Peach
Version 1.0
User's Guide

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Installing PEACH

PEACH and its installation program are both Windows Applications, so Windows must already be correctly installed and running in order to install PEACH.

System Requirements

- Windows 3.1 or greater

- DOS 5.0 or greater

- processor with 4 Megabytes of RAM (Preferably a 486DX with 8 Megabytes of RAM for better performance)

- 10 Megabytes free hard disk space

- VGA or better monitor

Installation of PEACH

- To install, insert the Windows version of the BioQUEST Library CD into the appropriate drive on your computer. Open the Online Guide. Using the instructions on the first page of the Online Guide, navigate to the "Peach" section of the Guide. Clicking on the Install button on the bottom of the page will start the installation process. Follow the instructions on the screen.

- Note: To use the Online Guide, the Acrobat Reader must be installed on your computer. For best results, we suggest that you install Acrobat Reader version 4.0 or later. An installer for Reader version 4.0 is included on the BioQUEST Library CD.

Using this Manual

⚑The following sections of this manual cover:

- Using PEACH

- Customizing PEACH for advanced application

- Scientific aspects of PEACH model design

Using PEACH

Getting Started with PEACH

Welcome to PEACH: A user friendly peach crop yield and tree growth simulation model for research and education..

In this section we will go through a quick tour of what to expect with PEACH and see how easy it is to simulate peach tree growth over a season-long cycle.

Features

- Windows-based application built around a spreadsheet model to allow easy and intuitive manipulation of the data.

- Forty-six cultivar, orchard, location, and respiration input parameters and 65 output parameters allow a high degree of specificity and give practical and understandable results.

- Input weather data from anywhere in the world can be used with PEACH. PEACH ships with 11 complete sets of data from California.

- Spreadsheets are compatible with Microsoft Excel, version 4.0.

- Built-in graphing capabilities, including 3D views.

Starting PEACH

From the Windows Program Manager, open the program group that was created during the installation process.

To start PEACH:

- Double click on the PEACH icon.

The first screen that you will see is:
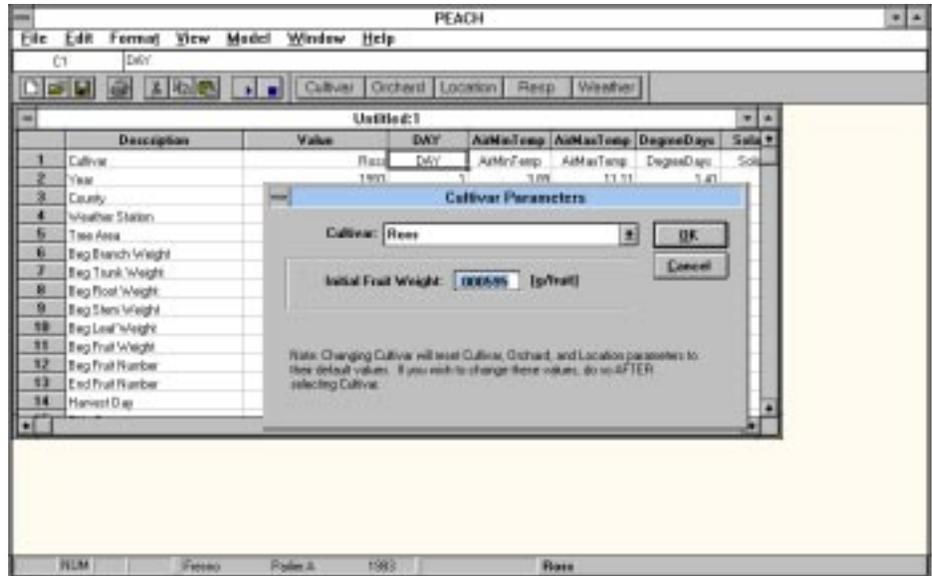
Use this screen to select the peach cultivar that will be simulated. Changing the cultivar will automatically change the initial fruit size.

> • Click on OK to proceed to the main PEACH screen.

What's in the Main PEACH screen

After you launch the PEACH application you are presented with the following screen.
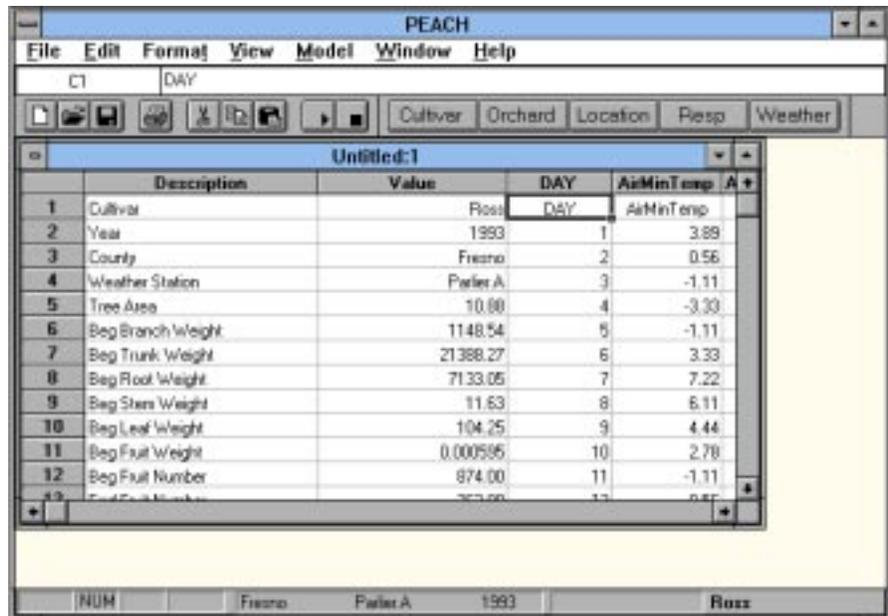
The Toolbar

The Toolbar appears above the main Peach screen.

Your First Simulation

You are now ready to take the model for a spin around the block. Each peachsheet represents one cultivar and one set of weather data. To do comparisons among various cultivars and locations, create a separate peachsheet for each simulation. Extended descriptions of the parameters that can be changed by the user appear at the end of this manual.

The default peachsheet that is loaded when you first launch PEACH is an example of a fully prepared peachsheet ready to run a simulation. The values are for the Ross cultivar and 1993 weather data from Fresno County, California. Let's take a closer look at the layout.

The first column in the spreadsheet describes the 46 changeable parameters that are related to the peach tree. They are grouped into the following categories: Orchard, Cultivar, Location, and Respiration. The values for each of these parameters are located in the second column. Any changes the user makes to these values will be visible in this column. Most changes are made through dialog boxes.

The fifth category of parameters is the weather data. These values appear in columns three through nine. This is actual weather data collected from weather stations by the California Irrigation Management Information System. Weather data is formatted into a weathersheet and imported into the peachsheet. There must be valid weather data for all the days between the earliest of start day, bloom day, and vegetative bud break day and the end day of the model. In other words, if the model starts its run on day 60 and ends on day 180 then weather data should appear for at least these days inclusively. Additional weather data will be ignored by the model.

It is advisable to keep all the weather data collected in a subdirectory under the application directory. PEACH will look for the data in the location set in the Options dialog box in the Edit menu (see page 11).

A Quick Tour of the Parameters Screens

Cultivar Parameters

To open the Cultivar parameters screen:

- Click on the toolbar button with the caption Cultivar

or,

- From the Peach menu select Model, then Model Parameters from the submenu, followed by Cultivar from the next submenu.

Keyboard shortcut to open Cultivar Parameters is Ctr+K
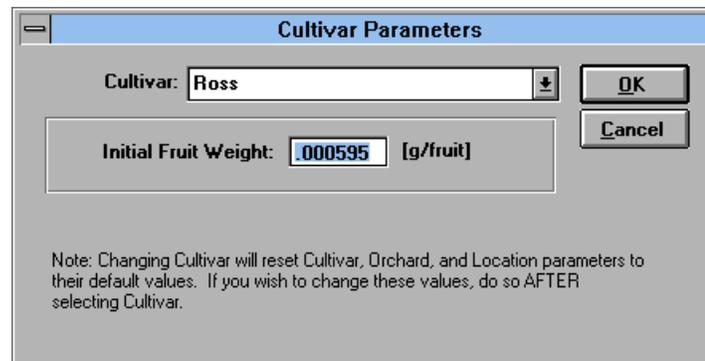
Remember that each peachsheet contains information relating to one cultivar. To change cultivars you will select one from the drop-down in this dialog box. Currently

there are three cultivars to choose from: Ross cling peach, and Cal Red and Spring Lady freestone peaches.

When a new cultivar is chosen all of the cultivar relevant parameters are reset to a set of defaults.

▥Description of Cultivar Parameters

Cultivar is the peach cultivar for which fruit growth is simulated. The model currently contains potential growth information for two freestone cultivars, Spring Lady and Cal Red, and one clingstone cultivar, Ross.

Initial fruit weight is the weight of *individual* fruits on the *bloom_day* or the first day of the simulation if the simulation begins after bloom.

Orchard Parameters

▥To open the Orchard Parameters dialog box:

- Select the toolbar button with the caption Orchard.

Or

Keyboard shortcut to open Orchard Parameters is Ctrl+O

- From the Peach menu select Model, then Model Parameters from the submenu, followed by Orchard from the next submenu.

The following screen will appear.

```
┌─────────────────────────────────────────────────────────┐
│ ▬            Orchard Parameters                          │
├─────────────────────────────────────────────────────────┤
│                                                          │
│        Tree Area:  [10.88]    [m^2/tree]      ┌────────┐ │
│                                               │   OK   │ │
│  Initial Branch Weight: [1148.54]  [g/tree]   └────────┘ │
│                                               ┌────────┐ │
│   Initial Trunk Weight: [21388.27] [g/tree]   │ Cancel │ │
│                                               └────────┘ │
│    Initial Root Weight: [7133.05]  [g/tree]              │
│                                                          │
│    Initial Stem Weight: [11.63]    [g/tree]              │
│                                                          │
│    Initial Leaf Weight: [104.25]   [g/tree]              │
│                                                          │
│    Initial Fruit Number: [874]     [Number/tree]         │
│                                                          │
│     Final Fruit Number: [363]      [Number/tree]         │
│                                                          │
│  Training System: [KAC Perpendicular V       ▼]          │
│                                                          │
│  Note:  Changing Training System will reset Orchard Parameters to their default │
│  values.  If you wish to change these values, do so AFTER selecting Training │
│  System.                                                 │
└─────────────────────────────────────────────────────────┘
```

For our first run we, will accept the parameters shown here and the default parameters for all the categories.

▥To close the Orchard Parameters screen:

- Click on OK

Note: Clicking on Cancel in any screen will discard any changes made in the dialog box.

Description of Orchard Parameters:

All orchard parameters are expressed on a per tree basis.

Tree area is the space (ground area) available for each tree. For example, trees planted 2m apart in the tree row and 5m between the rows would have a tree are of 10m^2.

Initial organ weights (branch, trunk, root, stem, leaf) are the weights of each organ on the first day of the simulation.

Initial fruit number is the number of fruits on one tree on the *bloom day.*

Final fruit number is the number of fruits after thinning on the *thin day.*

Training system describes the way that the trees are pruned and affects the seasonal patterns of light interception.

- *KAC Perpendicular V* is a high density, two scaffold training system with the scaffolds oriented perpendicular to the row direction (DeJong et al. 1994). For this training system, model light interception data are for trees planted 2 m apart in the tree row and 5.4 m between the rows (i.e. tree area=10.9 m^2). Tree height is maintained at approximately 4 m. (KAC is named for the Kearney Agricultural Center, a University of California agricultural research station located in Parlier, California,

- *High Density KAC Perpendicular V* is the KAC Perpendicular V system planted at a higher density. For this training system, model light interception data are for trees planted 1.8 m apart in the tree row and 4.6 m between the rows (i.e. tree area=8.4 m^2). Tree height is maintained at approximately 4 m.

- *Standard Open Vase* is a low density, multiple scaffold training system with 4-6 scaffolds. For this training system, model light interception data are for trees planted 5.5 m apart in the tree row and 6.1 m between the rows (i.e. tree area=33.5 m^2). Tree height is maintained at approximately 4 m.

- *Cordon* is a high density training system with two scaffolds tied to horizontal ropes, then turned upright. Horizontal laterals arising from the upright portions of the scaffolds are cropped. For this training system, model light interception data are for trees planted 2.4 m apart in the tree row and 3.9 m between the rows (i.e. tree area=9.7 m^2). Tree height is maintained at approximately 4 m.

- *Central Leader* is a high density, single leader training system. For this training system, model light interception data are for trees planted 2 m apart in the tree row and 4 m between the rows (i.e. tree area=8 m^2). Tree height is maintained at approximately 4 m.

Location Parameters
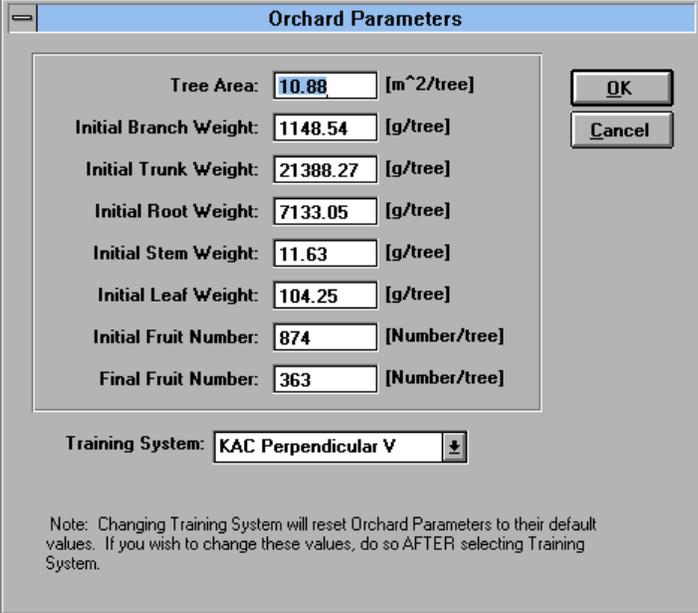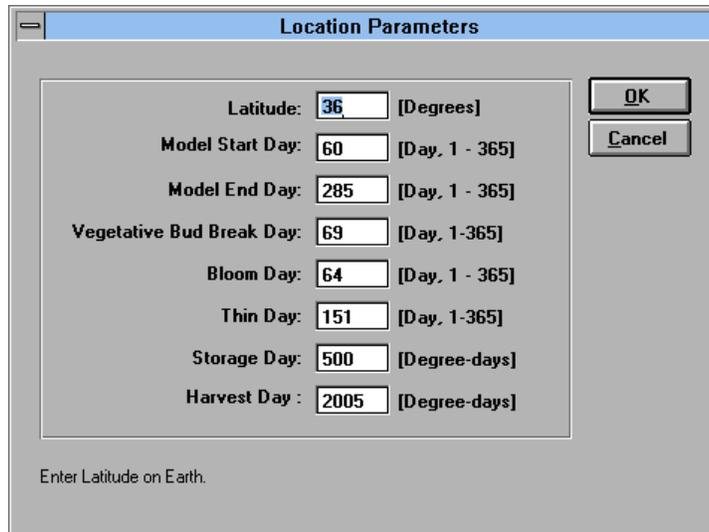
To Open the Location Parameters dialog box:

- Select the toolbar button with the caption Location

or

- From the peach menu select Model, then Model Parameters from the submenu, followed by Location from the next submenu.

Location Parameters

Latitude:	36,	[Degrees]
Model Start Day:	60	[Day, 1 - 365]
Model End Day:	285	[Day, 1 - 365]
Vegetative Bud Break Day:	69	[Day, 1-365]
Bloom Day:	64	[Day, 1 - 365]
Thin Day:	151	[Day, 1-365]
Storage Day:	500	[Degree-days]
Harvest Day :	2005	[Degree-days]

OK
Cancel

Enter Latitude on Earth.

Description of Location Parameters:

Model start day sets the beginning date for the simulation. If model start day is before bloom and vegetative bud break days, the simulation will begin on the earlier of bloom or vegetative bud break. If model start day is after bloom and vegetative bud break, the simulation will begin on model start day. In this case, the initial organ weights must be the weights on the start date, not the weights at bloom and vegetative bud break.

Model end day is the last day of the simulation. Model end day must be after model start day. The model is a growing season model and is not equipped to simulate leaf drop or the dormant season.

Latitude is the latitude of the location where the weather data were obtained.

Vegetative bud break day is the day on which vegetative growth begins. Vegetative bud break day depends on the cultivar and location.

Bloom day is the day on which the flowers bloom. Bloom day depends on the cultivar and location.

Storage day is the day on which the model begins to run using only current photosynthate. Prior to storage day, the model allows growth to occur at the potential rate using both current photosynthate and stored carbohydrate (see page 19).
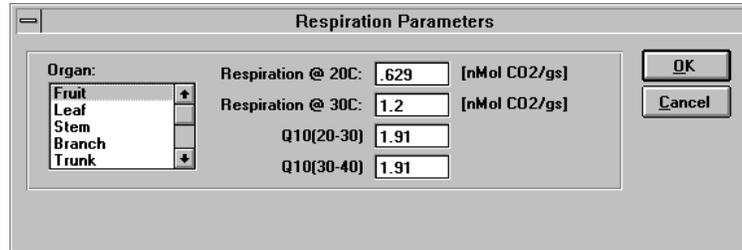
Maintenance Respiration Parameters

To Open the Maintenance Respiration Parameters dialog box:

- Select the toolbar button with the caption Resp.

or

- From the peach menu select Model, then Model Parameters from the submenu, followed by Respiration from the next submenu.

Description of Maintenance Respiration Parameters:

Respiration @ 20C is the organ maintenance respiration rate in nmol CO_2 per gram dry weight per second at 20°C.

Respiration @ 30C is the organ maintenance respiration rate in nmol CO_2 per gram dry weight per second at 30°C.

Q_{10} is the amount by which the respiration rate increases with a 10°C increase in temperature.

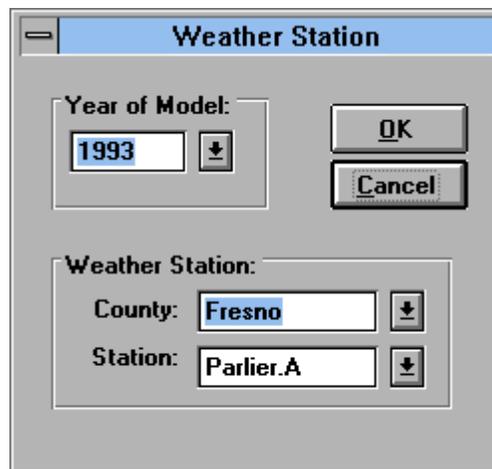*Q10(20-30)* is the Q_{10} between 20 and 30°C.

Q10(30-40) is the Q_{10} between 30 and 40°C.

Weather Parameters

To Open the Weather Station dialog box:

- Select the toolbar button with the caption Weather.

or

- From the peach menu select Model, then Model Parameters from the submenu, followed by Weather from the next submenu.

Description of Weather Parameters:

PEACH is shipped with 11 weathersheets for the Kearney Agricultural Center in Parlier, Fresno County, California.

Year is the year that the weather data were collected.

County is the county where the weather data were collected.

Station is the California Irrigation Management Information System designation for the weather station.

Starting and Stopping a Simulation

Once all of the various parameters are set, the next step is to begin the model. The amount of time it takes to run through an entire simulation depends on a couple of factors. First the time span of the run, i.e. the difference between the Model Start Date and the Model End Date. Secondly is the overall speed of the computer running the application. There is a lot of "number crunching" going on so you will notice a difference when running this program with a faster CPU and one equipped with a math coprocessor

To Start the Model:

Run Toolbutton

- Click on the Run button on the toolbar

or

- From the Peach menu select Model then select Start from the submenu.

To Stop the Model:

Stop Toolbutton

- Click on the Stop button on the toolbar

You can stop the model at anytime during the run. Any output calculated up to the point of termination will be in peachsheet. The data can then be graphed or examined. The data should be saved before beginning another run because the spreadsheet will be cleared when another run is started.

You use the mouse to move around on the spreadsheet during a run. The cursor may appear as an hourglass when it is moved to the scroll bars, but it is still active. Click above or below the box in the scroll bar to move one page at a time, or click and drag the scroll bar box.

Graphing the Data

After a run is complete there may be thousands of cells of data filled in the spreadsheet. All the data presented may be somewhat daunting. However, to help get things started we can have PEACH select and automatically generate a number of different graphs for us.

To Automatically Select data:

- Select the Model menu

- Choose Data Output (A submenu will appear with various choices)

- Select Organ Weight (Another submenu will appear)

- Select Fruit

If a chart appears to be missing axis labels, click on the up arrow on the chart title bar to maximize the chart. The axis labels should then appear.

Customizing PEACH

Advanced PEACH Options

Working Directly with the PEACHSHEET

Changes to the input parameters and weather data may be made directly on the spreadsheet by changing the values in any cell. Remember to rerun the model after making changes to the input parameters.

More About Weather Data

Setting location of weather data files

PEACH uses actual weather data collected from various weather stations in California, however, valid weather data from any region will work. These data are stored in data files called weathersheets. Weathersheets are spreadsheets with seven columns and 365 rows. Each column represents a specific weather parameter and the rows correspond to the days of the year. PEACH ships with weather data for the years 1984 to 1994 for the Parlier weather station in Fresno County, California.

These files are initially stored in a subdirectory of PEACH application directory. For example, c:\peach\weather. However they can be located anywhere you decide, the only requirement is that you specify the location of these files.

▦**To set the location of the weather files:**

- From the Edit menu select Options. (The following dialog box will appear.)
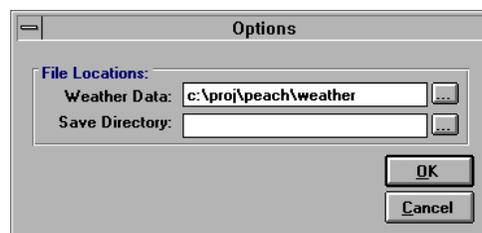
- Type in the directory containing the weather files, or click on the ellipsis (...) to select using the mouse.

Naming Conventions

The weather data file names may look a little cryptic, but they do have meaning. The extension follows the format of *.YYW, where YY represents the year. For example, CAFRAAF3.93W would be the weather file for 1993 data at Parlier. You may enter your own weather data into a weathersheet and give it any descriptive filename, however, you should follow the convention for the extension. PEACH does not have any knowledge of weather stations outside of California.

Weather Data Retrieval

There are two ways to retrieve the weather data. First is to select the Weather button from the toolbar and then choose from the available years and weather stations. If there is no weathersheet to match your selection then you will receive a message saying the file does not exist. The directory information for the weather files can be set under then menu items Edit/Options. Be sure to set the path correctly so that PEACH is looking in the right place.

The second method to retrieve a weather sheet is to select Retrieve Weather Info from the Model menu.
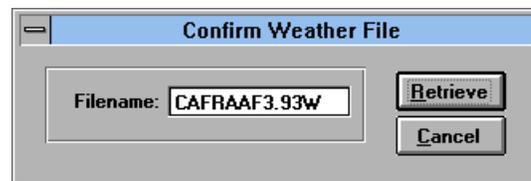
Type the full name of the weathersheet you want to retrieve (except for the path which is same for all weather files). Select Retrieve and PEACH will make an attempt to find the specified file.

Peachsheet Utilities

The Day/Date Calculator

To Open the Day/Date Calculator:

- From the View Menu select Day/Date Calculator

The Day/Date calculator is a useful utility that calculates the day of the year based on the calendar date. For example Day 16 is equal to the Calendar Date January 16.

The reverse can also be calculated. For example, if you input December 31 into the Day/Date calculator the Day result will be 365. That is, if it not a leap year. This very useful utility accounts for leap years.

The Day value, once derived, can then be copied to the Windows Clipboard and pasted into PEACH or any other Windows application.

Checking for Peachsheet Errors

At any point during the construction of the model parameters you can check the peachsheet for errors and inconsistencies in the values selected. Most errors can be avoided if you use the parameters dialog boxes to set values because many checks and defaults are built into these windows.

To check for errors in the peachsheet:

Ctrl+E is the keyboard shortcut

- From the Peach menu select Check for Errors.

If there are any errors or inconsistencies in the peachsheet a brief description will appear explaining how to remedy the problem.

The following is a list of the different types of errors that are checked:

- Missing weather data.

- Missing parameters. For example, no entry for the beginning trunk weight.

- Inconsistent parameters. For example, the model end date is before the model start date.

- Type checking. For example, numeric values are checked where PEACH expects to see numbers.

PEACH automatically checks for errors in the peachsheet before allowing a run to proceed. If any problems are found they must be corrected before the simulation will be completed.

Viewing a Summary of Parameters

To view a summary of all input parameters

- From the Model menu select Current Parameters

The following window will appear to give a synopsis of all the parameters the user is able to change. However, changes may not be made in this screen.

Peachsheet Variables

Variable name	Variable Description	Units
Day	Day of the year	Day (1-365)
AirMinTemp	Air minimum temperature	^{o}C
AirMaxTemp	Air maximum temperature	^{o}C
DegreeDays	Degree days	Degree-days/day
SolarRad	Solar radiation	Langleys (cal/cm^2)/day
SoilMinTemp	Soil minimum temperature	^{o}C
SoilMaxTemp	Soil maximum temperature	^{o}C
CumBloomDD	Cumulative degree days since bloom	Degree-days
DailyAssim	Assimilation by whole tree	g CHO/tree day
DailyMResp	Daily maintenance respiration	g CHO/tree day
DailyGRes	Daily growth respiration	g CHO/tree day
DailyCost	Daily cost of dry weight added and growth respiration	g CHO/tree day

CropWt	Fruit weight	g/tree
IndFruitWt	Individual fruit weight	g/fruit
LeafWt	Leaf weight	g/tree
StemWt	Stem weight	g/tree
BranchWt	Branch weight	g/tree
TrunkWt	Trunk weight	g/tree
RootWt	Root weight	g/tree
DailyFrCost	Daily fruit cost of dry weight added and growth respiration	g CHO/tree day
DailyLfCost	Daily leaf cost of dry weight added and growth respiration	g CHO/tree day
DailyStCost	Daily stem cost of dry weight added and growth respiration	g CHO/tree day
DailyBrCost	Daily branch cost of dry weight added and growth respiration	g CHO/tree day
DailyTrCost	Daily trunk cost of dry weight added and growth respiration	g CHO/tree day
DailyRtCost	Daily root cost of dry weight added and growth respiration	g CHO/tree day
DailyFrMres	Daily fruit maintenance respiration	g CHO/tree day
DailyLfMRes	Daily leaf maintenance respiration	g CHO/tree day
DailyStMRes	Daily stem maintenance respiration	g CHO/tree day
DailyBrMRes	Daily branch maintenance respiration	g CHO/tree day
DailyTRMRes	Daily trunk maintenance respiration	g CHO/tree day
DailyRtMRES	Daily root maintenance respiration	g CHO/tree day
DailyFrGRes	Daily fruit growth respiration	g CHO/tree day
DailyLfGRes	Daily leaf growth respiration	g CHO/tree day
DailyStGRes	Daily stem growth respiration	g CHO/tree day
DailyBrGRes	Daily branch growth respiration	g CHO/tree day
DailyTrGRes	Daily trunk growth respiration	g CHO/tree day
DailyRtGRes	Daily root growth respiration	g CHO/tree day
DailyResv	Daily storage reserves	g CHO/tree day
CumResrv	Cumulative storage reserves used	g CHO/tree
LAI-ground	Leaf area index	m^2 leaf area/m^2 ground area
DailyGRes	Daily growth respiration	g CHO/tree day
CHOAfterMRes	Carbohydrate available after maintenance respiration	g CHO/tree day
(Avail-Req)CHO	Carbohydrate available after main. resp. and above ground growth	g CHO/tree day
CostDailyPotGrwth	Cost of daily potential growth	g CHO/tree day
CumAssim	Cumulative assimilation	g CHO/tree
CumCost	Cumulative cost of dry weight and growth respiration	g CHO/tree
CumMRes	Cumulative maintenance respiration	g CHO/tree

CumGRes	Cumulative growth respiration	g CHO/tree
FracGrwth	Fraction of growth allowed for fruit, leaf, stem, and branch	Fraction
FracGrwth(Tr)	Fraction of growth allowed for trunk	Fraction
CumFrMRes	Cumulative fruit maintenance respiration	g CHO/tree
CumLfMRes	Cumulative leaf maintenance respiration	g CHO/tree
CumStMRes	Cumulative stem maintenance respiration	g CHO/tree
CumBrMRes	Cumulative branch maintenance respiration	g CHO/tree
CumTrMRes	Cumulative trunk maintenance respiration	g CHO/tree
CumRtMRes	Cumulative root maintenance respiration	g CHO/tree
CumFrGRes	Cumulative fruit growth respiration	g CHO/tree
CumLfGRes	Cumulative leaf growth respiration	g CHO/tree
CumStGRes	Cumulative stem growth respiration	g CHO/tree
CumBrGRes	Cumulative branch growth respiration	g CHO/tree
CumTrGRes	Cumulative trunk growth respiration	g CHO/tree
CumRtGRes	Cumulative root growth respiration	g CHO/tree
IndFrFrshWt	Fresh weight of individual fruits	g fresh weight/fruit
CumVegDD	Cumulative degree days since vegetative bud break	Degree-days

PEACH Model Design

Design Assumptions

PEACH is a state-variable model in which fruit, leaf, current-year stem, branch, trunk, and root weight are the state variables, and minimum and maximum air and soil temperatures, degree-days, and solar radiation are the driving variables. The rate variables that characterize carbohydrate supply and demand are derived from previous studies on photosynthesis, respiration, and growth potential in peach trees (DeJong and Goudriaan 1989b, DeJong, Johnson and Castagnoli 1990, Grossman and DeJong 1994a,b, 1995a,b). The model assumes that the trees are optimally irrigated and fertilized.

Further information on the model is published in Grossman, Y.L. and T.M. DeJong 1994. Peach: A simulation model of reproductive and vegetative growth in peach trees. Tree Physiology 14:329-345. Portions of this help manual are excerpted from this publication.

Carbohydrate Supply

The photosynthetic carbon assimilation submodel was modified from an annual crop growth model, SUCROS '86 (Simple and Universal CROp growth Simulator, van Keulen, Penning de Vries and Drees 1982, van Kraalingen and Spitters 1986), which explicitly simulates total daily canopy photosynthesis using Gaussian integration of the instantaneous rate of leaf photosynthesis over canopy depth and diurnal light conditions (Goudriaan 1986, Kropff, Bastiaans and Goudriaan 1987).

The assimilation module of SUCROS '86 was modified to account for the discontinuous canopy within a peach orchard using empirical data on the seasonal pattern of daily light interception within peach orchards to adjust the effective leaf area index throughout the day (DeJong and Goudriaan 1989b). The light-saturated instantaneous photosynthetic rate (DeJong and Doyle 1985, DeJong et al. 1989) is adjusted for the effect of air temperature (Grossman, unpublished data), leaf age (DeJong and Doyle 1984) and light exposure with canopy depth (DeJong and Doyle 1985). Leaf area index is calculated from simulated leaf weight using an experimentally determined average specific leaf area.

Carbohydrate Demand

Maintenance Respiration

Leaf maintenance respiration rates were estimated from previously determined leaf specific respiration rates by the mature tissue method (Amthor 1989, Grossman and DeJong 1994a). Stem, branch and trunk maintenance respiration rates at 20°C were estimated using the regression method:

$$RS = RM + (G * RGR)$$

where RS is the specific respiration rate (g carbohydrate g^{-1} second^{-1}), RM is the maintenance respiration rate (g carbohydrate g^{-1} second^{-1}), G is the growth respiration coefficient (g carbohydrate g^{-1}), and RGR is the relative growth rate (g g^{-1} second^{-1}) (Amthor 1989). The growth respiration coefficient, G, for peach fruits was used in the calculation (0.211 g carbohydrate g^{-1}, DeJong and Goudriaan 1989a) was used. Current-year stems, branches, and trunk specific respiration rates, RSs, and relative growth rates, RGRs, for were obtained experimentally as previously described (Grossman and DeJong 1995a,b). The maintenance respiration rate for roots was set to the rate determined from branches of similar size.

The model calculates temperature and maintenance respiration hourly because maintenance is sensitive to temperature, approximately doubling when the temperature increases from 20 to 30°C (Amthor 1989, Grossman and DeJong 1994a). Hourly temperatures are calculated from air and soil minimum and maximum temperatures assuming a sinusoidal temperature pattern during the day and an exponential temperature decline during the night (van Kraalingen and Rappoldt 1987). The daily carbohydrate cost of maintenance respiration is determined as the sum of the products of the hourly respiration rates and the dry weights for each organ type.

Growth

 The model determines daily potential net sink strength for each organ type from experimentally determined seasonal patterns of organ growth potential (Grossman and DeJong 1995a,b). The daily conditional net sink strength, reflecting the effect of temperature on growth, is determined from the potential net sink strength and the number of degree-days accumulated on each day. The carbohydrate cost of daily growth is calculated as the sum of the carbohydrate equivalent weight of the dry weight added by growth (sink strength) and the respiratory cost of that growth:

$$CG = (CEDM * DM) + (G * DM)$$

where CG (g carbohydrate day^{-1}) is the carbohydrate cost of the dry matter added, CEDM (g carbohydrate g^{-1}) is the carbohydrate equivalent weight of the dry matter, DM (g day^{-1}) is the weight of the dry matter added, and G (g carbohydrate g^{-1}) is the growth respiration coefficient. The carbohydrate equivalent weights of leaves, current-year stems, trunk and roots was determined by pyrolysis at the Microanalytical Laboratory, Department of Chemistry, University of California, Berkeley, CA.

Partitioning

PEACH simulates carbohydrate partitioning on a daily basis. The model supplies carbohydrate for maintenance respiration requirements before supplying carbohydrate for growth (Crapo and Ketellapper 1981). The carbohydrate requirements for growth are satisfied based on the conditional net sink strengths of the growing organs and their proximity to the source. Similar approaches to partitioning have been taken in modeling the growth of potatoes (Ng and Loomis 1984), grapevines (Wermelinger, Baumgärtner and Gutierrez 1991), and kiwifruit (Buwalda 1991). All carbohydrate partitioning is characterized in terms of dry

weight gain, representing the weight of structural growth and carbohydrate storage reserves.

Sink strength is calculated by grouping organs of the same type together, although it is recognized that transport occurs to individual growing organs. The fruits, leaves, stems, and branches are modeled as being closest to the source, followed by the trunk, and finally the roots. Daily carbohydrate availability after maintenance respiration, and the carbohydrate cost of daily potential fruit, leaf, stem, and branch growth are calculated. Growth occurs at the potential rate if sufficient carbohydrate is available. If this is not possible, the fraction of potential growth that can be supported is calculated as the ratio of carbohydrate availability after maintenance respiration to carbohydrate requirement for potential growth. This fraction is multiplied by the daily potential growth of each organ type to determine organ growth. Trunk growth is determined by calculating the ratio of carbohydrate available after fruit, leaf, stem, and branch growth to the carbohydrate cost of daily trunk growth potential.

The daily carbon budget is balanced by assigning remaining carbohydrate to root growth. No attempt is made to account for loss of carbohydrate from the roots by fine root turnover, exudation, and increased respiration during active transport of nutrients. For this reason, although the model calculates root growth, the values should more reasonably be attributed to root function, including metabolic processes and structural and storage biomass gain.

Until the "storage day," fruits, leaves, stems, and branches are allowed to grow at their conditional growth rates, unrestricted by carbohydrate availability. If the carbohydrate available from current photosynthesis is not sufficient to support this growth, it is provided by stored carbohydrate and deducted from the dry weight of the trunk and roots (Ryugo and Davis 1959, Johnson and Lakso 1986). During the rest of the season, the carbohydrate demand is met by daily carbon assimilation.

Organ growth potential

The organ growth potential is the genetically determined growth attained when an organ is grown under optimal environmental conditions in the presence of a non-limiting supply of carbon and other resources (Warren Wilson 1967, 1972; Wareing and Patrick 1975; Ho 1984, 1988). Under these conditions, organ growth is limited only by endogenous characteristics of the organ, and is termed sink-limited growth (Warren Wilson 1967, 1972; Wareing and Patrick 1975). In contrast, growth that is limited by resource supply is termed source-limited growth. The organ growth potential determines the potential net sink strength, the maximum rate at which an organ can accumulate dry matter per unit time (Warren Wilson 1967, 1972; Wareing and Patrick 1975; DeJong and Goudriaan 1989a; DeJong and Grossman 1992).

Potential net sink strength

The potential net sink strength is the maximum rate at which an organ can accumulate dry matter per unit time (Warren Wilson 1967, 1972; Wareing and Patrick 1975; DeJong and Goudriaan 1989a; DeJong and Grossman 1992). The potential net sink strength is the product of sink size and potential sink activity expressed as the relative growth rate:

$$\text{potential net sink strength} = \text{sink size} \times \text{potential sink activity}.$$

Potential gross sink strength

The potential gross sink strength is the sum of the potential net sink strength and the respiratory losses of the growing organ:

$$\begin{matrix} \text{potential} & & \text{potential} & & \text{growth} & & \text{maintenance} \\ \text{gross sink} & = & \text{net sink} & + & \text{respiration} & + & \text{respiration} & . \\ \text{strength} & & \text{strength} & & & & \end{matrix}$$

Model Parameterization

Input data

The trees used in the development and testing of the model were a mid-August maturing peach cultivar (*Prunus persica* (L.) Batsch cv. Cal Red) planted in 1984 at the University of California Kearney Agricultural Center in Parlier, California. Calibration data on fruit and vegetative growth potentials were obtained on trees that had been heavily thinned and defruited at bloom, respectively (Grossman and DeJong 1995a,b).

Minimum and maximum air and soil temperatures, and solar radiation was obtained from the California Irrigation Management Information System (CIMIS) weather station located at the Kearney Agricultural Center. Degree-days were calculated using the single sine, horizontal cutoff method, with critical temperatures of 7 and $35^{o}C$ (Zalom et al. 1983, DeJong and Goudriaan 1989a).

Model Predictions

Model predictions corresponded to observed field values for fruit and vegetative growth under conditions that differed greatly from those used to develop the growth potential equations (Grossman and DeJong 1994b). In particular, changes in the seasonal patterns of fruit and vegetative growth due to differences in the time of fruit thinning were accurately simulated by the model. The model predicted periods of carbohydrate limitations on fruit and stem growth which coincided with resource-limited growth periods identified in previous experimental studies (Grossman and DeJong 1995a, b).

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