.0	189	56.0	6.0	756.0	39.8	108.0	311	0.0	0.0	0.0	0.0	0.0
68	0.0	0.0	0.0	0.0	0.0	190	69.0	24.0	749.0	54.7	97.0	312	0.0	0.0	0.0	0.0	0.0
69	0.0	0.0	0.0	0.0	0.0	191	73.0	13.0	725.0	47.8	128.0	313	0.0	0.0	0.0	0.0	0.0
70	0.0	0.0	0.0	0.0	0.0	192	68.5	13.5	708.0	45.8	139.0	314	0.0	0.0	0.0	0.0	0.0
71	0.0	0.0	0.0	0.0	0.0	193	68.0	18.0	748.0	49.6	132.0	315	0.0	0.0	0.0	0.0	0.0
72	0.0	0.0	0.0	0.0	0.0	194	65.0	11.0	747.0	41.0	213.0	316	0.0	0.0	0.0	0.0	0.0
73	0.0	0.0	0.0	0.0	0.0	195	62.0	16.0	750.0	38.7	142.0	317	0.0	0.0	0.0	0.0	0.0
74	0.0	0.0	0.0	0.0	0.0	196	62.0	16.0	755.0	38.7	94.0	318	0.0	0.0	0.0	0.0	0.0
75	0.0	0.0	0.0	0.0	0.0	197	69.5	21.5	596.0	46.8	179.0	319	0.0	0.0	0.0	0.0	0.0
76	0.0	0.0	0.0	0.0	0.0	198	72.5	17.5	716.0	55.7	104.0	320	0.0	0.0	0.0	0.0	0.0
77	0.0	0.0	0.0	0.0	0.0	199	71.0	16.0	719.0	55.5	154.0	321	0.0	0.0	0.0	0.0	0.0
78	0.0	0.0	0.0	0.0	0.0	200	67.5	16.5	717.0	43.6	148.0	322	0.0	0.0	0.0	0.0	0.0
79	0.0	0.0	0.0	0.0	0.0	201	68.5	18.5	729.0	44.1	125.0	323	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	202	68.5	15.5	707.0	43.7	161.0	324	0.0	0.0	0.0	0.0	0.0
81	0.0	0.0	0.0	0.0	0.0	203	68.5	15.5	719.0	43.7	132.0	325	0.0	0.0	0.0	0.0	0.0
82	0.0	0.0	0.0	0.0	0.0	204	68.0	18.0	714.0	49.1	153.0	326	0.0	0.0	0.0	0.0	0.0
83	0.0	0.0	0.0	0.0	0.0	205	68.0	20.0	647.0	43.8	101.0	327	0.0	0.0	0.0	0.0	0.0
84	0.0	0.0	0.0	0.0	0.0	206	67.5	15.5	646.0	48.3	138.0	328	0.0	0.0	0.0	0.0	0.0
85	0.0	0.0	0.0	0.0	0.0	207	64.0	14.0	704.0	44.5	165.0	329	0.0	0.0	0.0	0.0	0.0
86	0.0	0.0	0.0	0.0	0.0	208	69.0	16.0	710.0	54.0	129.0	330	0.0	0.0	0.0	0.0	0.0
87	0.0	0.0	0.0	0.0	0.0	209	72.0	21.0	687.0	52.2	101.0	331	0.0	0.0	0.0	0.0	0.0
88	0.0	0.0	0.0	0.0	0.0	210	72.0	21.0	668.0	52.2	151.0	332	0.0	0.0	0.0	0.0	0.0
89	0.0	0.0	0.0	0.0	0.0	211	66.0	14.0	698.0	41.2	176.0	333	0.0	0.0	0.0	0.0	0.0
90	0.0	0.0	0.0	0.0	0.0	212	68.5	20.5	701.0	45.7	105.0	334	0.0	0.0	0.0	0.0	0.0
91	0.0	0.0	0.0	0.0	0.0	213	69.5	21.5	701.0	41.5	123.0	335	0.0	0.0	0.0	0.0	0.0
92	0.0	0.0	0.0	0.0	0.0	214	67.0	15.0	677.0	40.1	164.0	336	0.0	0.0	0.0	0.0	0.0
93	0.0	0.0	0.0	0.0	0.0	215	65.5	18.5	691.0	41.8	143.0	337	0.0	0.0	0.0	0.0	0.0
94	0.0	0.0	0.0	0.0	0.0	216	66.5	18.5	688.0	41.1	154.0	338	0.0	0.0	0.0	0.0	0.0

JULDAY/	AVTEMPF/	AVAMPF/	DTRAD/	AVDEWPTF/	WINDMD/	JULDAY/	AVTEMPF/	AVAMPF/	DTRAD/	AVDEWPTF/	WINDMD/	JULDAY/	AVTEMPF/	AVAMPF/	DTRAD/	AVDEWPTF/	WINDMD/
95	0.0	0.0	0.0	0.0	0.0	217	66.5	18.5	688.0	41.1	142.0	339	0.0	0.0	0.0	0.0	0.0
96	0.0	0.0	0.0	0.0	0.0	218	69.0	19.0	691.0	48.0	122.0	340	0.0	0.0	0.0	0.0	0.0
97	0.0	0.0	0.0	0.0	0.0	219	72.0	20.0	678.0	46.4	133.0	341	0.0	0.0	0.0	0.0	0.0
98	0.0	0.0	0.0	0.0	0.0	220	72.5	17.5	679.0	43.3	143.0	342	0.0	0.0	0.0	0.0	0.0
99	0.0	0.0	0.0	0.0	0.0	221	75.5	20.5	580.0	54.2	191.0	343	0.0	0.0	0.0	0.0	0.0
100	0.0	0.0	0.0	0.0	0.0	222	73.5	20.5	651.0	50.8	159.0	344	0.0	0.0	0.0	0.0	0.0
101	0.0	0.0	0.0	0.0	0.0	223	69.5	19.5	664.0	48.3	114.0	345	0.0	0.0	0.0	0.0	0.0
102	0.0	0.0	0.0	0.0	0.0	224	69.5	19.5	629.0	48.3	101.0	346	0.0	0.0	0.0	0.0	0.0
103	0.0	0.0	0.0	0.0	0.0	225	73.0	17.0	389.0	58.4	119.0	347	0.0	0.0	0.0	0.0	0.0
104	0.0	0.0	0.0	0.0	0.0	226	73.5	17.5	591.0	59.5	123.0	348	0.0	0.0	0.0	0.0	0.0
105	0.0	0.0	0.0	0.0	0.0	227	72.0	18.0	610.0	57.9	141.0	349	0.0	0.0	0.0	0.0	0.0
106	0.0	0.0	0.0	0.0	0.0	228	69.5	19.5	644.0	51.9	114.0	350	0.0	0.0	0.0	0.0	0.0
107	0.0	0.0	0.0	0.0	0.0	229	72.0	21.0	639.0	51.2	109.0	351	0.0	0.0	0.0	0.0	0.0
108	0.0	0.0	0.0	0.0	0.0	230	72.0	21.0	497.0	51.2	131.0	352	0.0	0.0	0.0	0.0	0.0
109	0.0	0.0	0.0	0.0	0.0	231	74.0	16.0	376.0	53.4	123.0	353	0.0	0.0	0.0	0.0	0.0
110	0.0	0.0	0.0	0.0	0.0	232	72.0	15.0	527.0	60.2	105.0	354	0.0	0.0	0.0	0.0	0.0
111	0.0	0.0	0.0	0.0	0.0	233	67.0	16.0	611.0	47.7	95.0	355	0.0	0.0	0.0	0.0	0.0
112	0.0	0.0	0.0	0.0	0.0	234	66.5	18.5	619.0	45.7	122.0	356	0.0	0.0	0.0	0.0	0.0
113	0.0	0.0	0.0	0.0	0.0	235	70.5	22.5	620.0	49.5	124.0	357	0.0	0.0	0.0	0.0	0.0
114	0.0	0.0	0.0	0.0	0.0	236	77.5	14.5	581.0	54.4	151.0	358	0.0	0.0	0.0	0.0	0.0
115	0.0	0.0	0.0	0.0	0.0	237	74.5	18.5	612.0	55.1	99.0	359	0.0	0.0	0.0	0.0	0.0
116	0.0	0.0	0.0	0.0	0.0	238	74.5	18.5	597.0	55.1	112.0	360	0.0	0.0	0.0	0.0	0.0
117	0.0	0.0	0.0	0.0	0.0	239	74.5	18.5	588.0	55.1	114.0	361	0.0	0.0	0.0	0.0	0.0
118	0.0	0.0	0.0	0.0	0.0	240	69.5	19.5	531.0	55.5	101.0	362	0.0	0.0	0.0	0.0	0.0
119	0.0	0.0	0.0	0.0	0.0	241	73.0	15.0	568.0	55.5	152.0	363	0.0	0.0	0.0	0.0	0.0
120	0.0	0.0	0.0	0.0	0.0	242	62.5	8.5	564.0	41.4	294.0	364	0.0	0.0	0.0	0.0	0.0
121	65.0	17.0	484.0	41.7	113.0	243	58.0	16.0	590.0	44.2	104.0	365	0.0	0.0	0.0	0.0	0.0
122	53.5	6.5	564.0	34.6	320.0	244	62.0	22.0	538.0	48.0	128.0	365	0.0	0.0	0.0	0.0	0.0

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************************************************************************************************************

&CNTRL
NDAYS=        10,IDAST=        148,IOUTPT=        5,IPLOTN=        1,IHEADR=        9
&END

************************************************************************************************************
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```
&PARS
AVTSOF=  36.000000   ,DMFIN= 0.63999951E-01,DMFLV= 0.11999995    ,DMFTUB= 0.10999995    ,DMFFR= 0.49999997E-01,DIVLV=
  10000.000    ,DYRCON= 0.79999995    ,DAYOFF=  10.000000    ,TAHOFF=  8.0000000    ,AVTSDV=  48.000000    ,TSAMPM= 0.44999999    ,
TSHOFF=  10.000000    ,SNHOFF=  12.000000    ,YINT= -4.1110992    , -4.2222195    , -4.3888998    , -4.4443998    ,ALBEDO=
 0.21999997    ,HLVAP=  58.000000    ,PC= 0.48999995    ,B= 0.29999996E-03,HTINT=  5.5000000    ,SLOPEM=  4097.5469    ,TRNFCI=
  1.2199993    ,TRNFCS=-0.17999995    ,TRNACI= 0.32499999    ,TRNACS=-0.44000000E-01,ACVPDV= 0.75000000    ,ACRDV=  60.000000    ,
WNDMIN=  2.2999992    ,XKM=  7000.0000    ,PSIOFF=  1450.0000    ,PSIMLT= 0.99999993E-03,WURINT= 0.15999997    ,WURS=
 0.33599999E-01,PSINRM=  333.32983    ,RUPLIM= 0.29200000    ,RWCMLT=  5.5555553    ,PHCCOR=  1.0499992    ,RINOD= 0.21499999E-01,
PNIR= 0.16999997E-01,MTSTOP=          50,STINRT= 0.99999979E-02,PMLINR= 0.16999997E-01,RMSL= 0.20699997E-01,SLAP=  350.00000    ,
DAGEML=  50.000000    ,STLFRT= 0.49999990E-02,AGLFST=  15.400000    ,PBRIR= 0.39999999E-01,PBNINR= 0.16999997E-01,CF=
 0.54999995    ,PBLIR= 0.16999997E-01,RBL= 0.20699997E-01,DAGEBL=  50.000000    ,RTUB= 0.20829998E-01,PTUBIR= 0.13999999E-01,
DAMNTU=  8.0000000    ,NTUBP=          28,NTADD=           3,STTBRT= 0.59999999E-01,RNFR=  1.0000000    ,RFR= 0.20829998E-01,BSUBR=
 0.15619997E-01,SFRW=  290.00000    ,SGRPIN= 0.38999999    ,SGRPML= 0.38999999    ,SGRPFR= 0.38999999    ,SGRPTU= 0.21999997    ,
BMRPIN= 0.62499987E-03,BMRPML= 0.62499987E-03,BMRPFR= 0.62499987E-03,BMRPTU= 0.19999999E-03,SBRLWT= 0.49999990E-02,DEDMLT=
 0.50000000    ,SATM=  4.5812292    ,PHOT= 0.0         , 0.0         , 0.0         , 0.0         , 0.0         ,
 0.0         , 0.0         , 0.0         , 0.0         , 0.0         , 0.0         , 0.0         , 0.59999999E-01,
 0.25999999    , 0.44000000    , 0.60999995    , 0.75000000    , 0.88000000    , 0.96999997    ,  1.0299997    ,  1.0499992    ,
  1.0699997    , 0.0         , 0.89999974E-01, 0.36999995    , 0.61999995    , 0.85999995    ,  1.0599995    ,  1.2299995    ,
  1.3699999    ,  1.4499998    ,  1.4799995    ,  1.5000000    , 0.0         , 0.99999964E-01, 0.41999996    , 0.70999998    ,
 0.97999996    ,  1.2099991    ,  1.4099998    ,  1.5599995    ,  1.6599998    ,  1.6899996    ,  1.7099991    , 0.0         ,
 0.99999964E-01, 0.44000000    , 0.73999995    ,  1.0299997    ,  1.2699995    ,  1.4799995    ,  1.6399994    ,  1.7399998    ,
  1.7799997    ,  1.7999992    , 0.0         , 0.99999964E-01, 0.44999999    , 0.75999999    ,  1.0499992    ,  1.2999992    ,
  1.5199995    ,  1.6799994    ,  1.7900000    ,  1.8299999    ,  1.8499994    , 0.0         , 0.99999964E-01, 0.44999999    ,
 0.75999999    ,  1.0599995    ,  1.3199997    ,  1.5400000    ,  1.6999998    ,  1.8099995    ,  1.8499994    ,  1.8699999    ,
 0.0         , 0.99999964E-01, 0.44999999    , 0.76999998    ,  1.0699997    ,  1.3199997    ,  1.5400000    ,  1.7099991    ,
  1.8199997    ,  1.8599997    ,  1.8799992    , 0.0         , 0.99999964E-01, 0.44999999    , 0.76999998    ,  1.0699997    ,
  1.3199997    ,  1.5499992    ,  1.7099991    ,  1.8199997    ,  1.8599997    ,  1.8799992    , 0.0         , 0.99999964E-01,
 0.44999999    , 0.76999998    ,  1.0699997    ,  1.3199997    ,  1.5499992    ,  1.7199993    ,  1.8199997    ,  1.8599997    ,
  1.8799992    , 0.0         , 0.99999964E-01, 0.44999999    , 0.76999998    ,  1.0699997    ,  1.3199997    ,  1.5499992    ,
  1.7099991    ,  1.8199997    ,  1.8599997    ,  1.8799992    ,PHCT= 0.0         , 0.0         , 0.0         ,
 0.0         , 0.0         , 0.0         , 0.0         , 0.0         , 0.0         , 0.0         , 0.0         ,
 0.0         , 0.28999996    , 0.72999996    ,  1.1699991    ,  1.4499998    ,  1.7599993    ,  2.1499996    ,  2.5499992    ,
  2.8699999    ,  3.0000000    ,  3.1299992    , 0.0         , 0.40999997    , 0.95999998    ,  1.6499996    ,  2.1399994    ,
  2.5999994    ,  3.1999998    ,  3.7299995    ,  4.0099993    ,  4.0499992    ,  4.0999994    , 0.0         , 0.46999997    ,
  1.0599995    ,  1.8499994    ,  2.4799995    ,  3.0699997    ,  3.7799997    ,  4.3799992    ,  4.6999998    ,  4.7500000    ,
  4.8399992    , 0.0         , 0.48999995    ,  1.0899992    ,  1.9299994    ,  2.6199999    ,  3.2599993    ,  4.0599995    ,
  4.6899996    ,  4.9099998    ,  4.8599997    ,  4.9199991    , 0.0         , 0.50000000    ,  1.1099997    ,  1.9599991    ,
  2.6899996    ,  3.3799992    ,  4.2199993    ,  4.8699999    ,  5.0999994    ,  5.0499992    ,  5.1099997    , 0.0         ,
 0.50000000    ,  1.1099997    ,  1.9799995    ,  2.7299995    ,  3.4399996    ,  4.2900000    ,  4.9599991    ,  5.1899996    ,
  5.1499996    ,  5.1999998    , 0.0         , 0.50999999    ,  1.1199999    ,  1.9799995    ,  2.7399998    ,  3.4699993    ,
  4.3299999    ,  5.0000000    ,  5.2399998    ,  5.1999998    ,  5.2500000    , 0.0         , 0.50999999    ,  1.1199999    ,
  1.9899998    ,  2.7500000    ,  3.4799995    ,  4.3499994    ,  5.0299997    ,  5.2699995    ,  5.2199993    ,  5.2799997    ,
 0.0         , 0.50000000    ,  1.1199999    ,  1.9899998    ,  2.7500000    ,  3.4899998    ,  4.3599997    ,  5.0400000    ,
  5.2799997    ,  5.2299995    ,  5.2900000    , 0.0         , 0.50000000    ,  1.1199999    ,  1.9799995    ,  2.7500000    ,
  3.4899998    ,  4.3599997    ,  5.0400000    ,  5.2799997    ,  5.2399998    ,  5.2900000    ,
```

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 PHOT2= 0.0          ,
 0.0           , 0.0           , 0.0           , 0.0           , 0.0           , 0.0           , 0.0           , 0.0           ,
 0.0           , 0.0           , 0.0           , 0.89999974E-01, 0.38999999    , 0.64999998    , 0.89999998    ,  1.0999994    ,
  1.2599993    ,  1.3899994    ,  1.4599991    ,  1.4899998    ,  1.5099993    , 0.0           , 0.13000000    , 0.53999996    ,
 0.90999997    ,  1.2699995    ,  1.5499992    ,  1.7900000    ,  1.9699993    ,  2.0899992    ,  2.1299992    ,  2.1499996    ,
 0.0           , 0.13999999    , 0.60999995    ,  1.0400000    ,  1.4399996    ,  1.7699995    ,  2.0400000    ,  2.2500000    ,
  2.3899994    ,  2.4299994    ,  2.4599991    , 0.0           , 0.14999998    , 0.63999999    ,  1.0799999    ,  1.5099993    ,
  1.8499994    ,  2.1499996    ,  2.3699999    ,  2.5099993    ,  2.5599995    ,  2.5899992    , 0.0           , 0.14999998    ,
 0.64999998    ,  1.1099997    ,  1.5400000    ,  1.8999996    ,  2.1999998    ,  2.4299994    ,  2.5699997    ,  2.6299992    ,
  2.6599998    , 0.0           , 0.14999998    , 0.65999997    ,  1.1199999    ,  1.5599995    ,  1.9199991    ,  2.2299995    ,
  2.4599991    ,  2.6099997    ,  2.6599998    ,  2.6899996    , 0.0           , 0.14999998    , 0.65999997    ,  1.1299992    ,
  1.5699997    ,  1.9299994    ,  2.2399998    ,  2.4699993    ,  2.6199999    ,  2.6799994    ,  2.6999998    , 0.0           ,
 0.14999998    , 0.66999996    ,  1.1299992    ,  1.5799999    ,  1.9399996    ,  2.2500000    ,  2.4799995    ,  2.6299992    ,
  2.6799994    ,  2.7099991    , 0.0           , 0.14999998    , 0.66999996    ,  1.1299992    ,  1.5799999    ,  1.9399996    ,
  2.2500000    ,  2.4799995    ,  2.6299992    ,  2.6899996    ,  2.7199993    , 0.0           , 0.14999998    , 0.66999996    ,
  1.1299992    ,  1.5799999    ,  1.9399996    ,  2.2500000    ,  2.4899998    ,  2.6299992    ,  2.6899996    ,  2.7199993    ,
 PHCT2= 0.0          , 0.0           , 0.0           , 0.0           , 0.0           , 0.0           , 0.0           ,
 0.0           , 0.0           , 0.0           , 0.0           , 0.0           , 0.42999995    ,  1.0400000    ,  1.6499996    ,
  2.1599998    ,  2.7099991    ,  3.1599998    ,  3.4399996    ,  3.5999994    ,  3.6699991    ,  3.6799994    , 0.0           ,
 0.59999996    ,  1.3799992    ,  2.3399992    ,  3.1799994    ,  3.9899998    ,  4.7500000    ,  5.2500000    ,  5.5499992    ,
  5.6699991    ,  5.6999998    , 0.0           , 0.67999995    ,  1.5099993    ,  2.6199999    ,  3.6799994    ,  4.6999998    ,
  5.6099997    ,  6.2199993    ,  6.5799999    ,  6.7299995    ,  6.7699995    , 0.0           , 0.70999998    ,  1.5599995    ,
  2.7299995    ,  3.8799992    ,  5.0000000    ,  6.0499992    ,  6.7699995    ,  7.2099991    ,  7.3899994    ,  7.4399996    ,
 0.0           , 0.72999996    ,  1.5799999    ,  2.7799997    ,  3.9899998    ,  5.1799994    ,  6.2799997    ,  7.0400000    ,
  7.4899998    ,  7.6899996    ,  7.7399998    , 0.0           , 0.73999995    ,  1.5899992    ,  2.7999992    ,  4.0400000    ,
  5.2699995    ,  6.3899994    ,  7.1699991    ,  7.6399994    ,  7.8399992    ,  7.8899994    , 0.0           , 0.73999995    ,
  1.5999994    ,  2.8099995    ,  4.0599995    ,  5.3199997    ,  6.4499998    ,  7.2399998    ,  7.7099991    ,  7.9099998    ,
  7.9699993    , 0.0           , 0.73999995    ,  1.5999994    ,  2.8199997    ,  4.0699997    ,  5.3399992    ,  6.4799995    ,
  7.2799997    ,  7.7500000    ,  7.9499998    ,  8.0099993    , 0.0           , 0.73999995    ,  1.5999994    ,  2.8199997    ,
  4.0799999    ,  5.3499994    ,  6.4899998    ,  7.2900000    ,  7.7699995    ,  7.9699993    ,  8.0299997    , 0.0           ,
 0.73999995    ,  1.5999994    ,  2.8199997    ,  4.0799999    ,  5.3599997    ,  6.5000000    ,  7.2999992    ,  7.7799997    ,
  7.9799995    ,  8.0400000    ,CROT= 0.0          ,  28.799988    ,  74.399994    ,  120.00000    ,  170.39999    ,
  233.20000    ,  276.00000    ,  324.00000    ,  384.00000    ,  432.00000    ,  472.79980    ,CRCT= 0.0          ,
  149.00000    ,  360.00000    ,  600.00000    ,  840.00000    ,  1104.0000    ,  1392.0000    ,  1680.0000    ,  1920.0000    ,
  2160.0000    ,  2376.0000
 &END
```

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```
&FUN1
T1L1= 0.0          ,T1L2=  2.5000000    ,T1P1=  40.000000    ,T2L1=  90.000000    ,T2L2= 0.0           ,T2P1=  1.5000000    ,T2P2=
-0.40043999E-01,T2P3= 0.34295994    ,T2P4= 0.17999995    ,T3L1= 0.50000000    ,T3L2=  1.0000000    ,T3L3=  1.5000000    ,T3L4=
  2.0000000    ,T3L5=  7.0000000    ,T3P1=  1.3199997    ,T3P2=  1.4699993    ,T3P3=-0.29999995    ,T3P4=  1.4099998    ,T3P5=
-0.23999995    ,T3P6=  1.3199997    ,T3P7=-0.17999995    ,T3P8=  1.1398592    ,T3P9=-0.25624996    ,T3P10= 0.69000000    ,T4L1=
 0.99999964E-01,T4L2= 0.38000000    ,T4P1=  3.7699995    ,T4P2=  6.1320496    ,T4P3= -26.427475    ,T4P4=  27.118805    ,T5L1=
  10.000000    ,T5L2=  20.000000    ,T5L3=  30.000000    ,T5L4=  40.000000    ,T5L5=  50.000000    ,T5L6=  60.000000    ,T5L7=
  70.000000    ,T5L8=  80.000000    ,T5L9=  90.000000    ,T5P1=  2.3299999    ,T5P2=  2.9399996    ,T5P3=-0.60999997E-01,T5P4=
  2.6199999    ,T5P5=-0.44999998E-01,T5P6=  2.3799992    ,T5P7=-0.36999997E-01,T5P8=  2.0999994    ,T5P9=-0.29999997E-01,T5P10=
  1.8499994    ,T5P11=-0.24999999E-01,T5P12=  1.3699999    ,T5P13=-0.16999997E-01,T5P14= 0.88000000    ,T5P15=-0.99999979E-02,
T5P16= 0.71999997    ,T5P17=-0.79999976E-02,T6L1= 0.69999999    ,T6L2=  60.000000    ,T6P1=  1.0000000    ,T6P2=  28.000000    ,
T6P3= 0.71298498    ,T6P4=  16.910660    ,T7L1= 0.0           ,T7L2=  1.0000000    ,T7L3=  10.000000    ,T7L4=  20.000000    ,T7L5=
  70.000000    ,T7P1= 0.39999999E-01,T7P2=-0.12669998    ,T7P3= 0.16669995    ,T7P4= 0.19999999    ,T7P5= 0.13399994    ,T7P6=
-0.39562996E-01,T7P7= 0.15827996    ,T7P8=-0.59059984E-03,T7P9=  8.1599998    ,T8L1=  1.1599998    ,T8L2=  2.2900000    ,T8L3=
  4.7900000    ,T8L4=  7.5999994    ,T8L5=  11.429999    ,T8L6=  20.000000    ,T8P1=  1.7399998    ,T8P2=  2.6022997    ,T8P3=
-0.74335998    ,T8P4=  1.3579998    ,T8P5=-0.19999999    ,T8P6= 0.62159997    ,T8P7=-0.46259999E-01,T8P8= 0.34936994    ,T8P9=
-0.10439999E-01,T8P10= 0.26999998    ,T8P11=-0.34999999E-02,T8P12= 0.19999999    ,T9L1=  5.0000000    ,T9L2=  10.000000    ,T9L3=
  20.000000    ,T9P1=-0.78999996    ,T9P2= 0.15799999    ,T9P3= 0.14999997E-01,T9P4= 0.10663998    ,T9P5=-0.28700000E-02,T9P6=
  1.1244497    ,T9P7= 0.13016999E-01,T9P8=-0.71049994E-03,T10L1= 0.64999998    ,T10L2= 0.89999998    ,T10P1= -9.2784195    ,T10P2=
  21.654785    ,T10P3= -11.367149    ,T11L1=  2.0000000    ,T11L2=  16.000000    ,T11L3=  20.000000    ,T11L4=  30.000000    ,
T11L5=  40.000000    ,T11P1=-0.13999999    ,T11P2= 0.69999993E-01,T11P3= 0.89999998    ,T11P4= 0.49999990E-02,T11P5=  4.0000000    ,
T11P6=-0.99999964E-01,T12L1=  150.00000    ,T12L2=  150.00000    ,T12P1=  2.5000000    ,T12P2=-0.99999964E-01,T13L1= -10.000000    ,
T13L2= 0.0           ,T13L3=  4.0000000    ,T13P1= 0.50000000    ,T13P2= 0.49999997E-01,T13P3= 0.50000000    ,T13P4= 0.12500000    ,
T14L1=  100.00000    ,T14L2=  400.00000    ,T14L3=  10000.000    ,T14P1=  1.4535694    ,T14P2=-0.41309968E-02,T14P3= 0.11899992E-05,
T14P4= 0.49999997E-01,T14P5= 0.52079998E-01,T14P6=-0.52099995E-05,T15L1=  5.0000000    ,T15L2=  9.0000000    ,T15P1= -1.2500000    ,
T15P2= 0.25000000    ,T16L1=  28.000000    ,T16L2=  38.000000    ,T16P1=-0.25000000    ,T16P2= 0.62500000E-01,T16P3=  2.9599991    ,
T16P4=-0.69999993E-01,T16P5=  6.0000000    ,T16P6=-0.14999998    ,T17L1=  3.0000000    ,T17L2=  15.000000    ,T17P1=  1.5335693    ,
T17P2=-0.19692999    ,T17P3= 0.63570999E-02,T17P4= 0.10810997E-01,T17P5=-0.54049990E-04,T18L1=  3.0000000    ,T18L2=  7.0000000    ,
T18P1=-0.75000000    ,T18P2= 0.25000000    ,T19L1= 0.0           ,T19L2=  125.00000    ,T19L3=  225.00000    ,T19P1=  1.0000000    ,
T19P2=-0.11439999E-02,T19P3=  1.2669992    ,T19P4=-0.32799998E-02,T19P5= 0.52899998    ,T20L1=  8.0000000    ,T20L2=  15.000000    ,
T20L3=  20.000000    ,T20L4=  200.00000    ,T20P1=  1.2285700    ,T20P2=-0.28570998E-01,T20P3= 0.79999995    ,T20P4= 0.88888997    ,
T20P5=-0.44443980E-02,T26L1= 0.19999999    ,T26L2= 0.69999999    ,T26P1=  1.3999996    ,T26P2= -2.0000000    ,T27L1=  8.5000000    ,
T27L2=  12.000000    ,T27P1= -2.4285698    ,T27P2= 0.28570998    ,T35L1= 0.15999997    ,T35L2= 0.84999996    ,T35P1=  2.1428995    ,
T35P2= -7.1428995
&END
&FUN2
T21L1=  11.000000    ,T21L2=  16.000000    ,T21L3=  25.000000    ,T21P1=  2.9799995    ,T21P2=-0.17999995    ,T21P3= 0.25999999    ,
T21P4=-0.99999979E-02,T21P5= 0.99999979E-02,T22L1=  9.0000000    ,T22L2=  13.000000    ,T22P1= -2.2500000    ,T22P2= 0.25000000    ,
T23L1= -10.000000    ,T23L2=  10.000000    ,T23L3=  23.750000    ,T23L4=  34.000000    ,T23P1= 0.25000000    ,T23P2= 0.24999999E-01,
T23P3=-0.24069995    ,T23P4= 0.74099958E-01,T23P5=  3.3170996    ,T23P6=-0.97599983E-01,T24L1=  6.0000000    ,T24L2=  10.000000    ,
T24P1= -1.5000000    ,T24P2= 0.25000000    ,T25L1=  12.000000    ,T25P1=-0.59490997E-01,T25P2=  6.6264496    ,T25P3=  74.230652    ,
T28L1=  5.0000000    ,T28L2=  12.000000    ,T28P1=-0.71428996    ,T28P2= 0.14286000    ,T29L1= -5.0000000    ,T29L2=  20.000000    ,
T29L3=  50.000000    ,T29P1= 0.69000000    ,T29P2= 0.75199997    ,T29P3= 0.12399998E-01,T29P4= 0.51732999    ,T29P5= 0.24129998E-01,
T29P6=  1.7240000    ,T30L1=  4.0000000    ,T30L2=  20.000000    ,T30L3=  35.000000    ,T30P1=-0.16666996    ,T30P2= 0.41666999E-01,
T30P3= 0.22221994    ,T30P4= 0.22221997E-01,T31L1= 0.39999998    ,T31L2=  4.0000000    ,T31L3=  9.0000000    ,T31L4=  30.000000    ,
T31P1=  1.0888796    ,T31P2=-0.22221994    ,T31P3= 0.35200000    ,T31P4=-0.37999999E-01,T31P5= 0.14285997E-01,T31P6=-0.47619990E-03,
T32L1= 0.0           ,T32L2=  45.000000    ,T32L3=  50.000000    ,T32P1= 0.18680997E-01,T32P2= 0.15356999E-01,T32P3= 0.10274998E-02,
T32P4=  7.7500000    ,T32P5=-0.10999995    ,T32P6=  2.2500000    ,T33L1= 0.0           ,T33L2=  10.000000    ,T33L3=  20.000000    ,
T33L4=  83.000000    ,T33P1= 0.41700000    ,T33P2= 0.41700000    ,T33P3= 0.58300000E-01,T33P4=  1.3174591    ,T33P5=-0.15872996E-01,
T34L1=  2.7999992    ,T34L2=  8.0999994    ,T34L3=  15.000000    ,T34L4=  50.000000    ,T34L5=  100.00000    ,T34P1= 0.18999998E-02,
T34P2=-0.29999996E-03,T34P3= 0.14614998E-02,T34P4=-0.14339999E-03,T34P5= 0.53477986E-03,T34P6=-0.28989991E-04,T34P7= 0.13428999E-03,
T34P8=-0.22899994E-05,T34P9= 0.38999991E-04,T34P10=-0.37999996E-06,T34P11= 0.99999943E-06
&END
```

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SETPOINTS FOR SIMULATION AND INITIAL PLANT STATUS

DLAT= 0.74 DENS= 3.6 PRES=10.00 DWMT= 20.00 AREALV= 12.1
TDWMSL=0.0543 TDWBRL=0.0 TDWBGI=0.9999 TDWMSI=0.2070 TDWBRI=0.0 TDWFR=0.0363 TDWTUB=0.0

TDW=1.2975

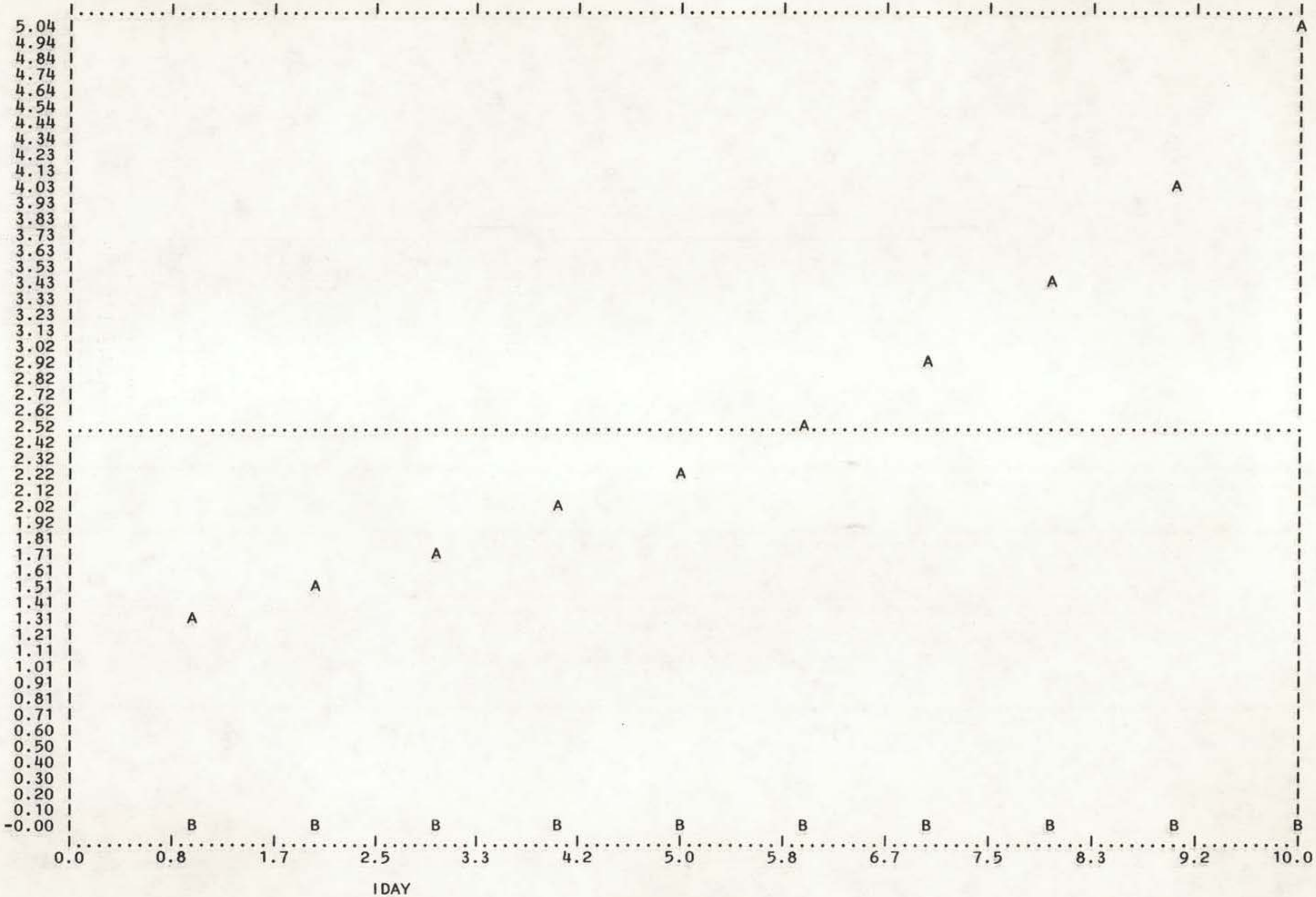
****

||||||| SIMULATION RESULTS |||||||

****

IDAY	TDW 12	TDWTUB 12	CMLAI 12	PRES 12	RWCPL 12
1	1.3498	0.0	0.0048	10.1096	0.9939
2	1.5244	0.0	0.0064	10.0042	0.9938
3	1.7310	0.0	0.0087	9.8938	0.9941
4	1.9986	0.0	0.0137	10.2447	0.9947
5	2.2309	0.0	0.0178	11.6673	0.9943
6	2.5419	0.0	0.0245	13.5025	0.9952
7	2.9569	0.0	0.0360	15.9250	0.9948
8	3.4075	0.0	0.0492	18.8776	0.9934
9	4.0343	0.0	0.0695	18.4718	0.9925
10	5.0410	0.0	0.1061	9.2075	0.9924

PLOT NUMBER 1 :
A = TDW AT HOUR 12
B = TDWTUB AT HOUR 12



Appendix C — Program Listing

Note that commons in each of the subroutines have been removed for brevity. They have been replaced with a statement of those commons that are necessary for that subroutine.

```
$$$$$POTATO (MAIN)
C   **  OPERATIONAL POTATO GROWTH MODEL
C   *******************************************************************
C   **   MAIN PROGRAM
C   *      ORIGINALLY DEVELOPED AT UC DAVIS, BY R. LOOMIS AND E. NG.
C   *
C   *      MAINTAINED AND MODIFIED AT UNIV. OF IDAHO,
C   *         STEINHORST, KLEINKOPF, AND GRUBE.
C   *
C   *      CURRENT VERSION REV 284:
C   *         MODIFIED LEAF SENESCENCE 3/84 MJG
C   *
C   *******************************************************************
C   *   THE MAIN PROGRAM READS CONTROL INFORMATION, AS WELL AS INITIAL
C   *   VALUES AND MODIFICATIONS TO PARAMETERS.  IT CONTAINS THE BASIC
C   *   DAILY AND HOURLY LOOPS, WITHIN WHICH IT CALLS ALL OF THE SUB-
C   *   ROUTINES WHICH PERFORM THE MODEL CALCULATIONS.
C   *
C   *******************************************************************
C   *   DEFINITIONS OF COMMON VARIABLES ARE FOUND IN BLOCK DATA
C
      COMMON/LOCL/ CDWMT, CRES, CTDW, CROPET, PCOVER, HEIGHT, NLVTOT,
     1 PLIVLV, SATVPA, SLOPE, TRNET, GFUNCT, HFUNCT, RL, RC, EAP, TOP,
     2 DENOM, POTET, RPL, XK, RPSI, DENOM2, ET, EFLFLR, ELNFR, WUP,
     3 RUPT, DMFPL, WATMAX, WATDEF, TPDEF, UPTAKE, PHCR, ETPH, EWPH,
     4 PSLIM, PNINR, ETNINR, ERNINR, ERINR, ERMSG, ERING, ETAGIG,
     5 ETBGIG, GLIMMS, EAGEIG, PLINR, ETLINR, ERLINR, ERLIR, ERMSIG,
     6 ERMLG, ERASLA, ETSLA, ETMSLG, GLIML, ALIML, EAGELG, EAGEAG, SLA,
     7 EBRAC, ETBRIR, ERBRIR, ETBNIR, ERBNIR, BNILIM, NBRIN, EABNIR,
     8 ETBRIG, ERBRIG, GLIMBI, EABRIG, ETBLIR, ERBLIR, BLILIM, NBL,
     9 EABLIR, ERBLG, ETBLG, BLGLIM, SLABL, EAGBLG, EABLAG,
     1 EPPTUB, ERTIR, ERIR, TUBIR, NTUB1, NTUBM, ETTUBG, ERTUBG, ERTBG,
     2 GLIMT, EATUBG, ERFRG, ERSFRG, ETFRG, FRGLIM, ETSFRW, ETSUBR,
     3 AFRL, EDWFRG, EAGRML, EAGE, EAGRBL, ETAMRP, ETSMRP, FRCRES,
     4 RPMTUB, TRTRAN, RTFDLV, GRTPP, TARMSL, TARBL, AVSLA, TFRL,
     5 TFRSUB, RSPBGI, RSPMSI, RSPMSL, RSPBRI, RSPBRL, RSPTUB, RSPFR,
     6 RSPMRP, RSPGRP, RSPRP, CMMLAR, CMBLAR, CMLAR
      COMMON /STVAR / AGEMS, RNMSIN, DWINOD(120), AGEIN(120), RNMSL,
     1 DWMSL(120), AGEMSL(120), ARMSL(120), TUBIS(30), DWTUB(30),
     2 AGETUB(30), TUBSTS, RSTBGI, RSTMSI, RSTMSL, RSTBRI, RSTBL,
     3 RSTTUB, RSTFR, RSTMRP, RSTGRP, DGRPBI, DGRPMI, DGRPML, DGRPBR,
     4 DGRPBL, DGRPTU, DGRPFR, DMRPBI, DMRPMS, DMRPML, DMRPBR, DMRPBL,
     5 DMRPTU, DMRPFR, DTMRP, DTGRP, DTRP, RES, DPHPP, DWMT,
     6 DTRANS, DCGR, RNBR, AGEBR(30), RNBRIN(30), DWBRIN(120),
     7 AGBRIN(120), RNBL(30), AGEBL(120), DWBL(120), ARBL(120),
     8 WATPL, AGEFR, DWFR, FRL, FRSUBL, DWDEDL
      COMMON /DERIV  / DEVRMS, ANINR, CWINOD(120), DEVRIN(120), AMLINR,
     1 CWMSL(120), DEVRML(120), CARMSL(120), TUBISR(30), CWTUB(30),
     2 DEVTUB(30), TUBSTR, RTBGIN, RTMSIN, RTMSL, RTBRIN, RTBL,
     3 RTTUB, RTFR, RTMRP, RTGRP, GRRBGI, GRRMSI, GRRMSL, GRRBRI,
     4 GRRBRL, GRRTUB, GRRFR, RMRPBI, RMRPMS, RMRPML, RMRPBR, RMRPBL,
     5 RMRPTU, RMRPFR, TRMRP, TRGRP, TRRP, CWRES, PHCRPP, CMTRES,
     6 TRANSP, CGR, ABRIR, DEVRBR(30), ABNIR(30), CWBRIN(120),
     7 DEVBRI(120), ABLIR(30), DEVRBL(120), CWBL(120), CARBL(120),
     8 CWATPL, DEVRFR, CWFR, CLFR, CSUBFR, CWDEDL
      COMMON /INFO / TSOIL, TAIR, DENS, PRES, EMTRES, NBGIN, NINTCT,
     A NMSL, NMST, NBR, NBRIT, NBLT, NTUB, DELTA, CMLAI, DEVRBG, DEVRAG,
     B ACR, DAYHRS, IDAY, IDATE, IHOUR, DAYRAD, DEC, DLAT, AREALV,
     C OLRES, OLTDW, OLDWMT, TRESFL, TCWIN, TCWMSL, TCWBRI, TCWBL,
     D TCWTUB, TCWFR, ANPNRA, WERR, IDACNT, DEWPT, WINDSP, NMSIN,
     E EWFRG, EWTUBG, EWSTG, EWLFG, EAGPSL, NDEDL, RWCPL, RNET, ACVP,
     F PSILPT, PSISOL, NDAYS, IDAST, IOUTPT, IOFLAG, IHR(24),
     G IHRPLT(24),IPLOTN,AVDTRN,AVDTMP(24)
      COMMON/TOTALS/ TTRANS, TPHPP, TGRPBI, TGRPMI, TGRPML, TGRPBR,
     1 TGRPBL, TGRPTU, TGRPFR, TMRPBI, TMRPMS, TMRPML, TMRPBR, TMRPBL,
     2 TMRPTU, TMRPFR, TTMRP, TTGRP, TTRP, TDW, TDWBGI, TDWMSI,
     3 TDWMSL, TDWBRI, TDWBRL, TDWTUB, TDWFR
      COMMON/CLIMAT/ AVTEMP(365), AVAMP(365), DTRAD(365), ADEWPT(365),
     $ WIND(365), AVTS, CRC, CRO, DRC, DRO, DRCP, DROP, FCL, FOV,
     $ PHC, PHO, SNHSUN
      COMMON/PARAM / AVTSOF, DMFIN, DMFLV, DMFTUB, DMFFR, DIVLV,
     A DYRCON, DAYOFF, TAHOFF, AVTSDV, TSAMPM, TSHOFF, SNHOFF,
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```
     B YINT(4), ALBEDO, HLVAP, PC, B, HTINT, SLOPEM, TRNFCI, TRNFCS,
     C TRNACI, TRNACS, ACVPDV, ACRDV, WNDMIN, XKM, PSIOFF, PSIMLT,
     D WURINT, WURS, PSINRM, RUPLIM, RWCMLT, PHCCOR, RINOD, PNIR,
     E STINRT, PMLINR, RMSL, SLAP, DAGEML, STLFRT, AGLFST, PBRIR,
     F PBNINR, CF, PBLIR, RBL, DAGEBL, RTUB, PTUBIR, DAMNTU, STTBRT,
     G RNFR, RFR, BSUBR, SFRW, SGRPIN, SGRPML, SGRPFR, SGRPTU,
     M BMRPIN, BMRPML, BMRPFR, BMRPTU, SBRLWT, DEDMLT, ZERO, ONE,
     N PHOT(11,11),PHCT(11,11),PHOT2(11,11),PHCT2(11,11),CROT(11),
     O CRCT(11), MTSTOP, NTUBP, NTADD, SATM
      COMMON/FUNCT1/T1L1,T1L2,T1P1,T2L1,T2L2,T2P1,T2P2,T2P3,T2P4,
     A T3L1,T3L2,T3L3,T3L4,T3L5,T3P1,T3P2,T3P3,T3P4,T3P5,T3P6,T3P7,
     B T3P8,T3P9,T3P10,T4L1,T4L2,T4P1,T4P2,T4P3,T4P4,T5L1,T5L2,T5L3,
     C T5L4,T5L5,T5L6,T5L7,T5L8,T5L9,T5P1,T5P2,T5P3,T5P4,T5P5,T5P6,
     D T5P7,T5P8,T5P9,T5P10,T5P11,T5P12,T5P13,T5P14,T5P15,T5P16,T5P17,
     E T6L1,T6L2,T6P1,T6P2,T6P3,T6P4,T7L1,T7L2,T7L3,T7L4,T7L5,T7P1,T7P2,
     F T7P3,T7P4,T7P5,T7P6,T7P7,T7P8,T7P9,T8L1,T8L2,T8L3,T8L4,T8L5,
     G T8L6,T8P1,T8P2,T8P3,T8P4,T8P5,T8P6,T8P7,T8P8,T8P9,T8P10,T8P11,
     H T8P12,T9L1,T9L2,T9L3,T9P1,T9P2,T9P3,T9P4,T9P5,T9P6,T9P7,T9P8,
     I T10L1,T10L2,T10P1,T10P2,T10P3
      COMMON/FUNCT2/T11L1,T11L2,T11L3,T11L4,T11L5,T11P1,T11P2,T11P3,
     A T11P4,T11P5,T11P6,T12L1,T12L2,T12P1,T12P2,T13L1,T13L2,T13L3,
     B T13P1,T13P2,T13P3,T13P4,T14L1,T14L2,T14L3,T14P1,T14P2,T14P3,
     C T14P4,T14P5,T14P6,T15L1,T15L2,T15P1,T15P2,T16L1,T16L2,T16P1,
     D T16P2,T16P3,T16P4,T16P5,T16P6,T17L1,T17L2,T17P1,T17P2,T17P3,
     E T17P4,T17P5,T18L1,T18L2,T18P1,T18P2,T19L1,T19L2,T19L3,T19P1,
     F T19P2,T19P3,T19P4,T19P5,T20L1,T20L2,T20L3,T20L4,T20P1,T20P2,
     G T20P3,T20P4,T20P5,T26L1,T26L2,T26P1,T26P2,T27L1,T27L2,T27P1,
     H T27P2,T35L1,T35L2,T35P1,T35P2
      COMMON/FUNCT3/T21L1,T21L2,T21L3,T21P1,T21P2,T21P3,T21P4,
     A T21P5,T22L1,T22L2,T22P1,T22P2,T23L1,T23L2,T23L3,T23L4,T23P1,
     B T23P2,T23P3,T23P4,T23P5,T23P6,T24L1,T24L2,T24P1,T24P2,T25L1,
     C T25P1,T25P2,T25P3
      COMMON/FUNCT4/T28L1,T28L2,T28P1,T28P2,T29L1,T29L2,T29L3,
     A T29P1,T29P2,T29P3,T29P4,T29P5,T29P6,T30L1,T30L2,T30L3,T30P1,
     B T30P2,T30P3,T30P4,T31L1,T31L2,T31L3,T31L4,T31P1,T31P2,T31P3,
     C T31P4,T31P5,T31P6,T32L1,T32L2,T32L3,T32P1,T32P2,T32P3,T32P4,
     D T32P5,T32P6,T33L1,T33L2,T33L3,T33L4,T33P1,T33P2,T33P3,T33P4,
     E T33P5,T34L1,T34L2,T34L3,T34L4,T34L5,T34P1,T34P2,T34P3,T34P4,
     F T34P5,T34P6,T34P7,T34P8,T34P9,T34P10,T34P11
C   ******************************************************************
      DATA IHEADR/4/
      REAL*8 WHEAD
C   ******************************************************************
C   * NAMELISTS CONTAIN THE RUN-MODIFIABLE VARIABLES SO THAT ANY CF
C   * THEM CAN BE CHANGED FROM THEIR DEFAULT VALUES WITHOUT HAVING TO
C   * HAVING TO CHANGE THEM ALL:
C

      NAMELIST/CNTRL/ NDAYS, IDAST, IOUTPT, IPLOTN, IHEADR
      NAMELIST/INCOND/ TDWMSL,TDWBRL,TDWBGI,TDWMSI,TDWBRI,TDWFR,TDWTUB,
     $ AREALV,PRES,DWMT,DLAT,DENS,NINTOT,AGEIN,DWINOD,AGEMS,NBGIN,NMST,
     $ RNMSIN,AGEMSL,DWMSL,ARMSL,RNMSL,AGEBR,RNBRIN,DWBRIN,AGBRIN,RNBR,
     $ RNBL,AGEBL,DWBL,ARBL,DWTUB,AGETUB,NTUB,AGEFR,DWFR,FRL,FRSUBL
      NAMELIST/PARS/ AVTSOF, DMFIN, DMFLV, DMFTUB, DMFFR, DIVLV,
     A DYRCON, DAYOFF, TAHOFF, AVTSDV, TSAMPM, TSHOFF, SNHOFF,
     B YINT, ALBEDO, HLVAP, PC, B, HTINT, SLOPEM, TRNFCI, TRNFCS,
     C TRNACI, TRNACS, ACVPDV, ACRDV, WNDMIN, XKM, PSIOFF, PSIMLT,
     D WURINT, WURS, PSINRM, RUPLIM, RWCMLT, PHCCOR, RINOD, PNIR,
     E MTSTOP, STINRT, PMLINR, RMSL, SLAP, DAGEML, STLFRT, AGLFST,
     F PBRIR, PBNINR, CF, PBLIR, RBL, DAGEBL, RTUB, PTUBIR, DAMNTU,
     G NTUBP, NTADD, STTBRT, RNFR, RFR, BSUBR, SFRW, SGRPIN, SGRPML,
     M SGRPFR, SGRPTU, BMRPIN, BMRPML, BMRPFR, BMRPTU, SBRLWT, DEDMLT,
     N SATM,PHOT, PHCT, PHOT2, PHCT2, CROT, CRCT
      NAMELIST/FUN1/T1L1,T1L2,T1P1,T2L1,T2L2,T2P1,T2P2,T2P3,T2P4,
     A T3L1,T3L2,T3L3,T3L4,T3L5,T3P1,T3P2,T3P3,T3P4,T3P5,T3P6,T3P7,
     B T3P8,T3P9,T3P10,T4L1,T4L2,T4P1,T4P2,T4P3,T4P4,T5L1,T5L2,T5L3,
     C T5L4,T5L5,T5L6,T5L7,T5L8,T5L9,T5P1,T5P2,T5P3,T5P4,T5P5,T5P6,
     D T5P7,T5P8,T5P9,T5P10,T5P11,T5P12,T5P13,T5P14,T5P15,T5P16,T5P17,
     E T6L1,T6L2,T6P1,T6P2,T6P3,T6P4,T7L1,T7L2,T7L3,T7L4,T7L5,T7P1,T7P2,
     F T7P3,T7P4,T7P5,T7P6,T7P7,T7P8,T7P9,T8L1,T8L2,T8L3,T8L4,T8L5,
     G T8L6,T8P1,T8P2,T8P3,T8P4,T8P5,T8P6,T8P7,T8P8,T8P9,T8P10,T8P11,
     H T8P12,T9L1,T9L2,T9L3,T9P1,T9P2,T9P3,T9P4,T9P5,T9P6,T9P7,T9P8,
     I T10L1,T10L2,T10P1,T10P2,T10P3,
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     X T11L1,T11L2,T11L3,T11L4,T11L5,T11P1,T11P2,T11P3,
     A T11P4,T11P5,T11P6,T12L1,T12L2,T12P1,T12P2,T13L1,T13L2,T13L3,
     B T13P1,T13P2,T13P3,T13P4,T14L1,T14L2,T14L3,T14P1,T14P2,T14P3,
     C T14P4,T14P5,T14P6,T15L1,T15L2,T15P1,T15P2,T16L1,T16L2,T16P1,
     D T16P2,T16P3,T16P4,T16P5,T16P6,T17L1,T17L2,T17P1,T17P2,T17P3,
     E T17P4,T17P5,T18L1,T18L2,T18P1,T18P2,T19L1,T19L2,T19L3,T19P1,
     F T19P2,T19P3,T19P4,T19P5,T20L1,T20L2,T20L3,T20L4,T20P1,T20P2,
     G T20P3,T20P4,T20P5,T26L1,T26L2,T26P1,T26P2,T27L1,T27L2,T27P1,
     H T27P2,T35L1,T35L2,T35P1,T35P2
      NAMELIST/FUN2/T21L1,T21L2,T21L3,T21P1,T21P2,T21P3,T21P4,
     A T21P5,T22L1,T22L2,T22P1,T22P2,T23L1,T23L2,T23L3,T23L4,T23P1,
     B T23P2,T23P3,T23P4,T23P5,T23P6,T24L1,T24L2,T24P1,T24P2,T25L1,
     C T25P1,T25P2,T25P3,
     X  T28L1,T28L2,T28P1,T28P2,T29L1,T29L2,T29L3,
     A T29P1,T29P2,T29P3,T29P4,T29P5,T29P6,T30L1,T30L2,T30L3,T30P1,
     B T30P2,T30P3,T30P4,T31L1,T31L2,T31L3,T31L4,T31P1,T31P2,T31P3,
     C T31P4,T31P5,T31P6,T32L1,T32L2,T32L3,T32P1,T32P2,T32P3,T32P4,
     D T32P5,T32P6,T33L1,T33L2,T33L3,T33L4,T33P1,T33P2,T33P3,T33P4,
     E T33P5,T34L1,T34L2,T34L3,T34L4,T34L5,T34P1,T34P2,T34P3,T34P4,
     F T34P5,T34P6,T34P7,T34P8,T34P9,T34P10,T34P11
C    ***********************************************************************
C    *  READ CONTROL INFORMATION FOR THIS RUN:
C
      READ(5,CNTRL)
C    *  READ OUTPUT REQUESTS AND SET UP FOR OUTPUT FOR THIS RUN:
C
      CALL OUTPUT
C    ***********************************************************************
C    *  READ CHANGES TO PARAMETERS OR INITIAL CONDITIONS:
C
      READ(5,PARS)
      READ(5,FUN1)
      READ(5,FUN2)
      READ(5,INCOND)
C    ***********************************************************************
C    *  READ FORCING DATA (TEMPS IN F, WIND IN MILES/DAY)
C
      READ(5,105)  WHEAD
      READ(5,103)  AVTEMP
      READ(5,103)  AVAMP
      READ(5,104)  DTRAD
      READ(5,103)  ADEWPT
      READ(5,104)  WIND
101   FORMAT(25I3)
102   FORMAT(4I5)
103   FORMAT(16F5.1)
104   FORMAT(16F5.0)
105   FORMAT(A8)
C    ***********************************************************************
C    *  SET STARTING VALUES FOR THESE VARIABLES DEPENDING ON INPUT VALUES:
C
      AVTS=(AVTEMP(IDAST)-AVTSOF)*0.5555556
      DLAT=.01745*DLAT
      TDW=TDWBGI+TDWMSI+TDWBRI+TDWMSL+TDWBRL+TDWTUB+TDWFR
      DMFPL=((TDWBGI+TDWMSI+TDWBRI)*DMFIN + (TDWMSL+TDWBRL)*DMFLV +
     $TDWTUB*DMFTUB + TDWFR*DMFFR)/TDW
      WATPL=TDW/DMFPL-TDW
      RES=(PRES/100.0)*TDW
      CMLAI=AREALV*DENS/DIVLV
      IDATE=IDAST-1
C    ***********************************************************************
C    *  INITIALIZE FOR THE RUN:
C
      CALL INITL
C    ***********************************************************************
C    *  WRITE FORCING DATA AND SETPOINTS FOR SIMULATION TO OUTPUT,
C    *  UNLESS INHIBITED BY (IHEADR):
C
      IF(IHEADR.LT.4) GO TO 10
      IHEADR=IHEADR-4
      WRITE(6,106)  WHEAD
      WRITE(6,107)
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106    FORMAT('1',50X,'POTATO GROWTH MODEL PRINTOUT'///132('*')//
      $58X,'TEST SITE WEATHER :  IDENTIFIER = ',A8 //)
107    FORMAT(1X,3('JULDAY/AVTEMPF/AVAMPF/DTRAD/AVDEWPTF/WINDMD/'))
       I=1
       J=123
       K=245
       DO 322 M=1,122
       IF(K.EQ.366) K=365
       WRITE(6,321) I,AVTEMP(I),AVAMP(I),DTRAD(I),ADEWPT(I),WIND(I),J,
      $AVTEMP(J),AVAMP(J),DTRAD(J),ADEWPT(J),WIND(J),K,AVTEMP(K),
      $AVAMP(K),DTRAD(K),ADEWPT(K),WIND(K)
321    FORMAT(3(I6,4F7.1,F9.1,1X))
       I=I+1
       J=J+1
       K=K+1
322    CONTINUE
C   **  WRITE RUN CONTROL VALUES
10     IF(IHEADR.LT.2) GO TO 20
       IHEADR=IHEADR-2
       WRITE(6,500)
500    FORMAT(//132('*')//)
       WRITE(6,CNTRL)
C   **  WRITE RUN PARAMETER VALUES
       WRITE(6,500)
       WRITE(6,PARS)
C   **  WRITE RUN TABLE FUNCTION VALUES
       WRITE(6,500)
       WRITE(6,FUN1)
       WRITE(6,FUN2)
       WRITE(6,500)
C   ** WRITE INITIAL PLANT STATUS INFORMATION
20     IF(IHEADR.LT.1) GO TO 30
       WRITE(6,110)
110    FORMAT(40X,'SETPOINTS FOR SIMULATION AND INITIAL PLANT STATUS'/)
       WRITE(6,120) DLAT,DENS,PRES,DWMT,AREALV
120    FORMAT(17X,'DLAT=',F6.2,3X,'DENS=',F6.1,3X,'PRES=',F5.2,3X,
      $ 'DWMT=',F6.2,3X,'AREALV=',F5.1)
       WRITE(6,130) TDWMSL,TDWBRL,TDWBGI,TDWMSI,TDWBRI,TDWFR,TDWTUB,TDW
130    FORMAT(14X,'TDWMSL=',F6.4,2X,'TDWBRL=',F6.4,2X,'TDWBGI=',F6.4,2X,
      $'TDWMSI=',F6.4,2X,'TDWBRI=',F6.4,2X,'TDWFR=',F6.4,2X,'TDWTUB=',
      $F6.4//39X,'TDW=',F6.4)
30     WRITE(6,150)
150    FORMAT('1'//132('*')//45X,'|||||||  SIMULATION RESULTS  |||||||'//
      $132('*')//)
C   ********************************************************************
C   *  THIS IS THE DAILY LOOP, BEGINNING AT (IDATE), GOING FOR (NDAYS).
C   *  EACH DAY, (DASTRT) IS CALLED, THEN ALL OTHER ROUTINES ARE CALLED
C   *  EACH HOUR IN THE HOURLY LOOP.
C
       DO 2000 IDAY=1,NDAYS
       IF(IDACNT .EQ. IDAOUT) IDACNT=0
       IDACNT=IDACNT+1
       CALL DASTRT
C
C   *  THIS IS THE HOURLY LOOP.
C
       DO 1500 IHOUR=1,24
       OLDWMT=DWMT
       OLTDW=TDW
       OLRES= RES
C
C   *  DETERMINE DRIVING DATA:
C
       CALL WEATHR
       CALL PLWAT
       CALL PHOTOS
C
C   *  DETERMINE GROWTH OF INDIVIDUAL PLANT ORGANS:
C
       CALL MSTEM
       CALL MSLEAF
       CALL BRANGR
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      CALL BRLFGR
      CALL TUBER
      CALL FIBRTG
C
C   *  DETERMINE DIVISION OF RESERVES AND RESPIRATION:
C
      CALL RPRES
C
C   *  UPDATE THE STATE VARIABLES USING AN EULER APPROXIMATION:
C
      CALL DEQSOL
C
C   *  DETERMINE COMMUNITY-WIDE INFORMATION:
C
      CALL COMMUN
C
C   *  CHECK MASS BALANCE
C
      CDWMT=OLDWMT-DWMT
      CRES=RES-OLRES
      CTDW=TDW-OLTDW
      WERR =DPHPP+CDWMT -CRES-CTDW-DTRP
C
C   *  OUTPUT, IF REQUIRED AT THIS HOUR:
C
      IF(IHR(IHOUR).NE.0) CALL OUTPUT
1500  CONTINUE
2000  CONTINUE
C
C   *  END OF LOOPS.  PLOT IF REQUESTED, THEN END.
C
      IOFLAG=3
      IF(IPLOTN.NE.0) CALL OUTPUT
      STOP
      END
$$$$$BLOCKDAT
      BLOCK DATA
C   ******************************************************************
C   *  THIS ROUTINE CONTAINS ALL OF THE INITIALIZATIONS FOR VARIABLES
C   *  WHICH ARE CONTAINED IN THE COMMON BLOCKS.
C
C   ******************************************************************
C   *  THE LOCL COMMON CONTAINS VARIABLES WHICH ARE USED WITHIN THE
C   *  SUBROUTINES OF POTATO WHICH ARE LOCAL TO THOSE ROUTINES.
C
      COMMON/LOCL/ CDWMT, CRES, CTDW, CROPET, PCOVER, HEIGHT, NLVTOT,
     1 PLIVLV, SATVPA, SLOPE, TRNET, GFUNCT, HFUNCT, RL, RC, EAP, TOP,
     2 DENOM, POTET, RPL, XK, RPSI, DENOM2, ET, EFLFLR, ELNFR, WUR,
     3 RUPT, DMFPL, WATMAX, WATDEF, TPDEF, UPTAKE, PHCR, ETPH, EWPH,
     4 PSLIM, PNINR, ETNINR, ERNINR, ERINR, ERMSG, ERING, ETAGIG,
     5 ETBGIG, GLIMMS, EAGEIG, PLINR, ETLINR, ERLINR, ERLIR, ERMSLG,
     6 ERMLG, ERASLA, ETSLA, ETMSLG, GLIML, ALIML, EAGELG, EAGEAG, SLA,
     7 EBRAC, ETBRIR, ERBRIR, ETBNIR, ERBNIR, BNILIM, NBRIN, EABNIR,
     8 ETBRIG, ERBRIG, GLIMBI, EABRIG, ETBLIR, ERBLIR, BLILIM, NBI,
     9 EABLIR, ERBLG, ETBLG, BLGLIM, SLABL, EAGBLG, EABLAG,
     1 EPPTUB, ERTIR, ERIR, TUBIR, NTUB1, NTUBM, ETTUBG, ERTUBG, ERTBG,
     2 GLIMT, EATUBG, ERFRG, ERSFRG, ETFRG, FRGLIM, ETSFRW, ETSUBR,
     3 AFRL, EDWFRG, EAGRML, EAGE, EAGRBL, ETAMRP, ETSMRP, FRCRES,
     4 RPMTUB, TRTRAN, RTFDLV, GRTPP, TARMSL, TARBL, AVSLA, TFRL,
     5 TFRSUB, RSPBGI, RSPMSI, RSPMSL, RSPBRI, RSPBRL, RSPTUB, RSPFR,
     6 RSPMRP, RSPGRP, RSPRP, CMMLAR, CMBLAR, CMLAR
C   ******************************************************************
C   *  THE COMMON STVAR CONTAINS ALL OF POTATO'S STATE VARIABLES.  THEY
C   *  ARE ARRANGED IN THE SAME ORDER AS THOSE IN DERIV, SINCE THERE IS
C   *  A ONE-TO-ONE CORRESPONDENCE BETWEEN THEM FOR THE EULER
C   *  APPROXIMATION ROUTINE (DEQSOL).
C
      COMMON /STVAR / AGEMS, RNMSIN, DWINOD(120), AGEIN(120), RNMSL,
     1 DWMSL(120), AGEMSL(120), ARMSL(120), TUBIS(30), DWTUB(30),
     2 AGETUB(30), TUBSTS, RSTBGI, RSTMSI, RSTMSL, RSTBRI, RSTBL,
     3 RSTTUB, RSTFR, RSTMRP, RSTGRP, DGRPBI, DGRPMI, DGRPML, DGRPBR,
     4 DGRPBL, DGRPTU, DGRPFR, DMRPBI, DMRPMS, DMRPML, DMRPBR, DMRPBL,
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     5 DMRPTU, DMRPFR, DTMRP, DTGRP, DTRP, RES, DPHPP, DWMT,
     6 DTRANS, DCGR, RNBR, AGEBR(30), RNBRIN(30), DWBRIN(120),
     7 AGBRIN(120), RNBL(30), AGEBL(120), DWBL(120), ARBL(120),
     8 WATPL, AGEFR, DWFR, FRL, FRSUBL, DWDEDL
C     ******************************************************************
C     *  THE DERIV COMMON CONTAINS THE RATE-OF-CHANGE VARIABLES FOR ALL OF
C     *  THE VARIABLES IN THE STVAR COMMON.  THEY ARE USED IN ROUTINE
C     *  (DEQSOL) TO UPDATE THE STATE VARIABLES TO THEIR NEW VALUES DURING
C     *  EACH ITERATION.
C
      COMMON /DERIV  / DEVRMS, ANINR, CWINOD(120), DEVRIN(120), AMLINR,
     1 CWMSL(120), DEVRML(120), CARMSL(120), TUBISR(30), CWTUB(30),
     2 DEVTUB(30), TUBSTR, RTBGIN, RTMSIN, RTMSL, RTBRIN, RTBL,
     3 RTTUB, RTFR, RTMRP, RTGRP, GRRBGI, GRRMSI, GRRMSL, GRRBRI,
     4 GRRBRL, GRRTUB, GRRFR, RMRPBI, RMRPMS, RMRPML, RMRPBR, RMRPBL,
     5 RMRPTU, RMRPFR, TRMRP, TRGRP, TRRP, CWRES, PHCRPP, CMTRES,
     6 TRANSP, CGR, ABRIR, DEVRBR(30), ABNIR(30), CWBRIN(120),
     7 DEVBRI(120), ABLIR(30), DEVRBL(120), CWBL(120), CARBL(120),
     8 CWATPL, DEVRFR, CWFR, CLFR, CSUBFR, CWDEDL
C     ******************************************************************
C     *  THE INFO COMMON CONTAINS INFORMATIONAL DATA WHICH MUST BE PASSED
C     *  FROM ROUTINE TO ROUTINE, WHICH IS NEITHER STATE VARIABLE NOR
C     *  RATE DATA.
C
      COMMON /INFO / TSOIL, TAIR, DENS, PRES, EMTRES, NBGIN, NINTCT,
     A NMSL, NMST, NBR, NBRIT, NBLT, NTUB, DELTA, CMLAI, DEVRBG, DEVRAG,
     B ACR, DAYHRS, IDAY, IDATE, IHOUR, DAYRAD, DEC, DLAT, AREALV,
     C OLRES, OLTDW, OLDWMT, TRESFL, TCWIN, TCWMSL, TCWBRI, TCWBL,
     D TCWTUB, TCWFR, ANPNRA, WERR, IDACNT, DEWPT, WINDSP, NMSIN,
     E EWFRG, EWTUBG, EWSTG, EWLFG, EAGPSL, NDEDL, RWCPL, RNET, ACVP,
     F PSILPT, PSISOL, NDAYS, IDAST, IOUTPT, IOFLAG, IHR(24),
     G IHRPLT(24),IPLOTN,AVDTPN, AVDTMP(24)
C     ******************************************************************
C     *  THE COMMON TOTALS CONTAINS THE OVERALL TOTALS OF THE WEIGHTS AND
C     *  RATES OF THE VARIOUS ORGANS OF THE POTATO PLANT.
C
      COMMON/TOTALS/ TTRANS, TPHPP, TGRPBI, TGRPMI, TGRPML, TGRPBR,
     1 TGRPBL, TGRPTU, TGRPFR, TMRPBI, TMRPMS, TMRPML, TMRPBR, TMRPBL,
     2 TMRPTU, TMRPFR, TTMRP, TTGRP, TTRP, TDW, TDWBGI, TDWMSI,
     3 TDWMSL, TDWBRI, TDWBRL, TDWTUB, TDWFR
C     ******************************************************************
C     *  CLIMAT CONTAINS THE WEATHER DRIVING VARIABLES, AS WELL AS THOSE
C     *  VARIABLES DERIVED FROM THEM.
C
      COMMON/CLIMAT/ AVTEMP(365), AVAMP(365), DTRAD(365), ADEWPT(365),
     $ WIND(365), AVTS, CRC, CRO, DRC, DRO, DRCP, DROP, FCL, FOV,
     $ PHC, PHO, SNHSUN
C     ******************************************************************
C     *  PARAM CONTAINS PARAMETERS FOR THE MODEL WHICH MAY BE CHANGED FOR
C     *  DIFFERING RUNS TO MODIFY THE ACTION OF THE GROWTH OF THE PLANT.
C
      COMMON/PARAM / AVTSOF, DMFIN, DMFLV, DMFTUB, DMFFR, DIVLV,
     A DYRCON, DAYOFF, TAHOFF, AVTSDV, TSAMPM, TSHOFF, SNHOFF,
     B YINT(4), ALBEDO, HLVAP, PC, B, HTINT, SLOPEM, TRNFCI, TRNFCS,
     C TRNACI, TRNACS, ACVPDV, ACRDV, WNDMIN, XKM, PSIOFF, PSIMLT,
     D WURINT, WURS, PSINRM, RUPLIM, RWCMLT, PHCCOR, RINOD, PNIR,
     E STINRT, PMLINR, RMSL, SLAP, DAGEML, STLFRT, AGLFST, PBRIR,
     F PBNINR, CF, PBLIR, RBL, DAGEBL, RTUB, PTUBIR, DAMNTU, STTBRT,
     G RNFR, RFR, BSUBR, SFRW, SGRPIN, SGRPML, SGRPFR, SGRPTU,
     M BMRPIN, BMRPML, BMRPFR, BMRPTU, SBRLWT, DEDMLT, ZERO, ONE,
     N PHOT(11,11),PHCT(11,11),PHOT2(11,11),PHCT2(11,11),CROT(11),
     O CRCT(11), MTSTOP, NTUBP, NTADD, SATM
C     ******************************************************************
C     *  FUNCT1 CONTAINS SOME OF THE TABLE VARIABLES USED IN THE SUB-
C     *  ROUTINES.  TMLN IS THE NTH LIMIT IN TABLE M, AND TMPQ IS THE
C     *  QTH FUNCTION PARAMETER IN TABLE M.
C
      COMMON/FUNCT1/T1L1,T1L2,T1P1,T2L1,T2L2,T2P1,T2P2,T2P3,T2P4,
     A T3L1,T3L2,T3L3,T3L4,T3L5,T3P1,T3P2,T3P3,T3P4,T3P5,T3P6,T3P7,
     B T3P8,T3P9,T3P10,T4L1,T4L2,T4P1,T4P2,T4P3,T4P4,T5L1,T5L2,T5L3,
     C T5L4,T5L5,T5L6,T5L7,T5L8,T5L9,T5P1,T5P2,T5P3,T5P4,T5P5,T5P6,
     D T5P7,T5P8,T5P9,T5P10,T5P11,T5P12,T5P13,T5P14,T5P15,T5P16,T5P17,
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     E T6L1,T6L2,T6P1,T6P2,T6P3,T6P4,T7L1,T7L2,T7L3,T7L4,T7L5,T7P1,T7P2,
     F T7P3,T7P4,T7P5,T7P6,T7P7,T7P8,T7P9,T8L1,T8L2,T8L3,T8L4,T8L5,
     G T8L6,T8P1,T8P2,T8P3,T8P4,T8P5,T8P6,T8P7,T8P8,T8P9,T8P10,T8P11,
     H T8P12,T9L1,T9L2,T9L3,T9P1,T9P2,T9P3,T9P4,T9P5,T9P6,T9P7,T9P8,
     I T10L1,T10L2,T10P1,T10P2,T10P3
C    ********************************************************************
C    *  FUNCT2 IS ANOTHER COMMON LIKE FUNCT1.
C
      COMMON/FUNCT2/T11L1,T11L2,T11L3,T11L4,T11L5,T11P1,T11P2,T11P3,
     A T11P4,T11P5,T11P6,T12L1,T12L2,T12P1,T12P2,T13L1,T13L2,T13L3,
     B T13P1,T13P2,T13P3,T13P4,T14L1,T14L2,T14L3,T14P1,T14P2,T14P3,
     C T14P4,T14P5,T14P6,T15L1,T15L2,T15P1,T15P2,T16L1,T16L2,T16P1,
     D T16P2,T16P3,T16P4,T16P5,T16P6,T17L1,T17L2,T17P1,T17P2,T17P3,
     E T17P4,T17P5,T18L1,T18L2,T18P1,T18P2,T19L1,T19L2,T19L3,T19P1,
     F T19P2,T19P3,T19P4,T19P5,T20L1,T20L2,T20L3,T20L4,T20P1,T20P2,
     G T20P3,T20P4,T20P5,T26L1,T26L2,T26P1,T26P2,T27L1,T27L2,T27P1,
     H T27P2,T35L1,T35L2,T35P1,T35P2
C    ********************************************************************
C    *  FUNCT3 IS ANOTHER COMMON LIKE FUNCT1.
C
      COMMON/FUNCT3/T21L1,T21L2,T21L3,T21P1,T21P2,T21P3,T21P4,
     A T21P5,T22L1,T22L2,T22P1,T22P2,T23L1,T23L2,T23L3,T23L4,T23P1,
     B T23P2,T23P3,T23P4,T23P5,T23P6,T24L1,T24L2,T24P1,T24P2,T25L1,
     C T25P1,T25P2,T25P3
C    ********************************************************************
C    *  FUNCT4 IS ANOTHER COMMON LIKE FUNCT1.
C
      COMMON/FUNCT4/T28L1,T28L2,T28P1,T28P2,T29L1,T29L2,T29L3,
     A T29P1,T29P2,T29P3,T29P4,T29P5,T29P6,T30L1,T30L2,T30L3,T30P1,
     B T30P2,T30P3,T30P4,T31L1,T31L2,T31L3,T31L4,T31P1,T31P2,T31P3,
     C T31P4,T31P5,T31P6,T32L1,T32L2,T32L3,T32P1,T32P2,T32P3,T32P4,
     D T32P5,T32P6,T33L1,T33L2,T33L3,T33L4,T33P1,T33P2,T33P3,T33P4,
     E T33P5,T34L1,T34L2,T34L3,T34L4,T34L5,T34P1,T34P2,T34P3,T34P4,
     F T34P5,T34P6,T34P7,T34P8,T34P9,T34P10,T34P11
C    ********************************************************************
C    *  CONTROL DEFAULTS: NUMBER OF DAYS, STARTING DOY, OUTPUT CONTROLS.
C
      DATA NDAYS, IDAST, IOUTPT, IOFLAG, IHR /
     $ 100, 160, 0, 1, 23*0, 1 /
C    ********************************************************************
C    *  INITIAL CONDITIONS AND ZEROING:
C
      DATA CROPET/0./
      DATA EAGRML,EAGE,EAGRBL/3*0./
      DIMENSION Z1(31),Z2(1422)
      EQUIVALENCE (Z1(1),RSTBGI),(Z2(1),DEVRMS)
      DATA Z1/31*0./,Z2/1422*0./
      DATA CDWMT,CRES,CTDW/3*0./
      DATA EMTRES,TCWIN,TCWMSL,TCWBRI,TCWBL,TCWTUB, TCWFR, ANPNRA/8*0./
      DATA NMST/3/
      DATA NBRIT,NBLT,NBR/3*0/
      DATA PHC,PHO/2*0./
      DATA WATPL/0.0/
      DATA PSISOL / 333.33 /
      DATA DRC,DRO/843.9,168.5/
      DATA MTSTOP, NTUBP, NTADD/ 50, 28, 3 /
      DATA SATM / 4.58123 /
      DATA CRCT/0.,149.,360.,600., 840.,1104., 1392.,1680.,1920.,2160.,
     $ 2376./
      DATA CROT/0.,28.8,74.4,120.,170.4,233.2,276.,324.,384.,432.,472.8/
      DATA AREALV,PRES,DWMT,DLAT,DENS/12.15,10.,20.,43.6,3.8/
      DATA TDWMSL,TDWBRL,TDWBGI,TDWMSI,TDWBRI,TDWFR,TDWTUB/0.0543,0.0,
     - 0.9999,0.2070,0.0,0.0363,0.0/
C    ********************************************************************
C    *  INITIALIZATION OF PARAMETERS
C
      DIMENSION F1(110),F2(83),F3(30),F4(64),PAR(74)
      EQUIVALENCE (T1L1,F1(1)),(T11L1,F2(1)),(T21L1,F3(1)),
     $ (T28L1,F4(1)),(AVTSOF,PAR(1))
      DATA PAR/ 36., .064, .12, .11, .05, 10000., .8, 10., 8., 48.,
     1 .45, 10., 12., -4.1111, -4.22222, -4.3889, -4.4444, .22, 58.,
     2 .49, 3E-04, 5.5, 4097.547, 1.22, -.18, .325, -.044, .75, 60.,
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     3 2.3, 7000., 1450., .001, .16, .0336, 333.33, .292, 5.555556,
     4 .60, .0208, .029166, .01, .029166, .02083, 550., 50.,
     5 .005, 15.4, .04, .029166, .6, .029166, .02083, 50., .02083,
     6 .014, 8., .06, 1., .02083, .01562, 290., 3*.39, .22,
     7 3*.000625, .0002, .005, .5, 0., 1./
      DATA F1/ 0., 2.5, 40., 90., 0., 1.5, -.040044, .34296, .18, .5,
     1 1., 1.5, 2., 7., 1.32, 1.47, -.3, 1.41, -.24, 1.32, -.18,
     2 1.13986, -.25625, .69, .1, .38, 3.77, 6.13205, -26.42749,
     3 27.11882, 10., 20., 30., 40., 50., 60., 70., 80., 90., 2.33,
     4 2.94, -.061, 2.62, -.045, 2.38, -.037, 2.1, -.03, 1.85, -.025,
     5 1.37, -.017, .88, -.01, .72, -.008, .7, 60., 1., 28., .712985,
     6 16.91066, 0., 1., 10., 20., 70., .04, -.1267, .1667, .2,
     7 .134, -.039563, .15828, -.0005906, 8.16, 1.16, 2.29, 4.79, 7.6,
     8 11.43, 20., 1.74, 2.6023, -.74336, 1.358, -.2, .6216, -.04626,
     9 .34937, -.01044, .27, -.0035, .2, 5., 10., 20., -.79, .158,
     1 .015, .10664, -.00287, 1.12445, .013017, -.0007105, .65, .9,
     2 -9.27842, 21.65479, -11.36715 /
      DATA F2/ 2., 16., 20., 30., 40., -.14, .07, .90, .005, 4., -.1,
     1 15., 25., 2.5, -.1, -10., 0., 4., .5, .05, .5, .125, 100.,
     2 400., 10000., 1.45357, -.004131, .00000119, .05, .05208,
     3 -.00000521, 5., 9., -1.25, .25, 28., 38., -.25, .0625, 2.96,
     4 -.07, 6., -.15, 3., 15., 1.53357, -.19693, .0063571, .010811,
     5 -.00005405, 3., 7., -.75, .25, 0., 125., 225., 1., -.001144,
     6 1.267, -.00328, .529, 8., 15., 20., 200., 1.22857, -.028571,
     7 .8, .88889, -.0044444, .2, .7, 1.4, -2., 8.5, 12., -2.42857,
     8 .28571, .16, .85, 2.1429, -7.1429 /
      DATA F3/ 11., 16., 25., 2.98, -.18, .26, -.01, .01, 9., 13.,
     1 -2.25, .25, -10., 10., 23.75, 34., .25, .025, -.2407, .0741,
     2 3.3171, -.0976, 6., 10., -1.5, .25, 12., -.059491, 6.62645,
     2 74.23066 /
      DATA F4/ 5., 12., -.71429, .14286, -5., 20., 50., .69, .752,
     1 .0124, .51733, .02413, 1.724, 4., 20., 35., -.16667, .041667,
     2 .22222, .022222, .4, 4., 9., 30., 1.08888, -.22222, .352,
     3 -.038, .014286, -.0004762, 0., 45., 50., .018681, .015357,
     4 .0010275, 7.75, -.11, 2.25, 0., 10., 20., 83., .417, .417,
     5 .0583, 1.31746, -.015873, 2.8, 8.1, 15., 50., 100., .0019,
     6 -.0003, .0014615, -.0001434, .00053478, -.00002899, .00013429,
     7 -.00000229, .000039, -.00000038, .000001 /
C    ******************************************************************
C    *  INITIAL CONDITIONS FOR PHOTOS
C
      DATA PHOT/12*0.,.06,.26,.44,.61,.75,.88,.97,1.03,1.05,1.07,
     A 0.,.09,.37,.62,.86,1.06,1.23,1.37,1.45,1.48,1.50,
     B 0.,.1,.42,.71,.98,1.21,1.41,1.56,1.66,1.69,1.71,
     C 0.,.1,.44,.74,1.03,1.27,1.48,1.64,1.74,1.78,1.80,
     D 0.,.1,.45,.76,1.05,1.30,1.52,1.68,1.79,1.83,1.85,
     E 0.,.1,.45,.76,1.06,1.32,1.54,1.70,1.81,1.85,1.87,
     F 0.,.1,.45,.77,1.07,1.32,1.54,1.71,1.82,1.86,1.88,
     G 0.,.1,.45,.77,1.07,1.32,1.55,1.71,1.82,1.86,1.88,
     H 0.,.1,.45,.77,1.07,1.32,1.55,1.72,1.82,1.86,1.88,
     I 0.,.1,.45,.77,1.07,1.32,1.55,1.71,1.82,1.86,1.88/
      DATA PHCT/12*0.,.29,.73,1.17,1.45,1.76,2.15,2.55,2.87,3.00,3.13,
     A 0.,.41,.96,1.65,2.14,2.60,3.20,3.73,4.01,4.05,4.10,
     B 0.,.47,1.06,1.85,2.48,3.07,3.78,4.38,4.70,4.75,4.84,
     C 0.,.49,1.09,1.93,2.62,3.26,4.06,4.69,4.91,4.86,4.92,
     D 0.,.50,1.11,1.96,2.69,3.38,4.22,4.87,5.10,5.05,5.11,
     E 0.,.50,1.11,1.98,2.73,3.44,4.29,4.96,5.19,5.15,5.20,
     F 0.,.51,1.12,1.98,2.74,3.47,4.33,5.00,5.24,5.20,5.25,
     G 0.,.51,1.12,1.99,2.75,3.48,4.35,5.03,5.27,5.22,5.28,
     H 0.,.50,1.12,1.99,2.75,3.49,4.36,5.04,5.28,5.23,5.29,
     I 0.,.50,1.12,1.98,2.75,3.49,4.36,5.04,5.28,5.24,5.29/
      DATA PHOT2/12*0.,.09,.39,.65,.90,1.10,1.26,1.39,1.46,1.49,1.51,
     A 0.,.13,.54,.91,1.27,1.55,1.79,1.97,2.09,2.13,2.15,
     B 0.,.14,.61,1.04,1.44,1.77,2.04,2.25,2.39,2.43,2.46,
     C 0.,.15,.64,1.08,1.51,1.85,2.15,2.37,2.51,2.56,2.59,
     D 0.,.15,.65,1.11,1.54,1.90,2.20,2.43,2.57,2.63,2.66,
     E 0.,.15,.66,1.12,1.56,1.92,2.23,2.46,2.61,2.66,2.69,
     F 0.,.15,.66,1.13,1.57,1.93,2.24,2.47,2.62,2.68,2.70,
     G 0.,.15,.67,1.13,1.58,1.94,2.25,2.48,2.63,2.68,2.71,
     H 0.,.15,.67,1.13,1.58,1.94,2.25,2.48,2.63,2.69,2.72,
     I 0.,.15,.67,1.13,1.58,1.94,2.25,2.49,2.63,2.69,2.72/
      DATA PHCT2/12*0.,.43,1.04,1.65,2.16,2.71,3.16,3.44,3.60,3.67,3.68,
```

```
     A 0.,.60,1.38,2.34,3.18,3.99,4.75,5.25,5.55,5.67,5.70,
     B 0.,.68,1.51,2.62,3.68,4.70,5.61,6.22,6.58,6.73,6.77,
     C 0.,.71,1.56,2.73,3.88,5.00,6.05,6.77,7.21,7.39,7.44,
     D 0.,.73,1.58,2.78,3.99,5.18,6.28,7.04,7.49,7.69,7.74,
     E 0.,.74,1.59,2.80,4.04,5.27,6.39,7.17,7.64,7.84,7.89,
     F 0.,.74,1.60,2.81,4.06,5.32,6.45,7.24,7.71,7.91,7.97,
     G 0.,.74,1.60,2.82,4.07,5.34,6.48,7.28,7.75,7.95,8.01,
     H 0.,.74,1.60,2.82,4.08,5.35,6.49,7.29,7.77,7.97,8.03,
     I 0.,.74,1.60,2.82,4.08,5.36,6.50,7.30,7.78,7.98,8.04/
C   *******************************************************************
C   *  INITIAL CONDITIONS FOR MSTEM
C
       DATA AGEIN/12.,12.,12.,11.,11.,11.,10.,10.,10.,9.,9.,9.,8.,8.,8.,
     - 7.,7.,7.,6.,6.,6.,5.,5.,5.,4.,4.,4.,2.,2.,2.,90*0./
       DATA DWINOD/.063,.063,.063,.058,.058,.058,.053,.053,.053,.045,
     - .045,.045,.043,.043,.043,.035,.035,.035,.033,.033,.033,.028,
     - .028,.028,.023,.023,.023,.018,.018,.018,90*999.99/
       DATA AGEMS,NBGIN,RNMSIN / 3.,21,9. /
C   *******************************************************************
C   *  INITIAL CONDITIONS FOR MSLEAF
C
       DATA AGEMSL/.7,.7,.7,.6,.6,.6,.5,.5,.5,111*999.99/
       DATA DWMSL/.0062,.0062,.0062,.006,.006,.006,.0059,.0059,.0059,
     - 111*999.99/
       DATA ARMSL/1.4,1.4,1.4,1.35,1.35,1.35,1.3,1.3,1.3,111*999.99/
       DATA RNMSL, NMSL  /9.0,9 /
C   *******************************************************************
C   *  INITIAL CONDITIONS FOR BRANGR
C
       DATA AGEBR/30*999.99 /
       DATA  RNBRIN / 30*999.99 /
       DATA DWBRIN / 120*999.99/
       DATA AGBRIN / 120*999.99 /
       DATA RNBR         /     0.0          /
C   *******************************************************************
C   *  INITIAL CONDITIONS FOR BRLFGR
C
       DATA RNBL/ 30*999.99/
       DATA AGEBL/ 120*999.99/
       DATA DWBL/ 120*999.99/
       DATA ARBL/ 120*999.99/
C   *******************************************************************
C   *  INITIAL CONDITIONS FOR TUBER
C
       DATA TUBSTS /0.5           /
       DATA TUBIS /.2, .1, .05, .0, .2, .1, .05, .0, .2, .1, .05, .0,
     $             .2, .1, .05, .0, .2, .1, .05, .0, .2, .1, .05, .0,
     $             .2, .1, .05, .0, .2, .1                     /
       DATA DWTUB /30*999.99/
       DATA AGETUB /30*999.99   /
       DATA NTUB / 0 /
C   *******************************************************************
C   *  INITIAL CONDITIONS FOR FIBRTG
C
       DATA AGEFR,DWFR,FRL,FRSUBL/8.,.03642,10.56,5.28/
C   *******************************************************************
C   *  INFO FOR SENESCENCE
C
       DATA DWDEDL, NDEDL        /0.0 ,0 /
C   *******************************************************************
C   *  INFO FOR DEQSOL
C
       DATA DELTA                  /1.0  /
       END
$$$$$INITL
       SUBROUTINE INITL
C   *******************************************************************
C   *  INITL IS USED PRIMARILY FOR ZEROING TOTALS, AT THE BEGINNING OF
C   *  THE RUN.
C   *******************************************************************
C
......(COMMONS INFO AND TOTALS GO HERE)
```

```
C
C   ***********************************************************************
C   *  INITIALIZE TOTALS, IDACNT, AND WERR
C
      IDACNT=0
      WERR=0.0
      TTRANS=0.0
      TPHPP=0.0
      TGRPBI=0.0
      TGRPMI=0.0
      TGRPML=0.0
      TGRPBR=0.0
      TGRPBL=0.0
      TGRPTU=0.0
      TGRPFR=0.0
      TMRPBI=0.0
      TMRPMS=0.0
      TMRPML=0.0
      TMRPBR=0.0
      TMRPBL=0.0
      TMRPTU=0.0
      TMRPFR=0.0
      TTMRP=0.0
      TTGRP=0.0
      TTRP=0.0
      RETURN
      END
$$$$$DASTRT
      SUBROUTINE DASTRT
C   ***********************************************************************
C   *  DASTRT IS CALLED AT THE BEGINNING OF EACH DAY.  IT PERFORMS THOSE
C   *  CALCULATIONS NEEDED AT THE DAILY LEVEL.
C   ***********************************************************************
C
......(COMMONS STVAR, INFO, TOTALS, CLIMAT AND PARAM GO HERE)
C
C   ***********************************************************************
C   *  UPDATE THE RUN DATE:
C
      IDATE=IDATE+1
C   ***********************************************************************
C   *  CONVERT TO METRIC:
C   *  TEMPERATURES FROM FAHRENHEIT TO CENTIGRADE:
C
      AVTEMP(IDATE)=(AVTEMP(IDATE)-32.) *0.5555556
      AVAMP(IDATE)=AVAMP(IDATE)*0.5555556
      DEWPT=(ADEWPT(IDATE)-32.)*0.5555556
C
C   *  WIND FROM MILES/DAY TO M/SEC
C
      WINDSP=WIND(IDATE)*0.01863
C   ***********************************************************************
C   *  RADIATION CALCULATIONS:
C   *  DETERMINE A STARTING RADIATION FIGURE:
C
      DAYRAD =(DTRAD(IDATE)*DYRCON)/CMLAI
C
C   *  SAVE OLD OVERCAST/CLEAR FIGURES, AND CALCULATE NEW ONES:
C
      DRCP=DRC
      DROP=DRO
      FCL=(DTRAD(IDATE)-DROP)/(DRCP-DROP)
      FOV=1.0-FCL
      IF(FOV .LT. 0.0) FOV=0.0
      DRC=0.0
      DRO=0.0
C   ***********************************************************************
C   *  CALCULATE DAYLENGTH IN HOURS THROUGH DECLINATION:
C
      DEC=-23.4*.01745*COS(6.2832*(IDATE+DAYOFF)/365.)
      DAYHRS=7.639435 * ARCOS(-TAN(DLAT)* TAN(DEC))
C   ***********************************************************************
```

```
C   *  ADD DAILY VALUES TO TOTALS, THEN ZERO DAILY VALUES:
C
       TTRANS=TTRANS+DTRANS
       TPHPP=TPHPP+DPHPP
       TGRPBI=TGRPBI+DGRPBI
       TGRPMI=TGRPMI+DGRPMI
       TGRPML=TGRPML+DGRPML
       TGRPBR=TGRPBR+DGRPBR
       TGRPBL=TGRPBL+DGRPBL
       TGRPTU=TGRPTU+DGRPTU
       TGRPFR=TGRPFR+DGRPFR
       TMRPBI=TMRPBI+DMRPBI
       TMRPMS=TMRPMS+DMRPMS
       TMRPML=TMRPML+DMRPML
       TMRPBR=TMRPBR+DMRPBR
       TMRPBL=TMRPBL+DMRPBL
       TMRPTU=TMRPTU+DMRPTU
       TMRPFR=TMRPFR+DMRPFR
       TTMRP=TTMRP+DTMRP
       TTGRP=TTGRP+DTGRP
       TTRP=TTRP+DTRP
C
       DTRANS=0.0
       DPHPP=0.0
       DGRPBI=0.0
       DGRPMI=0.0
       DGRPML=0.0
       DGRPBR=0.0
       DGRPBL=0.0
       DGRPTU=0.0
       DGRPFR=0.0
       DMRPBI=0.0
       DMRPMS=0.0
       DMRPML=0.0
       DMRPBR=0.0
       DMRPBL=0.0
       DMRPTU=0.0
       DMRPFR=0.0
       DTMRP=0.0
       DTGRP=0.0
       DTRP=0.0
       DCGR=0.0
       RETURN
       END
$$$$$WEATHR
       SUBROUTINE WEATHR
C   *****************************************************************
C   *  WEATHR TAKES THE DAILY WEATHER VALUES PROVIDED BY (DASTRT), AND
C   *  CALCULATES HOURLY VALUES FOR USE BY THE GROWTH ROUTINES.
C   *
C   *****************************************************************
C
......(COMMONS INFO, CLIMAT AND PARAM GO HERE)
C
C   *****************************************************************
C   *  CALCULATE AIR AND SOIL TEMPERATURES USING SINE APPROXIMATIONS.
C
       TAIR=AVTEMP(IDATE)+AVAMP(IDATE)*SIN(6.2832*(IHOUR-TAHOFF)/24.0)
       AVTS=AVTS + (AVTEMP(IDATE)-AVTS) / AVTSDV
       TSOIL=AVTS + TSAMPM *AVAMP(IDATE)*SIN(6.2832*(IHOUR-TSHOFF)/24.)
C   *****************************************************************
C   *  USE OVERCAST/CLEAR RADIATION TABLES, WITH SINE OF THE HEIGHT OF
C   *  THE SUN, TO DETERMINE POTENTIAL RADIATION:
C
       SNHSUN=SIN(DLAT)*SIN(DEC)+COS(DLAT)*COS(DEC)*COS(6.2832*
     $ (IHOUR-SNHOFF)/ 24.0)
       IF(SNHSUN .LT. 0.0) SNHSUN=0.0
C
C   *  USE OF CR TABLES (PREVIOUSLY FUNCTION SANTRP) - MJG
C
       XPTR= SNHSUN*10. + 1.
       I = XPTR
```

```
      FRAC = XPTR - I
      IF(I.GE.11) GO TO 20
      IF(I.LT.1) GO TO 10
      CRC = CRCT(I) + FRAC * (CRCT(I+1)-CRCT(I))
      CRO = CROT(I) + FRAC * (CROT(I+1)-CROT(I))
      GO TO 30
   10 CRC = CRCT(1)
      CRO = CROT(1)
      GO TO 30
   20 CRC = CRCT(11)
      CRO = CROT(11)
   30 CONTINUE
C     ******************************************************************
C     *  ADD TO DAILY TOTAL:
C
      DRC=DRC+CRC/24.0
      DRO=DRO+CRO/24.
C     ******************************************************************
C     *  DETERMINE ACTUAL RADIATION BASED ON FRACTION CLEAR/OVERCAST:
C
      ACR=FCL*CRC/24.0 + FOV*CRO/24.0
      RETURN
      END
$$$$$PLWAT
      SUBROUTINE PLWAT
C     ******************************************************************
C     *  PLWAT DETERMINES THE PLANT WATER BALANCE, USING ENVIRONMENT
C     *  MOISTURE CONDITIONS, AND NEEDS OF THE PLANT.  RELATIVE WATER
C     *  CONTENT (RWCPL) IS MODIFIED DEPENDING ON THE PLANT'S ABILITY TO
C     *  OBTAIN ITS WATER REQUIREMENT.
C     *
C     ******************************************************************
C
......(COMMONS LOCL, STVAR, DERIV, INFO, TOTALS, CLIMAT, PARAM AND
......  FUNCT1 GO HERE
C
      DIMENSION EW(4)
C     ******************************************************************
C     *  SATURATION VAPOR PRESSURE (MM HG) FUNCTION (MORGAN AND GOUDRIAAN)
C
      SATVP(T)  =SATM*EXP((17.269*T)/(T+237.28))
C     ******************************************************************
C     *  AT NIGHT TRANSP = 0
C
      TRANSP=0.0
      IF (ACR .LE. 0.0) GO TO 700
C     ******************************************************************
C     *  CALCULATE PERCENT COVER, HEIGHT OF CANOPY, AND PERCENT TOTAL
C     *  LEAVES STILL ALIVE:
C
      PCOVER=ZERO
      IF(CMLAI.GE.T1L1) PCOVER=T1P1*CMLAI
      IF(CMLAI.GT.T1L2) PCOVER=ONE*100.
C
      HEIGHT=NMSIN*HTINT
C
      NLVTOT=NMSL+NBLT
      PLIVLV=100.0*(NLVTOT-NDEDL)/NLVTOT
C     ******************************************************************
C     *  CALCULATE SATURATION VP AND SLOPE OF SAT. VP VS TEMP CURVE
C
      SATVPA=SATVP(TAIR)
      SLOPE=SLOPEM   *SATVPA/(TAIR+237.28)**2
C
C     *  CALCULATE ACTUAL VP OF THE AIR
C
      ACVP=SATVP(AMIN1(DEWPT, TAIR) )
C     ******************************************************************
C     *  CALCULATE NET THERMAL RAD. (LY/DAY) FOR S. IDAHO
C     *  (JENSEN 1974 PI5-27)
C
      TRNET= (TRNFCI*FCL+TRNFCS)*(TRNACI+TRNACS*SQRT(ACVP/ACVPDV))
```

```
      $ *11.71E-08*(TAIR+273.) **4
C     ***********************************************************************
C     *  CALCULATE NET RADIATION (EQ. 3.5 OF JENSEN, 1974)  ALBEDO FROM
C     *  NKMERDIAN, ACR ENTERS ON HR BASIS, CONVERT IT TO DAY BASIS
C
      RNET=((1.0-ALBEDO)*ACR - TRNET/24.0)
C     ***********************************************************************
C     *  USE RIJTEMA (1965) EQUATION TO CALCULATE ET.
C     *  EFFECT OF HEIGHT:
C
      GFUNCT=T2P1
      IF(HEIGHT.LE.T2L1) GFUNCT=T2P2 + T2P3*ALOG(HEIGHT)
      IF(HEIGHT.LE.T2L2) GFUNCT=T2P4
      GFUNCT=GFUNCT/24.
C
C     *  EFFECT OF WINDSPEED (M/SEC):
C
      HFUNCT=T3P1
      IF(WINDSP.GE.T3L1) HFUNCT=T3P2 + T3P3*WINDSP
      IF(WINDSP.GE.T3L2) HFUNCT=T3P4 + T3P5*WINDSP
      IF(WINDSP.GE.T3L3) HFUNCT=T3P6 + T3P7*WINDSP
      IF(WINDSP.GE.T3L4) HFUNCT=T3P8*WINDSP**(T3P9)
      IF(WINDSP.GT.T3L5) HFUNCT=T3P10
C
C     *  DIFFUSION RESISTANCE VS. MEAN RAD. INTENSITY (LY/MIN)
C
      RL=T4P1
      IF(ACR/ACRDV.GE.T4L1) RL=T4P2 + T4P3*(ACR/ACRDV) +
     $ T4P4*(ACR/ACRDV)**2
      IF(ACR/ACRDV.GT.T4L2) RL=ZERO
C
C     *  CALCULATE DIFFUSION RES. VS. PERCENT SOIL COVER
C
      RC=T5P1
      IF(PCOVER.GE.T5L1) RC = T5P2 + T5P3*PCOVER
      IF(PCOVER.GE.T5L2) RC = T5P4 + T5P5*PCOVER
      IF(PCOVER.GE.T5L3) RC = T5P6 + T5P7*PCOVER
      IF(PCOVER.GE.T5L4) RC = T5P8 + T5P9*PCOVER
      IF(PCOVER.GE.T5L5) RC = T5P10 + T5P11*PCOVER
      IF(PCOVER.GE.T5L6) RC = T5P12 + T5P13*PCOVER
      IF(PCOVER.GE.T5L7) RC = T5P14 + T5P15*PCOVER
      IF(PCOVER.GE.T5L8) RC = T5P16 +T5P17*PCOVER
      IF(PCOVER.GT.T5L9) RC=ZERO
C
C     *  CALCULATE POTENTIAL ET, INCLUDE NKMERDIAN ADVECTION CORRECTION
C
      EAP=GFUNCT*HFUNCT*WINDSP*(SATVPA-ACVP)
      IF(WINDSP .GT. WNDMIN) EAP=EAP/WINDSP
      TOP= SLOPE*RNET/HLVAP+ PC*EAP
      DENOM=SLOPE+PC*(1+GFUNCT*HFUNCT*WINDSP) *(RL+RC)*24.0
      POTET=TOP/DENOM
C
C     *  CALCULATE DIFFUSION RES DEPENDING ON SOIL MOISTURE SUPPLY AND
C     *  ULTIMATELY STOMATAL BEHAVIOR
C
      RPL=T6P1
      IF(PLIVLV.GT.T6L1) GO TO 1
      RPL=T6P2
      GO TO 2
    1 IF(PLIVLV.LT.T6L2) RPL=T6P3 + T6P4/PLIVLV
C
C     *  HYDRAULIC CONDUCTIVITY (MM/DAY) AND SOIL WATER POTENTIAL IN CMH20
C     *  REL FOR DIABLO LOAM WILLIS 1960 SSSAP24:239-242
C
    2 XK=XKM/(PSISOL*PSISOL + PSIOFF)
C
C     **  CONVERT PSISOL TO ATM. FROM CM H2O
C
      PSILPT=POTET*(RPL+B/XK)+PSISOL*PSIMLT
C
      RPSI=ZERO
      IF(PSILPT.GE.T7L1) RPSI = T7P1*PSILPT
```

```
      IF(PSILPT.GE.T7L2) RPSI = T7P2 + T7P3*PSILPT
      IF(PSILPT.GE.T7L3) RPSI = T7P4 + T7P5*PSILPT
      IF(PSILPT.GE.T7L4) RPSI=T7P6 + T7P7*PSILPT + T7P8*PSILPT**2
      IF(PSILPT.GT.T7L5) RPSI=T7P9
C
C   *  CALCULATE ET AND CORRECT FOR LOW LAI
C
      DENOM2= (SLOPE+PC*(1. +GFUNCT*HFUNCT*WINDSP)*(RL+RC+RPSI)*24.0     )
      ET=TOP/DENOM2
      CROPET=AMIN1(1.0, CMLAI)*ET
700   CONTINUE
C   ***********************************************************************
C   *  TRANSP IN MM/HR, CONVERT TO CM3/HR PL
C
      TRANSP = (CROPET*1000.0)/DENS
C   ***********************************************************************
C   *  CALCULATE WATER UPTAKE IN CM3/PL HR.
C   *  WEIGHT FOR SUBERIZATION:
C
      EFLFLR=T8P1
      IF(TDWFR.GE.T8L1) EFLFLR=T8P2 + T8P3*TDWFR
      IF(TDWFR.GE.T8L2) EFLFLR=T8P4 + T8P5*TDWFR
      IF(TDWFR.GE.T8L3) EFLFLR=T8P6 + T8P7*TDWFR
      IF(TDWFR.GE.T8L4) EFLFLR=T8P8 + T8P9*TDWFR
      IF(TDWFR.GE.T8L5) EFLFLR=T8P10 + T8P11*TDWFR
      IF(TDWFR.GE.T8L6) EFLFLR=T8P12
      ELNFR=EFLFLR*FRL
C
C   *  FIGURE WATER UPTAKE BASED ON ROOT ABILITY AND EXISTING SOIL H20.
C   *  BASE VALUE .292 G/M HR FOR UPTAKE.
C
      WUR=(WURINT+WURS*TSOIL)*(PSINRM/PSISOL)
      AFRL=FRL-FRSUBL
C
      RUPT=ELNFR*WUR*RUPLIM
C   ***********************************************************************
C   *  CALCULATE WATER IN THE PLANT, DEFICITS:
C   *  FIGURE DRY MATTER FRACTION OF TOTAL PLANT:
C
      DMFPL=( (TDWBGI+TDWMSI+TDWBRI) * DMFIN + (TDWMSL+TDWBRL)*DMFLV +
     $ TDWTUB*DMFTUB + TDWFR*DMFFR) / TDW
C
C   *  DETERMINE RELATIVE WATER CONTENT, MAX POSSIBLE, DEFICIT NEEDING
C   *  CORRECTION:
C
      RWCPL=WATPL/ (TDW/DMFPL -TDW)
      WATMAX=TDW/DMFPL -TDW
      WATDEF=WATMAX-WATPL
      IF(WATDEF .LT. 0.0) WATDEF=0.0
C
C   *  ACTUAL UPTAKE IS MINIMUM OF THAT NEEDED VS AMOUNT OBTAINABLE:
C
      TPDEF=WATDEF/DELTA + TRANSP
      UPTAKE=AMIN1(TPDEF,RUPT)
C
C   *  CHANGE OF WATER CONTENT IS OBTAINED MINUS OBTAINED:
C
      CWATPL=UPTAKE-TRANSP
C   ***********************************************************************
C   *  CALCULATE THE EFFECT OF RELATIVE WATER CONTENT ON ROOTS (EWFRG),
C   *  TUBERS (EWTUBG), STEMS (EWSTG), AND LEAVES (EWLFG):
C
      DO 800 I=1,4
      EW(I)=YINT(I) + RWCMLT*RWCPL
      IF(EW(I) .GT. ONE) EW(I)=ONE
      IF(EW(I) .LT. ZERO) EW(I)=ZERO
800   CONTINUE
      EWFRG=EW(1)
      EWTUBG=EW(2)
      EWSTG=EW(3)
      EWLFG=EW(4)
      RETURN
```

```
      END
$$$$$PHOTOS
      SUBROUTINE PHOTOS
C     *******************************************************************
C     *  PHOTOS CALCULATES THE AMOUNT OF PHOTSYNTHESIS CARRIED ON BY THE
C     *  PLANT, GIVEN THE CURRENT LEAF ACTIVITY, H20 CONTENT, TEMPERATURE,
C     *  AND INCIDENT RADIATION.
C
C     *******************************************************************
C
......(COMMONS LOCL, DERIV, INFO, CLIMAT, PARAM AND FUNCT1 GO HERE)
C
C     *******************************************************************
C     *  TEMPORARY NAMELIST AND INITIALIZATION FOR EFFECT OF TUBERIZATION
C     *  ON PHOTOSYNTHESIS LEVEL (EFBPST TABLE):
C
      DIMENSION EFBPST(13)
      DATA EFBPST/ 13.,0.,0.,.1,0.,.25,.4,.55,.65,1.0,.85,1.5,1.0/
      NAMELIST/PHEFB/ EFBPST
C
      IF(IDAY.EQ.1.AND.IHOUR.EQ.1) READ(5,PHEFB)
C     *******************************************************************
C     **  INITIALIZE TEMPORARY VARIABLES:
C
      ETPH=0.0
      EFBPS=0.0
      EWPH=0.0
      PHCR=0.0
      PHCRPP=0.0
C     *******************************************************************
C     *  SKIP CALCULATIONS IF THE SUN IS NOT ABOVE THE HORIZON.
C
      IF (SNHSUN .LE. 0) GO TO 20
C     *******************************************************************
C     *  CONVERT SINE OF THE HEIGHT OF THE SUN BACK TO ANGLE ABOVE THE
C     *  HORIZON (DEGREES):
C
      SUNANG=ARSIN(SNHSUN) * 57.29578
C     *******************************************************************
C     *  INTERPOLATE IN THE OVERCAST/CLEAR TUBERIZED/UNTUBERIZED TABLES
C     *  TO GET GROSS PHOTOSYNTHESIS FOR CURRENT CONDITIONS FOR EACH OF THE
C     *  FOUR POSSIBLE SITUATIONS:
C
      PHC1=STINTR (PHCT, CMLAI, 1.0, 0.0, SUNANG, 0.1, 0.5, 11, 11)
      PHO1=STINTR (PHOT, CMLAI, 1.0, 0.0, SUNANG, 0.1, 0.5, 11, 11)
      PHC2=STINTR (PHCT2, CMLAI, 1.0, 0.0, SUNANG, 0.1, 0.5, 11, 11)
      PHO2=STINTR (PHOT2, CMLAI, 1.0, 0.0, SUNANG, 0.1, 0.5, 11, 11)
C     *******************************************************************
C     *  DETERMINE THE EFFECT OF TUBERIZATION ON PHOTOSYNTHESIS, THEN
C     *  WEIGHT THE USE OF CLEAR/OVERCAST TABLES ACCORDING TO THE PERCENT
C     *  TUBERIZATION EFFECT:
C
      CALL TABINT(EFBPST,AVDTRN,EFBPS,'EFBP')
      PHC=(1.0-EFBPS)*PHC1 + EFBPS*PHC2
      PHO=(1.0-EFBPS)*PHO1 + EFBPS*PHO2
C     *******************************************************************
C     *  CALCULATE THE EFFECT OF AIR TEMPERATURE ON PHOTOSYNTHESIS:
C
      ETPH=0.0
      IF(TAIR.GE.T9L1) ETPH=T9P1 + T9P2*TAIR
      IF(TAIR.GE.T9L2) ETPH=T9P3 + T9P4*TAIR + T9P5*TAIR**2
      IF(TAIR.GT.T9L3) ETPH=T9P6 + T9P7*TAIR + T9P8*TAIR**2
      IF(ETPH.GT.ONE) ETPH =ONE
      IF(ETPH.LT.ZERO) ETPH =ZERO
C     *******************************************************************
C     *  CALCULATE THE EFFECT OF PLANT H20 CONTENT ON PHOTOSYNTHESIS:
C
      EWPH=ZERO
      IF(RWCPL.GE.T10L1) EWPH=T10P1 + T10P2*RWCPL + T10P3*RWCPL**2
      IF(RWCPL.GT.T10L2) EWPH=ONE
C     *******************************************************************
C     *  USE EFFECT OF LEAF AGING ON PHOTOSYNTHESIS, WITH FRACTION OF CLEAR
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C   *   AND OVERCAST SKIES, TO DETERMINE ACTUAL PHOTOSYNTHESIS; MODIFY
C   *   THIS BY THE MOST LIMITING EFFECT OF H20 OR TEMP:
C
        PHCR=( FCL*PHC + FOV*PHO) *EAGPSL *AMIN1(EWPH,ETPH)
C   ************************************************************************
C   *   ADJUST FOR USE OF NON-POTATO PHOTOSYNTHESIS TABLES (BY PHCCCR),
C   *   THEN CHANGE FROM PHOTOS/UNIT AREA (M2) TO PHOTOS/PLANT.
C
        PHCR=PHCR * PHCCOR
        PHCRPP=PHCR/DENS
   20 CONTINUE
        RETURN
        END
$$$$$MSTEM
        SUBROUTINE MSTEM
C   ************************************************************************
C   *   MSTEM CALCULATES THE INITIATION AND GROWTH OF INTERNODES ON THE
C   *   MAINSTEMS.  NO MAINSTEM IS CONSIDERED DOMINANT, SO ALL MAINSTEMS
C   *   ARE DEVELOPED IN PARALLEL.
C   *
C   ************************************************************************
C
......(COMMONS LOCL, STVAR, DERIV, INFO, PARAM AND FUNCT2 GO HERE)
C
C   ************************************************************************
C   *   CALCULATE ABOVE- AND BELOW-GROUND DEVELOPMENTAL RATES AS FUNCTIONS
C   *   OF AIR AND SOIL TEMPERATURE:
C   *   ABOVE-GROUND:
C
        DEVRAG=ZERO
        IF(TAIR.GE.T11L1)  DEVRAG=T11P1 + T11P2*TAIR
        IF(TAIR.GE.T11L2)  DEVRAG=T11P3 + T11P4*TAIR
        IF(TAIR.GE.T11L3)  DEVRAG=ONE
        IF(TAIR.GE.T11L4)  DEVRAG=T11P5 + T11P6*TAIR
        IF(TAIR.GE.T11L5)  DEVRAG=ZERO
C
C   *   BELOW-GROUND:
C
        DEVRBG=ZERO
        IF(TSOIL.GE.T11L1)  DEVRBG=T11P1 + T11P2*TSOIL
        IF(TSOIL.GE.T11L2)  DEVRBG=T11P3 + T11P4*TSOIL
        IF(TSOIL.GE.T11L3)  DEVRBG=ONE
        IF(TSOIL.GE.T11L4)  DEVRBG=T11P5 + T11P6*TSOIL
        IF(TSOIL.GE.T11L5)  DEVRBG=ZERO
        DEVRAG=DEVRAG/24.0
        DEVRBG=DEVRBG/24.0
C   ************************************************************************
C   *   INTERNODE INITIATION:
C   *   CALCULATE INTERNODE INITIATION RATE AS A FUNCTION OF AGE OF THE
C   *   MAINSTEMS:
C
        ANPNRA=ONE
        IF(AGEMS.GE.T12L1)  ANPNRA=T12P1 + T12P2*AGEMS
        IF(AGEMS.GT.T12L2)  ANPNRA=ZERO
        PNINR=ANPNRA*PNIR
C
C   *   THE TEMPERATURE EFFECT ON INIT. IS THE HOURLY DEV. RATE.
C   *   ALSO DETERMINE THE EFFECT OF PLANT RESERVES:
C
        ETNINR=DEVRAG    *24.0
C
        ERNINR=ZERO
        IF(PRES.GE.T13L1)  ERNINR=T13P1 + T13P2*PRES
        IF(PRES.GE.T13L2)  ERNINR=T13P3 + T13P4*PRES
        IF(PRES.GT.T13L3)  ERNINR=ONE
C
C   *   DETERMINE THE EFFECT OF MOTHER TUBER RESERVES, AS A FUNCTION OF
C   *   LENGTH OF PLANT GROWTH AND LEAF AREA FOR PHOTOSYNTHESIS:
C
        EMTRES=ZERO
        IF(IDAY .GT. MTSTOP) GO TO 5
        EMTRES=ONE
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      IF(AREALV.GE.T14L1) EMTRES=T14P1 + T14P2*AREALV +T14P3*AREALV**2
      IF(EMTRES.LT.T14P4) EMTRES=T14P4
      IF(AREALV.GT.T14L2) EMTRES=T14P5 + T14P6*AREALV
      IF(AREALV.GE.T14L3) EMTRES=ZERO
C
C  *   ACTUAL EFFECT OF RESERVES ON INIT. IS THE MAX OF PLANT RESERVE
C  *   EFFECT AND MOTHER TUBER RESERVE EFFECT:
C
    5 ERINR=AMAX1(ERNINR,EMTRES)
C
C  *   ACTUAL INTERNODE INITIATION RATE IS THE POTENTIAL RATE TIMES THE
C  *   MOST-LIMITING OF TEMP AND RESERVE EFFECTS:
C  **  (MULTIPLIED BY # MAINSTEMS TO KEEP ALL IN PARALLEL) MOD. - MJG
C
      ANINR=PNINR*AMIN1(ETNINR,ERINR) *NMST
C***********************************************************************
C  *   MAINSTEM DEVELOPMENTAL RATE IS THE ABOVE-GROUND RATE:
C
      DEVRMS=DEVRAG
C
C  **  (NUMBER OF ABOVE-GROUND INTERNODES IS MODULO 3,
C  **  ( TO KEEP ALL THREE MAINSTEMS EQUAL) MOD. - MJG
C
      NMSIN=INT(RNMSIN/3.0)*3
C
C  *   TOTAL NUMBER OF INTERNODES ON MAINSTEM IS SUM OF ABOVE- AND BELOW-
C  *   GROUND INTERNODES:
C
      NINTOT=NBGIN+NMSIN
C
C  **  (TECH. PROTECTION FOR TOO MANY INTERNODES) MOD. - MJG
C
      IF(NINTOT.GT.117) ANINR=0.0
C***********************************************************************
C  *   INTERNODE GROWTH:
C  *   CALCULATE EFFECT OF RESERVES ON INTERNODE GROWTH:
C
      ERMSG=ZERO
      IF(PRES.GE.T15L1) ERMSG=T15P1 + T15P2*PRES
      IF(PRES.GT.T15L2) ERMSG=ONE
C
C  *   ACTUAL EFFECT OF RESERVES IS MAX OF EFFECT OF PLANT RESERVES AND
C  *   EFFECT OF MOTHER TUBER RESERVES:
C
      ERING=AMAX1(ERMSG,EMTRES)
C
C  *   ZERO TOTALS FOR ALL INTERNODES:
C
      TCWIN=0.0
      RTBGIN=0.0
      RTMSIN=0.0
C
C  *   CALCULATE EFFECT OF TEMPERATURE FOR ABOVE- AND BELOW-GROUND
C  *   INTERNODES, AS FUNCTIONS OF TEMP:
C
      ETAGIG=T16P1 + T16P2*TAIR
      IF(TAIR.GT.T16L1) ETAGIG=T16P3 + T16P4*TAIR
      IF(TAIR.GT.T16L2) ETAGIG=T16P5 + T16P6*TAIR
      IF(ETAGIG.LT.ZERO) ETAGIG=ZERO
      IF(ETAGIG.GT.ONE) ETAGIG=ONE
C
      ETBGIG=T16P1 + T16P2*TSOIL
      IF(TSOIL.GT.T16L1) ETBGIG=T16P3 + T16P4*TSOIL
      IF(TSOIL.GT.T16L2) ETBGIG=T16P5 + T16P6*TSOIL
      IF(ETBGIG.LT.ZERO) ETBGIG=ZERO
      IF(ETBGIG.GT.ONE) ETBGIG=ONE
C***********************************************************************
C  *   BELOW-GROUND GROWTH:
C  *   CALCULATE LIMITER FOR BELOW-GROUND GROWTH AS MOST-LIMITING OF
C  *   RESERVE EFFECT, TEMP EFFECT, H20 EFFECT:
C
      GLIMMS=AMIN1(ERING,ETBGIG,EWSTG)
```

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C
C   *  FOR EVERY BELOW-GROUND INTERNODE:
C
      DO 100 I=1,NBGIN
C
C   *  DETERMINE EFFECT OF INTERNODE AGE ON ITS GROWTH:
C
      EAGEIG=ONE
      IF(AGEIN(I).GE.T17L1) EAGEIG=T17P1 + T17P2*AGEIN(I) +
     $ T17P3*AGEIN(I)**2
      IF(AGEIN(I).GT.T17L2) EAGEIG=T17P4 + T17P5*AGEIN(I)
C
C   *  GROWTH FOR THIS HOUR IS POTENTIAL RATE MODIFIED BY EFFECT OF AGE
C   *  AS WELL AS LIMITER DEFINED ABOVE (GLIMMS);
C   *  AND IS A FUNCTION OF CURRENT WEIGHT:
C
      GR=RINOD*EAGEIG*GLIMMS*DWINOD(I)
      CWINOD(I)=GR
C
C   *  ADD RATES TO TOTALS:
C
      RTBGIN=RTBGIN+GR
      DEVRIN(I)=DEVRBG
      TCWIN=CWINOD(I)+TCWIN
100   CONTINUE
C   ******************************************************************
C   *  ABOVE-GROUND GROWTH:
C   *  DETERMINE FIRST ABOVE-GROUND INTERNODE,
C   *  CALCULATE LIMITER (GLIMMS) FOR THE ABOVE-GROUND SITUATION:
C
      N=NBGIN+1
C
      GLIMMS=AMIN1(ERING, ETAGIG, EWSTG)
C
C   *  FOR EVERY ABOVE-GROUND INTERNODE:
C
      DO 200 I=N,NINTOT
C
C   *  IF THE INTERNODE IS NEW, (DW=999.99) SET ITS INITIAL RATES:
C
      IF (DWINOD(I) .NE. 999.99) GO TO 140
      DWINOD(I)=STINRT
      RTMSIN=RTMSIN+STINRT
      AGEIN(I)=0.0
140   CONTINUE
C
C   *  CALCULATE EFFECT OF INTERNODE AGE ON GROWTH:
C
      EAGEIG=ONE
      IF(AGEIN(I).GE.T17L1) EAGEIG=T17P1 + T17P2*AGEIN(I) +
     $ T17P3*AGEIN(I)**2
      IF(AGEIN(I).GT.T17L2) EAGEIG=T17P4 + T17P5*AGEIN(I)
C
C   *  GROWTH IS AS FOR BELOW-GROUND INTERNODES:
C
      GR=RINOD*EAGEIG*GLIMMS*DWINOD(I)
      CWINOD(I)=GR
C
C   *  TOTALS AS BEFORE:
C
      RTMSIN=RTMSIN+GR
      DEVRIN(I)=DEVRAG
      TCWIN=CWINOD(I)+TCWIN
200   CONTINUE
      RETURN
      END
$$$$$MSLEAF
      SUBROUTINE MSLEAF
C   ******************************************************************
C   *  MSLEAF DEVELOPS A LEAF FOR EVERY ABOVE-GROUND INTERNODE,
C   *  AND CALCULATES WEIGHT AND AREA GROWTH FOR EACH.
C   *
```

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C     ************************************************************************
C
C.....(COMMONS LOCL, STVAR, DERIV, INFO, PARAM AND FUNCT2 GO HERE)
C
C     ************************************************************************
C     *  TEMPORARY NAMELIST AND INITIALIZATION FOR SENESCENCE ROUTINE MJG
         DATA T36L1, T36L2, T36P1, T36P2, T36P3, T36P4, T36P5, RSLOSS /
        -     40.,    80.,    55.,    0.375, 60.0,  -0.5,  20.0,  0.02083 /
C
         NAMELIST/MLSEN/ T36L1, T36L2, T36P1, T36P2, T36P3, T36P4, T36P5,
        - RSLOSS
C
         IF(IDAY.EQ.1.AND.IHOUR.EQ.1) READ(5,MLSEN)
C     ************************************************************************
C     *  INITIATION OF MAINSTEM LEAVES:
C     *  DETERMINE INITIATION OF LEAVES, MODIFIED BY MAINSTEM AGE:
C
         PLINR=ONE
         IF(AGEMS.GE.T12L1) PLINR=T12P1 + T12P2*AGEMS
         IF(AGEMS.GT.T12L2) PLINR=ZERO
         PLINR=PLINR*PMLINR
C
C     *  CALCULATE TEMP EFFECT (HOURLY DEV. RATE), AND EFFECT OF RESERVES:
C
         ETLINR=DEVRAG  *24.0
C
         ERLINR=ZERO
         IF(PRES.GE.T13L1) ERLINR=T13P1 + T13P2*PRES
         IF(PRES.GE.T13L2) ERLINR=T13P3 + T13P4*PRES
         IF(PRES.GE.T13L3) ERLINR=ONE
C
C     *  ACTUAL EFFECT OF RESERVES IS MAX OF PLANT RESERVES EFFECT AND
C     *  MOTHER TUBER RESERVE EFFECT:
C
         ERLIR=AMAX1 (ERLINR,EMTRES)
C
C     *  ACTUAL INITIATION RATE IS POTENTIAL MODIFIED BY MOST-LIMITING OF
C     *  TEMP AND RESERVES:
C     ** (CHANGED TO INCLUDE MULTIPLE MAINSTEMS, AS IN MSTEM) MOD. - MJG
C
         AMLINR=PLINR*AMIN1(ETLINR,ERLIR) *NMST
C
C     ** (NUMBER OF MAINSTEM LEAVES IS EQUAL FOR ALL THREE MAINSTEMS
C     ** ( AS IN MSTEM) MOD. - MJG
C
         NMSL=INT(RNMSL/3.0)*3
C
C     ** (TECH. PROTECTION FOR TOO MANY LEAVES) MOD. -MJG
C
         IF(NMSL.GT.117) AMLINR=0.0
C     ************************************************************************
C     *  LEAF GROWTH SECTION
C     *  DETERMINE EFFECT OF RESERVES AS MAX OF PLANT RESERVE EFFECT AND
C     *  MOTHER TUBER RESERVE EFFECT:
C
         ERMSLG=ZERO
         IF(PRES.GE.T18L1) ERMSLG=T18P1 + T18P2*PRES
         IF(PRES.GT.T18L2) ERMSLG=ONE
         ERMLG=AMAX1(ERMSLG,EMTRES)
C
C     *  CALCULATE EFFECT OF RADIATION AND TEMP ON SPECIFIC LEAF AREA:
C
         ERASLA=ONE
         IF(DAYRAD.GE.T19L1) ERASLA=T19P1 + T19P2*DAYRAD
         IF(DAYRAD.GT.T19L2) ERASLA=T19P3 + T19P4*DAYRAD
         IF(DAYRAD.GT.T19L3) ERASLA=T19P5
C
         ETSLA=ONE
C
C     *  EFFECT OF TEMPERATURE ON GROWTH
C
         ETMSLG=T16P1 + T16P2*TAIR
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      IF(TAIR.GT.T16L1) ETMSLG=T16P3 + T16P4*TAIR
      IF(TAIR.GT.T16L2) ETMSLG=T16P5 + T16P6*TAIR
      IF(ETMSLG.LT.ZERO) ETMSLG=ZERO
      IF(ETMSLG.GT.ONE) ETMSLG=ONE
C
C   *  WEIGHT GROWTH LIMITER IS THE MOST-LIMITING OF RESERVES, TEMP,
C   *  AND PLANT WATER; AREA GROWTH LIMITER IS THE MOST-LIMITING OF
C   *  TEMP AND RADIATION:
C
      GLIML=AMIN1(ERMLG, ETMSLG, EWLFG)
C
      ALIML= AMIN1(ETSLA,ERASLA)
C
C   *  ZERO TOTALS FOR GROWTH RATES:
C
      TCWMSL=0.0
      RTMSL=0.0
      CWDEDL=0.0
C
C   *  FOR EVERY MAINSTEM LEAF:
C
      DO 100 I=1,NMSL
C
C   *  IF IT HAS SENESCED (DW=888.88), DO NOT INCLUDE IT;
C   *  IF IT IS A NEW LEAF (DW=999.99), SET ITS INTIAL VALUES:
C
      IF(DWMSL(I) .EQ. 888.88) GO TO 100
      IF (DWMSL(I) .NE. 999.99) GO TO 60
      AGEMSL(I)=0.0
      DWMSL(I)=STLFRT
      RTMSL=RTMSL+STLFRT
      ARMSL(I)=SLAP*DWMSL(I)
60    CONTINUE
C
C   ** (CHANGE TO ALLOW DIFFERENTIAL SENESCENCE OF LEAVES) MOD. - MJG
C   *  DETERMINE 'DEATH-AGE' OF THE LEAF AS A FUNCTION OF ITS INITIATION
C   *  DATE RELATIVE TO THAT OF THE MAINSTEMS:
C
      LEAFST = AGEMS - AGEMSL(I)
      IF (LEAFST.GT.T36L1) GOTO 61
      DAGEML = T36P1 - T36P2 * LEAFST
      GOTO 62
61    DAGEML = T36P3 - T36P4 * LEAFST
      IF (LEAFST.GT.T36L2) DAGEML = T36P5
C
C   *  DETERMINE PERCENT OF LIFE LIVED; IF 100%, REMOVE THE LEAF:
C
62    PCTMSL = AGEMSL(I)/DAGEML
      IF (PCTMSL .LT. 1.) GO TO 82
      TCWMSL=TCWMSL-DWMSL(I)
      NDEDL=NDEDL+1
      DWMSL(I)=888.88
      GO TO 100
82    CONTINUE
C
C   *  SET THE LEAF'S DEV. RATE AT THE ABOVE-GROUND RATE:
C
      DEVRML(I)=DEVRAG
C
C   *  USE PERCENT OF LIFE LIVED TO DETERMINE IF SENESCING:
C
      IF(PCTMSL.GT.T35L2) GOTO 83
C
C   *  FOR LEAVES NOT SENESCING, DETERMINE GROWTH AS A RESULT OF AGE:
C
      EAGELG=ONE
      IF(PCTMSL.GE.T35L1) EAGELG=T35P1 + T35P2*PCTMSL
      IF(EAGELG.LT.0.) EAGELG=0.
C
C   *  GROWTH OF THE LEAF IS POTENTIAL MODIFIED BY AGE EFFECT AND
C   *  LIMITER DEFINED ABOVE (GLIML); GROWTH IS A FUNCTION OF CURRENT
C   *  WEIGHT:
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```
C
      GR=RMSL*EAGELG*GLIML*DWMSL(I)
      CWMSL(I)=GR
C
      RTMSL=RTMSL+GR
C   ***********************************************************************
C   *  DETERMINE EFFECT OF LEAF AGE ON LEAF AREA GROWTH:
C
      EAGEAG=ONE
      IF(AGEMSL(I).GE.T20L1)  EAGEAG=T20P1 + T20P2*AGEMSL(I)
      IF(AGEMSL(I).GE.T20L2)  EAGEAG=T20P3
      IF(AGEMSL(I).GT.T20L3)  EAGEAG=T20P4 + T20P5*AGEMSL(I)
      IF(AGEMSL(I).GT.T20L4)  EAGEAG=ZERO
C
C   *  CHANGE IN LEAF AREA IS CURRENT AREA TIMES SPECIFIC LEAF AREA
C   *  POTENTIAL, MODIFIED BY EFFECT OF AGE AND LIMITER DEFINED ABCVE:
C
      CARMSL(I)= CWMSL(I)*SLAP*EAGEAG*ALIML
C
C   *  SPECIFIC LEAF AREA IN CM2/G LEAF
C
      SLA=ARMSL(I)/DWMSL(I)
      GOTO 84
C   ***********************************************************************
C   *  TRANSLOCATION OF MATERIAL BACK FROM LEAF TO PLANT DURING
C   *  SENESCENCE:
C
83    IF(CWMSL(I).EQ.0.)
     $   CWMSL(I) = - RSLOSS *(DWMSL(I)/(DAGEML-AGEMSL(I)))
      CWDEDL=CWDEDL-CWMSL(I)
C
C   *  TOTALING OF WEIGHT CHANGES:
C
84    TCWMSL=TCWMSL+CWMSL(I)
85    CONTINUE
100   CONTINUE
      RETURN
      END
$$$$$BRANGR
      SUBROUTINE BRANGR
C   ***********************************************************************
C   *  SUBROUTINE BRANGR DETERMINES THE INITIALIZATION AND GROWTH CF
C   *  BRANCHES IN THE POTATO PLANT.
C   *
C   ***********************************************************************
C
......(COMMONS LOCL, STVAR, DERIV, INFO, PARAM AND FUNCT2 GO HERE)
C
C   ***********************************************************************
C   *  BRANCH INITIATION:
C   *  MODIFY POTENTIAL BRANCHING RATE BY ACTIVITY OF PREVIOUS BRANCHES,
C   *  IF ANY:
C
      NBR=RNBR
      ANPNRA=ANPNRA*CF
      IF(NBR .GE. 1) ANPNRA=(ABNIR(NBR)*CF)/PBNINR
      EBRAC=ONE
      IF(ANPNRA.GE.T26L1)  EBRAC=T26P1 + T26P2*ANPNRA
      IF(ANPNRA.GT.T26L2)  EBRAC=ZERO
C
C   *  EFFECT OF TEMP IS HOURLY DEV. RATE; ALSO DETERMINE EFFECT OF
C   *  RESERVES ON BRANCH INITIATION:
C
      ETBRIR=DEVRAG  *24.0
C
      ERBRIR =ZERO
      IF(PRES.GE.T27L1)  ERBRIR=T27P1 + T27P2*PRES
      IF(PRES.GT.T27L2)  ERBRIR=ONE
C
C   *  ACTUAL BRANCH INIT. RATE IS POTENTIAL RATE MODIFIED BY EFFECT OF
C   *  PREVIOUS BRANCHING AND THE MOST-LIMITING OF TEMP AND RESERVES:
C
```

```
      ABRIR=PBRIR*EBRAC*AMIN1(ETBRIR,ERBRIR)
C
C  ** (TECH. PROTECTION AGAINST TOO MANY BRANCHES) MOD. - MJG
C
      IF(RNBR.GT.29.0) ABRIR=0.0
C*****************************************************************
C  *  BRANCH INTERNODE INITIATION:
C  *  DETERMINE LIMITER AS MOST-LIMITING OF EFFECT OF RESERVES OR TEMP,
C  *  WHERE EFFECT OF TEMP IS HOURLY DEV. RATE:
C
      ETBNIR=DEVRAG   *24.0
C
      ERBNIR=ZERO
      IF(PRES.GE.T13L1) ERBNIR=T13P1 + T13P2*PRES
      IF(PRES.GE.T13L2) ERBNIR=T13P3 + T13P4*PRES
      IF(PRES.GT.T13L3) ERBNIR=ONE
C
      BNILIM=AMIN1(ETBNIR, ERBNIR)
C*****************************************************************
C  *  CONTINUE ONLY IF AT LEAST ONE BRANCH EXISTS:
C
      IF(NBR .LT. 1) RETURN
C
C  *  ZERO TOTAL # OF INTERNODES ON BRANCHES, FOR SUMMING:
C
      NBRIT=0
C
C  *  FOR EVERY BRANCH:
C
      DO 100 I=1,NBR
C
C  *  IF THE BRANCH IS A NEW ONE (AGE=999.99), SET ITS VALUES TO
C  *  INITIAL STATES:
C
      IF (AGEBR(I) .NE. 999.99) GO TO 50
      AGEBR(I)=0.0
      RNBRIN(I)=0.0
      RNBL( I )=0.0
50    CONTINUE
C
C  *  RESET THIS BRANCH'S INTERNODE INIT. RATE; ALSO INCLUDE ITS
C  *  INTERNODES IN THE TOTAL (NBRIT):
C
      ABNIR(I)=0.0
C
      NBRIN=RNBRIN(I)
      NBRIT=NBRIT+NBRIN
C
C  *  DETERMINE EFFECT OF AGING OF THIS BRANCH ON ITS INTERNODE INIT.
C  *  RATE:
C
      EABNIR=ONE
      IF(AGEBR(I).GE.T12L1) EABNIR=T12P1 + T12P2*AGEBR(I)
      IF(AGEBR(I).GT.T12L2) EABNIR=ZERO
C
C  *  ACTUAL INTERNODE INIT. RATE FOR THIS BRANCH IS POTENTIAL RATE
C  *  MODIFIED BY THE LIMITER DEFINED ABOVE AND THE EFFECT OF AGE:
C
      ABNIR(I)=PBNINR*BNILIM*EABNIR
60    CONTINUE
C
C  *  DEV. RATE OF THIS BRANCH IS THE ABOVE-GROUND DEV. RATE:
C
      DEVRBR(I)=DEVRAG
100   CONTINUE
C
C  *  CONTINUE ONLY IF THERE ARE INTERNODES TO PROCESS:
C
      IF(NBRIT .LE. 0) RETURN
C
C  ** (TECH. PROTECTION AGAINST TOO MANY BRANCH INTERNODES) MOD. - MJG
C
```

```
      IF(NBRIT .GT. 120) NBRIT = 120
C     ******************************************************************
C     *  BRANCH INTERNODE GROWTH:
C     *  RESET TOTALS:
C
      TCWBRI=0.0
      RTBRIN=0.0
C
C     *  DETERMINE EFFECT OF TEMP ON INTERNODE GROWTH:
C
      ETBRIG=T16P1 + T16P2*TAIR
      IF(TAIR.GT.T16L1) ETBRIG=T16P3 + T16P4*TAIR
      IF(TAIR.GT.T16L2) ETBRIG=T16P5 + T16P6*TAIR
      IF(ETBRIG.LT.ZERO) ETBRIG=ZERO
      IF(ETBRIG.GT.ONE) ETBRIG=ONE
C
C     *  DETERMINE EFFECT OF RESERVES ON INTERNODE GROWTH:
C
      ERBRIG=ZERO
      IF(PRES.GE.T15L1) ERBRIG=T15P1 + T15P2*PRES
      IF(PRES.GT.T15L2) ERBRIG=ONE
C
C     *  LIMITER IS MOST-LIMITING OF EFFECTS OF TEMP, RESERVES, AND H20:
C
      GLIMBI=AMIN1(ERBRIG, ETBRIG, EWSTG)
C
C     *  FOR EVERY INTERNODE:
C
      DO 200 I=1,NBRIT
C
C     *  IF THIS IS A NEW INTERNODE (DW=999.99), SET ITS VALUES TO INITIAL
C     *  LEVELS:
C
      IF (DWBRIN(I) .NE. 999.99) GO TO 150
      DWBRIN(I)=STINRT
      RTBRIN=RTBRIN+STINRT
      AGBRIN(I)=0.0
150   CONTINUE
C
C     *  DETERMINE EFFECT OF AGE OF INTERNODE ON ITS GROWTH:
C
      EABRIG=ONE
      IF(AGBRIN(I).GE.T17L1) EABRIG=T17P1 + T17P2*AGBRIN(I) +
     $ T17P3*AGBRIN(I)**2
      IF(AGBRIN(I).GT.T17L2) EABRIG=T17P4 + T17P5*AGBRIN(I)
C
C     *  GROWTH OF INTERNODE IS POTENTIAL RATE MODIFIED BY EFFECT OF AGE
C     *  AND LIMITER DEFINED ABOVE; GROWTH IS A FUNCTION OF CURRENT WEIGHT:
C
      GR=RINOD*EABRIG*GLIMBI*DWBRIN(I)
      CWBRIN(I)=GR
C
C     *  TOTALS:
C
      TCWBRI=TCWBRI+CWBRIN(I)
      RTBRIN=RTBRIN+GR
C
C     *  BRANCH INTERNODE DEV. RATE IS ABOVE-GROUND DEV. RATE:
C
      DEVBRI(I)=DEVRAG
200   CONTINUE
      RETURN
      END
$$$$$BRLFGR
      SUBROUTINE BRLFGR
C     ******************************************************************
C     *  THIS SUBROUTINE DETERMINES GROWTH AND SENESCENCE OF THE LEAVES
C     *  ON THE BRANCHES.
C     *
C     ******************************************************************
C
......(COMMONS LOCL, STVAR, DERIV, INFO, PARAM AND FUNCT2 GO HERE)
```

```
C
C     ******************************************************************
C     *   TEMPORARY NAMELIST AND INITIALIZATION FOR SENESCENCE ROUTINE MJG
          DATA T36L1, T36L2, T36P1, T36P2, T36P3, T36P4, T36P5, RSLOSS /
     -       40.,    80.,    55.,   0.375, 60.0,  -0.5,  20.0,  0.02083 /
C
          NAMELIST/BLSEN/ T36L1, T36L2, T36P1, T36P2, T36P3, T36P4, T36P5,
     -    RSLOSS
C
          IF(IDAY.EQ.1.AND.IHOUR.EQ.1) READ(5,BLSEN)
C     ******************************************************************
C     *   IF THERE ARE NO BRANCHES, SKIP THIS ROUTINE
C
          NBR=RNBR
          IF(NBR .LE. 0) RETURN
C     ******************************************************************
C     *   BRANCH LEAF INITIATION:
C     *   EFFECT OF TEMP IS HOURLY DEV. RATE; ALSO, DETERMINE EFFECT OF
C     *   RESERVES ON LEAF INIT.:
C
          ETBLIR=DEVRAG     *24.0
C
          ERBLIR=ZERO
          IF(PRES.GE.T13L1) ERBLIR=T13P1 + T13P2*PRES
          IF(PRES.GE.T13L2) ERBLIR=T13P3 + T13P4*PRES
          IF(PRES.GT.T13L3) ERBLIR=ONE
C
C     *   LIMITER IS MOST-LIMITING OF TEMP AND RESERVES:
C
          BLILIM=AMIN1(ETBLIR,ERBLIR)
C
C     *   RESET TOTAL # OF BRANCH LEAVES:
C
          NBLT=0
C
C     *   FOR EVERY BRANCH:
C
          DO 100 I=1,NBR
C
C     *   RESET BRANCH LEAF INIT. RATE; ALSO INCLUDE THIS BRANCH'S LEAVES
C     *   IN TOTAL (NBLT):
C
          ABLIR(I)=0.0
C
          NBL=RNBL(I)
          NBLT=NBLT+NBL
C
C     *   DETERMINE EFFECT OF AGE ON LEAF INITIATION:
C
          EABLIR=ONE
          IF(AGEBR(I).GE.T12L1) EABLIR=T12P1 + T12P2*AGEBR(I)
          IF(AGEBR(I).GT.T12L2) EABLIR=ZERO
C
C     *   ACTUAL BRANCH LEAF INIT. IS POTENTIAL RATE MODIFIED BY LIMITER
C     *   DEFINED ABOVE AND EFFECT OF AGING:
C
          ABLIR(I)=PBLIR*BLILIM*EABLIR
85        CONTINUE
100       CONTINUE
C
C     **  (TECH. PROTECTION AGAINST TOO MANY LEAVES) MOD. - MJG
C
          IF (NBLT. GT. 120) NBLT = 120
C     ******************************************************************
C     *   BRANCH LEAF GROWTH:
C     *   RESET TOTALS:
C
          TCWBL=0.0
          RTBL=0.0
C
C     *   DETERMINE EFFECT OF RESERVES ON GROWTH:
C
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```
      ERBLG=ZERO
      IF(PRES.GE.T18L1) ERBLG=T18P1 + T18P2*PRES
      IF(PRES.GT.T18L2) ERBLG=ONE
C
C  *  DETERMINE EFFECT OF TEMP ON GROWTH:
C
      ETBLG=T16P1 + T16P2*TAIR
      IF(TAIR.GT.T16L1) ETBLG=T16P3 + T16P4*TAIR
      IF(TAIR.GT.T16L2) ETBLG=T16P5 + T16P6*TAIR
      IF(ETBLG.LT.ZERO) ETBLG=ZERO
      IF(ETBLG.GT.ONE) ETBLG=ONE
C
C  *  LIMITER IS MOST-LIMITING OF EFFECTS OF RESERVES, TEMP, AND H2O:
C
      BLGLIM=AMIN1(ERBLG, ETBLG, EWLFG)
C
C  *  DETERMINE SPECIFIC LEAF AREA OF BRANCH LEAVES, AS SPECIFIC LEAF
C  *  AREA POTENTIAL MODIFIED BY EFFECT OF RADIATION ON SLA:
C
      ERASLA=ONE
      IF(DAYRAD.GE.T19L1) ERASLA=T19P1 + T19P2*DAYRAD
      IF(DAYRAD.GE.T19L2) ERASLA=T19P3 + T19P4*DAYRAD
      IF(DAYRAD.GT.T19L3) ERASLA=T19P5
C
      SLABL=SLAP*ERASLA
C
C  *  FOR EVERY BRANCH LEAF:
      DO 200 I=1,NBLT
C
C  *  IF LEAF HAS SENESCED, DO NOT PROCESS IT; IF LEAF IS NEW, SET ITS
C  *  VALUES TO INITIAL STATES:
C
      IF(DWBL(I) .EQ. 888.88) GO TO 200
C
      IF (DWBL(I) .NE. 999.99) GO TO 150
      AGEBL(I)=0.0
      DWBL(I)=STLFRT
      RTBL=RTBL+STLFRT
      ARBL(I)=SLAP*DWBL(I)
150   CONTINUE
C
C  *  DETERMINE POTENTIAL LIFE SPAN OF THIS LEAF, BASED ON TIME OF
C  *  INITIATION RELATIVE TO BRANCH AGE:
C
      LEAFST = AGEMS - AGEBL(I)
      IF (LEAFST.GT.T36L1) GOTO 155
      DAGEBL = T36P1 - T36P2 * LEAFST
      GOTO 156
155   DAGEBL = T36P3 - T36P4 * LEAFST
      IF (LEAFST.GT.T36L2) DAGEBL = T36P5
C
C  *  CALCULATE PERCENT OF LIFE LIVED:
C
156   PCTBL=AGEBL(I)/DAGEBL
C
C  *  IF 100% LIVED, THEN DROP THIS LEAF:
C
      IF(PCTBL .LT. 1.) GO TO 160
      TCWBL=TCWBL-DWBL(I)
      NDEDL=NDEDL+1
      DWBL(I)=888.88
      GO TO 200
160   CONTINUE
C
C  *  FOR LIVING LEAVES:
C  *  DEV. RATE IS ABOVE-GROUND DEV. RATE:
C
      DEVRBL(I)=DEVRAG
C
C  *  DETERMINE EFFECT OF AGE ON GROWTH OF THIS LEAF:
C
      IF(PCTBL.GT.T35L2) GOTO 162
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      EAGBLG=ONE
      IF(PCTBL.GE.T35L1) EAGBLG=T35P1 + T35P2*PCTBL
      IF(EAGBLG.LT.0.) EAGBLG=0.
C
C   *   GROWTH IS POTENTIAL MODIFIED BY EFFECT OF AGE AND LIMITER DEFINED
C   *   ABOVE; GROWTH IS A FUNCTION OF CURRENT LEAF WEIGHT:
C
      GR=RBL*EAGBLG*BLGLIM*DWBL(I)
      CWBL(I)=GR
C
C   *   ADD TO TOTAL:
C
      RTBL=RTBL+GR
C   ************************************************************************
C   *   LEAF AREA GROWTH:
C   *   CALCULATE EFFECT OF AGE ON AREA GROWTH:
C
      EABLAG=ONE
      IF(AGEBL(I).GE.T20L1) EABLAG=T20P1 + T20P2*AGEBL(I)
      IF(AGEBL(I).GE.T20L2) EABLAG=T20P3
      IF(AGEBL(I).GT.T20L3) EABLAG=T20P4 + T20P5*AGEBL(I)
      IF(AGEBL(I).GT.T20L4) EABLAG=ZERO
C
C   *   CHANGE OF AREA IS CHANGE OF WEIGHT, MODIFIED BY SPECIFIC LEAF
C   *  AREA AND EFFECT OF AGE:
C
      CARBL(I)=CWBL(I)*SLABL*EABLAG
C
C   *   SPEC. LEAF AREA IS AREA DIVIDED BY WEIGHT:
C
      SLA=ARBL(I)/DWBL(I)
      GOTO 163
C   ************************************************************************
C   *   IF THE LEAF IS SENESCING, TRANSLOCATE HALF OF ITS DWT BACK TO THE
C   *   PLANT BEFORE IT DIES
C
  162 IF(CWBL(I) .EQ. 0.)
     $    CWBL(I)=- RSLOSS*(DWBL(I)/(DAGEBL-AGEBL(I)))
      CWDEDL=CWDEDL-CWBL(I)
C   ************************************************************************
C   *   TOTAL CHANGES IN WEIGHT:
C
  163 TCWBL=TCWBL+CWBL(I)
170   CONTINUE
200   CONTINUE
      RETURN
      END
$$$$$FIBRTG
      SUBROUTINE FIBRTG
C   ************************************************************************
C   *   FIBRTG DEVELOPS THE FIBROUS ROOTS OF THE PLANT, AND DETERMINES
C   *   THE AMOUNT OF SUBERIZATION WHICH HAS TAKEN PLACE.
C   *
C   ************************************************************************
C
......(COMMONS LOCL, STVAR, DERIV, INFO, PARAM, FUNCT2 AND FUNCT4 GO
......  HERE)
C
C   ************************************************************************
C   *   LIMITING EFFECTS FOR ROOT GROWTH:
C   *   CALCULATE EFFECT OF PLANT RESERVES ON ROOT GROWTH:
C
      ERFRG=ZERO
      IF(PRES.GE.T28L1) ERFRG=T28P1 + T28P2*PRES
      IF(PRES.GT.T28L2) ERFRG=ONE
C
C   *   EFFECT OF RESERVES ON ROOT GROWTH IS MAX OF PLANT RESERVE EFFECT
C   *   AND MOTHER TUBER RESERVE EFFECT:
C
      ERSFRG=AMAX1(EMTRES,ERFRG)
C
C   *   CALCULATE EFFECT OF TEMP:
```

```
C
      ETFRG=T16P1 + T16P2*TSOIL
      IF(TSOIL.GT.T16L1) ETFRG=T16P3 + T16P4*TSOIL
      IF(TSOIL.GT.T16L2) ETFRG=T16P5 + T16P6*TSOIL
      IF(ETFRG.LT.ZERO) ETFRG=ZERO
      IF(ETFRG.GT.ONE) ETFRG=ONE
C
C   * LIMITER IS MOST-LIMITING OF EFFECTS OF RESERVES, TEMP, AND H20:
C
      FRGLIM=AMIN1(ERSFRG,ETFRG, EWFRG)
C   **********************************************************************
C   * DETERMINE EFFECT OF TEMP ON SPECIFIC ROOT WEIGHT (FOR LENGTH):
C
      ETSFRW=T29P1
      IF(TSOIL.GE.T29L1) ETSFRW=T29P2 + T29P3*TSOIL
      IF(TSOIL.GT.T29L2) ETSFRW=T29P4 + T29P5*TSOIL
      IF(TSOIL.GT.T29L3) ETSFRW=T29P6
C   **********************************************************************
C   * DETERMINE EFFECT OF TEMP ON SUBERIZATION:
C
      ETSUBR=ZERO
      IF(TSOIL.GE.T30L1) ETSUBR=T30P1 + T30P2*TSOIL
      IF(TSOIL.GT.T30L2) ETSUBR=T30P3 + T30P4*TSOIL
      IF(TSOIL.GT.T30L3) ETSUBR=ONE
C   **********************************************************************
C   * ACTUAL FIBROUS ROOT LENGTH IS TOTAL MINUS SUBERIZED:
C
      AFRL=FRL-FRSUBL
C
C   * ROOT DEV. RATE IS BELOW-GROUND DEV. RATE:
C
      DEVRFR=DEVRBG
C
C   * DETERMINE EFFECT OF CURRENT DRY WEIGHT ON FURTHER GROWTH:
C
      EDWFRG=ONE
      IF(DWFR.GE.T31L1) EDWFRG=T31P1 + T31P2*DWFR
      IF(DWFR.GE.T31L2) EDWFRG=T31P3 + T31P4*DWFR
      IF(DWFR.GE.T31L3) EDWFRG=T31P5 + T31P6*DWFR
      IF(DWFR.GT.T31L4) EDWFRG=ZERO
C
C   * GROWTH IS POTENTIAL MODIFIED BY EFFECT OF CURRENT WEIGHT AND
C   * LIMITER DEFINED ABOVE; GROWTH IS A FUNCTION OF CURRENT WEIGHT:
C
      GR=RFR*EDWFRG*FRGLIM*DWFR
      CWFR=GR
C
C   * TOTALS:
C
      RTFR=GR
      TCWFR=CWFR
C   **********************************************************************
C   * CALCULATE THE CHANGE IN ROOT LENGTH, USING SPECIFIC ROOT WEIGHT
C   * AND EFFECT OF TEMP:
C
      CLFR=CWFR*SFRW*ETSFRW
C   **********************************************************************
C   * DETERMINE CHANGE IN SUBERIZED LENGTH, AS POTENTIAL MODIFIED BY
C   * EFFECTS OF TEMP AND RESERVES; CHANGE IS A FUNCTION OF CURRENT ROOT
C   * LENGTH:
C
      CSUBFR=BSUBR*ETSUBR*ERSFRG*AFRL
      RETURN
      END
$$$$$TUBER
      SUBROUTINE TUBER
C   **********************************************************************
C   * TUBER DETAILS THE INDUCTION, INITIALIZATION, AND GROWTH OF THE
C   * TUBERS ON THE PLANT.
C   *
C   **********************************************************************
C
```

```
......(COMMONS LOCL, STVAR, DERIV, INFO, PARAM AND FUNCT3 GO HERE)
C
C   ************************************************************************
C   **  NTUBP (# OF TUBERS POSSIBLE) SHOULD BE NTUBP*NTADD < 30
C   **  INDUCTION OF TUBERIZATION -- CUMULATIVE STIMULUS
C   **  EPPTST - EFFECT OF PHOTOPERIOD ON TUBERIZATION STIMULUS TABLE
C   **  DAMNTU-MIN # OF DAYS WITH PP<CPP OR EQUIVALENT
C   **  TUBSTS - TUBERIZATION STIMULATION STATUS
C   **  TUBSTR - TUBERIZATION STIMULATION RATE
C   **  NTADD - NUMBER OF TUBER INITIALS THAT MAY BE DEVELOPING AT 1 TIME
C   **  PTUBIR=INVERSE OF NUMBER OF HOURS OF SUFFICIENT CONDITIONS
C        NEEDED FOR TUBERIZATION AFTER INDUCTION.
C   ************************************************************************
C   *  IF THE MAX # OF TUBERS EXIST, DON'T ADD ANY MORE:
C
      IF( NTUB .GE. NTUBP) GO TO 102
C   ************************************************************************
C   *  DETERMINE THE EFFECT OF DAYLENGTH ON TUBERIZATION:
C
      EPPTUB=ONE
      IF(DAYHRS.GE.T21L1)  EPPTUB=T21P1 + T21P2*DAYHRS
      IF(DAYHRS.GE.T21L2)  EPPTUB=T21P3 + T21P4*DAYHRS
      IF(DAYHRS.GT.T21L3)  EPPTUB=T21P5
C
C   *  SET TUBERIZATION STIMULUS RATE:
C
      TUBSTR=EPPTUB/(DAMNTU*24.0)
C
C   *  CONTINUE ONLY IF THERE ARE TUBER STARTS:
C
      IF (TUBSTS .LE. 1) RETURN
C   ************************************************************************
C   *  TUBER INITIATION  --  PARALLEL PROCESS
C   *  DETERMINE EFFECT OF RESERVES ON INIT.:
C
      ERTIR=ZERO
      IF(PRES.GE.T22L1)  ERTIR=T22P1 + T22P2*PRES
      IF(PRES.GT.T22L2)  ERTIR=ONE
C
C   *  EFFECT OF RESERVES ON INIT. IS MAX OF EFFECTS OF PLANT RESERVES
C   *  AND MOTHER TUBER RESERVES:
C
      ERIR=AMAX1(ERTIR,EMTRES)
C
C   *  CALCULATE INIT. RATE AS POTENTIAL MODIFIED BY EFFECT OF RESERVES:
C
      TUBIR=ERIR*PTUBIR
C
C   *  START WITH NEXT TUBER NOT YET GROWING; INCLUDE THE NUMBER TO BE
C   *  INITIALIZED AT ONE TIME (NTADD):
C
      NTUB1=NTUB+1
      NTUBM=NTUB +NTADD
C
C   *  FOR EACH TUBER BEING INITIALIZED, SET ITS INIT. RATE; IF IT IS
C   *  INITIALIZED, ADD IT TO FULLY INITIALIZED TUBERS FOR GROWTH:
C
      DO 100 I=NTUB1, NTUBM
      TUBISR(I)=TUBIR
      IF(TUBIS(I) .GE. 1) NTUB=NTUB+1
100   CONTINUE
102   CONTINUE
C   ************************************************************************
C   *  LIMITERS TO TUBER GROWTH:
C   *  RESET TOTALS:
C
      RTTUB=0.0
      TCWTUB=0.0
C
C   *  DETERMINE EFFECT OF TEMP ON TUBER GROWTH:
C
      ETTUBG=ZERO
```

```
      IF(TSOIL.GT.T23L1)  ETTUBG=T23P1 + T23P2*TSOIL
      IF(TSOIL.GE.T23L2)  ETTUBG=T23P3 + T23P4*TSOIL
      IF(TSOIL.GE.T23L3)  ETTUBG=T23P5 + T23P6*TSOIL
      IF(TSOIL.GT.T23L4)  ETTUBG=ZERO
      IF(ETTUBG.GT.ONE)  ETTUBG=ONE
C
C  *  DETERMINE EFFECT OF RESERVES ON TUBER GROWTH:
C
      ERTUBG=ZERO
      IF(PRES.GE.T24L1)  ERTUBG=T24P1 + T24P2*PRES
      IF(PRES.GT.T24L2)  ERTUBG=ONE
C
C  *  EFFECT OF RESERVES IS MAX OF EFFECTS OF PLANT RESERVES AND MOTHER
C  *  TUBER RESERVES:
C
      ERTBG =AMAX1(ERTUBG,EMTRES)
C
C  *  LIMITER IS MOST-LIMITING OF EFFECTS OF TEMP, RESERVES, AND H20:
C
      GLIMT=AMIN1(ETTUBG, ERTBG, EWTUBG)
C  *********************************************************************
C  *  TUBER GROWTH:
C  *  CONTINUE ONLY IF TUBERS EXIST:
C
      IF (NTUB .LT. 1) GO TO 500
C
C  *  FOR EVERY TUBER:
C
      DO 200 I=1,NTUB
C
C  *  IF THE TUBER IS NEW (DW=999.99), SET ITS VALUES TO INITIAL STATES:
C
      IF(DWTUB(I) .NE. 999.99) GO TO 160
      AGETUB(I)=0.0
      DWTUB(I)=STTBRT
      RTTUB=RTTUB+STTBRT
160   CONTINUE
C
C  *  DETERMINE THE EFFECT OF THE AGE OF THE TUBER ON ITS GROWTH:
C
      EATUBG=ONE
      IF(AGETUB(I).GE.T25L1) EATUBG=T25P1 + T25P2/AGETUB(I) +
     $ T25P3/(AGETUB(I)**2)
      IF(EATUBG.LT.ZERO) EATUBG = ZERO
C
C  *  GROWTH IS POTENTIAL MODIFIED BY EFFECT OF AGING AND LIMITER
C  *  DEFINED ABOVE; GROWTH IS A FUNCTION OF CURRENT WEIGHT OF TUBER:
C
      GR=RTUB*EATUBG*GLIMT*DWTUB(I)
      CWTUB(I)=GR
C
C  *  SUM TO TOTALS:
C
      RTTUB=RTTUB+GR
      TCWTUB=TCWTUB+GR
C
C  *  TUBER DEV. RATE IS BELOW-GROUND DEV. RATE:
C
      DEVTUB(I)=DEVRBG
200   CONTINUE
500   CONTINUE
      RETURN
      END
$$$$$RPRES
      SUBROUTINE RPRES
C  *********************************************************************
C  *  RPRES CALCULATES THE USE AND MOVEMENT OF RESERVES OF THE PLANT.
C  *
C  *********************************************************************
C
......(COMMONS LOCL, STVAR, DERIV, INFO, TOTALS, PARAM AND FUNCT4 GO
...... HERE)
```

```
C
C     ******************************************************************
C     *   GROWTH RESPIRATION:
C     *   CALCULATE THE GROWTH RATE RESPIRATION REQUIRED BY VARIOUS PARTS
C     *   OF THE PLANT (INTERNODES, LEAVES, TUBERS, ROOTS):
C
      GRRBGI=RTBGIN*SGRPIN
      GRRMSI=RTMSIN*SGRPIN
      GRRMSL=RTMSL*SGRPML
      GRRBRI=RTBRIN*SGRPIN
      GRRBRL=RTBL*SGRPML
      GRRTUB=RTTUB*SGRPTU
      GRRFR=RTFR*SGRPFR
C     ******************************************************************
C     *   MAINTENANCE RESPIRATION:
C     *   DETERMINE EFFECTS OF AIR AND SOIL TEMP ON THE MAINT. RESP. OF
C     *   PLANT PARTS:
C
      ETAMRP=ZERO
      IF(TAIR.GE.T32L1) ETAMRP=T32P1 + T32P2*TAIR + T32P3*TAIR**2
      IF(TAIR.GT.T32L2) ETAMRP=T32P4 + T32P5*TAIR
      IF(TAIR.GT.T32L3) ETAMRP=T32P6
C
      ETSMRP=ZERO
      IF(TSOIL.GE.T32L1) ETSMRP=T32P1 + T32P2*TSOIL + T32P3*TSOIL**2
      IF(TSOIL.GT.T32L2) ETSMRP=T32P4 + T32P5*TSOIL
      IF(TSOIL.GT.T32L3) ETSMRP=T32P6
C
C     *   GET PERCENT RESERVES OF PLANT IN HUNDREDTHS:
C
      FRCRES=PRES/100.0
C
C     *   DETERMINE THE EFFECT OF LEAF AGING ON PHOTOSYNTHESIS AND
C     *   MAINT. RESP. OF THE PLANT:
C     *   RESET TOTALS:
C
      EAGRML=0.0
      EAGPSL=0.0
C
C     *   FOR EVERY MAINSTEM LEAF:
C
      DO 2 I=1,NMSL
C
C     *   IF IT HAS NOT SENESCED, DETERMINE THE EFFECT OF ITS AGING:
C
      IF(DWMSL(I) .EQ. 888.88) GO TO 2
C
      EAGE=T33P1
      IF(AGEMSL(I).GE.T33L1) EAGE=T33P2 + T33P3*AGEMSL(I)
      IF(AGEMSL(I).GE.T33L2) EAGE=ONE
      IF(AGEMSL(I).GT.T33L3) EAGE=T33P4 + T33P5*AGEMSL(I)
      IF(AGEMSL(I).GT.T33L4) EAGE=ZERO
C
C     *   INCLUDE ITS EFFECT IN PROPORTION TO ITS WEIGHT TO ALL LEAVES,
C     *   FOR RESERVES EFFECT, AND PHOTOS. EFFECT:
C
      EAGRML=EAGRML+ (DWMSL(I)/TDWMSL) *EAGE
C
      EAGPSL=EAGPSL+(ARMSL(I)/AREALV)*EAGE
2     CONTINUE
C
C     *   RESET FOR BRANCH LEAVES:
C
      EAGRBL=0.0
C
C     *   INCLUDE ONLY IF BRANCH LEAVES EXIST:
C
      IF(NBLT .LE. 0) GO TO 5
C
C     *   FOR EVERY BRANCH LEAF:
C
      DO 4 I=1,NBLT
```

```
C
C   *  IF IT HAS NOT SENESCED, DETERMINE THE EFFECT OF ITS AGING:
C
       IF(DWBL(I) .EQ. 888.88) GO TO 4
C
       EAGE =T33P1
       IF (AGEBL (I) .GE. T33L1)  EAGE=T33P2 + T33P3*AGEBL(I)
       IF (AGEBL (I) .GE. T33L2)  EAGE=ONE
       IF (AGEBL (I) .GT. T33L3)  EAGE=T33P4 + T33P5*AGEBL(I)
       IF (AGEBL (I) .GT. T33L4)  EAGE=ZERO
       IF (NBLT.EQ.1) TDWBRL=SBPLWT
C
C   *  INCLUDE ITS EFFECT IN PROPORTION TO ITS WEIGHT TO ALL LEAVES,
C   *  FOR RESERVES EFFECT, AND PHOTOS. EFFECT:
C
       EAGRBL=EAGRBL+ (DWBL(I)/TDWBRL) *EAGE
C
       EAGPSL=EAGPSL+(ARBL(I)/AREALV)*EAGE
4      CONTINUE
5      CONTINUE
C
C   *  CALCULATE THE AMOUNTS OF MAINT. RESP. FOR ALL PLANT PARTS:
C
       RMRPBI= (TDWBGI-FRCRES*TDWBGI) *ETSMRP*BMRPIN
       RMRPMS= (TDWMSI-FRCRES*TDWMSI) *ETAMRP*BMRPIN
       RMRPML= (TDWMSL-FRCRES*TDWMSL) *ETAMRP*BMRPL*EAGRML
       RMRPBR= (TDWBRI-FRCRES*TDWBRI) *ETAMRP*BMRPIN
       RMRPBL= (TDWBRL-FRCRES*TDWBRL) *ETAMRP*BMRPL*EAGRBL
C
C   *  FOR TUBERS, INCLUDE EFFECT OF CURRENT INDIVIDUAL WEIGHTS:
C
       RMRPTU=0.0
       IF(NTUB .LE. 0) GO TO 7
C
       DO 6 I=1,NTUB
       BMRPTU=T34P1 + T34P2*DWTUB(I)
       IF (DWTUB (I) .GE. T34L1)  BMRPTU=T34P3 + T34P4*DWTUB(I)
       IF (DWTUB (I) .GE. T34L2)  BMRPTU=T34P5 + T34P6*DWTUB(I)
       IF (DWTUB (I) .GE. T34L3)  BMRPTU=T34P7 + T34P8*DWTUB(I)
       IF (DWTUB (I) .GE. T34L4)  BMRPTU=T34P9 + T34P10*DWTUB(I)
       IF (DWTUB (I) .GE. T34L5)  BMRPTU=T34P11
       RPMTUB=BMRPTU*DWTUB(I) *ETSMRP
       RMRPTU=RMRPTU+RPMTUB
6      CONTINUE
7      CONTINUE
       RMRPFR= (TDWFR-FRCRES*TDWFR) *ETSMRP*BMRPFR
C   *****************************************************************
C   *  RESPIRATION TOTALS:
C
       TRMRP=RMRPBI+RMRPMS+RMRPML+RMRPFR+RMRPBR+RMRPBL+RMRPTU
       TRGRP=GRRBGI+GRRMSI+GRRMSL+GRRFR+GRRBRI+GRRBRL+GRRTUB
       TRRP=TRMRP+TRGRP
C
       RTMRP=TRMRP
       RTGRP=TRGRP
C   *****************************************************************
C   *  CALCULATE TOTAL MOVEMENT OF RESERVES:
C
       TRTRAN=RTBGIN +RTMSIN +RTMSL +RTBRIN +RTBL +RTTUB +RTFR +RTMRP
      1 +RTGRP
C   *****************************************************************
C   *  SAVE HOURLY TUBER PROPORTION OF RESERVE USAGE, FOR USE IN
C   *  PHOTOSYNTHESIS CALCULATIONS:
C
       AVDTMP(IHOUR) = (RTTUB + RMRPTU + GRRTUB)/TRTRAN
       AVDTRN=0.
C
C   *  AVDTRN IS A MOVING AVERAGE OVER THE PAST DAY:
C
       DO 10 I= 1,24
    10 AVDTRN=AVDTRN + AVDTMP(I)
       AVDTRN=AVDTRN/24.
```

```
C    ***********************************************************************
C    *   RESERVE STATUS:
C    *   DETERMINE THE EFFECT OF RESERVE USAGE ON MOTHER TUBER RESERVES:
C
         CMTRES=-TRTRAN*EMTRES
C
C    *   DETERMINE THE AMOUNT OF TRANSLOCATION BACK FROM SENESCING LEAVES:
C
         RTFDLV=DEDMLT*CWDEDL
C
C    *   CHANGE IN RESERVES IS TOTAL OF PHOTOS. INPUT, RECOVERY FROM
C    *   LEAVES, AND INPUT FROM THE MOTHER TUBER - MINUS THE AMOUNT LOST
C    *   TO MAINTENANCE AND GROWTH:
C
         CWRES=PHCRPP+RTFDLV+(TRTRAN*EMTRES)-TRTRAN
         RETURN
         END
$$$$$COMMUN
         SUBROUTINE COMMUN
C    ***********************************************************************
C    *   THIS SUBROUTINE TAKES THE INFORMATION DEVELOPED FOR AN INDIVIDUAL
C    *   PLANT IN THE OTHER ROUTINES, AND DERIVES COMMUNITY VALUES FOR
C    *   MULTIPLE PLANTS BASED ON DENSITY
C
C    ***********************************************************************
C
......(COMMONS LOCL, STVAR, DERIV, INFO AND TOTALS GO HERE)
C
C    ***********************************************************************
C    *   CALCULATE TOTAL GROWTH RATE PER PLANT:
C
         GRTPP=(TCWIN+TCWMSL+TCWBRI+TCWBL+TCWTUB+TCWFR)/DELTA
C    ***********************************************************************
C    *   TOTALS OF PLANT PARTS (WEIGHTS AND AREAS):
C    *   BELOW-GROUND INTERNODES:
C
         TDWBGI=0.
         DO 100 I=1,NBGIN
  100    TDWBGI=TDWBGI+DWINOD(I)
C
C    *   ABOVE-GROUND INTERNODES:
C
         N=NBGIN+1
         TDWMSI=0.
         DO 200 I=N,NINTOT
  200    TDWMSI=TDWMSI+DWINOD(I)
C
C    *   MAINSTEM LEAVES:
C
         TARMSL=0.
         TDWMSL=0.
         DO 300 I=1,NMSL
         IF(DWMSL(I).EQ.888.88) GO TO 300
         TARMSL=TARMSL+ARMSL(I)
         TDWMSL=TDWMSL+DWMSL(I)
  300    CONTINUE
C
C    *   BRANCH INTERNODES:
C
         TDWBRI=0.
         IF(NBRIT.LE.0) GO TO 550
         DO 500 I=1,NBRIT
  500    TDWBRI=TDWBRI+DWBRIN(I)
  550    CONTINUE
C
C    *   BRANCH LEAVES:
C
         TARBL=0.
         TDWBRL=0.
         IF(NBLT.LE.0) GO TO 650
         DO 600 I=1,NBLT
         IF(DWBL(I).EQ.888.88) GO TO 600
```

```
      TDWBRL=TDWBRL+DWBL(I)
      TARBL=TARBL+ARBL(I)
  600 CONTINUE
  650 CONTINUE
C
C    *  TOTALS FOR MAINSTEM AND BRANCH LEAVES:
C    *  INCLUDE PROPORTIONAL INCLUSION FOR SPECIFIC LEAF AREA:
C
      AREALV=TARMSL+TARBL
      AVSLA=AREALV/(TDWMSL+TDWBRL)
C
C    *  TUBERS:
C
      TDWTUB=0.
      IF(NTUB.LE.0) GO TO 750
      DO 700 I=1,NTUB
  700 TDWTUB=TDWTUB+DWTUB(I)
  750 CONTINUE
C
C    *  ROOTS:
C
      TDWFR=DWFR
      TFRL=FRL
      TFRSUB=FRSUBL
      AFRL=TFRL-TFRSUB
C   ************************************************************************
C    *  CALCULATE TOTAL DRY WEIGHT OF THE PLANT, AND THE AMOUNT OF THAT
C    *  WHICH IS IN RESERVES:
C
      TDW=TDWBGI+TDWMSI+TDWBRI+TDWMSL+TDWBRL+TDWFR+TDWTUB
C
      PRES=100.0*RES/TDW
C   ************************************************************************
C    *  PARTITION RESERVES ACCORDING TO REQUIREMENTS OF PLANT PARTS:
C
      TRESFL=RSTBGI+RSTMSI+RSTMSL+RSTBRI+RSTBL+RSTTUB+RSTFR
     $ +RSTMRP+RSTGRP
      IF(TRESFL.EQ.0.) TRESFL=0.0001
      RSPBGI=RSTBGI/TRESFL
      RSPMSI=RSTMSI/TRESFL
      RSPMSL=RSTMSL/TRESFL
      RSPBRI=RSTBRI/TRESFL
      RSPBRL=RSTBL/TRESFL
      RSPTUB=RSTTUB/TRESFL
      RSPFR=RSTFR/TRESFL
      RSPMRP=RSTMRP/TRESFL
      RSPGRP=RSTGRP/TRESFL
C
      RSPRP=RSPMRP+RSPGRP
C   ************************************************************************
C    *  CALCULATE VALUES FOR COMMUNITY LEVEL ATTRIBUTES
C
      CGR=GRTPP*DENS
      CMMLAR=TARMSL*DENS
      CMBLAR=TARBL*DENS
      CMLAR=CMMLAR+CMBLAR
      CMLAI=CMLAR/10000.
      RETURN
      END
$$$$OUTPUT
      SUBROUTINE OUTPUT
C   ************************************************************************
C    *  OUTPUT HANDLES THE OUTPUT FOR POTATO.  TWO FORMS ARE POSSIBLE:
C    *  TABULAR (UP TO 12 ITEMS), AND PLOTTED (UP TO 10 PLOTS OF 5
C    *  VARIABLES EACH).
C    *
C   ************************************************************************
C    *  COMMONS FOR DATA:
C
......(COMMONS LOCL, STVAR, DERIV, INFO, TOTALS AND CLIMAT GO HERE)
C
C   ************************************************************************
```

```
C    *  EQUIVALENCES FOR CONSIDERING DATA IN ARRAYS:
C
      REAL RLOC(131), RSTV(1422), RDER(1422), RINF(131),
     $ RTOT(27), RCLI(12)
      INTEGER ILOC(84), IINF(43)
      EQUIVALENCE (CDWMT,RLOC(1)), (NLVTOT,ILOC(1)),
     $      (AGEMS,RSTV(1)),
     $      (DEVRMS,RDER(1)),
     $      (TSOIL,RINF(1)), (NBGIN,IINF(1)),
     $      (TTRANS,RTOT(1)),
     $      (AVTS,RCLI(1))
C    ********************************************************************
C    *  EQUIVALENCES FOR FINDING NAMES OF VARIABLES REQUESTED:
C
      REAL*8 RLN(131), RSN1(726), RSN2(696), RDN1(726), RDN2(696),
     $ RIN(131), RTN(27), RCN(12), ILN(84), IIN(43)
      REAL*8 RSN(1422), RDN(1422)
      EQUIVALENCE (RSN(1),RSN1(1)), (RSN(727),RSN2(1)),
     $      (RDN(1),RDN1(1)), (RDN(727),RDN2(1))
C
      DATA RLN / 'CDWMT', 'CRES', 'CTDW','CROPET', 'PCOVER','HEIGHT',
     1 '      ','PLIVLV', 'SATVPA', 'SLOPE', 'TRNET', 'GFUNCT','HFUNCT',
     2 'RL', 'RC', 'EAP', 'TOP','DENOM', 'POTET', 'RPL', 'XK', 'RPSI',
     3 'DENOM2','ET', 'EFLFLR', 'ELNFR', 'WUR','RUPT', 'DMFPL',
     4 'WATMAX', 'WATDEF','TPDEF', 'UPTAKE', 'PHCR', 'ETPH', 'EWPH',
     5 'PSLIM', 'PNINR', 'ETNINR', 'ERNINR', 'ERINR','ERMSG', 'ERING',
     6 'ETAGIG','ETBGIG', 'GLIMMS', 'EAGEIG', 'PLINR','ETLINR','ERLINR',
     7 'ERLIR', 'ERMSLG','ERMLG', 'ERASLA', 'ETSLA', 'ETMSLG', 'GLIML',
     8 'ALIML', 'EAGELG', 'EAGEAG', 'SLA','EBRAC','ETBRIR','ERBRIR',
     9 'ETBNIR', 'ERBNIR','BNILIM', '      ', 'EABNIR','ETBRIG','ERBRIG',
     0 'GLIMBI', 'EABRIG','ETBLIR', 'ERBLIR', 'BLILIM', '      ','EABLIR',
     1 'ERBLG', 'ETBLG', 'BLGLIM', 'SLABL','EAGBLG', 'EABLAG','EPPTUB',
     2 'ERTIR', 'ERIR', 'TUBIR', '      ', '      ', 'ETTUBG', 'ERTUBG',
     3 'ERTBG','GLIMT', 'EATUBG', 'ERFRG', 'ERSFRG', 'ETFRG','FRGLIM',
     4 'ETSFRW', 'ETSUBR','AFRL', 'EDWFRG', 'EAGRML', 'EAGE','EAGRBL',
     5 'ETAMRP','ETSMRP','FRCRES','RPMTUB','TRTRAN','RTFDLV','GRTPP',
     5 'TARMSL','TARBL','AVSLA','TFRL','TFRSUB','RSPBGI','RSPMSI',
     6 'RSPMSL','RSPBRI', 'RSPBRL', 'RSPTUB', 'RSPFR',
     7 'RSPMRP', 'RSPGRP', 'RSPRP', 'CMMLAR', 'CMBLAR', 'CMLAR'/
      DATA ILN / 'NLVTOT',60*' ','NBRIN',8*' ','NBL',11*' ',
     1 'NTUB1','NTUBM'/
C
      DATA RSN1/'AGEMS','RNMSIN','DWINOD1','DWINOD2','DWINOD3','DWINOD4'
     1 ,'DWINOD5','DWINOD6','DWINOD7','DWINOD8','DWINOD9',111*'DWINOD0',
     2 'AGEIN1','AGEIN2','AGEIN3','AGEIN4','AGEIN5','AGEIN6','AGEIN7',
     3 'AGEIN8','AGEIN9',111*'AGEIN0','RNMSL','DWMSL1','DWMSL2','DWMSL3'
     4 ,'DWMSL4','DWMSL5','DWMSL6','DWMSL7','DWMSL8','DWMSL9',
     5 111*'DWMSL0','AGEMSL1','AGEMSL2','AGEMSL3','AGEMSL4','AGEMSL5',
     6 'AGEMSL6','AGEMSL7','AGEMSL8','AGEMSL9',111*'AGEMSL0','ARMSL1',
     7 'ARMSL2','ARMSL3','ARMSL4','ARMSL5','ARMSL6','ARMSL7','ARMSL8',
     8 'ARMSL9',111*'ARMSL0','TUBIS1','TUBIS2','TUBIS3','TUBIS4',
     9 'TUBIS5','TUBIS6','TUBIS7','TUBIS8','TUBIS9',21*'TUBIS0',
     0 'DWTUB1','DWTUB2','DWTUB3','DWTUB4','DWTUB5','DWTUB6','DWTUB7',
     1 'DWTUB8','DWTUB9',21*'DWTUB0','AGETUB1','AGETUB2','AGETUB3',
     2 'AGETUB4','AGETUB5','AGETUB6','AGETUB7','AGETUB8','AGETUB9',
     3 21*'AGETUB0','TUBSTS','RSTBGI','RSTMSI','RSTMSL','RSTBRI',
     4 'RSTBL','RSTTUB','RSTFR','RSTMRP','RSTGRP','DGRPBI','DGRPMI',
     5 'DGRPML','DGRPBR','DGRPBL','DGRPTU','DGRPFR','DMRPBI','DMRPMS',
     6 'DMRPML','DMRPBR','DMRPBL','DMRPTU','DMRPFR','DTMRP','DTGRP',
     7 'DTRP','RES','DPHPP','DWMT','DTRANS','DCGR','RNBR'/
      DATA RSN2 /'AGEBR1','AGEBR2','AGEBR3','AGEBR4','AGEBR5','AGEBR6',
     1 'AGEBR7','AGEBR8','AGEBR9',21*'AGEBR0','RNBRIN1','RNBRIN2',
     2 'RNBRIN3','RNBRIN4','RNBRIN5','RNBRIN6','RNBRIN7','RNBRIN8',
     3 'RNBRIN9',21*'RNBRIN0','DWBRIN1','DWBRIN2','DWBRIN3','DWBRIN4',
     4 'DWBRIN5','DWBRIN6','DWBRIN7','DWBRIN8','DWBRIN9',111*'DWBRIN0',
     5 'AGBRIN1','AGBRIN2','AGBRIN3','AGBRIN4','AGBRIN5','AGBRIN6',
     6 'AGBRIN7','AGBRIN8','AGBRIN9',111*'AGBRIN0','RNBL1','RNBL2',
     7 'RNBL3','RNBL4','RNBL5','RNBL6','RNBL7','RNBL8','RNBL9',
     8 21*'RNBL0','AGEBL1','AGEBL2','AGEBL3','AGEBL4','AGEBL5',
     9 'AGEBL6','AGEBL7','AGEBL8','AGEBL9',111*'AGEBL0','DWBL1','DWBL2',
     0 'DWBL3','DWBL4','DWBL5','DWBL6','DWBL7','DWBL8','DWBL9',
     1 111*'DWBL0','ARBL1','ARBL2','ARBL3','ARBL4','ARBL5','ARBL6',
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```
     2 'ARBL7','ARBL8','ARBL9',111*'ARBL0','WATPL','AGEFR','DWFR','FRL',
     3 'FRSUBL','DWDEDL'/
C
      DATA RDN1/'DEVRMS','ANINR','CWINOD1','CWINOD2','CWINOD3','CWINOD4'
     1 ,'CWINOD5','CWINOD6','CWINOD7','CWINOD8','CWINOD9',111*'CWINOD0',
     2 'DEVRIN1','DEVRIN2','DEVRIN3','DEVRIN4','DEVRIN5','DEVRIN6',
     3 'DEVRIN7','DEVRIN8','DEVRIN9',111*'DEVRIN0','AMLINR','CWMSL1',
     4 'CWMSL2','CWMSL3','CWMSL4','CWMSL5','CWMSL6','CWMSL7','CWMSL8',
     5 'CWMSL9',111*'CWMSL0','DEVRML1','DEVRML2','DEVRML3','DEVRML4',
     6 'DEVRML5','DEVRML6','DEVRML7','DEVRML8','DEVRML9',111*'DEVRML0',
     7 'CARMSL1','CARMSL2','CARMSL3','CARMSL4','CARMSL5','CARMSL6',
     8 'CARMSL7','CARMSL8','CARMSL9',111*'CARMSL0','TUBISR1','TUBISR2',
     9 'TUBISR3','TUBISR4','TUBISR5','TUBISR6','TUBISR7','TUBISR8',
     0 'TUBISR9',21*'TUBISR0','CWTUB1','CWTUB2','CWTUB3','CWTUB4',
     1 'CWTUB5','CWTUB6','CWTUB7','CWTUB8','CWTUB9',21*'CWTUB0',
     2 'DEVTUB1','DEVTUB2','DEVTUB3','DEVTUB4','DEVTUB5','DEVTUB6',
     3 'DEVTUB7','DEVTUB8','DEVTUB9',21*'DEVTUB0','TUBSTR','RTBGIN',
     4 'RTMSIN','RTMSL','RTBRIN','RTBL','RTTUB','RTFR','RTMRP','RTGRP',
     5 'GRRBGI','GRRMSI','GRRMSL','GRRBRI','GRRBRL','GRRTUB','GRRFR',
     6 'RMRPBI','RMRPMS','RMRPML','RMRPBR','RMRPBL','RMRPTU','RMRPFR',
     7 'TRMRP','TRGRP','TRRP','CWRES','PHCRPP','CMTRES','TRANSP',
     8 'CGR','ABRIR'/
      DATA RDN2/'DEVRBR1','DEVRBR2','DEVRBR3','DEVRBR4','DEVRBR5',
     1 'DEVRBR6','DEVRBR7','DEVRBR8','DEVRBR9',21*'DEVRBR0','ABNIR1',
     2 'ABNIR2','ABNIR3','ABNIR4','ABNIR5','ABNIR6','ABNIR7','ABNIR8',
     3 'ABNIR9',21*'ABNIR0','CWBRIN1','CWBRIN2','CWBRIN3','CWBRIN4',
     4 'CWBRIN5','CWBRIN6','CWBRIN7','CWBRIN8','CWBRIN9',111*'CWBRIN0',
     5 'DEVBRI1','DEVBRI2','DEVBRI3','DEVBRI4','DEVBRI5','DEVBRI6',
     6 'DEVBRI7','DEVBRI8','DEVBRI9',111*'DEVBRI0','ABLIR1','ABLIR2',
     7 'ABLIR3','ABLIR4','ABLIR5','ABLIR6','ABLIR7','ABLIR8','ABLIR9',
     8 21*'ABLIR0','DEVRBL1','DEVRBL2','DEVRBL3','DEVRBL4','DEVRBL5',
     9 'DEVRBL6','DEVRBL7','DEVRBL8','DEVRBL9',111*'DEVRBL0','CWBL1',
     0 'CWBL2','CWBL3','CWBL4','CWBL5','CWBL6','CWBL7','CWBL8','CWBL9',
     1 111*'CWBL0','CARBL1','CARBL2','CARBL3','CARBL4','CARBL5',
     2 'CARBL6','CARBL7','CARBL8','CARBL9',111*'CARBL0','CWATPL',
     3 'DEVRFR','CWFR','CLFR','CSUBFR','CWDEDL'/
C
      DATA RIN/ 'TSOIL','TAIR','DENS','PRES','EMTRES',' ',' ',
     A ' ',' ',' ',' ',' ',' ','DELTA','CMLAI','DEVRBG',
     B 'DEVRAG','ACR','DAYHRS',' ',' ',' ',' ','DAYRAD','DFC',
     C 'DLAT','AREALV','OLRES','OLTDW','OLDWMT','TRESFL','TCWIN',
     D 'TCWMSL','TCWBRI','TCWBL','TCWTUB','TCWFR','ANPNRA','WERR',
     E ' ',' ','DEWPT','WINDSP',' ',' ','EWFRG','EWTUBG','EWSTG',
     F 'EWLFG','EAGPSL',' ',' ','RWCPL','RNET','ACVP','PSILPT','PSISCL'/
      DATA IIN/'NBGIN','NINTOT','NMSL','NMST','NBR','NBRIT','NBLT',
     1 'NTUB',6*' ','IDAY','IDATE','IHOUR',16*' ','IDACNT',2*' ',
     2 'NMSIN',5*' ','NDEDL'/
C
      DATA RTN /'TTRANS','TPHPP','TGRPBI','TGRPMI','TGRPML','TGRPBR',
     1 'TGRPBL','TGRPTU','TGRPFR','TMRPBI','TMRPMS','TMRPML','TMRPBR',
     2 'TMRPBL','TMRPTU','TMRPFR','TTMRP','TTGRP','TTRP','TDW','TDWBGI',
     3 'TDWMSI','TDWMSL','TDWBRI','TDWBRL','TDWTUB','TDWFR'/
C
      DATA RCN/ 'AVTS','CRC','CRO','DRC','DRO','DRCP','DROP',
     $ 'FCL','FOV','PHC','PHO','SNHSUN'/
C     ******************************************************************
C     *  DATA FOR PRINTING AND PLOTTING:
C
      REAL*8 NAMES(12), FNAMES(50), WNAMES(12), NBLANK
      DIMENSION NWCOMM(12), NWSITE(12), NWHOUR(12), WDATA(12)
      DIMENSION NPCOMM(50), NPSITE(50), NPHOUR(50), DATA(150,50)
      DIMENSION NPCONT(10), NPLOT(10,5), LETT(5),NHR(12),PLOT(50),
     $ ZX(13), GRAPH(121,51),XMN(10),XMX(10),YMN(10),YMX(10)
      INTEGER GRAPH,BLANK,BORDER,PERD
      DATA NWCOMM,NWSITE,NWHOUR/36*0/
      DATA NPCOMM,NPSITE,NPHOUR/150*0/
      DATA BORDER,BLANK,PERD,NBLANK/'IIII',' ','....',' '/
      DATA LETT/'A','B','C','D','E'/
      DATA XMN,XMX,YMN,YMX/40*0.0/
C     ******************************************************************
C     *  DETERMINE WHICH CALL THIS IS: FIRST(1),MID(200),LAST(500)
C     *  FIRST FOR REQUESTS, MID FOR TABLE AND PLOT SAVES, LAST FOR PLOTS
```

```
C
      GO TO (1,300,500), IOFLAG
C
C   * INITIALIZATION OF OUTPUT
C
1     ICHEK=0
C
C   * CHECK FOR TABULAR OUTPUT
C
      IF(IOUTPT.LE.0) GO TO 2
      IF(IOUTPT.GT.12) IOUTPT=12
C
C   * READ VARIABLES FOR TABULAR OUTPUT
C
      READ(5,1008) (NAMES(J),NHR(J),J=1,IOUTPT)
1008  FORMAT(7(A8,I2))
      ITEMP=IOUTPT
      GO TO 5
2     IOFLAG=2
C
C   * READ PLOTTING REQUEST: VARIABLES, HOURS, AND RANGES FOR PLOT(OPT)
C
      IF (IPLOTN.LE.0) GOTO 90
      I=0
3     I=I+1
      READ(5,1000) (NAMES(J),NHR(J),J=1,5),L
      IF(L.GT.0) READ(5,1090)    XMN(I),XMX(I),YMN(I),YMX(I)
1000  FORMAT(5(A8,I2),I1)
1090  FORMAT(4F10.0)
C
C   * DETERMINE VARIABLE POSITIONS IN COMMON AND IN FILE 7
C
      ITEMP=5
      DO 4 L=1,5
      IF(NAMES(L).EQ.NBLANK) ITEMP=ITEMP-1
4     CONTINUE
      NPCONT(I)=ITEMP
5     DO 70 J=1,ITEMP
      IF(ICHEK.EQ.0) GO TO 9
      DO 7 K=1,ICHEK
      IF(NAMES(J).NE.FNAMES(K)) GO TO 7
      IF(NHR(J).NE.NPHOUR(K)) GO TO 7
      NPLOT(I,J)=K
      GO TO 70
7     CONTINUE
9     DO 10 K=1,131
      IF(NAMES(J).NE.RLN(K)) GO TO 10
      L=5
      GO TO 60
10    CONTINUE
      DO 15 K=1,84
      IF(NAMES(J).NE.ILN(K)) GO TO 15
      L=6
      GO TO 60
15    CONTINUE
      DO 20 K=1,1422
      IF(NAMES(J).NE.RSN(K)) GO TO 20
      L=2
      GO TO 60
20    CONTINUE
      DO 25 K=1,1422
      IF(NAMES(J).NE.RDN(K)) GO TO 25
      L=7
      GO TO 60
25    CONTINUE
      DO 30 K=1,131
      IF(NAMES(J).NE.RIN(K)) GO TO 30
      L=3
      GO TO 60
30    CONTINUE
      DO 35 K=1,43
      IF(NAMES(J).NE.IIN(K)) GO TO 35
```

```
      L=4
      GO TO 60
35    CONTINUE
      DO 40 K=1,27
      IF(NAMES(J).NE.RTN(K)) GO TO 40
      L=1
      GO TO 60
40    CONTINUE
      DO 45 K=1,12
      IF(NAMES(J).NE.RCN(K)) GO TO 45
      L=8
      GO TO 60
45    CONTINUE
C
C  *  IF NOT FOUND, DELETE AND OUTPUT
C
58    WRITE(6,1001) NAMES(J)
1001  FORMAT(/1X,'***** ',A8,' NOT FOUND, DELETED (OUTPUT) *****'//)
      GO TO 70
C
C  *  SAVE THE FOUND INFORMATION ABOUT REQUESTS:
C
60    IF(IOFLAG.EQ.2) GO TO 65
      WNAMES(J)=NAMES(J)
      NWCOMM(J)=L
      NWSITE(J)=K
      IF(NHR(J).EQ.0) NHR(J)=12
      NWHOUR(J)=NHR(J)
      IHR(NHR(J))=1
      GO TO 70
65    ICHEK=ICHEK+1
      NPCOMM(ICHEK)=L
      NPSITE(ICHEK)=K
      PNAMES(ICHEK)=NAMES(J)
      NPLOT(I,J)=ICHEK
      IF(NHR(J).EQ.0) NHR(J)=12
      NPHOUR(ICHEK)=NHR(J)
      IHR(NHR(J))=1
70    CONTINUE
      IF(IOFLAG.EQ.1) GO TO 2
      IF(I.LT.IPLOTN) GO TO 3
      RETURN
C
   90 ICHEK=0
      RETURN
C     ************************************************************************
C  *  SECOND CALLS TO ROUTINE ARE FOR OUTPUT AND PLOT-SAVES
C  *  TABLE:
C
300   IF (IOUTPT.LE.0) GOTO 399
      DO 399 I=1,IOUTPT
      IF(NWHOUR(I).NE.IHOUR) GO TO 399
      J=NWCOMM(I)
      GO TO (310,315,320,325,330,335,340,345), J
      GO TO 399
310   WDATA(I)=RTOT(NWSITE(I))
      GO TO 399
315   WDATA(I)=RSTV(NWSITE(I))
      GO TO 399
320   WDATA(I)=RINF(NWSITE(I))
      GO TO 399
325   WDATA(I)=IINF(NWSITE(I))
      GO TO 399
330   WDATA(I)=RLOC(NWSITE(I))
      GO TO 399
335   WDATA(I)=ILOC(NWSITE(I))
      GO TO 399
340   WDATA(I)=RDER(NWSITE(I))
      GOTO 399
345   WDATA(I)=RCLI(NWSITE(I))
399   CONTINUE
C
```

```
C   *   PLOTS:
C
        IF (IPLOTN.LE.0) GOTO 499
        DO 499 I=1,ICHEK
        IF(NPHOUR(I).NE.IHOUR) GO TO 499
        J=NPCOMM(I)
        GO TO (410,415,420,425,430,435,440,445), J
        GO TO 499
410     PLOT(I)=RTOT(NPSITE(I))
        GO TO 499
415     PLOT(I)=RSTV(NPSITE(I))
        GO TO 499
420     PLOT(I)=RINF(NPSITE(I))
        GO TO 499
425     PLOT(I)=IINF(NPSITE(I))
        GO TO 499
430     PLOT(I)=RLOC(NPSITE(I))
        GO TO 499
435     PLOT(I)=ILOC(NPSITE(I))
        GO TO 499
440     PLOT(I)=RDER(NPSITE(I))
        GO TO 499
445     PLOT(I)=RCLI(NPSITE(I))
499     CONTINUE
C
C   *   PRINT AND SAVE PLOT VALUES IF END-OF-DAY:
C
        IF(IHOUR.NE.24) RETURN
        IF(IOUTPT.LE.0) GOTO 9001
        IF(MOD(IDAY,20).EQ.1) WRITE(6,9080)
      $ (WNAMES(J),NWHOUR(J),J=1,IOUTPT)
9080    FORMAT(/' IDAY   ',12(1X,A7,I2)/)
        WRITE(6,9090) IDAY,(WDATA(J),J=1,IOUTPT)
9090    FORMAT(1X,I4,2X,12(1X,F9.4))
9001    IF(IPLOTN.LE.0) RETURN
        WRITE(7,9100) (PLOT(J),J=1,ICHEK)
9100    FORMAT(50F12.5)
        RETURN
C   ******************************************************************
C   *   FINAL CALL TO PLOT IS FOR PLOTTING
C   *   READ DATA FROM OUTPUT
C
500     REWIND 7
        IOBS=1
510     READ(7,1002,END=600) (DATA(IOBS,I),I=1,ICHEK)
1002    FORMAT(50F12.5)
        IOBS=IOBS+1
        GO TO 510
600     IOBS=IOBS-1
C
C   *   PLOT
C
        DO 800 II=1,IPLOTN
        IFLAG=0
        LL=NPCONT(II)
C
C   *   DETERMINE RANGES, EITHER BY INPUT OR VARIABLE VALUES
C
        XMIN=XMN(II)
        XMAX=XMX(II)
        YMIN=YMN(II)
        YMAX=YMX(II)
        IF(YMAX.NE.0.OR.YMIN.NE.0) GO TO 615
        YMIN=9.99E10
        YMAX=-9.99E10
        DO 610 JJ=1,LL
        IF(NPLOT(II,JJ).EQ.0) GO TO 610
        DO 610 KK=1,IOBS
        TEMP=DATA(KK,NPLOT(II,JJ))
        IF(YMIN.GT.TEMP) YMIN=TEMP
        IF(YMAX.LT.TEMP) YMAX=TEMP
610     CONTINUE
```

```
615   IF(XMAX.NE.0.OR.XMIN.NE.0) GO TO 619
      XMAX=IOBS
619   IF(YMAX.EQ.YMIN) GO TO 800
      DO 700 JJ=1,LL
      IF(NPLOT(II,JJ).EQ.0) GO TO 700
      NP=NPLOT(II,JJ)
      IF(IFLAG.NE.0) GO TO 670
C
C  *  FOR FIRST VARIABLE OF PLOT, PREPARE PLOT FORMATS
C
      IFLAG=1
      DO 620 I=1,51
      DO 620 J=1,121
620   GRAPH(J,I)=BLANK
      DO 630 I=1,51
      GRAPH(121,I)=BORDER
630   GRAPH(1,I)=BORDER
      DO 640 I=1,121
640   GRAPH(I,26)=PERD
      XSCALE=(XMAX-XMIN)/120.
      YSCALE=(YMAX-YMIN)/50.
      DO 660 K=1,13
660   ZX(K)=10.*FLOAT(K-1)*XSCALE+XMIN
C
C  *  PLOT VALUES WHICH FALL WITHIN THE PLOT RANGE
C
670   DO 680 I=1,IOBS
      IF(DATA(I,NP).GT.YMAX) GO TO 680
      IF(DATA(I,NP).LT.YMIN) GO TO 680
      DAY=I
      IF(DAY.GT.XMAX) GO TO 680
      IF(DAY.LT.XMIN) GO TO 680
      IX=(DAY-XMIN)/XSCALE+1.5
      IY=(DATA(I,NP)-YMIN)/YSCALE+1.5
      GRAPH(IX,IY)=LETT(JJ)
680   CONTINUE
700   CONTINUE
C
C  *  OUTPUT THE PLOT
C
      IF(IFLAG.EQ.0) GO TO 800
      WRITE(6,1003) II
1003  FORMAT('1'/3X,'PLOT NUMBER ',I2,' :')
      DO 710 JJ=1,LL
      IF(NPLOT(II,JJ).EQ.0) GO TO 710
      NP=NPLOT(II,JJ)
      WRITE(6,1009) LETT(JJ),FNAMES(NP),NPHOUR(NP)
1009  FORMAT(11X,A1,' = ',A8,' AT HOUR ',I2)
710   CONTINUE
      WRITE(6,1004)
      YES=YMAX+YSCALE
      DO 720 I=1,51
      KK=52-I
      YES=YES-YSCALE
      WRITE(6,1005) YES,(GRAPH(J,KK),J=1,121)
720   CONTINUE
      WRITE(6,1006)
      WRITE(6,1007) ZX
800   CONTINUE
      RETURN
1004  FORMAT(/1X,9X,'I',12(9('.'),'I'))
1005  FORMAT(1X,F8.2,1X,121A1)
1006  FORMAT(1X,9X,'I',12(9('.'),'I'))
1007  FORMAT(2X,13F10.1//40X,'IDAY')
      END
$$$$$DEQSOL
      SUBROUTINE DEQSOL
C   *********************************************************************
C   *  DEQSOL UPDATES THE STATE VARIABLES IN (STVAR) BY THE APPLICABLE
C   *  RATE VARIABLES IN (DERIV) FOR EACH HOURLY STEP.
C   *
C   *********************************************************************
```

```
C
      COMMON/STVAR/ S(1422)
      COMMON/DERIV/ D(1422)
      COMMON /INFO / TSOIL, TAIR, DENS, PRES, EMTRES, NBGIN, NINTCT,
     A NMSL, NMST, NBR, NBRIT, NBLT, NTUB, DELTA, CMLAI, DEVRBG, DEVRAG,
     B ACR, DAYHRS, IDAY, IDATE, IHOUR, DAYRAD, DEC, DLAT, AREALV,
     C OLRES, OLTDW, OLDWMT, TRESFL, TCWIN, TCWMSL, TCWBRI, TCWBL,
     D TCWTUB, TCWFR, ANPNRA, WERR, IDACNT, DEWPT, WINDSP, NMSIN,
     E EWFRG, EWTUBG, EWSTG, EWLFG, EAGPSL, NDEDL, RWCPL, RNET, ACVP,
     F PSILPT, PSISOL, NDAYS, IDAST, IOUTPT, IDAOUT, IHR(24),
     G IHRPLT(24),IPLOTN,AVDTRN,AVDTMP(24)
C   ********************************************************************
C   *  FOR EVERY STATE VARIABLE:
C
      DO 1000 I=1,1422
C
C   *  IF IT IS NOT YET OR NO LONGER BEING USED, SKIP IT:
C
      IF(S(I).EQ.999.99) GO TO 1000
      IF(S(I).EQ.888.88) GO TO 1000
C
C   *  UPDATE THE VARIABLE BY ITS CHANGE PER TIME STEP (EULER APPROX.):
C
      S(I)=S(I)+D(I)*DELTA
1000  CONTINUE
      RETURN
      END
$$$$$TABINT
      SUBROUTINE TABINT(TABLE, X, Y, NAME)
C   ********************************************************************
C   *  TABINT IS A TABLE INTERPOLATION ROUTINE.
C   *      TABLE IS THE VECTOR OF ALTERNATING INDEPENDENT AND DEPENDENT
C   *  VARIABLES.  THE INDEPENDENT VARIABLES MUST BE MONOTONICALLY
C   *  INCREASING.  THE FIRST ELEMENT OF THE TABLE IS THE TOTAL NUMBER
C   *  OF ELEMENTS IN THE TABLE.
C   *      X IS THE INDEPENDENT VARIABLE FOR WHICH A CORRESPONDING
C   *  DEPENDENT VARIABLE IS SOUGHT.
C   *      Y IS THE INTERPOLATED VALUE WHICH IS RETURNED.
C   *      NAME IS THE ALPHANUMERIC NAME OF THE TABLE (4 CHARACTERS
C   *  MAXIMUM).
C   *      THE Y RETURNED IF THE X IS OUTSIDE THE RANGE OF THE TABLE IS
C   *  THE MAX OR MIN Y IN THE TABLE ON THE BOUND CLOSEST TO X.
C   ********************************************************************
C
      DIMENSION TABLE(1)
      N=TABLE(1)
      N1=N-1
      IF ( X .LT. TABLE(2)) GO TO 300
      IF ( X .GT. TABLE(N1)) GO TO 400
      DO 100 I=4,N1,2
      IF (X .LE. TABLE(I)) GO TO 200
  100 CONTINUE
  200 Y = TABLE(I-1) + (TABLE(I+1)-TABLE(I-1))
     $    *((X-TABLE(I-2))/(TABLE(I)-TABLE(I-2) ) )
      RETURN
  300 Y=TABLE(3)
      RETURN
  400 Y=TABLE(N)
      RETURN
      END
$$$$$STINTR
      FUNCTION STINTR  (TABLE,H,SLH,YIH,V,SLV,YIV,N,M)
C   ********************************************************************
C   *
C   *   2 WAY TABLE INTERPOLATION ROUTINE.  BOTH INDEPENDENT VARIABLES
C   *   MUST BE TRANSFORMABLE VIA LINEAR RELATIONSHIP TO CORRESPOND TO
C   *   1, 2, 3....ETC.
C   *   ROUTINE FINDS IHS, IHL, IVS & IVL, AS DENOTED IN
C   *   THE FOLLOWING DIAGRAM.  THE SYMBOLS STARTING WITH 'T' ARE
C   *   TABLE ENTRIES; SYMBOLS STARTING WITH 'I' ARE ARRAY POSITIONS OF
C   *  THE TABLE ENTRIES.  X IS THE INTERPOLATED POINT SOUGHT.
C   *
```

```
C   *          ... ... IHS  IHL  ...  ...  ...
C   *
C   *      IVS ... ... TSS  TLS  ...  ...  ...
C   *                      X
C   *      IVL ... ... TSL  TLL  ...  ...  ...
C   *
C   *****************************************************************************
      DIMENSION TABLE(N,M)
      XH=H*SLH+YIH
      XV=V*SLV+YIV
      IHS=INT(XH) + 1
      IF(IHS .LT. 1 .OR. IHS .GE. M) GO TO 20
      IHL=IHS + 1
      IVS=INT(XV)+1
      IF(IVS .LT. 1 .OR. IVS .GE. N) GO TO 20
      IVL=IVS+1
      TSS=TABLE(IVS,IHS)
      TLS=TABLE(IVS,IHL)
      TSL=TABLE(IVL,IHS)
      TLL=TABLE(IVL,IHL)
      H1=(XH-(IHS-1)) * (TLS-TSS)+TSS
      H2=(XH-(IHS-1)) * (TLL-TSL)+TSL
      STINTR =(XV-(IVS-1)) * (H2-H1) +H1
      RETURN
   20 CONTINUE
      IF(IHS .LT. 1) IHS=1
      IF(IHS .GT. M) IHS=M
      IF(IVS .LT. 1) IVS=1
      IF(IVS .GT. N) IVS=N
      STINTR=TABLE(IVS,IHS)
      RETURN
      END
```

SERVING THE STATE

Teaching . . . Research . . . Service . . . this is the three-fold charge of the College of Agriculture at your state Land-Grant institution, the University of Idaho. To fulfill this charge, the College extends its faculty and resources to all parts of the state.

Service . . . The Cooperative Extension Service has offices in 42 of Idaho's 44 counties under the leadership of men and women specially trained to work with agriculture, home economics and youth. The educational programs of these College of Agriculture faculty members are supported cooperatively by county, state and federal funding.

Research . . . Agricultural Research scientists are located at the campus in Moscow, at Research and Extension Centers near Aberdeen, Caldwell, Parma, Tetonia and Twin Falls and at the U. S. Sheep Experiment Station, Dubois and the USDA/ARS Soil and Water Laboratory at Kimberly. Their work includes research on every major agricultural program in Idaho and on economic activities that apply to the state as a whole.

Teaching . . . Centers of College of Agriculture teaching are the University classrooms and laboratories where agriculture students can earn bachelor of science degrees in any of 20 major fields, or work for master's and Ph.D. degrees in their specialties. And beyond these are the variety of workshops and training sessions developed throughout the state for adults and youth by College of Agriculture faculty.