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Chapter 1: Interface of ORYZA v3

Objective: To learn how to load input files, run the model using the ORYZA v3 Standalone Interface for Windows, and visualize the simulation results using the ORYZA Analysis Tool.

1.1. Load Control File

1) Click on the **Load Control** button.
2) Find and select the control file, ***CONTROL.DAT***.
3) Double-click on the control file to load.
4) To open and view the file, click on the **SIMULATION CONTROL FILEPATH** textbox.
5) Edit the control file according to the actual file locations and filenames.
6) Click on **Save** to retain the changes in the control file itself, or use **SaveAs** to save it as a new file.

> *** NOTES:**
> - The control file is conventionally named CONTROL.DAT, but it can be changed according to the user's preference.
> - Make sure that the first line of the file reads either:
>
>   **CONTROLFILE = 'filepath/filename'**
>
>   **or**
>
>   ***CONTROLFILE = filepath/filename**
> - The control file lists all data input files that will be used in the simulation.

1.2. Load Input Files

1) Click on the **Load Inputs** button.
2) Find and select the needed inputs: crop, experimental, soil, weather, and rerun files.
3) Click on **Open**.
4) To open, view, and edit an input file, click on the filename in the **INPUT FILE** selection box. The content of the input file will be shown on the Display window.
5) Edit the content by modifying the values of the variables, as needed.
6) Click on **Save** to retain the changes in the working file, or use **SaveAs** to save it as a new file.

> ***NOTES:**
> - Once the load window is open, **CTRL + <click filename/s>**, to select and load needed input files.
> - A loaded input file can be removed from the INPUT FILE selection box by selecting the file, pressing the right click button, and confirming file delete.

1.3. Simulate ORYZA

1) After loading, double-check the control and input files if correct and if necessary information is supplied.
2) Click on the **Execute** button to do the simulation.
3) A successful simulation will show:

   a. The message ***"ORYZA: Initialize model SUCCESS"***.
   b. The output files in the **OUTPUT FILE** selection box.
4) The output files include the simulation logs for any warning (weather.log and model.log) and the simulation results, **OP.DAT** and **RES.DAT**.
5) To open and view files for simulation results, select between the RES.DAT and the OP.DAT files.

> ***NOTES:**
> - Errors exist if the output box does not have four files: ***weather.log***, ***model.log***, ***op.dat***, and ***res.dat***.
> - Before opening any file in the output box, please check for warning messages displayed after the simulation is completed to make sure that there are no errors.
> - The **RES.DAT** file contains the detailed simulation results of the model in daily time step.
> - The **OP.DAT** file contains the summary or end-of-simulation values (e.g., final yield and total crop duration).
> - It is also important to check for warning messages in *weather.log* and *model.log*. The error message/s will be very helpful in troubleshooting unsuccessful simulation runs.

1.4. Visualize simulation results using the ORYZA Analysis Tool

1) Open the **ORYZA Analysis Tool**.
2) Click on the **Options** button. Tick the '***Enable the content***' option on the Security Alert-Macro.
3) Make a link to the target simulation output by changing file path to the output file you want to visualize.
4) Click on the **Analysis** button.
5) A message showing ***"Successfully Done!"*** appears.
6) The statistical analysis results and graphs can be found in the **'Table'** and **'Graphs'** worksheets, respectively.
7) The seasonal and detailed outputs per time step are re-organized into '**op**' and '**res**' worksheets, respectively.

> ***NOTE:**
> - Use '**ORYZA Analysis Tool(v4.2).xlsm**' for MS Excel 2007 or higher; or
>   '**ORYZA Analysis Tool(v4.2).xls**' for versions earlier than MS Excel 2007.
> - You can save the Excel workbook with your preferred filename and edit the tables and/or graphs as needed using Excel functions.

> ***NOTE:**
> - If you are running ORYZA in LINUX system, you should use lower case in the filename.

Chapter 2: Conversion of experimental data to modeling data

It is important to perform a quality check of your raw data before you proceed. Ideally, you should have a sequential dry weight measurement of green leaves, dead leaves, stem, panicles, and LAI. See Appendix 1 for other data needed for the ORYZA simulation. Data availability will determine the accuracy of model outputs.

The modeling data differs from the field experiment data. In most cases, the field experiment data must be converted into data for ORYZA in terms of format and unit of measurements. Prepare a new spreadsheet file that summarizes the data you will need for the simulation.

If you have several treatments, it is best to separate each treatment into different sheets.

2.1. Crop management data

1) Take note of the phenological stages of the variety you are simulating, such as sowing date, transplanting date, panicle initiation, flowering, and physiological maturity. Change them into Julian days (*.exp file, section 8).
2) Prepare an irrigation table (if applicable), providing the date and the amount of irrigation water (in mm) applied on the given date (*.exp file, section 6).
3) Prepare a table for fertilizer application, providing the date and the amount of fertilizer applied (in kg N ha^{-1}) on the given date (*.exp file, section 7).
4) Planting distance and density (plants m^{-2}) should also be provided (*.exp file, section 5).

2.2. Biomass data

1) Take note of the corresponding date of sampling for each measurement and convert them into Julian days. Get the mean if the sampling dates of the replicates are not the same.
2) Get the mean of the replicates of your measured raw data and convert the units into kg ha^{-1}. Place them in the cell beside the corresponding sampling date.
3) Repeat Steps **1** and **2** for every variety and treatment that will be used.

2.3. Other data

For an experiment, you may also have other observed, measured, and/or recorded data. These should also be reorganized.

1) The date must correspond to each data collection.
2) The mean is drawn from each set of replicates per data collection date.

Chapter 3: Preparation of input files

Objective: To learn the preparation of all input files of the ORYZA modeling study using the modeling dataset.

Reading: Appendices 2 and 3.

3.1. Template of input files

At least 7 types of input files are needed to run ORYZAv3 for a given experiment, and more input files are needed if the experiment has more treatments. However, the format of a type of input file is the same for different treatments and experiments and only the variable values need to be changed according to the treatment of a given experiment. Those files can be prepared from standard templates. The following sections will guide you in preparing the input files step-by-step.

1) Make a working folder in your target computer drive with folder name: "**C:\oryzatrain**".

> ***NOTE:**
> - The full folder name could be either "**C:\oryzatrain**" or "**D:\oryzatrain**", depending on the local drive location and name. Pay attention to the location of the input files because the file path will be provided in the input files accordingly.
> - In all input templates, the variable definition with "`!*`" or "`*!*`" means that the variable can be commented out. Otherwise, the variable must have a value.

2) Copy all file templates in the folder "**InputTemplates**" from the training materials into the working folder "**C:\oryzatrain**".
3) Make sure that you have the following files:
    (1) "`standard.exp`" for experimental file
    (2) "`paddyin.sol`" for paddy soil file
    (3) "`standard.sol`" for soil file
    (4) "`lowbalin.sol`" for lowland soil file
    (5) "`sahelin.sol`" for freely draining upland soil file
    (6) "`sawain.sol`" for lowland or upland soil file
    (7) "`soilpfin.sol`" for soil water tension file
    (8) "`standard.crp`" for crop file
    (9) "`reruns.rer`" for rerun file
    (10) "`PHIL1.992`" for weather file
    (11) "`PHIL2.cli`" for multiple year weather file
    (12) "`control.dat`" for simulation control file
    (13) "`hydraulic.txt`" for input to compute soil hydraulic parameters
    (14) "`CALIBRIN.dat`" for calibration control file
    (15) "`PARAM.in`" for input information of model parameterization

3.2. Weather file

The weather data provided is not in the format for ORYZA. The weather data must be re-organized into the ORYZA weather file format, which is a comma separated value file (.csv file). This can be easily done using MS Excel.

1) Use the MS Excel spreadsheet to open the weather data.
2) Organize different weather variables according to the following sequence of columns:
    (1) Station number
    (2) Year
    (3) Day
    (4) Radiation or sunshine hours
    (5) Minimum temperature
    (6) Maximum temperature
    (7) Vapor pressure
    (8) Windspeed
    (9) Precipitation

***NOTE:**

- If the station number, year, or day is not included in the columns, those data should also be integrated in the Excel file.
- If the vapor pressure, windspeed, and/or precipitation are missing for **some days**, these can be replaced with a value of ***-99.0***.
- If all the variables of weather data are missing in some days, a secondary source must be found. An example is getting them from the nearest meteorological station or replacing them with historical data of the year that has a similar weather pattern as the year of data preparation.

3) Only weather data for one year is allowed per worksheet. If the required data is more than one year, place the weather data for the succeeding year in another worksheet.
4) Insert on the first row the additional required data according to this required sequence:
    (1) Longitude
    (2) Latitude
    (3) Altitude
    (4) Angstrom A parameter
    (5) Angstrom B parameter

***NOTE:**

- The value for Angstrom A and Angstrom B is ***0*** if the data available is **solar radiation**. However, the appropriate values must be provided if the data available is sunshine hours.
- Normally, the values of Angstrom A and B can be found from the local meteorological station or climate bureau. Otherwise, refer to the values in number 4.

5) Save each of the yearly weather worksheet as a .csv file.
    (1) Select **Save As** then click on **Other Formats**.

(2) Choose **CSV (Comma delimited) and** select your desired location for the weather file.
(3) For the filename, use "***station name + station number***" as convention. For example, ***PHIL1***, where ***PHIL*** is the station name and ***1*** is the station number.
(4) Click on **Save**.
(5) Click on **OK** to 'save only the active sheet', then click on **Yes**.

***NOTE:**
- For multiple weather data files in different worksheets, convert each of the worksheet to the required weather file format.

6) Go to the saved .csv weather file and change the file extension from .csv to only the ***last three digits*** of the weather data year. For example, ***PHIL1.csv*** will be changed to ***PHIL1.988*** for weather data in 1988.

***NOTES:**
- The units of measurement for weather data:

Element	***Unit***
Irradiance	KJ/m^2/d
Minimum temperature	℃
Maximum temperature	℃
Vapor pressure	kPa
Mean wind speed	m/s
Precipitation	mm/d

- Missing observations are indicated by ***-99.0***.
- The conversion of available data to the required data follows:

1) The daily saturated vapor pressure (E_s, kPa) can be calculated using Equation 1 with mean daily air temperature (T, °C).

$$\boldsymbol{E_s = 0.6108 \times 10^{\frac{7.5T}{237.7+T}}} \quad \textbf{(Equation 1)}$$

2) The actual daily vapor pressure (E_a, kPa) can be calculated using Equation 1 with air temperature at dew point (Td, ^{o}C) replacing T with Td.

3) Equation 2 can be used to calculate the actual vapor pressure (E_a, kPa) from relative humidity (RH, %).

$$\boldsymbol{E_a = E_s \frac{RH}{100}} \quad \textbf{(Equation 2)}$$

4) In the weather file, the first row of the data will provide the geo-coordinates and elevation of the weather station. The last two values in the first data row must be set to ***0*** if solar radiation, also called irradiance, was provided. Otherwise, the Angstrom A and B parameter values must be provided if the radiation was given in sunshine hours. The values of A and B could be obtained at local meteorological station. If not, values presented in the table below can be used for different climatic zones.

Zones	**A**	**B**
Cold and Temperate	0.18	0.55
Dry tropical	0.25	0.45
Humidity tropical	0.29	0.45

***NOTES:**

- It is an option to integrate multiple years of weather data from a weather station into one weather input file.
- If multiple year format is chosen, the filename must be composed of "*<weather station name> <weather station number>.CLI*".
- The weather station details will only be needed on the first line of weather data, and the data must be in correct year order.
- The example of multiple year weather file:

Weather file example: ***phil1.cli***

```
*-----------------------------------------------------------
*  Station Name: IRWE0001    IRRI wetland site, Los Banos
*  Author      : Climate Unit, IRRI    -99.: nil value
*  Source      : International Rice Research Institute (IRRI
*  Comments    : This file is extracted from CLICOM database.
*  Longitude: 121 15 E   Latitude: 14 11 N    Altitude: 21.0
*  Column    Daily Value
*     1      Station number
*     2      Year
*     3      Day
*     4      irradiance         KJ m-2 d-1
*     5      min temperature            oC
*     6      max temperature            oC
*     7      vapor pressure            kPa
*     8      mean wind speed         m s-1
*     9      precipitation          mm d-1
*-----------------------------------------------------------
121.25, 14.18,  21.00,0.000,0.000
    1,1980,  1, 14003.00, 20.50, 29.50,  2.60,  0.60,  0.00
    1,1980,  2, 12527.00, 21.50, 29.50,  2.71,  0.30,  0.50
    1,1980,  3, 17135.00, 21.00, 29.70,  2.60,  0.60,  0.00
    1,1980,  4, 18359.00, 19.50, 29.90,  2.81,  0.60,  0.20
    ⋮,  ⋮ ,  ⋮,     ⋮    ,   ⋮  ,   ⋮  ,   ⋮  ,   ⋮  ,   ⋮
    1,1980,366, 10655.00, 22.60, 26.80,  2.88,  2.80,  0.00
    1,1981,  1, 16091.00, 21.80, 28.50,  2.83,  1.20,  0.00
    ⋮,  ⋮ ,  ⋮,     ⋮    ,   ⋮  ,   ⋮  ,   ⋮  ,   ⋮  ,   ⋮
    1,1981,365, 14615.00, 22.40, 29.60,  2.93,  1.50,  0.00
    1,1982,  1, 17135.00, 21.70, 29.20,  2.93,  1.80,  0.00
    ⋮,  ⋮ ,  ⋮,     ⋮    ,   ⋮  ,   ⋮  ,   ⋮  ,   ⋮  ,   ⋮
    1,1982,365, 16091.00, 22.40, 30.50,  2.78,  1.20,  0.00
```

3.3. Experiment file

Open the modeling dataset file that you have prepared in Chapter 2. The experiment used in this training course consists of three treatments: CF (continuously flooded), W-limited (continuously flooded in vegetative stage and rainfed in reproductive stage), and N-limited (continuously flooded field with low or no nitrogen fertilizer application). Three experiment files will be prepared step-by-step in the following sections.

3.3.1. Understanding experiment file for special attention

Open experiment template file "**standard.exp**" using Notepad.

Read through Sections 6, 7, and 8 to understand the definition of each variable and pay attention to the data type of each variable.

Section 6: Variables ICOMBA and IRMTAB describe the irrigation management and other variables for water management switches and the irrigation amount.

The data of variable RIRRIT has two columns for irrigation application.The first column contains dates according to the Julian calendar, and the second column is for the amount of irrigation applied (mm).

Section 7: The data of variable FERTIL has two columns. The first column represents the date of fertilizer application in days after sowing (**NOTE: It is not in Julian days**). The second column is for the amount of fertilizer applied.

Section 8: The data type for **phenology** development parameters are all **integers**. Data of all observation variables (variables have characters "_OBS") are composed of three columns and all are **real** numbers. The second column is for Julian days of observation. The values of these variables should be filled in by the data in the experimental dataset file.

Also, variables LAI_FRC and NFLV_FRC should be carefully chosen. These can be set to "Forcing" condition if you would like the model to use observed values on leaf area index (LAI) and/or leaf nitrogen content (NFLV) for simulation computation. In this case, the model outputs on LAI and/or NFLV are the same as the input value, and other outputs will be limited by the LAI and/or NFLV inputs.

3.3.2. Working with data Excel file

As we have understood the data structure in Sections 6, 7, and 8, we have to work in an Excel dataset file as follows:

1) Open modeling dataset Excel file "***SampleData.xlsx***" in your source folder.
2) Move to the "***crop mgt***" sheet to calculate the Julian days of all phenological stages.
3) Compose the data into input format for all treatments by using the string concatenate function.

4) Repeat Steps **2** and **3** for other observation data. The observation data should include year, Julian day, and measured data in three columns.

3.3.3. Prepare experiment file for CF treatment

1. Work with Section 1:

1) Open template file for experiment, "standard.exp", in your work folder "***C:\oryzatrain***".
2) Click on and "**Save As**" "***CF.exp***".
3) Scroll up the Section 1.
4) Set `RUNMODE` to '`EXPERIMENT`' by removing "*" at the beginning of the line.

> ***NOTE:**
> - For variables that have a string value, do not miss the single quotation mark at the beginning and end of the string value. The setting switches of variables in Section 1 will be discussed in the scenario study (Chapter 5).

5) Set `PRODENV` to '`POTENTIAL`' because it is continuously flooded and we are not interested in the irrigation management for this experiment.
6) Set `WATBAL` to be '`PADDY`' because the experimental condition for all treatments were in paddy.

> ***NOTE:**
> - 'PADDY' module can also be used for upland and rainfed conditions, but care for the setting in the Section 2 of soil file.

7) Set `NITROENV` to `'NITROGEN BALANCE`' because we are not sure whether or not the nitrogen supply is enough to support potential growth of rice in the experiment.
8) Set `ETMOD` to '`PENMAN`' because we have weather data for radiation, max and min air temperature, rainfall, wind speed, and vapor pressure.

2. Work with Section 2:

1) Set `IYEAR` to `1988`, which is the start year of our experiment.

> ***NOTE:**
> - Data type for this variable is an integer.

2) Set `STTIME` to be `337.`, which is the start Julian day of our experiment.

> ***NOTE:**
> - The data type for this variable is '**real**', so do not forget the decimal point "**.**" after the number. The value of `STTIME` could be earlier than the start day of the experiment, if we are not sure of the initial conditions of the soil; but, do not set it to later than the start day of the experiment, which will stop simulation.

3) Set `FINTIME` at a large real number to ensure that the model will not stop before crop maturity provided that all inputs are correct.

3. Work with Section 3:

1) Set WTRDIR to '***C:\oryzatrain***', a string value of the full folder name of your weather file.

> ***NOTE:**
> ➢ The full folder name must end with a "\"; the weather file can be in a different folder.

2) Set CNTR to 'PHIL', which is the character part of the filename of your weather file.
3) Set ISTN to 1, which is the digit part of the filename of your weather file.
4) If multiple year weather file was used in the weather input, one additional variable, MULTIY, should be set as MULTIY = 'YES'.
5) Change values of ANGA and ANGB to your reference number if the radiation in your weather file is in sunshine hours. The reference number can be found in your local meteorological station.
6) Variables TMCTB, TMINCTB, TMAXCTB, and CO2A are climate change factors for daily mean air temperature, daily maximum and minimum air temperature, and daily atmospheric CO_2 concentration (ppm). The first column is for a Julian day, as a real number, the second is for the value. Temperature change can be set by either TMCTB or TMINCTB and TMAXCTB.
7) No change for FAOF, unless you are sure that the model over- or underestimated the potential evapotranspiration.
8) No change for TMPSB, unless you grow your rice seedling with facilities to increase seedbed temperature.

4. Work with Section 4:

1) Set ESTAB to 'TRANSPLANT', which is the plant establishment method used in your experiment.
2) Set EMD to 337., because it was a transplanted crop. For direct-seeded crops, this will be the same as emergence date.
3) Set EMYR to 1988, which is the year of sowing.
4) Set SBDUR to 21, which is the duration from emergence (it is sowing in your case) to transplanting.

5. Work with Section 5:

1) Set NPLH to 3.0.
2) Set NH to 25.0. In the case study, it is calculated from the planting space.
3) No change for NPLSB because there is no information for it; we use the default value. Of course, it is better to use the true value from experiment, if available.

> ***NOTE:**
> ➢ NPLH, NH, and NPLSB are useless for a direct-seeding system.

4) No change for NPLDS; this variable is not used for transplanted crops, but it must have a given value for direct-seeded crops.
5) No change for LAPE, DVSI, WLVGI, WSTI, WRTI, WSOI, and ZRTI. These are initial plant situations. Normally, the default values present in the input template are applicable. These can be changed if your experiment has a specified condition affecting the initiation of your seedlings at sowing.
6) No change for ZRTTR. The default value is generally used for cases where no information is available for it.

6. ***Work with Section 6:***

No work to do in this section because PRODENV was set as 'POTENTIAL' in Section **1**. All concerned parameters should be set accordingly if it was set as 'WATER BALANCE'.

7. ***Work with Section 7:***

> ***NOTE:**
> - If NITROENV was set as 'NITROGEN BALANCE, all parameters under this section have to be carefully set.
> - If NITROENV was set as 'POTENTIAL', all parameters will be useless, and no change is needed.

1) Set NUTRIENT to 'FIXED SUPPLY'.

> ***NOTE:**
> - There are two options for NUTRIENT, 'GENERAL SOM' will ask for data of soil chemical properties such as organic carbon and nitrogen and mineral nitrogen content, which must be provided in the soil file. If these data are not available, 'FIXED SUPPLY' can be used, but the soil nutrient dynamics cannot be simulated.

2) If 'FIXED SUPPLY' is used, then RECNT and SOILSP must be carefully set.
3) Set 'FERTIL' by using the fertilizer data from the data file.

> ***NOTE:**
> - Do not forget the special notification in 3.3.1.

8. ***Work with Section 8:***

1) Change the values of IDOYTR, IYRTR, IDOYPI, IYRPI, IDOYFL, IYRFL, IDOYM, and IYRM using phenology information from the "***crop mgt***" sheet of the data file, which was reorganized.
2)

> ***NOTE:**
> - All these variables have integer values.

3) Copy and paste the data from the data file to make the all observation information right. For observation parameters without observation data in the data file, these must be eliminated by putting “*” at beginning of each line.
4) Re-check the setting of `LAI_FRC` and `NFLV_FRC`.
5) Make sure the year and day in the first row of the observation data are the same as `RMYR` and `EMD`.
6) Make sure the year and day in the row of observation data are not later than that date defined by `IYRM` and `IDOYM`.
7) Make sure that all observations are presented in real numbers.

Finally, save all your work again.

3.3.4. Prepare experiment file for W-limited

We can easily prepare the experiment file for the W-limited treatment from “CF.exp” with essential modifications.

1) Copy “***CF.exp***” and rename it as “***W-limited.exp***”.
2) Check the data in the data file to understand the differences between CF and W-limited. The differences are:
   (1) Production environment settings in Section 1
   (2) Phenological dates: sowing date, transplanting date; and soon in Sections 2, 4 and 8
   (3) Water (irrigation) management: method and switching dates in Sections 1 and 6
   (4) Fertilizer application: application dates and amount in Section 1 and 7
   (5) Biomass measurements: measuring dates and biomass weight in Section 8

1. For differences in phenology dates:

1) Change the values of `IYEAR`, `STTIME`, `EMD`, and `SBDUR` according to the data in the data file.
2) Change the values of `IDOYTR`, `IYRTR`, `IDOYPI`, `IYRPI`, `IDOYFL`, `IYRFL`, `IDOYM`, and `IYRM` according to the data in the data file.

2. For difference in water management:

1) Change `PRODENV` to `'WATER BALANCE'` and `WATBAL` to `'PADDY'`.
2) Change the value of `ICOMBA` to `1`, because water management was switched from full irrigation to rainfed on 1 March (Julian day = 59).
3) Set the values of `IRMTAB` as follows:

```
  1.0, 2.0,
 58.0,2.0,
 59.0,0.0,
200.0,0.0,
300.0,2.0,
366.0,2.0
```

> ***NOTE:**
> - Lines 1 and 2 ensure that the field is under flood conditions before 1 March by using water management Switch 2. Lines 3 and 4 ensure that crop is under rainfed conditions from 1 March up to maturity with no irrigation with Switch 0. Lines 5 and 6 ensure full irrigation from sowing by setting water management switch to 2. Because the numbers on the first column must be from the smallest to the largest, water management of the seedbed and the early vegetative stage can only be concatenated into the format to accommodate the cropping season covering two years.

4) Set water management Switch 2 by changing the value of `IRRI2` to `30.0` and `WL0MIN` to `5.0`.

3. ***For differences in fertilizer application:***
   Change the values of `FERTIL` according to the fertilizer data.

4. ***For differences in measurements:***
   Do the same as Steps 2 to 6 as the work for section 8 in 3.3.3.

Finally, save it again.

3.3.5. Prepare experiment file for N-limited

Similarly, we can easily prepare the experiment file for N-limited treatment from "***CF.exp***" with essential modifications.

1) Copy "***CF.exp***" and rename it as "***N-limited.exp***".
2) Check the data in the data file to understand the differences between CF and N-limited. The differences are:
   (1) Production environment in Section 1
   (2) Phenological dates: sowing date, transplant date; and soon in Sections 2, 4 and 8
   (3) Fertilizer application: no fertilizer application in Sections 1 and 7
   (4) Biomass measurements: measuring dates and biomass weight in Section 8

1. ***For differences in phenology dates:***
   1) Change the values of `IYEAR`, `STTIME`, `EMD`, and `SBDUR` according to the data in the data file.
   2) Change the values of `IDOYTR`, `IYRTR`, `IDOYPI`, `IYRPI`, `IDOYFL`, `IYRFL`, `IDOYM`, and `IYRM` according to the data in the data file.

2. ***For differences in fertilizer application:***
   Change the values of `FERTIL` to:

```
   0.0,0.0,
 200.0,0.0
```

3. ***For differences in measurements:***
   Do the same as Steps 2 to 6 as the work for Section 8 in 3.3.3.

Finally, save it again.

3.4. Soil file

The three treatments in the experiment were located at three different fields in the IRRI farm with similar soil types; but, their detailed soil physical and chemical properties were different. Three soil files should be prepared.

There is no soil information for the N-limited treatment. In this case, the soil information for lowland soil may be temporarily used to prepare the soil file, but we need to correct some chemical parameters during model parameterization.

3.4.1. Understanding the soil file

The ORYZA model has five soil water balance modules with different complexities to calculate soil water movement in the soil profile. The selection of module depends on (1) *the rice cropping system* and (2) *data availability*. Please check the ***standard.exp*** file to understand the options.

In this experiment, all three treatments are transplanted crops in paddy field, and soil data is given layer by layer. Therefore, the soil file will be prepared for paddy module.

Open soil template file, "***paddyin.sol***" using Notepad.

Read through sections 1, 7, and 8 to understand the meaning of each variable, and pay attention to the data type and format of each. Most information in soil data will be set in these three sections of the soil file. Variables with multiple values to represent the properties of different soil layers in the soil profile are separated by a comma.

In Section 1, the number of soil layers considered is indicated by the variable `NL`. Soil layers are defined along the soil profile depth from the surface, layer by layer, with a given thickness (`TKL`).

***NOTE:**

- The values, which are the same for adjacent layers, can be presented as "number of layers with same values * the value". For example, `3*0.25` for `TKL` implies that three layers have thickness of 0.25 m.
- The number of values of variables for the soil layer data must equal the value of `NL` in Section 1.
- The PADDY module and its input soil file can be used for all rice ecosystems, but please care of the settings for variables: SWITPN, NLPUD, DPLOWPAN in the section 2.

In Section 7, the soil organic carbon and nitrogen and the mineral nitrogen amounts are given, but the data file only provides soil organic matter content.

In Section 8, soil hydraulic parameters are asked for each layer, but the data file does not provide such information. **In this case, additional work is needed before the soil file can be prepared.**

3.4.2. Work with data

To adopt the data format in the soil file and re-calculate the missing data from available data, the original data must go through the following:

1. To convert soil data as needed:

1) Open Excel data file "***SampleData.xlsx***", and work on both available data "**upland**" and "**lowland**" for Steps 2 to 4.
2) Calculate the layer thickness from the depth of the upper and bottom boundary of the layers.
3) Convert soil texture number from percentage to fraction.
4) Convert soil organic matter content from percentage to fraction. However, the amount of soil organic carbon cannot be calculated yet because soil bulk density is still to be obtained in the following steps.

2. To estimate soil hydraulic parameters:

1) Open template file "***hydraulic.txt***" and save it as "***lowlandhydraulic.txt***" (work on lowland soil first).
2) Change the numbers on the first row to `6,1,0` (number of layers), use compact factor (1.0 for YES vs. 0.0 for NO), calculate EC (1.0 for YES vs. 1.0 for NO) for the lowland soil with 6 layers. These have compact layers because the plow pan exists and no change is needed for `EC`.
3) Change numbers in row 2 according to the fraction number of soil clay content in data sheet "***lowland***".
4) Change numbers in row 3 according to the fraction number of soil sand content in data sheet "***lowland***".
5) Change numbers in row 4 according to the fraction number of soil organic matter content in data sheet "***lowland***".
6) Change row 5 as `2*1.0, 4*0.0` for two top soil layers and 4 sub-layers.
7) Change row 6 as `0.9, 1.0, 1.1, 1.05, 2*1.0` to represent that paddy happened in two top soil layers and first layer is puddled even more heavily, the third layer has plow pan, and compaction is less in deeper layers after the plow pan.
8) Save the file again.
9) Repeat Steps 1 to 8 to edit another file for upland as "***uplandhydraulic.txt***" using the data from data sheet "***upland***".
10) Explore the training package, find the folder "***Tools***", double–click on "***SoilHydrau.exe***", and wait for a pop-up window.
11) In the pop-up windows, find and select "***lowlandhydraulic.txt***" in "***C:\oryzatrain***" and click on "**Open**".
12) A file named "***HYDR_PARAM.TXT***" will be generated in the same folder as input file "lowlandhydraulic.txt".
13) Rename "***HYDR_PARAM.TXT***" to "***lowlandHydruParam.txt***". It will be used later on.
14) Repeat Steps 10 to 13with input file "***uplandhydraulic.txt***" to generate "***uplandHydrauParam.txt***".

3. To estimate soil chemical parameters

1) Go back to data file "***SampleData.xl***sx", move to "***lowland***" sheet.
2) Open "***lowlandHydrauParam.txt***" with Excel, convert text into data, and make sure the column title and column data correspond to each other.
3) Copy "`BD`" (bulk density), `WCST` (Saturated soil water content), `WCFC` (Field capacity), `WCWP` (Wilting point), `WCAD` (Air drying moisture), and `KST` (Saturated hydraulic conductivity) data into "***lowland***" sheet.

> ****NOTE:***
> - Don't worry about the units, all of them are in units required by ORYZA.

4) Convert soil organic matter into soil organic carbon amount using formula 5 in Appendix 2.

> ****NOTE:***
> - Ensure that the unit of soil organic carbon is correct, as needed by ORYZA.

5) Estimate the amount of soil organic nitrogen from the amount of soil organic carbon by C:N ratio for soil layer in Table 3.4.1.

Table 3.4.1. General estimation of soil organic carbon and nitrogen ratio for rice field, which is under conventional farming management with straw return.

Soil layer	**C:N ratio**
Layer strongly disturbed by cultivation operation	20.0 to 40.0
Layer slightly disturbed by cultivation operation	16.0 to 30.0
Layer rarely disturbed by cultivation operation, but not old soil	12.0 to 20.0
Deep layer, old soil layer	11.0

> ***NOTE:**
> - More information in Mooshammer et al. 2014. Stoichiometric imbalances between terrestrial decomposer communities and their resources: mechanisms and implications of microbial adaptations to their resources. Frontiers in Microbiology.
>
>   http://www.frontiersin.org/Journal/Abstract.aspx?s=1102&name=terrestrial%20microbiology&ART_DOI=10.3389/fmicb.2014.00022

6) Estimate the amount of soil mineral nitrogen from organic N and the previous cropping management, especially fertilizer and water management. Normally, NH_4-N is not more than 0.5% of organic nitrogen, and NO_3-N is not more than 0.25% of organic N.
7) Format the data according to ORYZA needs.
8) Repeat Steps1 to 7 for upland soil data.

3.4.3. Preparing soil file for the CF treatment

1) Open template "***paddyin.sol***" using MS Notepad and save it as "***CF.sol***".
2) Ensure that the `SCODE` has value 'PADDY', which must be the same as the value of `WATBAL` in experiment file "***CF.exp***".

1. Work with Section 1:

1) Set `WL0MX` to `100.0`.

> ***NOTE:**
> - It should be the actual measurement. Otherwise, the number should be much larger than the irrigation amount for water management Switches 2, 3, and 4 in the corresponding experiment file ("***CF.exp***" for this case).

2) `NL` is `6`.
3) Copy and paste thickness data from "***lowland sheet***" in data file "***SampleData.xlsx***" for TKL.
4) Set `ZRTMS` to have the value depth of the deepest soil layer; it is `1.0` in this case.

2. Work with Section 2:

1) Set `SWITPD` to have a value of `1` for field that was puddled.
2) Set `NLPUD = 2`, because plow pan is the third layer.
3) Set `WCSTRP` to have the same values as `WCST`.
4) No change for `PFCR` unless you have data for it.
5) Optional: set DPLOWPAN to have value corresponding to it from 2)

3. Work with Section 3:

1) Set `SWITGW = 0,` because there is no observation data for groundwater depth; also, the depth won't be calculated in the process of simulation.
2) Set `ZWTB` to have the following values because groundwater is shallow in the IRRI lowland farm.
```
     1.,100.,
   366.,100.
```
3) Set `ZWTBI = 100.0`, because the experiment is in the dry season, groundwater depth is assumed to be the usual.
4) Set `MINGW = 50.0`, based on the general understanding of the IRRI lowland farm.
5) Set `MAXGW = 200.0, ZWA = 1.0`, and `ZWB = 0.5`

4. Work with Section 4:

1) Set `SWITVP = -1`, for fixed percolation rate.
2) Set `FIXPERC = 3.0`, it could be 1/10 of the `KST` of bottom soil layer if there is no measurement for it.

5. ***Work with Section 5:***

   Set `SWITKH = 0`, because we would like to use the soil water content data rather than re-calculating the soil water content using Van Genuchten function.

6. ***Work with Section 6:***

   Set `SWITPF = 0`, for the same reason as with `SWITKH`.

7. ***Work with Section 7:***

   Copy and paste the data accordingly from the "***lowland***" sheet in the data file "***SampleData.xlsx***" for variables `CALYX`, `SANDX`, `BD`, `SOC`, `SON`, `SNH4X`, `SNO3X`, and `pH`.

***NOTE:**
➢ If you also add organic fertilizer into soil layers, please give values for variables FORGANC, FORGANN, FCARBONH, FCELLULO. First two variables have the same number of values as SOC while last two variables are single value.

8. ***Work with Section 8:***
   1) Copy and paste the data accordingly from the "***lowland***" sheet in the data file "***SampleData.xlsx***" for variables `KST`, `WCST`, `WCFC`, `WCWP`, and `WCAD`.
   2) Remove the "*" at the first column of text in the data rows for variables `WCFC`, `WCWP`, and `WCAD`.

9. ***Work with Section 9:***
   1) Set `WLI0 = 2.0,` for a layer of very shallow water in the seedbed.
   2) Set the values of `WCLI` to 98% of `WCST` for each layer. They can be set to the same value as `WCST,` but this will cause error because of rounding-off during computation.
   3) Set `RIWCLI = 'YES'`, because paddy field will be forced to return initial soil water conditions at transplanting, i.e., very shallow surface water layer, and soil moisture is close to saturation.

10. ***Work with Section 10:***

    If there are no data for variables `SATAV` and `SOILT`, please estimate them according to weather and field conditions. In the IRRI farm in the dry season, they could be set as:

```
SATAV = 24.0
SOILT = 24.0, 23.0, 22.0, 21.0, 21.0, 20.0
```

11. ***Work with Section 11:***
    1) Set `WCLINT` as follows for 6 soil layers, and no interpolation should be done for observed soil variables.

```
1, 1, 1
2, 2, 2
3, 3, 3
4, 4, 4
5, 5, 5
6, 6, 6
```

2) There is no observation for soil, so there's no work to be done with them. If there are observations on soil moisture and/or soil water potential, the information can be fed in a format shown on the template.

Finally, save the file again.

3.4.4. Preparation of soil file for W-limited treatment

By comparing the "***lowland***" and "***upland***" data sheets in the data file "***SampleData.xlsx***", the difference is released as follows:

1) Soil layer
2) Layer thickness
3) Soil texture
4) Soil chemical properties
5) Soil hydraulic properties

Therefore, the file can be modified from "***CF.sol***".

1) Copy the file "***CF.sol***" and rename it as "***W-limited.sol***".
2) Open "***W-limited.sol***" with Notepad.
3) Change the values of variables `NL, TKL, WCSTRP, CLAYX, SANDX, BD, SOC, SON, SNH4X, SNO3X, KST, WCST, WCFC, WCWP, WCAD`, and `WCLI` according to the data in the "***upland***" sheet in data file "***SampleData.xlsx***".
4) Set the values of `SOILT` as `24.0, 23.0, 22.0, 21.0, 21.0,`and `2*20.0`
5) Set the values of `WCLINT` as

```
1, 1, 1
2, 2, 2
3, 3, 3
4, 4, 4
5, 5, 5
6, 6, 6
7, 7, 7
```

Finally, save the file again.

3.4.5. Preparation of the soil file for N-limited treatment

There is no soil data for treatment "N-limited"; but with the understanding that the field conditions are similar to lowlands, the soil file for lowland can be borrowed and the values of a few parameters may be modified during parameterization.

- Copy "***CF.sol***" and rename as "***N-limited.sol***".

3.5. Crop file

The crop file can be prepared as copy template "***standard.crp***" and renamed as "***X.crp***" because of the variety name is "**X**".

Three treatments used a same variety. Only one crop file will be asked in simulation. However, for an experiment dealing with multiple varieties, multiple crop files should be prepared.
There is no more work to be done at this point. Parameter values in the crop file will be modified in Chapter 4 Parameterization.

***NOTE:**

- At this point, the template files "***standard.exp***", "***standard.crp***", "***phil1.992***", "***hydraulic.txt***", and "***paddyin.sol***" may be deleted from "***C:\oryzatrain***". The working folder would be less messy.

3.6. Control file of simulation

At this point, the weather, experimental, soil, and crop files have already been prepared. The CF treatment can be released as the basic treatment to prepare a simulation control file.

1) Open "***control.dat***" with Notepad.

***NOTE:**

- The file name may be defined by the user as needed, but the full file name (file path + file name) should not be more than **128 characters** (including spaces); use of space is discouraged.

2) Replace all folder names with the working folder name "***C:\oryzatrain***".
3) Check for the correct setting of "*CONTROLFILE =" or "CONTROLFILE = '<......>'". It must point to the location of the simulation control file with folder name and filename.

***NOTE:**

- The first line is the identity of the simulation , it must be set as either:
  1. "CONTROLFILE = '<folder name>/<control file name>'" or
  2. "*CONTROLFILE = *<folder name>/<control file name>*"

4) Change the value of ENDRUN from 72 to 3 for this case study, but keep it commented out. It will be opened for use later on.
5) For FILEIT, change "standard.exp" to "CF.exp".
6) For FILEI1, change "standard.crp" to "X.crp".
7) No change for FILEIR.
8) For FILEI2, change "standard.sol" to "CF.sol".

> ***NOTE:**
> - FILEON, FILEOL, FILEIT, FILEI1, FILEIR, and FILEI2 provide the full filenames for storing instant simulation outputs, storing simulation warning and error information, and the input files for experiment, crop, rerun, and soil. Except for FILEI2, all variables cannot be omitted.
> - Absolute and relative folder path are acceptable. However, the relative folder path must be relative to the location of the executable ORYZA file.

9) No change on SOILKILL because this experiment is not a crop rotation system.
10) No change on PRDEL because daily output is needed.

> ***NOTE:**
> - Its value can be 1.0 or higher. When the value is large, only two rows of data will be in the res.dat (the data for emergence and maturity of crop). If it is 10.0, outputs will be written into file "res.dat" every 10 days.

11) No change for IPFORM because a tab delimited file is preferred for MS Excel, in which the ORYZA output analyzer works.
12) No change for COPINF. It is unnecessary to have input in the output file.
13) No change for DELTMP; it is useless in ORYZA v3.
14) No change for IFLAG. We would like to store errors and warnings about weather data in a separate file.
15) Comment out PRSEL by putting "*" before the variable, if the full output is needed. Otherwise, list output variables in its format.

> ***NOTE:**
> - Available variables selected for output in "***res.dat***" file can be found in Appendix 4.

16) Comment out OPSTRING if default variables are expected in "op.dat" (seasonal summary output). Otherwise, list the output variable in its format.

> ***NOTE:**
> - Available variables selected for output in "***op.dat***" file can be found in Appendix 5.

17) Comment out IOBSD to display all output data points, not only for observation days.

> ***NOTE:**
> - If ORYZA Output Analyzer will be used to analyze the simulation output, it must be commented out.

Finally, save the file again.

3.7. Rerun file

In the case study, the experiment involved three treatments in three fields with different water or nitrogen management practices. The complete rerun file will have three rerun sets.

1) Open ***reruns.rer*** with Notepad.
2) Delete all contents in the file.
3) Copy "`FILEIT = 'C:\oryzatrain\CF.exp'`" and paste it into the "***reruns.rer***" file three times because this experiment has three treatments.
4) Copy "`FILEI2 = 'C:\oryzatrain\CF.sol`" and paste it in the "***reruns.rer***" file three times, because the soil properties are different for the three treatments in this experiment.
5) Place the 6 lines into three groups, each group including the corresponding `FILEIT` and `FILEI2` for the treatment.
6) Insert "`*Rerun set 1`", "`*Rerun set 2`", and "`*Rerun set 3`" to the correct lines to identify three rerun groups.

***NOTE:**

- Any variable existing in the experiment, soil, crop, and control files may be used in the rerun file to reset its value(s).
- One rerun group can also have an unlimited number of variables.
- Rerun groups are also unlimited.
- Variable number and order of variables must be completely the same in each rerun group if multiple rerun groups existed in the rerun file.

3.8. Control file of parameterization

To parameterize crop characteristics, two programs, '***DRATE(v2).exe***' and '***PARAM(v2).EXE'***, will be used together with a file, which provides the input files and storage location of outputs. This is similar to control file of simulation.

1) Open "***param.in***" in the working folder "***C:\oryzatrain***".
2) Replace "***G:\drateTEST***" with "***C:\oryzatrain***" because input files of this experiment are stored in "***C:\oryzatrain***".
3) Check the first line of the file and make sure it is correct because it is the identity of all parameterization.

***NOTE:**

- The filename of the parameterization control may be defined as needed, but the identity must be correct as "`*PARAMFILE = <folder name>\<parameterizing control file name>`".
- In the file, `FILEIR` does not have a value because this case is only for one variety. If parameterization is for multiple varieties, the corresponding experiment file for each variety must be set in rerun file.

4) No change to other variable values and all variables have the same meaning as those in the simulation control file.
5) Check the variables FILEOP and FILEOR to have correct values as your observed values.

3.9. Control file of auto-calibration

In most cases, the simulations may differ from measured values. To increase the confidence of simulations, the differences between simulations and measurements must be minimized. Auto-calibration is a tool designed to correct crop parameters for minimizing the differences. To use the auto-calibration tool, a file is necessary to provide information to control the auto-calibration process.

Open the ***CALIBRIN.DAT*** file in "***C:\oryzatrain***".

> ***NOTE:**
> - The filename may be defined by the user as needed.

1. ***Work with Section 1:***
   Replace the values of `FILEON, FILEOL, FILEIT, FILEIR, FILEI1`, and `FILEI2` with the same values in the simulation control file.

2. ***Work with Section 2:***
   1) Set `RERUNS = 1000`

   > ***NOTE:**
   > - The maximum number of iterations is 1000 because of the memory allocation of most computers. Although it can be set to a higher value, users must understand that the total simulations will be multiple results of 100 times the number of the calibration parameters, `INRERUNS`, and `RERUNS`. For example, if calibration parameters is `30`, `INRERUNS = 4`, then the maximum simulation will be 12,000,000, so the auto-calibration may take a long time.
   >
   > - Also, note that the ORYZA crop file has table-type parameters; in the auto-calibration, each row in the table-type parameter is recognized as one parameter.

   2) Set `INRERUNS = 3`, for three experimental treatments in this case study.
   3) Set `OUTFOLDER = 'C:\oryzatrain\'` to direct the calibration output in our working folder.
   4) The `OUTCROP` and `OUTSOIL` will not be changed. These values correspond to the name of the calibrated crop file and/or soil file, respectively, that will be generated after auto-calibration.
   5) Set `ORYZA = 'C:\oryzatrain\ORYZA3.exe'`.Make sure that the executable file is present in the working folder.

> ***NOTE:**
> - To run the Auto-Calibration program, the ***ORYZA3.exe*** in the ORYZA installed folder must be copied inside "***C:\oryzatrain***".

6) Set `CROPSVN = 'FNTRT', 'FSTR', 'RGRLMX', 'RGRLMN', 'ZRTMCD', 'SHADET', 'NMAXSO'`, and `'FSWTD'`, because this experiment involved three environments of full irrigated, water, and nitrogen limitation.

> ***NOTE:**
> - Calibration parameter settings must correspond to the experimental environment. For instance, parameters representing water and nitrogen effects on crop growth cannot be used if an experiment was implemented in potential conditions only.
>
> - Similarly, parameters for nitrogen effects on crop growth cannot be used if an experiment is performed in water-limited conditions without nitrogen. Parameters for water effects should be used instead.

7) Users can find the variable definition in the template of the crop file.
8) Set `CROPSVR = 0.5 ,0.5, 0.3, 0.3, 0.5, 0.99, 0.15, 0.70`

> ***NOTE:**
> - The possible value of a parameter, with reference value (**x**) from the crop file defined in Section 1, will be $[\mathbf{x} \times (\mathbf{1.0} - \mathbf{CROPSVR}), \mathbf{x} \times (\mathbf{1.0} + \mathbf{CROPSVR})]$**.** Users should have a general rice physiological knowledge to give the range. If not, the default value of **0.5** could be used. However, users must ensure that the minimum value of the parameter is **≥0.0**. Users should also pay attention to all other parameters listed in the file.
> - Carefully check the range of values of variable to ensure they are not beyond the physiological meanings, and also not in conflict with the values of related variables.
> - Variable values can also be set with their minimum and maximum values.

9) `CROPTVN = 'FSHTB','FSOTB','FLVTB','FSTTB','DRLVT', 'KDFTB', 'EFFTB'`,`'SLATB'`, and `'NMAXLT'`
10) Set `CROPTVR = 0.5,0.5,0.5,0.5,0.5,0.25,0.25,0.50,0.4`
11) Set `CROPTXMI = 0.0,0.65,0.0,0.0,0.65,0.0,0.0,0.0,0.0`
12) Set `CROPTXMA = 1.0,2.5,1.2,2.5,2.5,2.5,60.0,2.5,2.5`

> ***NOTE:**
> - In the crop file, all table-type parameters are defined in the growth stage, above two rows applied range of growth stage for `CROPTVR`.

13) No settings for soil parameters (Section 4) because this calibration will only work on crop parameters.

3. *Work with Section 4:*

Set `CMETHODS = 1`, to use the normalized root of mean square error as the critical method for minimizing the difference between simulations and measurements.

4. ***Work with Section 6:***
   1) Comment out `NFLV` because there are no measurements on leaf nitrogen content in this study.
   2) No change for other variables because there were measurements for these variables and critical differences in fraction of measurements (for `CMETHODS = 1`) are expected.

> ***NOTE:**
> - Do not list variables that do not have measurements. Otherwise, the calibration outputs will be incorrect.
> - If `CMETHODS` was set as `1`, the critical values for variables are given by the user to represent his/her tolerance of the differences between simulations and measurements.
> - If `CMETHODS` was set as `2`, the critical values are the model efficiency to represent all measurements.

5. ***Work with Section 3:***
   No setting for Section 3, because no calibration is needed for phenology and it is not a feature for a new ORYZA user.

   Finally, save this file again.

Chapter 4: Parameterization

4.1. Crop parameterization

4.1.1. Preparation of the parameterization control file

Prepare the crop, experiment, and weather files as described in earlier steps. Refer to Appendix 7 of Training Handouts for the templates of the input files needed for '***DRATE(v2).exe***' and '***PARAM(v2).EXE'***.

1) Verify the "oryzatrain" folder and make sure that the input files (crop, experimental, soil, rerun, weather files, CALIBRIN.dat, and PARAM.IN) are inside.
2) Open the file prepared in Section 3.8, "***param.in***", which is similar to the control file.
3) Ensure that the folder has the correct filename and file path in the first line of "***param.in***".

> ***NOTE:**
> - Make sure that the identifying line, at the first column and first line of the file, is in the proper format:
>   `PARAMFILE = '<file path/ parameterization control file name>'`

4) Ensure that the correct file paths and file names are supplied for `FILEOP`, `FILEOR`, `FILEOL`, `FILEIR`, `FILEIT`, and `FILEI1`.

4.1.2. Determination of phenology development rates

The application, ***'DRATE(v2).exe'***, is used to determine the phenology development rate of a given variety.

Prerequisites:

1) Ensure that the phenological data in Section 8 of the experimental file was supplied correctly (see Section 3.3).
2) Ensure that the crop and weather files exist.
3) If the rerun file was also used, check to ensure it contains the parameters needed. Check that the multiple experiment and crop files were set correctly in the rerun file.

Steps:

1) Make sure to include a copy of the application,***'DRATE(v2).exe'***, to the folder with a parameterization control file ("***param.in***"). In this case, these files should be contained in the "oryzatrain" folder.
2) Double-click on the application, ***'DRATE(v2).exe'***.
3) Type in the filename of the parameterization control file when the DOS prompt appears.
4) Open the ***drate.out***.
5) Use the values of `DVRI`, `DVRI`, `DVRP`, and `DVRR` from ***drate.out*** for the crop file that you are calibrating.
6) If reruns exist, please ensure that the values of about four parameters have been pasted into the correct crop files.

4.1.3. Determination of other crop parameters

The application '***PARAM(v2).EXE'*** is used to estimate crop parameters such as assimilate partitioning, specific leaf area, and non-structure C&N translocation, etc.

Prerequisites:

1) The sequential measurements (observed values) in Section 8 of the experimental file (see Appendix 6b):
   (1) Total aboveground biomass
   (2) Green and dead leaf biomass
   (3) Stem biomass
   (4) Panicle biomass
   (5) Leaf area index
   (6) Leaf nitrogen content (if applicable)
2) The measurement for partitioned biomass must correspond to the observation dates
3) The same order of observations must be followed.

Steps:

1) Verify that '***param(v2).exe***' is in the folder that contains the parameterization control file (***param.in***)
2) Double-click on the application.
3) Open the output file (***param.out***).
4) Copy the values of variables listed in the output file into the crop file or rerun file.
   (1) `SLATB`
   (2) `FLVTB`, `FSTTB`, `FSOTB`

      i) The partitioning factors (`FLV, FST, FSO`) in the ***param.out*** correspond to these variables.
      ii) `DVSM` is the calculated development stage midway between two consecutive measurements.
      iii) After flowering (indicated by `DVS = 1`), internal remobilization of assimilates occur and are manifested by the negative values of `FLV` and `FST`. Ignore the negative values and rectify by changing the values to `0` and `FSO` to `1`.
      iv) For multiple calibrations, get the average of the values of the partitioning factors and update the values accordingly.

***NOTES:**

- For partition parameters (`FLVTB, FSTTB, FSOTB`), negative values should be changed to `0.0`; values larger than `1.00` should be changed to `1.0`.
- For table variables with `DVS` for the first column, the first row for `DVS` is `0.0` and the last row for `DVS` is `2.5`. These should be added as needed.

   (3) `DRLV`

4.2. Calibration

Calibration of crop parameters in ORYZA is performed to characterize the cultivar (crop file) that will be simulated. It involves fitting the numerical values of some parameters appropriate for the test cultivar based on the experimental data. Its aim is to minimize the deviation between the simulated outputs and the observed values for parameters based on the experimental data.

4.2.1. Prerequisites:

1) Parameterized crop file
2) Experimental file
3) Parameterized soil file (needed for water- and/or nitrogen-limited conditions)
4) Weather
5) Rerun file (needed for multiple treatments and/or multiple environments)

4.2.2. Steps:

1) Open the auto-calibration control file template (see Appendix 6h).
2) Modify the input and output folder path and filenames accordingly.
3) Identify the crop and soil parameters that you would like to calibrate.
4) Change the parameter settings and adjust the varying range of each parameter as desired.
5) Select the method to use for critical value limits and set their values accordingly.
6) Save it to the target folder with the filename set by the user.
7) Double-click on the auto-calibration application (***AutoCalibration(V2).exe***).
8) Select the auto-calibration control file.
9) Wait for results.

***NOTES:**

- The variable '`INRERUNS`' must be set to 0 for calibration with a single treatment and environment.
- You will know that the auto-calibration is finished when you see '***OUTCROP***' and/or '***OUTSOIL***' in the folder where calibration was performed.
- If there is a suffix '**X**' in the output file/s generated, the calibration process produced the best calibrated parameter set possible after reaching the maximum number of iterations; the output does not necessarily meet all required criteria.
- If there is a suffix '**B**' in the output file/s generated, the calibration process produced the best calibrated parameter set possible, which cannot be improved further with additional iterations; the output does not necessarily meet all required criteria.

Chapter 5: Simulation of scenarios

5.1. Simulation scenarios with different water management practices

Objective: To evaluate effects of water management on yield of lowland rice under non-limiting N.

Needed input files:

- Control file
- W-limited.crp
- W-limited.exp
- W-limited.sol.
- Phil1.88-Phil1.89
- W-limited.rer

The simulation scenarios will be set using the ***W-limited.rer*** (rerun) file.

For this exercise, six water management approaches will be used and compared under the same environmental conditions.

1. ***Check experiment file settings*** using MS Notepad***:***
   1) Open file '***W-limited.exp***'.
   2) For water-limited scenarios, make sure that the experiment file has the following settings in Section 1:
      ```
      RUNMODE = 'EXPERIMENT'
      PRODENV = 'WATER BALANCE'
      NITROENV = 'POTENTIAL'
      ```
   3) In section 6, also make sure **you have the** following settings.
      ```
      ICOMBA = 1
      ```
      This setting means that we will provide water management information based on Julian days.

   4) The changes in irrigation management within the season may be indicated in IRMTAB under Section 6 (Irrigation parameters) of the experiment file. However, make sure that the settings in the switches (`SWITIR`) you wish to use match the conditions that you want to test.

      ```
      * If SWITIR = 1, supply irrigation table, amount of irrigation
      * (y in mm) for a given calendar * day (x), used if
      RIRRIT = 0., 0.0,
      166., 0.0,
      366., 0.0

      * If SWITIR = 2, 1) supply amount of irrigation using IRRI2 (mm);
      * 2) supply minimum standing water depth using WL0MIN (mm), below which
      * irrigation water is applied
      IRRI2  = 5.         ! Amount of water applied (mm) per irrigation event
      WL0MIN = 10.        ! Minimum standing water depth (mm) maintained from
                          ! the soil surface
      ```

```
* If SWITIR = 3, 1) supply amount of irrigation using IRRI3 (mm);
* 2) supply minimum soil water potential using KPAMIN (KPa),
* 3) supply soil layer for which KPAMIN is applied using SLMIN3

IRRI3 = 50.     ! irrigation amount (mm)
KPAMIN = 10.    ! critical soil water potential at layer SLMIN3 for
                ! irrigation applied
SLMIN3 = 2      ! soil layer for critical value of KPAMIN

* If SWITIR = 4, 1) supply amount of irrigation IRRI4 (mm);
* 2) supply minimum soil water content WCAMIN (-),
* 3) supply soil layer, for which KPAMIN is applied, SLMIN4

IRRI4 = 50.    ! irrigation amount (mm)
WCMIN = 0.30   ! critical soil water content at layer SLMIN4 for
               ! irrigation applied
SLMIN4 = 2     ! soil layer for critical value of WCMIN

* If SWITIR = 5, 1) supply amount of irrigation IRRI5 (mm);
* 2) supply number of days after disappearance of standing water
* (WL0DAY), at which irrigation water is applied

IRRI5 = 50.    ! irrigation amount (mm)
WL0DAY = 5     ! number of days after disappear1nce of (-)

* If SWITIR = 6, 1) supply amount of irrigation using IRRI6 (mm);
* 2) Supply soil layer, for which KPAMIN applied, SLMIN6; period table
* as "start DVS' 'finish DVS' 'KPAMIN during period'. Irrigation will
* be applied in the periods between 'start DVs' to 'end DVS' and only
* when the soil water tension in layer SLMIN is above KPAMIN in that
* period.

* Note: At maximum, 5 stages can be defined
* (no more than 15 data in table)
IRRI6 = 50.        ! irrigation amount (mm)
SLMIN6 = 2         ! Soil layer for critical applied
ISTAGET = 0.00, 0.20, 1.,
          0.65, 0.80, 50.,
          1.00, 1.20, 1.,
          1.50, 1.60, 50.,
          1.70, 1.80, 50.
```

Save the file.

5) Copy this portion:

```
IRMTAB = 0.,1.0,
       28.0,1.0,
       29.0,1.0,
      366.0,1.0
```

2. Editing rerun file:

1) Open your rerun file, delete all content, and save as "***W-limited.rer***" using Notepad.
2) Paste the `IRMTAB` portion that you copied from '***W-limited.exp***'.

3) Create a continuously flooded scenario by setting the IRMTAB as below:

```
*---Run set 1: Continuously flooded
     IRMTAB = 0.,2.0,
            60.0,2.0,
            61.0,2.0,
           366.0,2.0
```

4) Create the AWD scenario-based soil water potential by setting the IRMTAB as below:

```
*---Run set 2: Alternate wetting and drying
IRMTAB = 0.,2.0,
20.0, 2.0,   !CF conditions was stopped at one week after transplanting
21.0, 3.0,   !AWD starting at one week after transplanting
80.0,3.0,    !Stop AWD at flowering
81.0, 2.0,
96.0, 2.0,   !Stop flood after flowering and grain filling
97.0, 0.0,   !Naturally drain out the field at maturity
299.0, 0.0,
300.0, 2.0,  !CF at seedling
366.0,2.0
```

***NOTES:**

- The last two rows are to ensure that the seedbed and early-growth stage is completely flooded. This is because the rice was sown in 1988, but majority of the growth season was in 1989. The cropping season crossed over two years in this experiment.

5) Create the drought-stress at reproductive stage scenario by setting the IRMTAB as below:

```
*---Run set 3: Drought from reproductive stage onwards
 IRMTAB = 0.,2.0,
 34.0, 2.0,
 35.0, 2.0,
 51.0, 2.0,
 52.0, 0.0,  !Stop irrigation thereafter panicle initiation
 77.0, 0.0,
 78.0, 0.0,
300.0, 2.0,  !CF in seedling stage
366.0, 2.0
```

6) Create a rainfed scenario immediately after transplanting by setting the `IRMTAB` as below:

```
*---Run set 4: Rainfed
IRMTAB = 0.,2.0,
 20.0,2.0,
 21.0,0.0,    !Creating rainfed conditions after transplanting
300.0,2.0,
366.0,2.0
```

7) Create a rainfed scenario for the whole season by setting the `IRMTAB` as below:

```
*---Run set 5: Rainfed right after transplanting
IRMTAB = 0.,0.0,
 33.0,0.0,
 34.0,0.0,
366.0,0.0
```

Save the rerun file.

3. **Managing the simulations:**
   1) Open the ***ORYZA v3 interface*** by double-clicking on the icon.
   2) Load your control file.
   3) Open your control file by double-clicking on the control file path box. Make sure that the path on the address bar matches the location indicated for the input files in your control file. Modify the input file location if the file path does not match (include paths for output files `FILEON` and `FILEOL`).
   4) Change rerun file setting from "***reruns.rer***" to "***W-limited.rer***".
   5) Press the '**Run**' button.
   6) Check the output and the files "***model.log***" and "***weather.lo***g" to make sure that there are no errors in the simulation. If there was an error, read the error message carefully, then correct it.

4. **Analyzing the simulations:**

   1) Open "***ORYZA Analysis Tool.xlsm***" (for MS 2007 or later) or "ORYZA Analysis Tool.xls" (for MS 2003 or older).
   2) Follow the steps in **Chapter 1.4**, to display the simulation results.

5.2. Simulation scenarios with different amounts of nitrogen

Objective: To evaluate different levels of nitrogen application on yield under continuously flooded lowland rice.

Needed input files:

- Control file
- X.crp
- N-limited.exp
- lowland.sol.
- PHIL1.988-PHIL1.989
- Reruns

The simulation scenarios will be set and provided to the model by the RERUNS file.
For this exercise, four levels of nitrogen application will be used and compared with potential conditions.

- N0 = Zero N input
- N1 = Low N input (60 kg ha^{-1})
- N2 = Medium N input (120 kg ha^{-1})
- N3 = High N input (200 kg ha^{-1})

Please take note that the soil and crop parameters in the soil and crop file are calibrated for the site and conditions of the simulations.

1. Check experiment file settings:

1) Open the experiment file "***N-limited.exp***" using Notepad.
2) Make sure the following settings are right in Section 1.

```
RUNMODE = 'EXPERIMENT'
PRODENV = 'POTENTIAL'
NITROENV = 'NITROGEN BALANCE'
```

Under the Section 7 nitrogen parameters, the mode of computation of your nitrogen balance has been already set to `'FIXED SUPPLY'`

```
NUTRIENT = 'FIXED SUPPLY'
```

3) Copy this portion:

```
FERTIL =
  0.,   0.,
  1.,   0.,
 11.,   0.,
 12.,   60.,
 13.,   0.,
 29.,   0.,
 30.,   60.,
 31.,   0.,
 66.,   0.,
 67.,   60.,
 68.,   0.,
 94.,   0.,
 95.,   45.,
 96.,   0.,
366.,   0.
```

In the current version of Oryza, the blue font entries (which sets the fertilizer amounts to zero before and after fertilizer applications) are optional.

2. Editing rerun file:

1) Open your rerun file, delete all content and save "***N-limited.rer***" using Notepad.
2) Paste the `FERTIL` portion that you copied from 'N-limited.exp'.
3) Create potential N scenario using the following in "***N-limited.rer***"

```
*Rerun set 1 (potential condition)
NITROENV = 'POTENTIAL'
FERTIL =
  0., 0.,
365., 0
```

4) Create zero N fertilizer application scenario

```
*Rerun set 2 (No fertilizer application)
NITROENV = 'NITROGEN BALANCE'
FERTIL =
  0., 0.,
365., 0
```

5) Create an N fertilizer application scenario with a rate of 60 kg Nha^{-1}.

```
*Rerun set 3 (Application of 60 N kgha-1)
NITROENV = 'NITROGEN BALANCE'
```

```
FERTIL =
 0., 0.,
 1., 0.,
34., 0.,
35., 30.,
36., 0.,
44., 0.,
45., 30.,
46., 0.,
365., 0
```

6) Create an N fertilizer application scenario with a rate of 120 kg Nha^{-1}.

```
*Rerun set 4 (Application of 120 N kgha-1)
NITROENV = 'NITROGEN BALANCE'
FERTIL =
 0., 0.,
 1., 0.,
34., 0.,
35., 60.,
36., 0.,
44., 0.,
45., 60.,
46., 0.,
365., 0
```

7) Create an N fertilizer application scenario with a rate of 200 kg Nha^{-1}.

```
*Rerun set 5 (Application of 200 N kg/ha)
NITROENV = 'NITROGEN BALANCE'
FERTIL =
 0., 0.,
 1., 0.,
34., 0.,
35., 80.,
36., 0.,
44., 0.,
45., 80.,
46., 0.,
64., 0.,
65., 40.,
66., 0.,
365., 0
```

3. ***Managing simulations:***
   1) Open the ***ORYZA v3 interface*** by double-clicking on the icon.
   2) Load your control file.
   3) Open your control file by double-clicking on the control file path box. Make sure that the path on the address bar matches the location indicated for the input files in your control file. Modify the input file location if the file path does not match (include paths for output files `FILEON` and `FILEOL`).
   4) Change rerun file setting from "***reruns.rer***" to "***N-limited.rer***".
   5) Press the '**Run**' button.

6) Check the output and the files "***model.log***" and "***weather.log***" to make sure that there are no errors in the simulation. If there isan error, read the error message carefully, then correct it.

4. Analyzing the simulations:

1) Open "***ORYZA Analysis Tool.xlsm***" (for MS 2007 or later) or "***ORYZA Analysis Tool.xls***" (for MS 2003 or older).
2) Follow the steps in **Chapter 1.4**, to display the simulation results.

5. Playing with nitrogen calculation modules:

1) Open "***N-limited.exp***".
2) Set `NUTRIENT` to `'GENERAL SOM'` in Section 7.
3) Repeat above 3 and 4 work sections to check the differences.

6. Playing with various indigenous N supplies:

1) Open "***N-limited.exp***".
2) Set `SOILSP` to 1.8 in Section 7.
3) Repeat above 3 and 4 work sections to check the differences.

5.3. Simulation scenarios with N × W interaction

Objective: To evaluate different levels of nitrogen application on yield under continuously flooded lowland rice.

Needed input files:

- Control file
- X.crp
- N-limited.exp
- upland.sol.
- Phil1.88-Phil.89
- Reruns

The simulation scenarios will be set and provided to the model by the RERUNS file.
For this exercise, nine W × N treatments will be used for exercise.

- N0 = Zero N input, W=Rainfed after transplanting
- N0 = Zero N input, W=AWD one week after transplanting
- N0 = Zero N input, W=Full irrigation
- N1 = Medium N input (120 kg ha^{-1}), W=Rainfed after transplanting
- N1 = Medium N input (120 kg ha^{-1}), W=AWD one week after transplanting
- N1 = Medium N input (120 kg ha^{-1}), W=Full irrigation
- N2 = Medium N input (200 kg ha^{-1}), W=Rainfed after transplanting
- N2 = Medium N input (200 kg ha^{-1}), W=AWD one week after transplanting
- N2 = Medium N input (200 kg ha^{-1}), W=Full irrigation

Please take note that the soil and crop parameters in the soil and crop file are calibrated for the site and conditions of the simulations.

1. Check experiment file settings:

1) Open the experiment file "***W-limited.exp***" using Notepad.
2) Make sure that the following settings are right in Section 1.

```
RUNMODE = 'EXPERIMENT'
NITROENV = 'NITROGEN BALANCE'
PRODENV = 'WATER BALANCE'
```

Under Section 7 nitrogen parameters, the mode of computation of your nitrogen balance has been already set to `'FIXED SUPPLY'`

```
NUTRIENT = 'FIXED SUPPLY'
SOILSP = 0.8
```

2. Editing rerun file:

1) Open "***W-limited.rer***" file, and save as "***NandW.rer***" using Notepad.
2) Keep Run 2, 3, and 5, and delete all the others.
3) Copy all content, paste them into the file twice, and set the rerun number from 1 to 9.
4) Open "***N-limited.rer***" file, copy FERTIL and its values in Rerun Set 1, and insert it into "***NandW.rer***" thereafter all variables in each of rerun sets 1, 2 and 3.
5) Copy `FERTIL` and its values in Rerun Set 4 in "***N-limited.rer***" and insert them into "***NandW.rer***" thereafter all variables in each of rerun sets 4, 5 and 6.
6) Copy FERTIL and its values in rerun set 5 in "***N-limited.rer***" and insert them into "***NandW.rer***" thereafter all variables in each of rerun sets 7, 8 and 9.
7) Save "***AandW.rer***", and close "***N-limited.rer***".

3. Managing simulations:

1) Open the ***ORYZA v3 interface*** by double-clicking on the icon.
2) Load your control file.
3) Open your control file by double-clicking on the control file path box. Make sure that the path on the address bar matches the location indicated for the input files in your control file. Modify the input file location if the file path does not match (include paths for output files `FILEON` and `FILEOL`).
4) Change the rerun file setting to point to "***NandW.rer***".
5) Make sure the experiment file points to "***W-limited.exp***".
6) Press the '**Run**' button.
7) Check the output and the files "***model.log***" and "***weather.log***" to make sure that there are no errors in the simulation. If there is an error, read the error message carefully, then correct it.

4. Analyzing simulations:

1) Open "***ORYZA Analysis Tool.xlsm***" (for MS 2007 or later) or "***ORYZA Analysis Tool.xls***" (for MS 2003 or older).
2) Follow the steps in Chapter 1.4, to display the simulation results.

Appendices

Appendix 1. DATA REQUIREMENTS FOR SIMULATION

Data collection from actual research experiments is a key component in modeling studies. The quality and quantity of data will determine the quality of calibration and validation. Good calibration can be achieved with more intensive datasets, which is critical in optimizing confidence on the simulation and prediction outputs of the model.

ORYZA v3 preferably requires the ideal data listed below to achieve well-calibrated and good-fitting simulations. However, having less data does not prohibit the use of ORYZA v3 on available experimental datasets. ORYZA v3 has functions and modules which can derive the needed information based on the available data from the experiment.

Data requirement for ORYZA v3 simulations

Depending on the completeness of data collected (ideal, adequate, usable), the confidence on the simulation outputs vary (high, acceptable, uncertain).

#	Data	Ideal data (High)	Adequate data (Acceptable)	Usable data (Uncertain)
1	Nursery density	√	√	√
2	Field density	√	√	√
3	Sowing date	√	√	√
4	Planting date	√	√	√
5	Daily radiation/sunshine	√ on-site	√	√
6	Maximum temperature	√ on-site	√ on-site	√
7	Minimum temperature	√ on-site	√ on-site	√
8	Rainfall	√ on-site	√ on-site	√
9	Wind speed	√ on-site	√	
10	Vapor pressure	√ on-site	√	
11	Phenology	PI, FL, PM	FL, PM	PM
12	Biomass accumulation	>3 measurements, component	1 measurement, component	Final, total
13	N uptake	>3 measurements, component		
14	Final grain yield	√	√	√
15	Harvest index	√	√	√
16	Grain weight	√	√	
17	Transpiration	√		
18	Soil texture	√	√	
19	Soil organic carbon	√	√	

20	Soil organic N	√		
21	Soil mineral N	√		
22	Irrigation	√	√	√
23	Soil water	√	√	
24	Fertilizer application	√	√	√
25	Pest & disease control	√	√	
26	Nutrient deficiency	√		

√ means that the data has been collected; PI, FL, and PM are phenological stages of panicle initiation, flowering, and physiological maturity, respectively.

Appendix 2. GENERAL RULES IN WRITING INPUT FILES

1) ORYZA is very restrictive in the type of input value. Note that a variable defined as an integer must be given an integer value (denoted as numbers without decimal points) and real variables with real numbers (denoted as numbers with decimal points).

   Syntax: (*variable name*) = (*integer value*) (!*comment or definition*)
   Example: `IYEAR  = 1992        ! Start year of simulation (year)`

   Syntax: (*variable name*) = (*real value*) (!*comment or definition*)
   Example: `NPLH   = 5.        ! Number of plants per hill`

2) String variables must have character values and must be enclosed between 2 single quotation marks.

   Syntax: (variable name) = (character value) (!comment or definition)
   Example: **`RUNMODE = 'EXPERIMENT'`** `!ORYZA simulates particular experiment`

3) Only ‘Space’ and ‘Enter’ are acceptable when editing input files, not ‘Tab’. ‘Enter’ is used to format a new line or separate values in uniform columns.

4) Identical array values can be written as n*<value>.

   Syntax: (*variable name*) = ($V_1, V_2, V_3, \ldots, V_n$) (!*comment or definition*)
   Example: `CLAYX = 4*0.55,0.53,0.5,3*0.45  !soil clay contents, fraction`

5) For array variables, more than one value can follow the equal sign, separated by commas with spaces, or use ‘Enter’.

   Syntax: (*variable name*) = ($V_1, V_2, V_3, \ldots, V_n$) (!*comment or definition*)
   Example: `IOBSD = 2008,161             !List of observation data for which`

6) Comment lines start with ‘*’ in the first column, or with ‘!’ in any column; the rest of the line following these marks will be ignored. The “!*” or “*!*” implies that the variable can be commented out, and the program will use the internal default values.

Syntax: *(*comment*)

Example: `*ESTAB is method of establishment: 'TRANSPLANT' or 'DIRECT-SEED'`

Syntax: !(*comment*)

Example:
```
! The string array PRSEL contains the output variables for which
! formatted tables have to be made.
```

Appendix 3. UNIT CONVERSION FOR REQUIRED DATA

Often, the raw data may not have the same unit as required in the ORYZA input files. In such cases, the data must be converted into the required unit or format.

1. Calculate the saturated water content (θ_s, cm^3 cm^{-3}) from bulk density (BD, g cm^{-3}) using Equation 1.

$$\boldsymbol{\theta_s = 1.0 - \frac{BD}{2.65}} \qquad \textbf{(1)}$$

2. Calculate the daily saturated vapor pressure (E_s, kPa) from daily mean air temperature (T, ^{o}C) using Equation2, where T is derived from maximum and minimum air temperature (T_{max}, T_{min}, ^{o}C).

$$\boldsymbol{E_s = 0.6108 \times 10^{\frac{7.5T}{237.7+T}}} \qquad \textbf{(2)}$$

3. Calculate the actual daily vapor pressure (E_a, kPa) from air temperature at dew point (T_d, ^{o}C) using Equation 2 but replacing T with T_d.

4. Calculate actual vapor pressure (E_a, kPa) from relative humidity (RH, %) using Equation 3.

$$\boldsymbol{E_a = E_s \frac{RH}{100}} \qquad \textbf{(3)}$$

5. Estimate soil organic carbon (SOC, kg C ha^{-1}) from soil organic matter content (SOM, %) using Equation 4.

$$\boldsymbol{SOC = 550 \times z \times BD \times SOM} \qquad \textbf{(4)}$$

where z is the thickness of a soil layer (cm) and BD is the bulk density (BD, g cm^{-3}).

6. Estimate the soil organic nitrogen content (SON, kg N ha^{-1}) from SOC with an assumed C:N ratio ($\boldsymbol{r_{CN}}$) (Eq. 5). The r_{CN} is 16 above for the top soil layer, where fresh organic matter is often integrated through the application of crop residue, organic fertilizer, and/or crop roots, where the number should be adjusted by the user according to the C:N ratio of applied organic matter. The $\boldsymbol{r_{CN}}$ is 11 to 16 for subsoil layers, which are affected by agronomic operation, particularly plowing, but have very little fresh organic matter input. The $\boldsymbol{r_{CN}}$ is 10 to 11 for soil layers which often remain undisturbed.

$$\boldsymbol{SON = \frac{SOC}{r_{CN}}} \qquad \textbf{(5)}$$

Appendix 4. VARIABLES USED FOR *PRSEL*IN CONTROL FILE

Variable Name	Unit	Definition
General variables available in all situation		
TIME		Accumulative day number starting from Julian day of simulation starting
YEAR		Simulation year
DOY		Julian day in a year
CROPSTA		Crop growth status for 1 for sowing, 2 for seed bed , 3 for transplanting, and 4 for main field
ETD	mm/d	Potential ET
TRC	mm/d	Potential transpiration
EVSC	mm/d	Potential evaporation
RAIN	mm/d	Rainfall
RAINCU	Mm	Total rainfall accumulated from simulation starting time
DVS		Development stage number
RDD	$J/m^2/d$	Daily shortwave radiation
TMIN	^oC	Daily minimum temperature
TMAX	^oC	Daily maximum temperature
NFLV	g N /m^2 leaf	Leaf N fraction in leaf
SLA	ha/kg	Special leaf area
SLASIM	ha/kg	Special leaf area of green leaves
LESTRS		Leaf expansion stress factor
LRSTRS		Leaf rolling stress factor
LDSTRS		Leaf death stress factor
PCEW		Factor in potential transpiration rate
NSP		Number of spikelet
LAI		Leaf area index
WAGT	kg/ha	Total above ground biomass
WST	kg/ha	Dry weight of stems
WLVG	kg/ha	Dry weight of green leaves
WLVD	kg/ha	Dry weight of dead leaves
WSO	kg/ha	Dry weight of storage organs
WRR14	kg/ha	Grain yield with 14% of moisture
ZRT	M	Rooting depth
ROOTM	kg/ha	Root biomass in a soil layer subject to the observation ROOT_OBS
ROOT_OBS	kg/ha	Observed root biomass in a soil layer
NFLV_OBS	g N /m^2 leaf	Observed leaf N fraction in leaf
FNLV_OBS	kg N/kg leaf	Observed leaf N fraction on weight basis
FNST_OBS	kg N/kg stem	Observed stem N fraction on weight basis
FNSO_OBS	kg N/kg storage	Observed storage organ N fraction on weight basis
LAI_OBS		Observed leaf area index

WLVG_OBS	kg/ha	Dry weight of green leaves
WLVD_OBS	kg/ha	Dry weight of dead leaves
WST_OBS	kg/ha	Dry weight of stems
WSO_OBS	kg/ha	Dry weight of storage organs
WAGT_OBS	kg/ha	Total above ground biomass
ANLV_OBS	kg N/ha	Observed nitrogen in green leaves
ANST_OBS	kg N/ha	Observed nitrogen in stem
ANSO_OBS	kg N/ha	Observed nitrogen in storage organ
ANCR_OBS	kg/ha/d	Observed N uptake rate by the crop
ZRT_OBS	M	Observed rooting depth
Specific variables if DRASHE module was used		
IR	mm/d	Irrigation rate
IRCUM2	Mm	Accumulative irrigation from emergence
RAINCUM2	Mm	Accumulative rain from emergence
EVSW	Mm	Daily evaporation
MSKPA1	kPa	Soil water potential at soil layer 1
MSKPA2	kPa	Soil water potential at soil layer 2
MSKPA3	kPa	Soil water potential at soil layer 3
MSKPA4	kPa	Soil water potential at soil layer 4
MSKPA5	kPa	Soil water potential at soil layer 5
MSKPA6	kPa	Soil water potential at soil layer 6
MSKPA7	kPa	Soil water potential at soil layer 7
MSKPA8	kPa	Soil water potential at soil layer 8
MSKPA9	kPa	Soil water potential at soil layer 9
MSKPA10	kPa	Soil water potential at soil layer 10
WCL1_OBS		Observed soil water content at soil layer 1
WCL2_OBS		Observed soil water content at soil layer 2
WCL3_OBS		Observed soil water content at soil layer 3
WCL4_OBS		Observed soil water content at soil layer 4
WCL5_OBS		Observed soil water content at soil layer 5
WCL6_OBS		Observed soil water content at soil layer 6
WCL7_OBS		Observed soil water content at soil layer 7
WCL8_OBS		Observed soil water content at soil layer 8
WCL9_OBS		Observed soil water content at soil layer 9
WCL10_OBS		Observed soil water content at soil layer 10
MSKPA1_OBS	kPa	Observed soil water potential at soil layer 1
MSKPA2_OBS	kPa	Observed soil water potential at soil layer 2
MSKPA3_OBS	kPa	Observed soil water potential at soil layer 3
MSKPA4_OBS	kPa	Observed soil water potential at soil layer 4
MSKPA5_OBS	kPa	Observed soil water potential at soil layer 5
MSKPA6_OBS	kPa	Observed soil water potential at soil layer 6
MSKPA7_OBS	kPa	Observed soil water potential at soil layer 7
MSKPA8_OBS	kPa	Observed soil water potential at soil layer 8

MSKPA9_OBS	kPa	Observed soil water potential at soil layer 9
MSKPA10_OBS	kPa	Observed soil water potential at soil layer 10
Specific variables if LOWBAL module was used		
PERC	mm/d	Daily percolation loss of water
RUNOF	mm/d	Daily runoff loss of water
IR	mm/d	Daily irrigation
IRCUM3	Mm	Accumulative irrigation from transplanting
RAINCUM3	Mm	Accumulative rain from transplanting
WL0	Mm	Depth of surface water
EVSW	mm/d	Daily evaporation rate
EVSWCUM3	Mm	Evaporation accumulated from transplanting
TRWCUM3	Mm	Transpiration accumulated from transplanting
MSKPA1	kPa	Soil water potential at the surface layer
WCL1		Soil water content at the surface layer
WL0_OBS	Mm	Observed depth of surface water
WCL1_OBS	Mm	Observed soil water content at surface layer
MSKPA1_OBS	kPa	Observed soil water potential at surface layer
Additional variables with simulation under nitrogen balance		
NSLLV		Stress factor for leaf death caused by N stress
RNSTRS		Decrease factor for leaf growth caused by N stress
NUPP	kg N/ha/d	Nitrogen uptake rate
ANCR	Kg N/ha	Accumulative nitrogen uptake
ANLV	Kg N/ha	Nitrogen in leaves
ANLD	Kg N/ha	Nitrogen in dead leaves
ANST	Kg N/ha	Nitrogen in stem
ANSO	Kg N/ha	Nitrogen in storage
ANRT	Kg N/ha	Nitrogen in root
NMAXL	kg N/kg leaf	Maximum leaf N fraction on weight basis
NMINL	kg N/kg leaf	Minimum leaf N fraction on weight basis
FNLV	kg N/kg leaf	Leaf N fraction on weight basis
ROOTN	Kg N/ha	Root nitrogen at soil layers
ROOTC	Kg/ha	Root biomass at soil layers
SNH4	Kg N/ha	Mineral nitrogen in NH4 type at soil layers
SNO3	Kg N/ha	Mineral nitrogen in NO3 type at soil layers
XFERT	kg N/ha	Nitrogen fertilizer application
TNSOIL	Kg N/ha	Total soil mineral nitrogen
Specific variables If PADDY module was used		
WL0	mm	Depth of surface water
IR	mm/d	Amount of daily irrigation
IRCUM2	mm	Irrigation amount accumulated from sowing
RAINCUM2	mm	Rain amount accumulated from sowing
RUNOFCUM2	mm	Runoff amount accumulated from sowing
EVSW	mm/d	Evaporation amount

EVSWCUM2	mm	Evaporation amount accumulated from sowing
TRWCUM2	mm	Transpiration amount accumulated from sowing
GWTOT	mm/d	Rate of ground water recharge
CAPTOT	mm/d	Rate of capillary water
MSKPA	kPa	Soil water potential at soil layer have observed values
MSKPA_OBS	kPa	Observed soil water potential at observation soil layer
WL0_OBS	mm	Observed depth of surface water
WCL		Soil water content at soil layer have observed values
WCL_OBS		Observed soil water content at observation soil layer
WLFLOUT	mm/d	Deep drainage rate
Specific variables If SAWAH module was used		
IR	mm/d	Amount of daily irrigation
IRC	mm	Irrigation amount accumulated from sowing
MSKPA1	kPa	Soil water potential at soil layer 1
MSKPA2	kPa	Soil water potential at soil layer 2
MSKPA3	kPa	Soil water potential at soil layer 3
MSKPA4	kPa	Soil water potential at soil layer 4
MSKPA5	kPa	Soil water potential at soil layer 5
MSKPA6	kPa	Soil water potential at soil layer 6
MSKPA7	kPa	Soil water potential at soil layer 7
MSKPA8	kPa	Soil water potential at soil layer 8
MSKPA9	kPa	Soil water potential at soil layer 9
MSKPA10	kPa	Soil water potential at soil layer 10
WCL1		Soil water content at soil layer 1
WCL2		Soil water content at soil layer 2
WCL3		Soil water content at soil layer 3
WCL4		Soil water content at soil layer 4
WCL5		Soil water content at soil layer 5
WCL6		Soil water content at soil layer 6
WCL7		Soil water content at soil layer 7
WCL8		Soil water content at soil layer 8
WCL9		Soil water content at soil layer 9
WCL10		Soil water content at soil layer 10
WL0_OBS	mm	Observed depth of surface water
WCL1_OBS		Observed soil water content at soil layer 1
WCL2_OBS		Observed soil water content at soil layer 2
WCL3_OBS		Observed soil water content at soil layer 3
WCL4_OBS		Observed soil water content at soil layer 4
WCL5_OBS		Observed soil water content at soil layer 5
WCL6_OBS		Observed soil water content at soil layer 6
WCL7_OBS		Observed soil water content at soil layer 7
WCL8_OBS		Observed soil water content at soil layer 8
WCL9_OBS		Observed soil water content at soil layer 9

WCL10_OBS		Observed soil water content at soil layer 10
MSKPA1_OBS	kPa	Observed soil water potential at soil layer 1
MSKPA2_OBS	kPa	Observed soil water potential at soil layer 2
MSKPA3_OBS	kPa	Observed soil water potential at soil layer 3
MSKPA4_OBS	kPa	Observed soil water potential at soil layer 4
MSKPA5_OBS	kPa	Observed soil water potential at soil layer 5
MSKPA6_OBS	kPa	Observed soil water potential at soil layer 6
MSKPA7_OBS	kPa	Observed soil water potential at soil layer 7
MSKPA8_OBS	kPa	Observed soil water potential at soil layer 8
MSKPA9_OBS	kPa	Observed soil water potential at soil layer 9
MSKPA10_OBS	kPa	Observed soil water potential at soil layer 10
Specific variables if soilPF modules was used		
MSKPA	kPa	Soil water potential
WCLQT		Soil water content
Specific variables if General SOM was used		
N2O	kg N/ha/d	N2O loss
NH3	kg N/ha/d	NH3 loss
Leached	kg N/ha/d	Nitrogen loss through leaching
Mineralized	kg N/ha/d	Mineralized nitrogen
Fertilizer	kg N/ha	Nitrogen fertilizer application
CO2Released	kg C/ha	CO2 loss from soil
SOC	kg C/ha	Total soil organic carbon
SON	kg N/ha	Total soil organic nitrogen
Additional variable with simulation under water stress		
TRW	mm/d	Actual transpiration

Appendix 5. VARIABLES USED FOR *OPSTRING* IN CONTROL FILE

Variable Name	Unit	Definition
Variables available for all simulations		
ETDCUM	mm	Radiation forced potential evapotranspiration in main field
EVSCCUM	mm	Potential evaporation in main field
TRCCUM	mm	Potential transpiration in main field
EMD		The Julian day for emergence
DAE	d	The days after emergence
ANCR	kg N/ha	Total nitrogen uptake
WRR14	kg/ha	Grain yield with 14% moisture
WSO	kg/ha	Dry weight of storage organ
WAGT	kg/ha	Dry weight of above-ground plant organs
PARCUM	MJ	Photosynthetic radiation from emergence to maturity
TS	^{o}Cd	Total thermal time
TMAXC	^{o}C	Accumulative maximum air temperature from emergence
TIMNC	^{o}C	Accumulative minimum air temperature from emergence
TAVERC	^{o}C	Accumulative average air temperature from emergence
DAYSFL	d	Days to flowering from emergence
SF1		Spikelet fertility fraction after cold caused sterility
SF2		Spikelet fertility fraction after hot caused sterility
SPFERT		Total spikelet fertility after cold and hot caused sterility
COLDTT		The accumulative temperature lower than threshold value of cold caused sterility
CONSEC		Consecutive days of cold cause sterility
NSP	#/ha	Potential spikelet number
Specific variables if DRSAHE module was used		
RAINCUM	mm	Accumulative rainfall in main field
IRCUM	mm	Accumulative irrigation in main field
RUNOFCUM	mm	Accumulative runoff in main field
TRWCUM	mm	Accumulative actual transpiration in main field
EVSWCUM	mm	Accumulative actual evaporation in main field
DRAICUM	mm	Accumulative drainage in main field
Specific variables if LOWBAL module was used		
RAINCUM	mm	Accumulative rainfall in main field
IRCUM	mm	Accumulative irrigation in main field
RUNOFCUM	mm	Accumulative runoff in main field
TRWCUM	mm	Accumulative actual transpiration in main field
EVSWCUM	mm	Accumulative actual evaporation in main field
PERCCUM	mm	Accumulative drainage in main field
Specific variables if PADDY module was used		
RAINCUM	mm	Accumulative rainfall in main field
IRCUM	mm	Accumulative irrigation in main field

RUNOFCUM	mm	Accumulative runoff in main field
TRWCUM	mm	Accumulative actual transpiration in main field
EVSWCUM	mm	Accumulative actual evaporation in main field
DRAICUM	mm	Accumulative drainage in main field
CAPTOTCUM	mm	Accumulative capillary in main field
DSWC	mm	Total soil water change in main field
RAINCUM0	mm	Accumulative rainfall from emergence
IRCUM0	mm	Accumulative irrigation from emergence
RUNOFCUM0	mm	Accumulative runoff from emergence
TRWCUM0	mm	Accumulative actual transpiration from emergence
EVSWCUM0	mm	Accumulative actual evaporation from emergence
DRAICUM0	mm	Accumulative drainage from emergence
CAPTOTCUM0	mm	Accumulative capillary from emergence
Specific variables If SAWAH module was used		
RAINC	mm	Accumulative rainfall in main field
IRC	mm	Accumulative irrigation in main field
TRWC	mm	Accumulative actual transpiration in main field
EVSWC	mm	Accumulative actual evaporation in main field
RNOFC	mm	Accumulative runoff in main field
Specific variables if GENERAL SOM module was used		
SOC	kg C/ha	Soil organic carbon content at the end of season
SON	kg N/ha	Soil organic carbon content at the end of season
N2O	kg N/ha	Total N2O loss
CO2	kg C/ha	Total CO2 loss
NH3	kg N/ha	Total NH3 loss
LEACHEDN	kg N/ha	Total N loss through leaching

Appendix 6. INPUT FILE TEMPLATES

A. CONTROL FILE

```
CONTROLFILE = 'E:\exercise\control.dat'
STRUN = 1
ENDRUN = 72
FILEON = 'res.dat'                      ! Output file
FILEOL = 'model.log'                    ! Log file
FILEIR = 'E:\exercise\reruns.rer'       ! Rerun file
FILEIT = 'E:\exercise\standard.exp'     ! Experiment file
FILEI1 = 'E:\exercise\standard.crp'     ! Crop file
FILEI2 = 'E:\exercise\standard.sol'     !* Soil file

*----------------------------------------------------------------------*
* Optionally, Weather Station information can be provided here         *
* It is useful for large amount of simulations under same management   *
*----------------------------------------------------------------------*
*WTRDIR = 'E:\exercise\weather\'    !* Folder name of weather files
*CNTR = 'PHIL'                   !* Weather station name
*ISTN = 2                        !* Weather station number
*MULTIY = 'YES'                   !* Whether multiple year weather file is used,
                                  !* default is 'NO' or if the variable do not appear.

*------------------------------------------------------------------------*
* Rice monoculture cropping system                                       *
* the default for SOILKILL is "YES", soil will be re-initiated every     *
* crop season, and all processes in soil will also stop as growth stop.  *
* if "NO", soil will only be initiated at the starting date of simulation*
* and all processes in soil will continue after growth stop.             *
*------------------------------------------------------------------------*
*SOILKILL = 'NO'
*----------------------------------------------------------------------*
* Set output/print options                                             *
*----------------------------------------------------------------------*
PRDEL = 1000. ! Output time step (day), too much reruns, omit detail outputs
IPFORM = 5    ! Code for output table format:
COPINF = 'N' ! Switch variable whether to copy the input files to the output
              ! file ('N' = do not copy,
              ! 'Y' = copy)
DELTMP = 'N' ! Switch variable what should be done with the temporary output
              ! file ('N' = do not delete,
              ! 'Y' = delete)
IFLAG  = 1100 ! Indicates where weather error and warnings go
              ! (1101 means errors and warnings to log file, errors to screen
              ! see FSE manual)
*PRSEL = 'WAGT','WRR14','WSO'
*         'LAI', 'LAI_OBS'       !*It is for the output variables in res.dat
OPSTRING = 'DAE,WRR14,WAGT'     !*It is for the output variables in op.dat
*IOBSD = 2008,161
!* List of observation data for which output is required.
!* The list should consist of pairs <year>,<day> combination
```

***NOTES:**

- The highlighted portion in the template is for advanced application of ORYZA v3. It will not appear in the control file in basic application.

B. EXPERIMENT FILE

```
*--------------------------------------------------------------------*
* EXPERIMENTAL DATA FILE                                             *
*                                                                    *
* File name        : (user defined)                                  *
* Crop             : (user defined)                                  *
* Year/Season      : (user defined)                                  *
* Additional info  : (user defined)                                  *
*--------------------------------------------------------------------*

*--------------------------------------------------------------------*
* 1. Selection of modes of running                                   *
*--------------------------------------------------------------------*
*--  RUNMODE: mode of running ORYZA
RUNMODE = 'EXPERIMENT'      ! ORYZA simulates particular experiment
*RUNMODE ='EXPLORATION'     ! ORYZA used for exploration

*--  PRODENV is Water production situation setting
*PRODENV = 'POTENTIAL'      ! Potential production
PRODENV = 'WATER BALANCE'   ! Production may be water-limited

*-- WATBAL is choice of water balance
*   needs only be given when PRODENV = 'WATER BALANCE'
WATBAL = 'PADDY'  ! PADDY water balance (for lowland soils)
*WATBAL = 'SAHEL'  ! SAHEL water balance (for freely draining upland soils)
*WATBAL = 'SAWAH'  ! SAWAH water balance (for lowland or upland soils)
*WATBAL = 'LOWBAL' ! LOWBAL water balance (for lowland soils)
*WATBAL = 'SOILPF' ! SOILPF water balance (Soil water tension read from file)

*--  NITROENV is Nitrogen production situation setting
NITROENV = 'POTENTIAL'        ! Potential production
*NITROENV = 'NITROGEN BALANCE' ! Production may be nitrogen-limited


*--  ETMOD is method for evapotranspiration calculation:
ETMOD = 'PENMAN'            ! Penman-based (Van Kraalingen& Stol,1996)
*ETMOD = 'PRIESTLY TAYLOR'  ! Priestly-Taylor (")
*ETMOD = 'MAKKINK'          ! Makkink (Van Kraalingen&Stol, 1996)

*--------------------------------------------------------------------*
* 2. Timer data for simulation                                       *
*--------------------------------------------------------------------*
IYEAR  = 2008           ! Start year of simulation (year)
STTIME = 161.           ! Start time  (day number)
FINTIM = 1000.          ! Finish time (days after start)
DELT   = 1.             ! Time step   (day)


*--------------------------------------------------------------------*
* 3. Weather station and climatic data for simulation                *
*--------------------------------------------------------------------*
WTRDIR = 'E:\exercise\weather\'   ! Directory of weather data
CNTR   = 'PHIL'                  ! Country code
ISTN   = 2                       ! Station code
MULTIY  = ‘YES’                  !*  Whether multiple year weather file is used,
                                 !* default is ‘NO’ or if the variable do not appear.
ANGA = 0.29                      ! Angstrom A parameter
```

```
ANGB = 0.45                  ! Angstrom B parameter

*TMCTB =  0., 0.,            !* Table for temperature increase
*       366., 0.             !* Climatic Change studies

TMINCTB = 0.,0.   !*Table for temperature increase for minimum temperature
        366.,0.   !*It has been used with TMAXCTB

TMAXCTB = 0., 0., !*Table of temperature increase for maximum temperature
        366., 0.  !*use TMINCTB & TMAXCTB, must disable TMCTB

*CO2A = 0.,375.,  !*Table for daily CO2 concentration AFTER EMERGENCY
*       1.,400.,  !*if this table appear, its value will overwrite the value
*       5.,400.,  !*of CO2 in crop file.
*       6.,720.,  !*Please pay attention on the CO2 concentration in crop
*      50.,720.,  !*and experiment files to make them compatible except for
*      51.,375.,  !*CO2 testing period during crop growth
*     150.,375.   !*Note: column one is the DAYS AFTER EMERGENCY

FAOF  = 1.       ! Multiplying factor for potential evapotranspiration (FAO)
                 ! Value Murty&Tuong

TMPSB = 0.       ! Temperature increase in seed-bed due to cover:
                 ! Zero when no cover over seed-bed; 9.5 with seed-bed

*TMCTB = 0.0, 0.0,   !*Daily average temperature increment table (oC)
*      366.0, 0.0    !*Column 1: Julian day, Column 2: change value

*TMAXCTB = 0.0, 0.0, !*Daily maximum temperature change,
*      366.0, 0.0    !*either TMCTB or TMAXCTB
                     !*Column 1: Julian; Column 2: Increment value (oC)

*TMINCTB = 0.0,0.0,  !*Daily minimum temperature change, use with TMAXCTB
*      366.0, 0.0    !*Column 1: Julian day; Column 2: Increment (oC)

*RADCTB = 0.0, 0.0,  !*Total daily radiation change
*      190.0, 0.0,   !*Column 1: Julian day; Column 2: change percentage (%)
*      191.0, -5.0,
*      366.0, -5.0

*XFRDIF = 0.0        !*How you count diffusive radiation change?
*                    !*0: no change
*                    !*1: change in percentage based theoretical fraction
*                    !*2: Change with given diffusive radiation fraction

*FRDIFCTB = 0.0,0.0, !*Diffusive radiation change table if XFRDIF>0
*         366.0,0.0  !*Column 1: Julian day; Column 2: change value (% or-)

*CCYEAR = 2008       !*The start year for climate change computation

*FRINCTB = 0.0,0.0,  !*Rainfall change table
*        366.0,0.0   !*Column 1: Julian day; Column 2: change value (%)

*VAPPCTB = 0.0,0.0, !* Vapor pressure change table
*        366.0,0.0  !*Column 1: Julian day; Column 2: change value (% or-)

*WINDCTB = 0.0,0.0, !*Wind speed change table
```

```
*        366.0,0.0  !*Column 1: Julian day; Column 2: change value (% or-)

*--------------------------------------------------------------------*
* 4. Establishment data
*--------------------------------------------------------------------*
*--  ESTAB is method of establishment: 'TRANSPLANT' or 'DIRECT-SEED'
ESTAB='TRANSPLANT'
*ESTAB='DIRECT-SEED'

* Transplanting date May 25 (145), 2001; sowing date April 15;
* 50% emergence April 29 (119)
EMD    = 164   ! Day of emergence (either direct, or in seed-bed)
EMYR   = 2008  ! Year of emergence
SBDUR  = 23    ! Seed-bed duration (days between emerging and transplanting)


*--------------------------------------------------------------------*
* 5. Management parameters                                           *
*--------------------------------------------------------------------*
NPLH   = 2.0        ! Number of plants per hill
NH     = 33.0       ! Number of hills/m2 (13 x 27 cm)
NPLSB  = 1000.      ! Number of plants in seed-bed (???)
NPLDS  = 165.       ! Number of plants/m2 direct-seeded

*-- Initial data at emergence, for either direct-seeding or seed-bed
*   Standard data used.
LAPE   = 0.0001     ! Initial leaf area per plant
DVSI   = 0.0        ! Initial development stage
WLVGI  = 0.0        ! Initial leaf weight
WSTI   = 0.0        ! Initial stem weight
WRTI   = 0.0        ! Initial stem weight
WSOI   = 0.0        ! Initial weight storage organs
ZRTI   = 0.0001     ! Initial root depth (m)

*-- Re-initialization at transplanting (standard data used)
ZRTTR  = 0.05       ! Root depth at transplanting (m)

*---------------------------------------------------------------*
* 6. Irrigation parameters
* Need only to be filled-in when PRODENV = 'WATER BALANCE'
*---------------------------------------------------------------*
* NEW, SEPT 2006:
DVSIMAX = 2.0   ! Development stage after which no more irrigation is applied
* NEW SETTING,21 MAY 2010
* The determination for switch critical
ICOMBA = 1 !1: Use Julian day;
           ! 2: Use DVS;
           ! 3: Use mixture of DVS and Julian day,
           ! but the Julian day is not allowed to be smaller than 2;
           ! 4: use DAE;

* Combining irrigation management methods table IRMTAB, it must have at least
* two lines,X (Julian day or DVS or DVS+Julian, present the switching day),
*          Y (methods in real number)
IRMTAB = 187.,1.0,
         202.,1.0
```

```
AUTODEPT = -10.0   ! The surface water depth (mm) for determining irrigation
                   ! amount automatically
                   ! Function is disabled when it did not appear or with
                   ! negative number

** Following options are available for setting IRMTAB:
*SWITIR = 0 !* No irrigation; rainfed
*SWITIR = 1 !* Irrigation supplied as input data
*SWITIR = 2 !* Irrigation at minimum standing soil water depth
*SWITIR = 3 !* Irrigation at minimum soil water potential
*SWITIR = 4 !* Irrigation at minimum soil water content
*SWITIR = 5 !*Irrigation at x days after disappearance of standing water
*SWITIR = 6 !* Irrigation at minimum soil water potential in defined periods
            !*only

** If SWITIR = 1, supply irrigation table, amount of irrigation
** (y in mm) for a given calendar * day (x),
RIRRIT =1.0,0.00,
     365.00,0.00

** If SWITIR = 2:
***1) supply amount of irrigation IRRI2 (mm)
***2) supply minimum standing water depth WL0MIN (mm) below which irrigation
***   water is applied
IRRI2 = 75.  ! Irrigation gift (mm) !IT MUST BE REAL DATA
WL0MIN = 10. ! Minimum standing water depth (mm) !IT MUST BE REAL DATA

** IF SWITIR =3:
***1) supply amount of irrigation IRRI3 (mm)
***2) supply minimum soil water potential KPAMIN (KPa)
***3) supply soil layer for which KPAMIN applied, SLMIN3
IRRI3 = 50.            !IT MUST BE REAL DATA
KPAMIN = 70.           !IT MUST BE REAL DATA
SLMIN3 = 3             !IT MUST BE INTEGER DATA

** IF SWITIR = 4:
***1) supply amount of irrigation IRRI4 (mm)
***2) supply minimum soil water content WCAMIN (-)
***3) Supply soil layer for which KPAMIN applied, SLMIN4
IRRI4 = 50.      !IT MUST BE REAL DATA
WCMIN = 0.30     !IT MUST BE REAL DATA
SLMIN4 = 3       !IT MUST BE INTEGER DATA

** IF SWITIR = 5:
***1) supply amount of irrigation IRRI5 (mm)
***2) supply number of days after disappearance of standing water (WL0DAY) at
***   which irrigation water is applied
IRRI5 = 50.    !IT MUST BE REAL DATA
WL0DAY = 5     !number of days after disappearance of (-) INTEGER!!

** IF SWITIR = 6:
***1) supply amount of irrigation IRRI6 (mm)
***2) Supply soil layer for which KPAMIN applied, SLMIN6
***3) period table as "start DVS' 'finish DVS' 'KPAMIN during period'
* Irrigation will be applied in the periods between 'start DVs' to 'end DVS'
* and only when the soil water tension in layer SLMIN is above KPAMIN in that
* period
```

```
* Note: at maximum 5 stages can de defined (no more than 15 data in table)
IRRI6 = 50.     !IT MUST BE REAL DATA
SLMIN6 = 3      !IT MUST BE INTEGER DATA
ISTAGET = 0.00, 0.20, 5.,
          0.65, 0.80, 50.,
          1.00, 1.20, 5.,
          1.50, 1.60, 50.,
          1.70, 1.80, 5.

*--------------------------------------------------------------------*
* 7. Nitrogen parameters                                             *
*--------------------------------------------------------------------*
*TWO SOIL C AND N DYNAMICS
NUTRIENT = 'GENERAL SOM' !USE GENERAL SOIL ORGANIC C AND N MODULE TO HANDLE
                          ! THE NUTRIENT CHANGES
*NUTRIENT  =  'FIXED  SUPPLY'  !Use  fixed  mineralization  rate  with  fertilizer
                             ! recovery rate

* Table of recovery fraction of Nitrogen in the soil (-) second column
* versus development stage (DVS) (first column) STANDARD VALUE
RECNIT =
0.0, 0.30,
0.2, 0.35,
0.4, 0.50,
0.8, 0.75,
1.0, 0.75,
2.5, 0.75

* NO DATA ON SOILSP: THIS 0.8 IS FOR IRRI CONDITIONS IN THE DS......
SOILSP = 0.8       ! Soil N mineralization rate (kg N/ha/d)

* Table of fertilizer rate (kg N/ha) (second column) versus days after sowing
* in the seed-bed (!) (first column)
FERTIL =
0.,    0.,
25.,   0.,
26.,   60.,
27.,   0.,
32.,   0.,
33.,   90.,
34.,   0.,
86.,   0.,
87.,   38.,
88.,   0.,
366.,  0.

*Fresh organic residue input at land surface if it is applicable
*SORGANC = 1000.0   !*Surface residue carbon input at kg C/ha
*SORGANN = 20.0     !*Surface residue nitrogen input at kg N/ha

*--------------------------------------------------------------------*
* 8. Measured data for model calibration and comparison              *
*    And option to force measured LAI during simulation              *
*    (instead of using simulated values)                             *
*--------------------------------------------------------------------*
* Observed phenology: only required if program DRATES is run!!
IDOYTR = 187    ! Day of transplanting (give 0 if direct-seeded)
```

```
IYRTR  = 2008   ! Year of transplanting (give 0 if direct-seeded)
IDOYPI  =  228  !  Day  of  panicle  initiation  (estimated  as  same  day  as
                ! jointing)
IYRPI  = 2008  ! Year of panicle initiation
IDOYFL = 260   ! Day of flowering
IYRFL  = 2008  ! Year of flowering
IDOYM  = 288   ! Day of maturity (estimated as 7 d before harvest)
IYRM   = 2008  ! Year of maturity

*!* Leaf Area Index (m2 leaf / m2 ground):
LAI_OBS =
2008.00,   209.00,   1.00,
2008.00,   222.00,   1.3,
2008.00,   234.00,   2.5,
2008.00,   250.00,   3.5,
2008.00,   263.00,   3.5,
2008.00,   280.00,   3.00,
2008.00,   295.00,   1.8

*-- Parameter to set forcing of observed LAI during simulation
LAI_FRC = 0       ! No forcing
*LAI_FRC = 2      ! Forcing

*!* Green leaf dry wt (kg/ha)
WLVG_OBS =
2008.00,   209.00,   176.69,
2008.00,   222.00,   995.2,
2008.00,   234.00,   2189.9,
2008.00,   250.00,   2320.4,
2008.00,   263.00,   2580.00,
2008.00,   280.00,   2262.19,
2008.00,   295.00,   1189.4

*!* Dead leaf dry wt (kg/ha)
WLVD_OBS =
2008.00,   209.00,   0.00,
2008.00,   222.00,   0.00,
2008.00,   234.00,   0.00,
2008.00,   250.00,   343.3,
2008.00,   263.00,   516.69,
2008.00,   280.00,   1530.00,
2008.00,   295.00,   2109.2

*!* Stem dry wt (kg/ha)
WST_OBS =
2008.00,   209.00,   306.69,
2008.00,   222.00,   1054.5,
2008.00,   234.00,   2315.5,
2008.00,   250.00,   3029.00,
2008.00,   263.00,   3386.69,
2008.00,   280.00,   3621.4,
2008.00,   295.00,   2812.3

*!* Panicle dry wt (kg/ha)
WSO_OBS =
2008.00,   209.00,   0.00,
2008.00,   222.00,   0.00,
```

```
2008.00,   234.00,   0.00,
2008.00,   250.00,   0.00,
2008.00,   263.00,   663.2,
2008.00,   280.00,   3317.39,
2008.00,   295.00,   5850.89

*!* Total dry wt (kg/ha)
WAGT_OBS =
2008.00,   209.00,   483.39,
2008.00,   222.00,   2049.69,
2008.00,   234.00,   4505.39,
2008.00,   250.00,   5892.69,
2008.00,   263.00,   6946.59,
2008.00,   280.00,   10731.00,
2008.00,   295.00,   11961.79


*!* Leaf N (g N/g leaf):
*FNLV_OBS =

*!* Leaf N (g N/m2 leaf):
*NFLV_OBS =

*-- Parameter to set forcing of observed NFLV values during simulation
*NFLV_FRC = 0      !* No forcing
*NFLV_FRC = 2      !* Forcing

*!* Root biomass observation in a layer
*ROOTM1_OBS =
*2008.00,   209.00,   0.00,
*2008.00,   263.00,   663.2

*!* Root biomass observed in a year
*TOORM3_OBS =
*2008.00,   209.00,   0.00,
*2008.00,   263.00,   663.2

*----------------------------------------------------------------------------
*Additional input for night temperature control experiment, if you have
* temperature control
*----------------------------------------------------------------------------
ISTEMC = 0    ! WHETHER USE TEMPERATURE CONTROL 0 = NO,
*             ! 1= NIGHT CONTROL, 2=DAY CONTROL, 3=Both Control

SHOUR  = 19. ! Start time for temperature control
EHOUR  = 5.  ! Ending time for temperature control
*The SHOUR and EHOUR define the night time period, it should be SHOUR>EHOUR

SDAY   = 202. ! Julian day temperature control starting
TSYEAR = 1989.
EDAY   = 303. ! Julian day temperature control ending
TEYEAR = 1989.
TTEMPD = 28. ! Target, -999 means net change is used
TTEMPN = 21. ! Target temperature for nighttime,
               ! -999 means net change is used
TCHANG = -999. ! Net change of temperature,
               ! -999 means target temperature is used
```

```
CONTRM = 2      ! 1 = control the temperature exceed the defined range,
                ! 2 = constant temperature
```

> ***NOTES:**
> - The highlighted portion in the template is for advance application of ORYZA v3. It may or may not appear in the experiment file for basic applications.

C. CROP FILE

```
**********************************************************************
* Crop data file for ORYZA rice growth model                        *
* Variety   : <provided by user>                                      *
* File name : STANDARD.CRP                                            *
* <Information of user's reference>                                   *
**********************************************************************
*---------------------------------------------------------------------
* 1. Phenological development parameters
*---------------------------------------------------------------------
TBD    = 8.       ! Base temperature for development (oC)
TBLV   = 8.       ! Base temperature for juvenile leaf area growth (oC)
TMD    = 42.      ! Maximum temperature for development (oC)
TOD    = 30.      ! Optimum temperature for development (oC)
DVRJ = 0.0006560   ! Development rate in juvenile phase (oCd-1)
DVRI = 0.0007576   ! Development rate in photoperiod-sensitive phase (oCd-1)
DVRP = 0.0006810   ! Development rate in panicle development (oCd-1)
DVRR = 0.0023510   ! Development rate in reproductive phase (oCd-1)
MOPP   = 11.50    ! Maximum optimum photoperiod (h)
PPSE   = 0.0      ! Photoperiod sensitivity (h-1)
SHCKD  = 0.4      ! Relation between seedling age and delay in phenological
                  ! development (oCd oCd-1)

*---------------------------------------------------------------------
* 2. Leaf and stem growth parameters
*---------------------------------------------------------------------
RGRLMX = 0.0085   ! Maximum relative growth rate of leaf area (oCd-1)
RGRLMN = 0.0040   ! Minimum relative growth rate of leaf area (oCd-1)
SHCKL  = 0.25     ! Relation between seedling age and delay in leaf area
                  ! development (oCd oCd-1)
SHADET = 0.90     !* Tolerance index to shading with value 0.1 to 0.99
                  !* from susceptible to high tolerance, default
                  !* is 0.5 to indicate fair tolerance.

* Switch to use SLA as table (give values below) or as fixed function
*SWISLA = 'FUNCTION' ! Give function parameters ASLA, BSLA, CSLA, DSLA,
                     ! SLAMAX
SWISLA = 'TABLE'    ! Give SLA as a function of DVS in the table SLATB

* If SWISLA='FUNCTION', supply SLA function parameters:
* SLA = ASLA + BSLA*EXP(CSLA*(DVS-DSLA)), and SLAMAX
ASLA = 0.0024    ! (-)
BSLA = 0.0025    ! (-)
CSLA = -4.5      ! (-)
DSLA = 0.14      ! (-)
SLAMAX = 0.0045 ! Maximum value of SLA (ha/kg)
```

```
* If SWISLA='TABLE', supply table of specific leaf area (ha kg-1; Y value)
* as a function of development stage (-; X value):
SLATB = 0.00, 0.0045,
        0.16, 0.0045,
        0.33, 0.0033,
        0.65, 0.0028,
        0.79, 0.0024,
        2.10, 0.0023,
        2.50, 0.0023

* Table of specific green stem area (ha kg-1; Y value) as a function of
* development stage (-; X value):
SSGATB = 0.0, 0.0003,
         0.9, 0.0003,
         2.1, 0.0000,
         2.5, 0.0000

*----------------------------------------------------------------------
* 3. Photosynthesis parameters
*----------------------------------------------------------------------
FRPAR  = 0.5  ! Fraction of sunlight energy that is
              ! photosynthetically active (-)
SCP    = 0.2  ! Scattering coefficient of leaves for PAR (-)
CO2REF = 340. ! Reference level of atmospheric CO2 (ppm)
CO2    = 385. ! Ambient CO2 concentration (ppm)

* Table of light extinction coefficient for leaves (-; Y-value) as a function
* of development stage (-; X value):
KDFTB = 0.00, 0.4,
        0.65, 0.4,
        1.00, 0.6,
        2.50, 0.6

* Table of extinction coefficient of N profile in the canopy (-; Y-value)
* as a function of development stage (-; X value):
KNFTB = 0.0, 0.4,
        0.65,0.4,
        1.00,0.4,
        2.5, 0.4

* Table of light use efficiency (-; Y-value) as a function of
* temperature (oC; X value):
EFFTB  =   0.,0.54,
          10.,0.54,
          25.,0.54,
          40.,0.36,
          60.,0.24

* Table of effect of temperature on AMAX (-; Y-value) as a function of
* temperature (oC; X value):
REDFTT = -10., 0.,
10., 0.,
20., 1.,
37., 1.,
43., 0.,
60., 0.
```

```
* Table of N fraction in leaves on leaf area basis (g N m-2 leaf; Y-value)
* as a function of development stage (-; X value):
NFLVTB = 0.00, 0.54,
         0.16, 0.54,
         0.33, 1.53,
         0.65, 1.22,
         0.79, 1.56,
         1.00, 1.29,
         1.46, 1.37,
         2.02, 0.83,
         2.50, 0.83

*!* Leaf nitrogen content corresponding coefficient to AMax (g N/m-2 leaf))
AMAXSLN0 = 22.0

*!* Minimum leaf nitrogen content for that Am (maximum rate CO2 assimilation)
* is 0.0 (g N/m2 leaf)
MINSLN = 0.2

*----------------------------------------------------------------------
* 4. Maintenance parameters
*----------------------------------------------------------------------
* Maintenance respiration coefficient (kg CH2O kg-1 DM d-1) of:
MAINLV = 0.02   ! Leaves
MAINST = 0.015  ! Stems
MAINSO = 0.003  ! Storage organs (panicles)
MAINRT = 0.01   ! Roots

TREF   = 25.    ! Reference temperature (oC)
Q10    = 2.     ! Factor accounting for increase in maintenance
                ! respiration with a 10 oC rise in temperature (-)

*----------------------------------------------------------------------
* 5. Growth respiration parameters
*----------------------------------------------------------------------
* Carbohydrate requirement for dry matter production (kg CH2O kg-1 DM leaf)of:
CRGLV  = 1.326  ! Leaves
CRGST  = 1.326  ! Stems
CRGSO  = 1.462  ! Storage organs (panicles)
CRGRT  = 1.326  ! Roots
CRGSTR = 1.11   ! Stem reserves

LRSTR  = 0.947  ! Fraction of allocated stem reserves that is
                ! available for growth (-)

*----------------------------------------------------------------------
* 6. Growth parameters
*----------------------------------------------------------------------
FSTR   = 0.20      ! Fraction of carbohydrates allocated to stems that
                   ! is stored as reserves (-)
TCLSTR = 10.       ! Time coefficient for loss of stem reserves (1 d-1)
SPGF   = 64900.    ! Spikelet growth factor (no kg-1)
WGRMX  = 0.0000249 ! Maximum individual grain weight (kg grain-1)

* Partitioning tables
* Table of fraction total dry matter partitioned to the shoot (-; Y-value)
```

```
* as a function of development stage (-; X value):
FSHTB  = 0.00,  0.50,
         0.43,  0.75,
         1.00,  1.00,
         2.50,  1.00

* Table of fraction shoot dry matter partitioned to the leaves (-; Y-value)
* as a function of development stage (-; X value):
FLVTB  = 0.000, 0.60,
         0.500, 0.60,
         0.750, 0.30,
         1.000, 0.00,
         1.200, 0.00,
         2.5  , 0.

* Table of fraction shoot dry matter partitioned to the stems (-; Y-value)
* as a function of development stage (-; X value):
FSTTB  = 0.000, 0.40,
         0.500, 0.40,
         0.750, 0.60,
         1.000, 0.10,
         1.200, 0.00,
         2.5  , 0.

* Table of fraction shoot dry matter partitioned to the panicles (-; Y-value)
* as a function of development stage (-; X value):
FSOTB  = 0.000, 0.000,
         0.500, 0.000,
         0.750, 0.100,
         1.000, 0.900,
         1.200, 1.000,
2.5  , 1.

* Table of leaf death coefficient (d-1; Y-value) as a function of development
* stage (-; X value):
DRLVT  = 0.00, 0.000,
         0.60, 0.000,
         1.00, 0.015,
         1.60, 0.025,
         2.10, 0.050,
         2.50, 0.050

*----------------------------------------------------------------------
* 7. Carbon balance parameters
*----------------------------------------------------------------------
* Mass fraction carbon (kg C kg-1 DM) in the:
FCLV   = 0.419  ! Leaves
FCST   = 0.431  ! Stems
FCSO   = 0.487  ! Storage organs (panicles)
FCRT   = 0.431  ! Roots
FCSTR  = 0.444  ! Stem reserves

*----------------------------------------------------------------------
* 8. Root parameters
*----------------------------------------------------------------------
GZRT   = 0.01   ! Growth rate of roots (m d-1)
ZRTMCW = 0.25   ! Maximum depth of roots if no drought stress (m)
```

```
ZRTMCD = 0.40   ! Maximum depth of roots if drought (m)

*ADDITONAL INFORMATION since V2.13 - JUNE 2009
*SROOTL = 90.0  ! Special root length cm/g DM
RMINT  = 5.0    ! Minimum temperature for root growth
ROPTT  = 25.0   ! Optimum temperature of root growth
RTBS   = 2.0    ! Minimum temperature for root to survive
RCNL   = 0.012  ! Lowest root nitrogen content (residue root N content,
                ! kg N kg-1 ROOT DM)
SODT   = 0.9    ! The tolerance index of oxygen deficiency

*----------------------------------------------------------------------
* 9. Temperature and drought stress parameters
*----------------------------------------------------------------------
COLDMIN = 12.    ! Lower air temperature threshold for growth (oC)
COLDEAD = 3.     ! Consecutive number of days below COLDMIN that crop dies (-)
COLDREP = 21.    !* The threshold temperature for cold caused sterility (oC)
CTSTER = 36.5    !* The threshold temperature for heat caused sterility (oC)

* Upper and lower limits for drought stress effects
ULLS =   74.13    ! Upper limit leaf rolling (kPa)
LLLS =  794.33    ! Lower limit leaf rolling (kPa)
ULDL =  630.95    ! Upper limit death of leaves (kPa)
LLDL = 1584.89    ! Lower limit death of leaves (kPa)
ULLE = 1.45       ! Upper limit leaf expansion (kPa)
LLLE = 1404.      ! Lower limit leaf expansion (kPa)

* Switch to use ULTR and LLTR as given above or function built in ORYZA
* for the reduction in relative transpiration:
* SWIRTR = 1, Use ULRT AND LLRT for transpiration; SWIRTR = 2, Use SWIRTRF
* for transpiration; SWIRTR = 3, Use FSWTD for transpiration
SWIRTR = 3 ! Use function

* Give value of ULRT and LLRT for SWIRTR = 1
ULRT =   74.13    ! Upper limit relative transpiration reduction (kPa)
LLRT = 1584.89    ! Lower limit relative transpiration reduction (kPa)

* Give value for SWIRTRF if SWIRTR= 2, default value SWIRTRF=0.003297
SWIRTRF = 0.020597

* Give value for FSWTD if SWIRTR= 3, default value SWIRTRF=0.003297
* The upper limit factor while transpiration declines which is the ratio of
* remaining available water to total water supply capability
FSWTD = 0.40

*----------------------------------------------------------------------
* 10. Nitrogen parameters
*----------------------------------------------------------------------
NMAXUP  = 8.      ! Maximum daily N uptake (kg N ha-1 d-1)
RFNLV   = 0.004   ! Residual N fraction of leaves (kg N kg-1 leaves)
FNTRT   = 0.15    ! Fraction N translocation from roots, as (additional)
                  ! fraction of total N translocation from stems and leaves
                  ! (-)
RFNST   = 0.0015  ! Residual N fraction of stems (kg N kg-1 stems)
TCNTRF  = 10.     ! Time coefficient for N translocation to grains (d)
NFLVI   = 0.5     ! Initial leaf N fraction (on area basis: g N m-2 leaf)
FNLVI   = 0.025   ! Initial leaf N fraction (on weight basis: kg N kg-1 leaf)
```

```
NDSENS = 0.95     !* Nitrogen deficiency sensitivity, 0.5=fair as default,
                  !* >0.5 tolerance, <0.5 sensitive, Value range 0.0 to 1.0
NMAXSO  = 0.0175  ! Maximum N concentration in storage organs (kg N kg-1)

* Table of minimum N concentration in storage organs (kg N kg-1 DM; Y value)
* as a function of the amount of N in the crop till flowering (kg N ha-1; X
* value):
NMINSOT =  0., .006,
          50., .0008,
         150., .0125,
        250., .015,
        400., .017,
       1000., .017

* Table of maximum leaf N fraction on weight basis (kg N kg-1 leaves; Y value)
* as a function of development stage (-; X value):
NMAXLT = 0.0, .053,
         0.4, .053,
        0.75, .040,
         1.0, .028,
         2.0, .022,
         2.5, .015

* Table of minimum leaf N fraction on weight basis (kg N kg-1 leaves; Y value)
* as a function of development stage (-; X value):
NMINLT = 0.0, 0.025,
         1.0, 0.012,
         2.1, 0.007,
         2.5, 0.007

*--- Table of effect of N stress on leaf death rate (-; Y value)
* as a function of N stress level (-; X value):
NSLLVT = 0.,  1.0,
        1.1, 1.0,
        1.5, 1.4,
        2.0, 1.5,
        2.5, 1.5
```

D. INPUT FILE FOR SOIL HYDRAULIC PROPERTIES

```
9,1,0         ! Layers,whether use compact factor (YES=1,NO=0), whether calculate EC (YES=1.0, NO=0)
0.35,2*0.38,3*0.40,0.42,0.46,0.46           ! soil clay contents, fraction
0.42,0.46,0.40,2*0.46,0.22,0.18,0.12,0.12   !Sand contents, fraction
0.0089,0.00735,4*0.0015,3*0.001     !ORGANIC MATTER CONTENT (fraction)
3*1.0,6*0.0             !TOP SOIL (=1.0) OR NON TOP SOIL (=0.0)
0.90,1.0,1.1,1.05,5*1.0 !Compact factor, Padduled soil or new tilled soil <1.0,
                        ! normal soil=1.0, compacted soil >1.0
```

E. SOIL FILE

```
**********************************************************************
* Template soil data file for PADDY soil water balance model.        *
* File name    : PADDYIN.DAT                                         *
* Soil         : IRRI lowland farm, Los Banos, Philippines           *
*                 (Isohyperthermic Typic Hapludalf)                  *
* Experiment   : Drought stress and well-watered control experiment. *
*                Data was given by Dr. Tao Li with file name:        *
*                     "root growth simulation 2010DS" at             *
*                     E:\oryza 2000_DATA\Data\root growth.           *
*                     ORYZA2000. IRRI, Los Banos.                    *
**********************************************************************

* Give code name of soil data file to match the water balance PADDY:
SCODE = 'PADDY'

*----------------------------------------------------------------*
* 1. Various soil and management parameters
*----------------------------------------------------------------*
WL0MX = 100.  ! Bund height (mm)
NL = 7        ! Number of soil layers (maximum is 10) (-)
TKL = 0.1,0.1,0.1,0.2,0.2,0.3,0.3      ! Thickness of each soil layer (m)
ZRTMS = 1.0   ! Maximum rooting depth in the soil (m)

*----------------------------------------------------------------*
* 2. Puddling switch: 1=PUDDLED or 0=NON PUDDLED
*----------------------------------------------------------------*
SWITPD = 0  !Non puddled
*SWITPD = 1  ! Puddled

* If PUDDLED, supply parameters for puddled soil
NLPUD = 3 ! Number of puddled soil layers, including the plow sole (-)
! (NLPUD cannot exceed the total number of soil layers NL)

* Saturated volumetric water content of ripened (previously puddled)
* soil (m3 m-3), for each soil layer:
*WCSTRP = 3*0.52, 3*0.55, 3*0.61, 0.64
WCSTRP = 0.51779,0.51779,0.52601,0.44934,0.51259,0.49898,0.47412

* Soil water tension of puddled soil layer at which cracks reach
* break through the plow sole (pF):
PFCR = 6.0

DPLOWPAN = 0.3   !* The depth of plow pan (m); if it does not appear, it is:
                 !* if SWITPN = 1, DPLOWPAN = sum(TKL(1:NPLUD))
                 !* if SWITPN = 0, DPLOWPAN = sum(TKL(1:NL))
*----------------------------------------------------------------*
* 3. Groundwater switch: 0=DEEP (i.e., not in profile), 1=DATA
* (supplied), 2=CALCULATE
*----------------------------------------------------------------*
*SWITGW = 0 ! Deep groundwater
*SWITGW = 2 ! Calculate groundwater
SWITGW = 1 ! Groundwater data
```

```
* If DATA, supply table of groundwater table depth (cm; Y-value)
* as function of calendar day (d; X value):
ZWTB =   1.,200.,
       366.,200.

* If CALCULATE, supply the following parameters:
ZWTBI = 100. ! Initial groundwater table depth (cm)
MINGW = 100. ! Minimum groundwater table depth (cm)
MAXGW = 100. ! Maximum groundwater table depth (cm)
ZWA   = 1.0  ! Receding rate of groundwater with no recharge (cm d-1)
ZWB   = 0.5  ! Sensitivity factor of groundwater recharge (-)

*---------------------------------------------------------------*
* 4. Percolation switch
* Value for SWITVP cannot be 1 (CALCULATE) for non-puddled soil
*---------------------------------------------------------------*
SWITVP = -1 ! Fixed percolation rate
*SWITVP = 0 ! Percolation as function of the groundwater depth
*SWITVP = 1 ! Calculate percolation
*SWITVP = 2 ! Fixed percolation rate as function of time

* If SWITVP = -1, supply fixed percolation rate (mm d-1):
FIXPERC = 0.0

* If SWITVP = 0, supply table of percolation rate (mm d-1; Y-value)
* as function of water table depth (cm; X value):
*PERTB =   0., 3.,
*        200., 3.

* If SWITVP = 2, give percolation rate (mm/d) as function of calendar day
PTABLE =
  1., 1.0,   !First number is calendar day, second is percolation rate)
 50., 1.0,
100.,20.0,
366.,20.0

*---------------------------------------------------------------*
* 5. Conductivity switch: 0=NO DATA, 1=VAN GENUCHTEN or 2=POWER
*  OR 3= SPAW  function used
*---------------------------------------------------------------*
*SWITKH = 0 ! No data
*SWITKH = 2 ! Power
SWITKH  = 1 ! van Genuchten
*SWITKH = 11 ! Spaw function

*---------------------------------------------------------------*
* 6. Water retention switch: 0=DATA; 1=VAN GENUCHTEN. When DATA, data
* have to be supplied for saturation, field capacity,
* wilting point and at air dryness
*---------------------------------------------------------------*
*SWITPF = 0 ! Data
SWITPF  = 1 ! vanGenuchten
*SWITPF = 11 ! SPAW FUNCTION

*---------------------------------------------------------------*
* 7. Soil physical properties, these parameters will be used when model
* runs under actual water or nitrogen condition, or even both. Otherwise
```

```
* these parameters will not be used.
*----------------------------------------------------------------*
CLAYX = 4*0.55,0.53,0.5,0.45      !soil clay content, fraction
SANDX = 4*0.08,0.1,0.13,0.18      !soil sand content, fraction
BD = 3*1.17,1.42,1.26,1.31,1.37   !Soil bulk density (g/cm3)

SOC = 2*11831.64,8044.87,4529.56,2632.66,673.66,80.62 !soil organic C content (kg C/ha)
SON = 2*829.48,186.57,167.488,82.48,51.63,6.41 !Soil organic N content (kg N/ha)

SNH4X = 2*4.97,3.77,3.13,1.62,0.50,0.05       !* soil ammonium content (kg N/ha)
SNO3X = 2*2.49,0.628,0.52,0.27,0.083,0.0088   !*soil natre content (kg N/ha)

*FORGANC =200.0,1000.0, 5*0.0   !* Fresh organic carbon (kg C/ha)
*FORGANN = 10.0,100.0,5*0.0     !* Fresh organic nitrogen (kg N/ha)
*FCARBONH = 0.54                !*Fraction of carbonhydrate in fresh organic matter (--)
*FCELLULO = 0.38                !*Fraction of cellulose in fresh organic matter (--)
*----------------------------------------------------------------*
* 8. Soil hydrological properties. Required type of data input
* according to setting of conductivity and water retention switch
*----------------------------------------------------------------*
* Saturated hydraulic conductivity, for each soil layer
* (cm d-1) (always required!):
*KST = 2*255.850266, 297.858490, 114.549477, 0.789587, 1.244055, 2*74.991531
KST  =  161.57672,  161.57672,  224.75884,  22.81329,  71.78426,  51.08835,
0.18755  !):

* Saturated volumetric water content, for each soil layer
* (m3 m-3)(always required!):
*WCST = 2*0.533142, 0.542527, 0.491697, 0.339206, 0.429186, 2*0.481078
WCST = 0.51779,0.51779,0.52601,0.44934,0.51259,0.49898,0.47412 !):

* Van Genuchten parameters, for each soil layer
* (needed if SWITKH = 1 and/or SWITPF = 1):
VGA = 2*0.0196,0.0177,0.0147,0.0145,0.0189,0.558        !* a parameter (cm-1)
VGL = -1.945,-1.945,-1.836,-3.773,-1.646,-0.564,1.268   !* l parameter (-)
VGN = 2*1.104,1.120,1.062,1.0965,1.097,1.026            !* n parameter (-)
VGR = 7*0.01                                           ! Residual soil water content (-)

* Power function parameters, for each soil layer (-)
* (needed if SWITKH = 2):
*PN = 3*-2.5, 3*-2.5, 2*-2.5, -2.5

*!* Volumetric water content at field capacity, for each soil layer
*!* (m3 m-3)(needed if SWITPF = 0):
*WCFC = 2*0.439149, 0.448714, 0.407265, 0.274259, 0.352447, 2*0.396666

*!* Volumetric water content at wilting point, for each soil layer
*!* (m3 m-3) (needed if SWITPF = 0):
*WCWP = 2*0.262450, 0.278898, 0.254430, 0.156693, 0.207871, 2*0.237632

*!* Volumetric water content at air dryness, for each soil layer
*!* (m3 m-3) (needed if SWITPF = 0):
*WCAD = 2*0.109187, 0.124051, 0.114157, 0.060378, 0.084557, 2*0.099269
*----------------------------------------------------------------*
* 9. Initialization conditions, and re-initialization
*----------------------------------------------------------------*
WL0I = 10.   ! Initial ponded water depth at start of simulation (mm)
```

```
* Initial volumetric water content at the start of simulation,
* for each soil layer (m3 m-3):  USE ALWAYS FIELD CAPACITY, OR 0.5 TIMES WCST
WCLI = 2*0.51,0.52,0.44,0.51,0.49,0.47 !Initial ponded water depth at start of simulation (mm)

* Initial ponded water depth and water contents may be reset:
* Ponded water depth: at minimum of WL0I and WL0MX
* Water contents in all soil layers: at saturation value
* For direct-seeded rice, this happens at sowing, for transplanted
* rice, this happens at transplanting
* Re-initialize switch RIWCLI is YES or NO
RIWCLI = 'NO'
*RIWCLI = 'YES'

*----------------------------------------------------------------*
* 10. Initialization of soil thermal conditions
*----------------------------------------------------------------*
SATAV = 18.0       ! Soil annual average temperature of the first layers
SOILT = 22.0, 17.0, 16.0, 15.0, 14.0, 2*15.0
!Initial soil temperature in each layer
!Have to provide above either one or two of above parameter, otherwise,
!model start the calculation of soil temperature at 0 degree

*----------------------------------------------------------------*
* 11. Observations/measurements
*    Switches to force observed water content in water balance
*----------------------------------------------------------------*
*!* WCL1_OBS, WCL2_OBS,...WCL10_OBS: Observed soil water contents
*!* in layer 1, 2, ..., 10. Format: year, day number, water content
*!* Not obligatory to give data

*WCL1_OBS =
* TO BE FILLED-IN (OPTIONAL)

*!* Parameter to set forcing of observed water content yes (2) or no (0)
*!* during simulation (instead of using simulated values)
*WCL1_FRC = 0 ! No forcing
*WCL1_FRC = 2 ! Forcing

* Table for interpolation of water content between soil layers for
* those layers for which no observations were made: first number is
* the soil layer for which interpolation needs to be done, the second
* is the number of the underlying soil layer, the third is the number
* of the overlying soil layer. No interpolation is performed when all
* three numbers are the same:
WCLINT = 1,1,1,
         2,2,2,
         3,3,3,
         4,4,4,
         5,5,5,
         6,6,6,
         7,7,7

*!* MSKPA1_OBS, MSKPA2_OBS,...MSKPA10_OBS: Observed soil water contents
*!* in layer 1, 2, ..., 10. Format: year, day number, water content
*!* Not obligatory to give data
```

```
*MSKPA1_OBS =
* TO BE FILLED-IN (OPTIONAL)

****Any additional variable will be added after this line****
```

F. WEATHER FILE

```
*-----------------------------------------------------------
*  Station Name:
*  Author       : Climate Unit, IRRI    -99.: nil value
*  Source       :
*  Comments     : This file is extracted from CLICOM database.
*  Longitude    :         Latitude:      Altitude:
*
*  Column    Daily Value
*     1      Station number
*     2      Year
*     3      Day
*     4      irradiance         KJ m-2 d-1
*     5      min temperature            oC
*     6      max temperature            oC
*     7      vapor pressure            kPa
*     8      mean wind speed         m s-1
*     9      precipitation          mm d-1
*-----------------------------------------------------------
121.25, 14.18, 21.00,0.000,0.000
    1,1992,  1, 16379.00, 21.60, 29.00,  2.38,  1.90,  0.00
    1,1992,  2, 15911.00, 22.20, 29.20,  2.51,  2.30,  0.00
    1,1992,  3, 16631.00, 21.50, 29.00,  2.50,  2.50,  0.00
    1,1992,  4, 18251.00, 22.10, 29.00,  2.52,  2.40,  0.00
    1,1992,  5, 11519.00, 21.60, 29.00,  2.61,  1.10,  0.90
    1,1992,  6, 15119.00, 19.90, 29.40,  2.59,  1.40,  0.40
    1,1992,  7, 10475.00, 21.20, 28.00,  2.72,  1.20,  2.20
    1,1992,  8, 16739.00, 22.00, 30.00,  2.62,  1.10,  0.00
    1,1992,  9, 18862.00, 20.60, 29.50,  2.51,  1.70,  0.00
    1,1992, 10, 12095.00, 21.90, 28.20,  2.58,  2.40,  1.10
    :  :     :      :       :      :      :      :      :
    :  :     :      :       :      :      :      :      :
    :  :     :      :       :      :      :      :      :
    1,1992,360, 19330.00, 21.20, 28.60,  2.47,  3.00,  0.40
    1,1992,361, 14759.00, 22.00, 29.00,  2.53,  2.20,  6.00
    1,1992,362,  9683.00, 22.70, 27.00,  2.72,  1.70,  0.80
    1,1992,363,  9323.00, 23.50, 28.20,  2.80,  1.20,  0.00
    1,1992,364, 17531.00, 22.90, 29.60,  2.67,  1.70,  0.40
    1,1992,365, 21994.00, 20.70, 30.00,  2.57,  2.20,  0.00
    1,1992,366, 23650.00, 20.50, 29.50,  2.51,  1.70,  0.00
```

G. RERUN FILE

```
*---------------------------------------------------------*
* Sample rerun file for ORYZA V3 rice growth model        *
* File name   : reruns.rer                                *
*---------------------------------------------------------*
*-- Rerun set 1
*IYEAR = 1993
*EMYR = 1993

*-- Rerun set 2
*IYEAR = 1994
*EMYR = 1994
```

H. PARAMETERIZATION CONTROL FILE

```
*PARAMFILE = E:\input\PARAM.in
strun = 1
*endrun = 72
*---------------------------------------------------------------------*
* control file for ORYZA model AUTOCOLIBRATION                *
*---------------------------------------------------------------------*
FILEOP = 'E:\input\PARAM.OUT'
FILEOR = 'E:\input\DRATE.OUT'
FILEOL = 'E:\input\MODEL.LOG'
FILEIR = 'E:\input\Rerunscal.rer'
FILEIT = 'E:\input\CF.exp'
FILEI1 = 'E:\input\standard.CRP'
PRDEL  = 1.
IPFORM = 5
COPINF = 'N'
DELTMP = 'N'
IFLAG  = 1100
```

I. CALIBRATION CONTROL FILE

```
* CALIBRIN.DAT                                                        *
* THE CONTROL FILE FOR AUTOMATIC CALIBRATION                          *
* USE with ORYZA (version 3.0 AND 4.0)                                *
* Date: Jan 2012                                                      *
*                                                                     *
* DEVELOPED BY DR. TAO LI                                             *
*---------------------------------------------------------------------*
*---------------------------------------------------------------------
*1. Input files
*---------------------------------------------------------------------
FILEON = 'E:\input\RES.DAT'
FILEOL = 'E:\input\MODEL.LOG'
FILEIR = 'E:\input\Reruns.DAT'        ! Real experiment rerun
FILEIT = 'E:\input\experiment.exp'    ! Experimental data file
FILEI1 = 'E:\input\HD297.CRP'         ! Crop data file
FILEI2 = 'E:\input\thesoil.sol'       ! Soil data (PADDY model)

*---------------------------------------------------------------------*
*2. CALIBRATION PARAMETER CONTROLS
*---------------------------------------------------------------------*
RERUNS   = 1000    ! HOW MANY RERUN WILL BE MADE
INRERUNS = 0  !7   ! THE MULTIPLE ENVIRONMENTS
```

```
USEREFER = 'YES'   ! Whether the calibration conducted from referenced crop
                   ! and/or soil file, default is 'YES' if
                   ! this variable did not appear or set as 'YES',

OUTFOLDER = 'E:\output\'     !THE PLACE FOR CALIBRATION OUTPUTS
OUTCROP = 'HD297_C.crp'
OUTSOIL = 'C_Soil.sol'
ORYZA = 'E:\ModelPrograms\AutoCalibration\ORYZA3.exe'

*------------------------------------------------------------------------
*3. CROP PARAMETERS WITH SINGLE VALUES FOR CALIBRATION
*------------------------------------------------------------------------
*!* THE NAMES OF CROP PARAMETERS WITH SINGLE VALUE
CROPSVN = 'FNTRT','FSTR','RGRLMX','RGRLMN','SLAMAX','ASLA','BSLA','DSLA'

*!* Use change fraction based one the value of reference genotype
CROPSVR = 0.25,0.25,0.25,0.25,0.25,0.25,0.25,0.25

*!* THE MAXIMUM VALUES OFEACH CROP 'CROPSVN' if CHANGE RANGE WAS NOT PROVIDED
CROPSVMA = 0.05, 0.02, 0.04, 0.005,0.5,0.5,0.5,0.5

*!* THE MINIMUM VALUES OF EACH CROP 'CROPSVN'
CROPSVMI = 0.75, 0.5, 0.10, 0.35,0.5,0.5,0.5,0.5

*-------------------------------------------------------------------------
*Optional: If parameters for phenology is listed in the single value
*parameters, calibration for phenology is activated
*------------------------------------------------------------------------
* In this case, you can consider to give data for 'GDURAT', and give critical
* value for 'DVS' if 'DVS_OBS' is given in experiment file.
*-------------------------------------------------------------------------

*-------------------------------------------------------------------------
*4. CROP PARAMETERS WITH TABLE VALUES FOR CALIBRATION
*-------------------------------------------------------------------------
*!* THE NAME OF CROP PARAMETERS WITH TABLE VALUES
CROPTVN = 'FSHTB','FSOTB','FLVTB','FSTTB','DRLVT' !, 'SLATB'

*!* Use change fraction based one the value of reference genotype
CROPTVR = 0.25,0.25,0.25,0.25,0.25 !,0.25

* The maximum and minimum values provided if range is not available
*CROPTVMA = 0.5,0.5,0.5,0.5,0.5 !,0.5   !*THE MAXIMUM VALUES OF PARAMETERS
*CROPTVMI = 0.5,0.5,0.5,0.5,0.5 !,0.5   !* THE MINIMUM VALUES OF PARAMETERS

*The growth stage effective for parameter change
CROPTXMI = 0.0,0.65,0.0,0.0,0.65 !,0.0  !* THE MINIMUM VALUES
CROPTXMA = 1.0,2.5,1.2,2.5,2.5 !,2.5    !* THE MAXIMUM VALUES OF X

*-----------------------------------------------------------------------
*5. SOIL PARAMETERS WITH SINGLE VALUES FOR CALIBRATION
*-----------------------------------------------------------------------
*SOILSVN =  'FIXPERC'   !* THE NAMES OF SOIL PARAMETERS WITH SINGLE VALUES
*SOILSVR =  0.99  !* Use change fraction based on the value of reference soil
*SOILSVMA = 0.90  !* THE MAXIMUM VALUES OF SOIL PARMETERS WITH SINGLE VALUES
*SOILSVMI = 0.90  !* THE MINIMUM VALUES OF SOIL PARMETERS WITH SINGLE VALUES
```

```
*----------------------------------------------------------------------
*6. SOIL PARAMETERS WITH MULTIPLE VALUES FOR CALIBRATION
*----------------------------------------------------------------------
*SOILMVN = 'KST','VGA','VGL'   !* THE NAMES OF SOIL PARAMETERS WITH MULTIPLE
VALUES
*SOILMVR = 0.45,0.75,0.90 !* Use change fraction based on the value of
reference soil
*SOILMVMA = 0.9,0.5,0.5   !* THE MAXIMUM VALUES OF PARAMETER
*SOILMVMI = 0.9,0.5,0.5   !* THE MINIMUM VALUES RANGES OF PARAMETER

*---------------------------------------------------------------------------
*7. GIVE CRITICAL METHODS: 1 FOR RMSEn; 2 FOR MODELING EFFICIENCY.
*   NORMALLY, IF THE MINIMUM OBERSERVATION NUMBERIS LESS THAN 4, USE
*   METHODS 1, OTHERWISE USE 2; CRITICAL VALUE SHOULD BE CORREPOND
*   TO METHODS, DEFAULT IS 2
*---------------------------------------------------------------------------
* FOR METHODS =1, THE CRITICAL VALUE FOR THE BEST IS APPROXIMATE TO 0.0
* FOR METHODS = 2, THE CRITICAL VALUE FOR THE BEST IS APPROXIMATE TO 1.0
CMETHODS = 1

*--------------------------------------------------------------------------
*8. GIVE CRITICAL VALUE FOR ALL OBSERVERED VARIABLES, WHICH ARE USED
*   TO CRITICTHE CALIBRATIONIF THE CRITIC VALUE WAS NOT GIVEN,
*   THEN PROGRAM TREATS 300% DIFFERENCE IS ACCEPTABLE FOR THIS VARIABLE
CRITVARS = 'WSO','WAGT','WLVG','WLVD','WST','LAI','NFLV','MSKPA3'
CRITVALU = 0.10,0.15,0.20,0.25,0.20,0.15,0.30,0.80

*----------------------------------------------------------------------------
* Optional: If growth duration is used for the phenology calibration,
*  each number for one experiment, total number of the data should be
*  the same INRERUNS. It must be commented out if it won't be
*  used in calibration.
*----------------------------------------------------------------------------
*GDURAT =114.,117.0,121.,109. !* SOIL HYDRAULIC PARAMETERS INPUT FILE
```

Appendix 7. DATES AND DAYNUMBER

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Date	*Daynumber*											
1	1	32	60	91	121	152	182	213	244	274	305	335
2	2	33	61	92	122	153	183	214	245	275	306	336
3	3	34	62	93	123	154	184	215	246	276	307	337
4	4	35	63	94	124	155	185	216	247	277	308	338
5	5	36	64	95	125	156	186	217	248	278	309	339
6	6	37	65	96	126	157	187	218	249	279	310	340
7	7	38	66	97	127	158	188	219	250	280	311	341
8	8	39	67	98	128	159	189	220	251	281	312	342
9	9	40	68	99	129	160	190	221	252	282	313	343
10	10	41	69	100	130	161	191	222	253	283	314	344
11	11	42	70	101	131	162	192	223	254	284	315	345
12	12	43	71	102	132	163	193	224	255	285	316	346
13	13	44	72	103	133	164	194	225	256	286	317	347
14	14	45	73	104	134	165	195	226	257	287	318	348
15	15	46	74	105	135	166	196	227	258	288	319	349
16	16	47	75	106	136	167	197	228	259	289	320	350
17	17	48	76	107	137	168	198	229	260	290	321	351
18	18	49	77	108	138	169	199	230	261	291	322	352
19	19	50	78	109	139	170	200	231	262	292	323	353
20	20	51	79	110	140	171	201	232	263	293	324	354
21	21	52	80	111	141	172	202	233	264	294	325	355
22	22	53	81	112	142	173	203	234	265	295	326	356
23	23	54	82	113	143	174	204	235	266	296	327	357
24	24	55	83	114	144	175	205	236	267	297	328	358
25	25	56	84	115	145	176	206	237	268	298	329	359
26	26	57	85	116	146	177	207	238	269	299	330	360
27	27	58	86	117	147	178	208	239	270	300	331	361
28	28	59	87	118	148	179	209	240	271	301	332	362
29	29		88	119	149	180	210	241	272	302	333	363
30	30		89	120	150	181	211	242	273	303	334	364
31	31		90		151		212	243		304		365

Leap years: 1992, 1996, 2000, 2004, 2008, 2012, 2016, 2020. The *day number* should be *plus one*after February 29for these leap years.