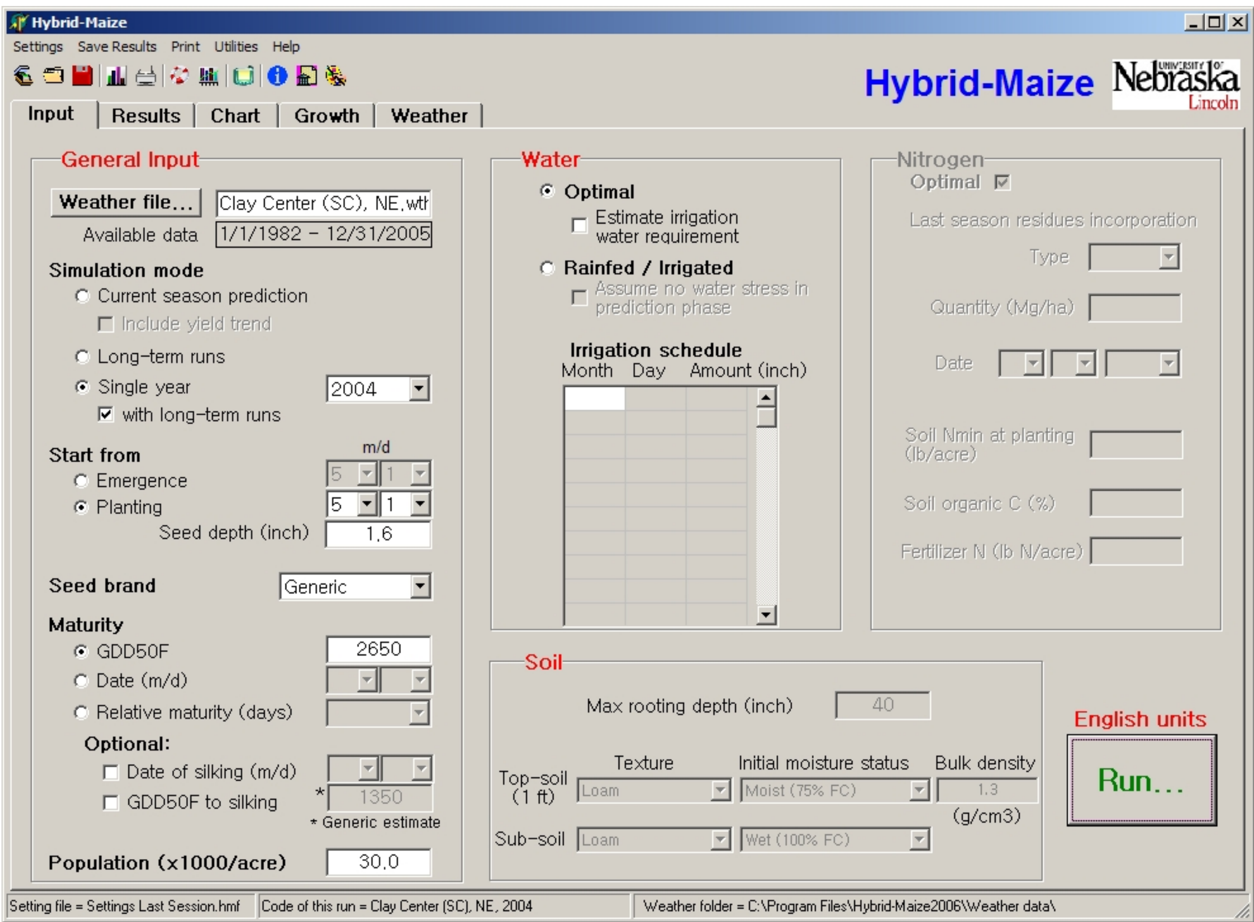
2.3. Model Inputs

All model inputs must be specified by the user on the front page (see sections 2.3.2.-2.3.6.). Inputs are grouped into three panels: **General input** (weather data, simulation mode, planting or emergence date, hybrid choice/maturity, plant population), **Water** (yield potential or water-limited), and **Soil** (soil properties relevant for simulating soil moisture). Default values are provided for many of these parameters. In general, all white boxes require an entry, whereas grayed boxes do not. The simulation will not run until all required input parameters are specified.

NOTE: A fourth panel on ***Nitrogen*** *is displayed on the main page but grayed out. The present version of Hybrid-Maize does not allow simulation of nitrogen dynamics, but this mode is intended to become available in subsequent releases of the model.*

Users may review or change general model options and input parameters required to run the model (see section 2.3.1.). On the main menu bar, click on **Settings** to (i) save and retrieve input settings for specific simulation runs, (ii) retrieve settings of the last session, (iii) review/change general options and default input values, (iv) review/modify model parameters, or (v) erase all current model results.



2.3.1. General Options and Parameter Settings

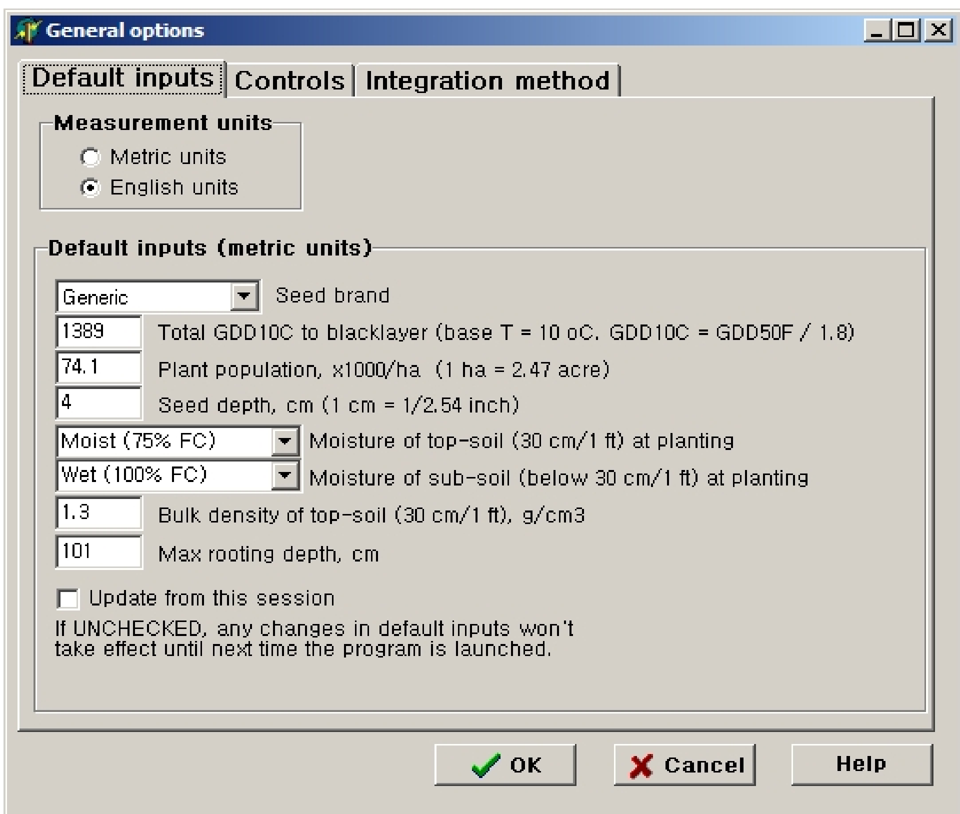
2.3.1.1. Settings – Retrieve / Save Input Settings

All model input settings specified on the front page can be saved to a file and re-used later. This not only saves time, but more importantly, avoids creating any unintended differences in future runs if the user wants to use the same settings when repeating or modifying simulations.

Click '**Settings**' on the menu bar, select **Save input settings**, (shortcut is **Ctrl-S**), or click the icon on the toolbar. Then specify a name for the file and directory. Settings files have the default file extension **.stg**. To retrieve input settings saved in a file, click '**Settings**' on the menu bar, select **Retrieve input settings** (shortcut is **Ctrl-R**), or click the icon on the toolbar. Then select the desired file. To retrieve settings of the last session, click **Settings** on the menu bar, select **Use settings of last session** (shortcut is **Ctrl-L**), or click the icon on the toolbar.

NOTE: The weather file name retrieved from a settings file contains the full file path. It may be necessary to verify the existence of the weather file if the settings are retrieved from a settings file that was saved in another computer or if the weather file has been moved to a different location.

2.3.1.2. Settings -- General Options



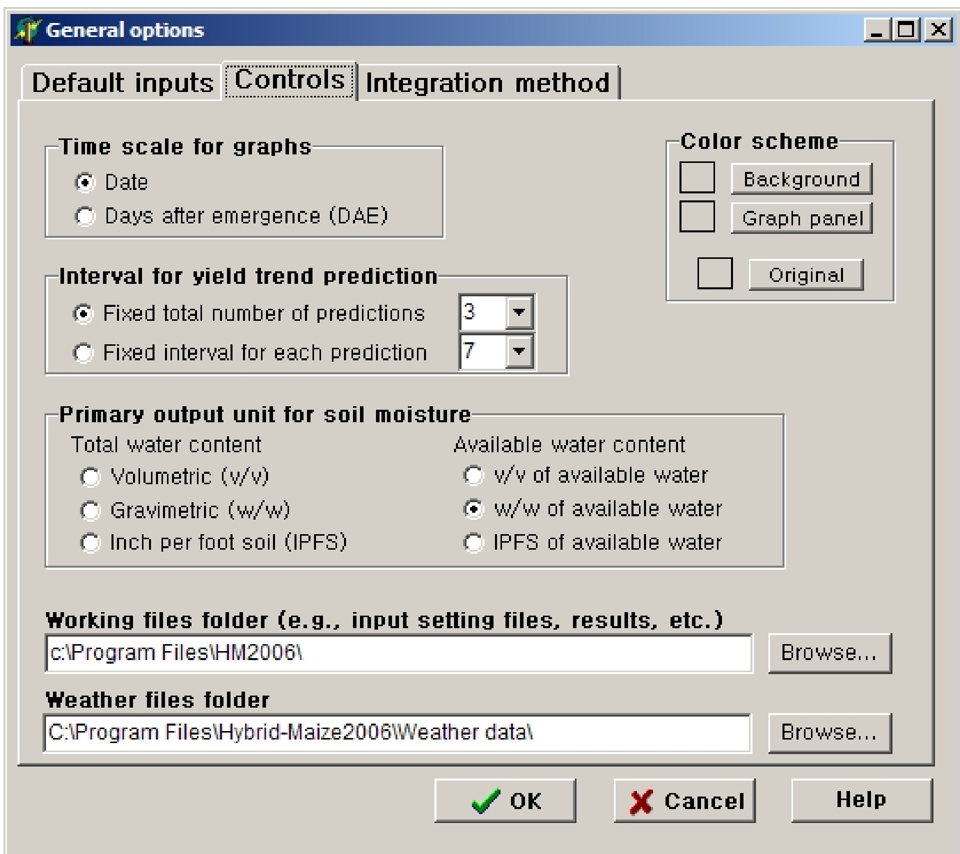
General options are grouped on three pages: Default inputs, Controls, and Integration methods.

Default inputs

Measurement units: Select **Metric** (e.g., final yield and dry matter in Mg/ha, daily dry matter gain in kg/ha, rainfall or ET in mm, temperature in Celsius) or **English** (e.g., final yield in bu/acre, dry matter in short ton/acre, daily dry matter gain in lb/acre, rainfall or ET in inches, temperature in Fahrenheit) as measurement units for your simulations.

Default inputs: The default input values are provided for seed brand, hybrid maturity rating (growing degree days [or GDD] from emergence to physiological maturity), plant density, planting depth, soil moisture status in the top 30 cm and subsoil at planting, topsoil bulk density, and maximum rooting depth. These values are used when Hybrid-Maize is launched and all are expressed in metric units. Instead of changing these default values, users can also save/retrieve their own input settings for specific simulations they perform (see below).

Controls



Default time scale for graphs: Select either **Date** or **Days after emergence** (DAE) as the X-axis time scale for plotting graphs. The two scales can be toggled instantly in any of the graphs.

Interval for yield trend prediction: When running a real-time simulation for **Current season prediction** with the option of **Include yield trend**, either the total number of prediction intervals or the duration of each interval (in days) can be set.

Primary out unit for soil moisture: Select one of the six (in English unit system) or four (in Metric unit system) units for soil moisture content. The unit with inch per foot soil are not available in the Metric unit system. The selected unit is used for numerical results and the default unit for plotting graphs of seasonal soil water dynamics on **Water** page.

Directory of working files: This box allows the user to change the default folder for storing input settings files **(*.stg**) and simulation results.

Directory of weather files: This box allows the user to change the default folder for the weather data used in the simulations.

Color scheme: Users can set colors for the main frame background and for the graph panels. Note that the color for individual graph panels can be set independently by clicking **Settings**, **Set graph panel color** on the main menu, or by clicking the icon  on the toolbar.

Integration method

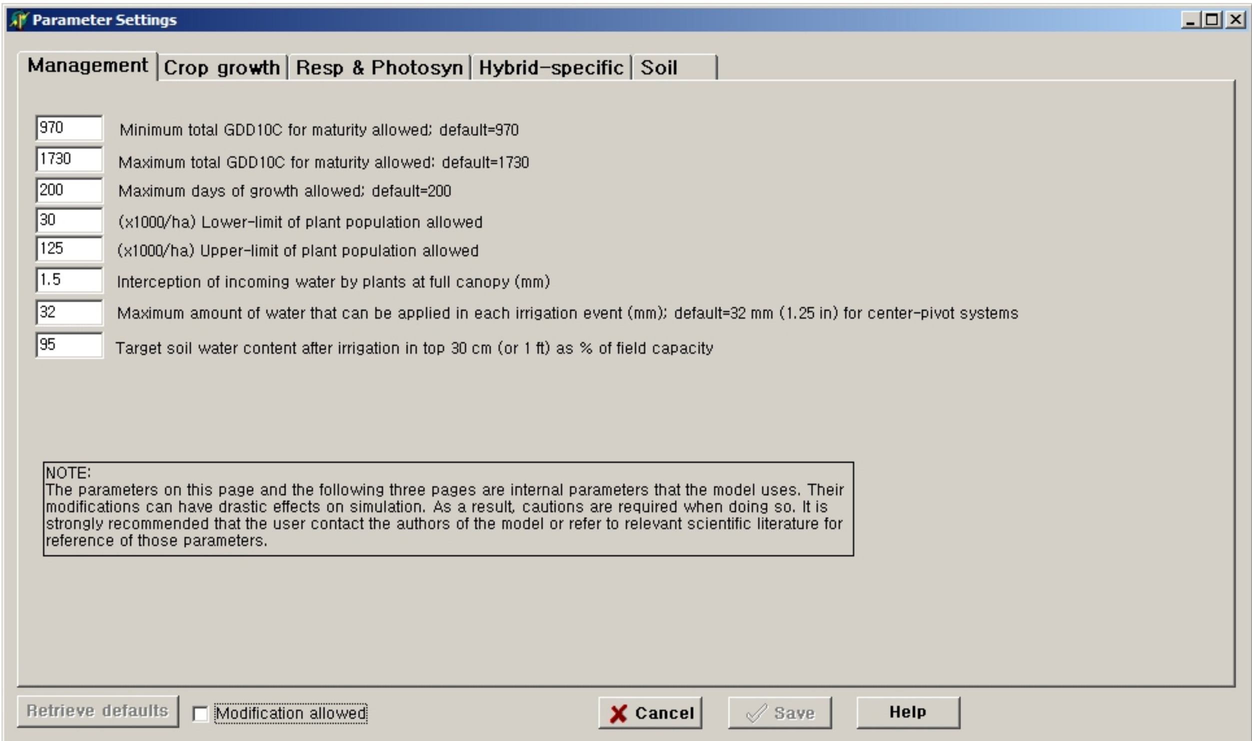
On this page users can select the method of numerical integration for the computation of photosynthesis. The default method is the Three-Point Gaussian method (Goudriaan, 1986), which is recommended because it is fast and accurate. A second option, the Simpson method, is intended for research purposes only, because it is slower and requires the user to specify the relative precision of integration. See section 4.1.2 for an explanation of 'Maximum negligible progressive gain, %'.

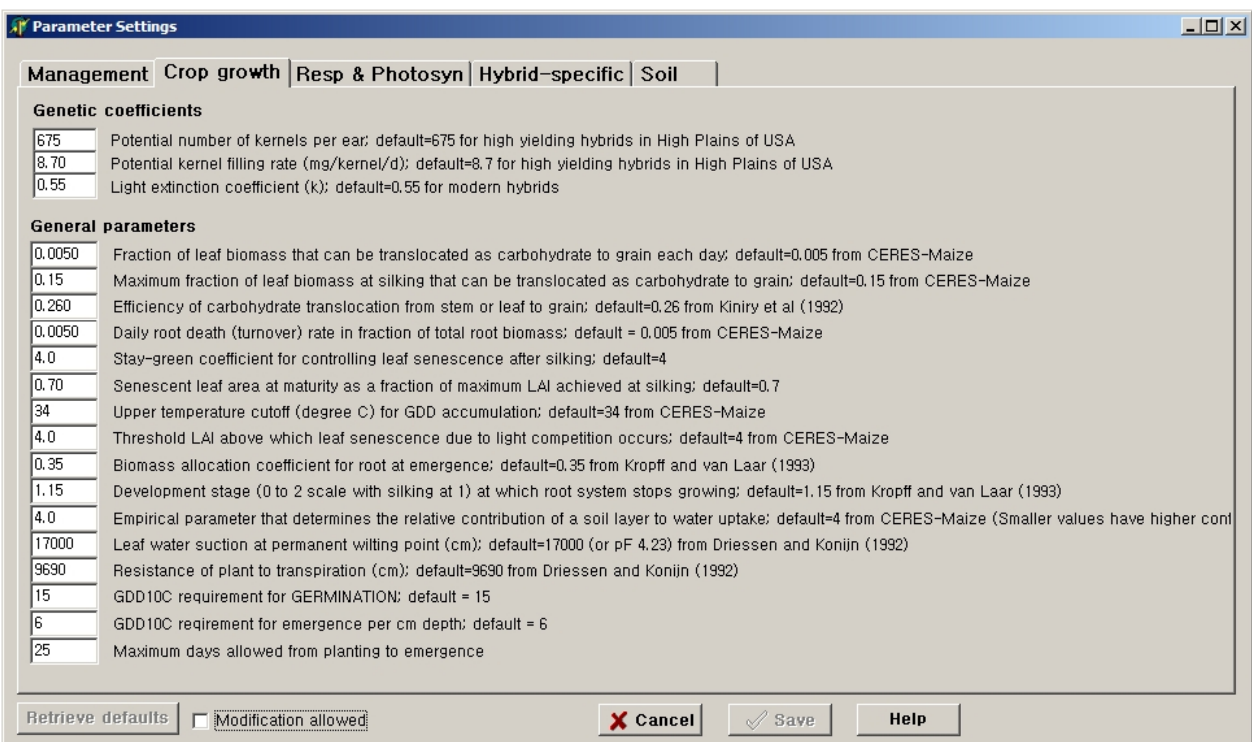
2.3.1.3. Settings --- Parameter Settings

A unique feature of the Hybrid-Maize model is that all important internal model parameters are transparent and accessible to users. However, model parameters should not be modified unless the user understands the scientific basis of these parameters and their function in the model. For most of the internal model parameters, their functions are described in Yang et al. (2004) and in section 4 of this documentation; for the rest, the user should refer to the references given in the program. One reason for modifying model parameters might be for testing the sensitivity of the model to changes in key parameters. Modifying some parameters may also be necessary under special circumstances, e.g., when new experimental data become available or if the model is being used in situations for which it has not been developed or validated. An example of the latter would be simulations with maize hybrids that differ significantly in canopy architecture from the commonly used commercial maize hybrids, for which Hybrid-Maize was developed and validated against.

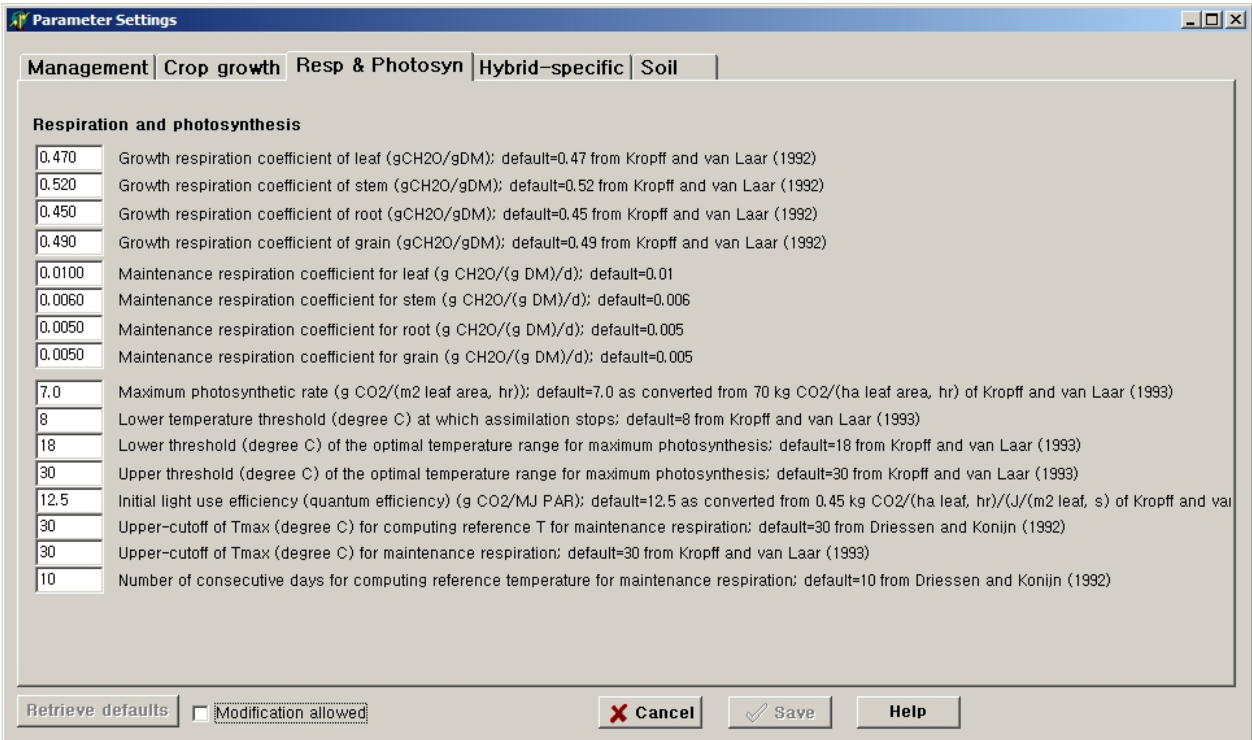
To access the internal model parameters, click **Settings**, then **Parameter settings** on the main menu bar. The parameters are shown in five groups (tabs): **Management**, **Crop growth**, **Resp & Photosyn** (respiration and photosynthesis), **Hybrid-specific**, and **Soil**. Each parameter has a brief explanation, and most of them also have default values. To change parameter values, check the option **Modification allowed** at the bottom of the page, which allows the user to modify specific parameter values. When saving the new parameters, the old ones are also saved automatically into the file **Parameter, old.hmf** and **Parameter-2, old.hmf** in the program folder (note that only one version of the old parameter files are kept at any time). If the user wants to restore all the parameters to their original default values, click the button **Retrieve defaults** (if the button is still grayed, make sure the option **Modification allowed** is checked).

Management: These parameters provide various constraints to the simulations in order to avoid unrealistic results or to limit the range of model applications to those situations for which experimental validation has been conducted.



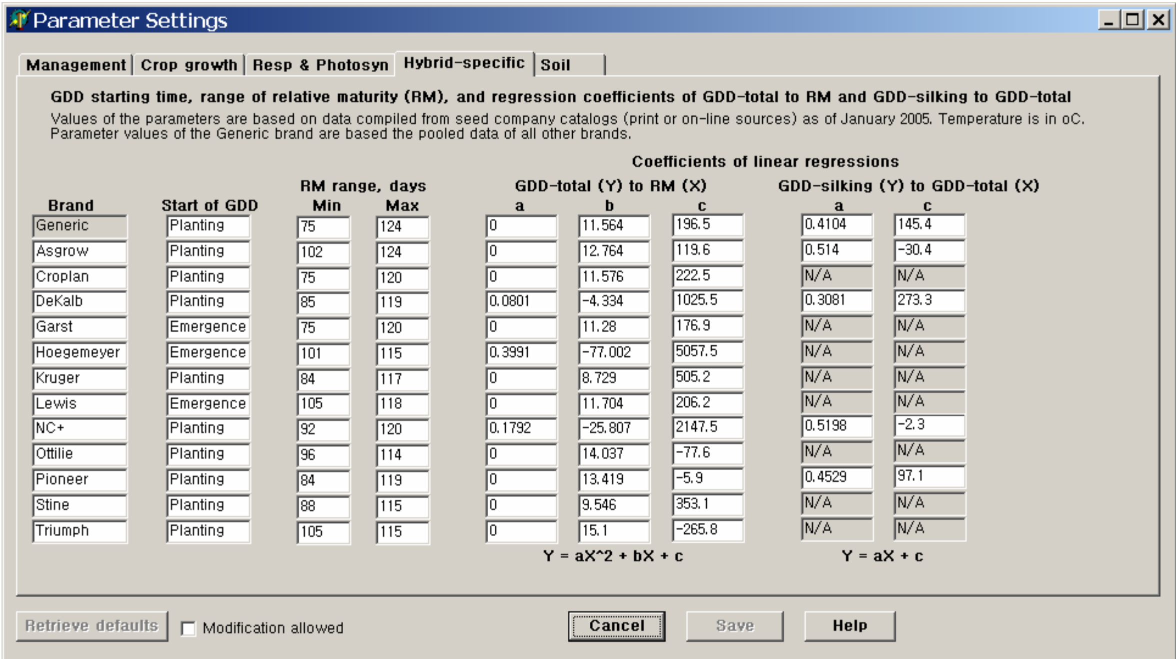


Crop growth, respiration & photosynthesis: These parameters provide general physiological coefficients used in functions describing crop growth and development. See Appendix 6.1 for a complete list and section 4.1 for a more detailed description of these parameters.



Hybrid-specific: These are brand-specific hybrid parameters. They describe the starting time for growing degree days (GDD) computation (i.e., either from planting or emergence), the minimum and maximum of relative maturity ratings (RM, in days), and coefficients of linear regression of total GDD (Y) to GDD-to-silking (X) in the form of $Y=aX^2 + bX + c$, and the coefficients of linear regression of GDD-to-silking (Y) to total GDD (X) in the form of $Y = aX + c$. Note that only the brands that have GDD-to-silking data along with total GDD data have the coefficients for the regression of GDD-to-silking to total GDD. When one of those brands is selected, the brand-specific function will be used to estimate GDD-to-silking from total GDD when the former is not provided. For other brands that don't have GDD-to-silking data and thus have no regression of GDD-to-silking to total GDD (shown as '**N/A**'), GDD-to-silking will be estimated using the coefficients for Generic brand, which are based on the pooled data of all available data. Details about the regression functions are discussed in section 4.3.

Soil: These parameters provide generic default values of soil physical properties for major soil texture classes. See Appendix 6.2 for a complete list and Section 4.2 for more detailed descriptions of these parameters.



Parameter Settings

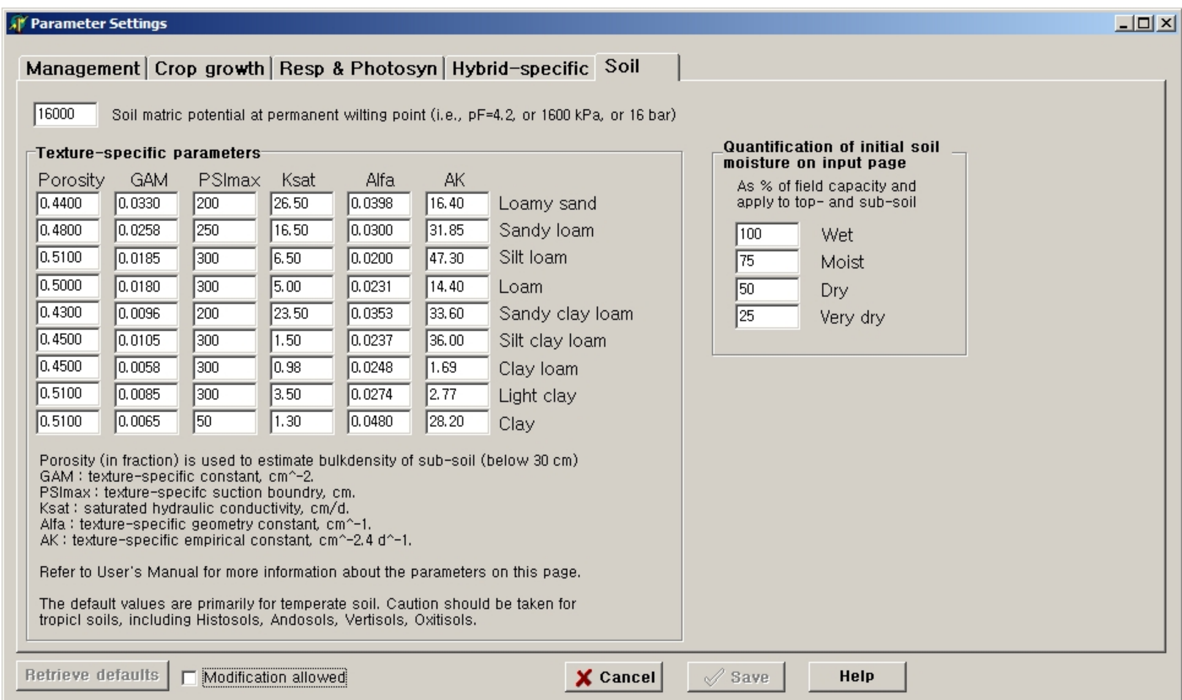
Management | Crop growth | Resp & Photosyn | Hybrid-specific | Soil

GDD starting time, range of relative maturity (RM), and regression coefficients of GDD-total to RM and GDD-silking to GDD-total

Values of the parameters are based on data compiled from seed company catalogs (print or on-line sources) as of January 2005. Temperature is in oC. Parameter values of the Generic brand are based the pooled data of all other brands.

		RM range, days		Coefficients of linear regressions: GDD-total (Y) to RM (X)			GDD-silking (Y) to GDD-total (X)	
Brand	Start of GDD	Min	Max	a	b	c	a	c
Generic	Planting	75	124	0	11.564	196.5	0.4104	145.4
Asgrow	Planting	102	124	0	12.764	119.6	0.514	-30.4
Croplan	Planting	75	120	0	11.576	222.5	N/A	N/A
DeKalb	Planting	85	119	0.0801	-4.334	1025.5	0.3081	273.3
Garst	Emergence	75	120	0	11.28	176.9	N/A	N/A
Hoegemeyer	Emergence	101	115	0.3991	-77.002	5057.5	N/A	N/A
Kruger	Planting	84	117	0	8.729	505.2	N/A	N/A
Lewis	Emergence	105	118	0	11.704	206.2	N/A	N/A
NC+	Planting	92	120	0.1792	-25.807	2147.5	0.5198	-2.3
Ottilie	Planting	96	114	0	14.037	-77.6	N/A	N/A
Pioneer	Planting	84	119	0	13.419	-5.9	0.4529	97.1
Stine	Planting	88	115	0	9.546	353.1	N/A	N/A
Triumph	Planting	105	115	0	15.1	-265.8	N/A	N/A
				Y = aX^2 + bX + c			Y = aX + c	

Retrieve defaults | Modification allowed | Cancel | Save | Help



Parameter Settings

Management | Crop growth | Resp & Photosyn | Hybrid-specific | Soil

16000 Soil matric potential at permanent wilting point (i.e., pF=4.2, or 1600 kPa, or 16 bar)

Texture-specific parameters

Porosity	GAM	PSImax	Ksat	Alfa	AK	
0.4400	0.0330	200	26.50	0.0398	16.40	Loamy sand
0.4800	0.0258	250	16.50	0.0300	31.85	Sandy loam
0.5100	0.0185	300	6.50	0.0200	47.30	Silt loam
0.5000	0.0180	300	5.00	0.0231	14.40	Loam
0.4300	0.0096	200	23.50	0.0353	33.60	Sandy clay loam
0.4500	0.0105	300	1.50	0.0237	36.00	Silt clay loam
0.4500	0.0058	300	0.98	0.0248	1.69	Clay loam
0.5100	0.0085	300	3.50	0.0274	2.77	Light clay
0.5100	0.0065	50	1.30	0.0480	28.20	Clay

Porosity (in fraction) is used to estimate bulkdensity of sub-soil (below 30 cm)
GAM : texture-specific constant, cm^-2.
PSImax : texture-specifc suction boundry, cm.
Ksat : saturated hydraulic conductivity, cm/d.
Alfa : texture-specific geometry constant, cm^-1.
AK : texture-specific empirical constant, cm^-2.4 d^-1.

Refer to User's Manual for more information about the parameters on this page.

The default values are primarily for temperate soil. Caution should be taken for tropicl soils, including Histosols, Andosols, Vertisols, Oxitisols.

Quantification of initial soil moisture on input page

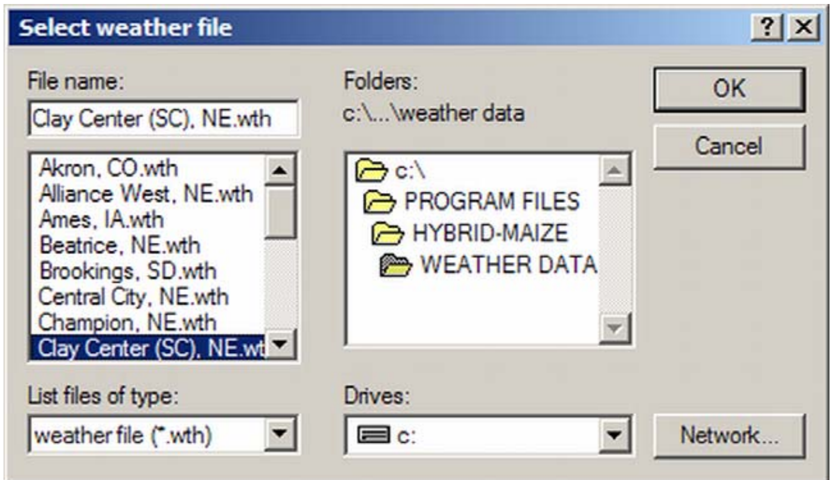
As % of field capacity and apply to top- and sub-soil

100	Wet
75	Moist
50	Dry
25	Very dry

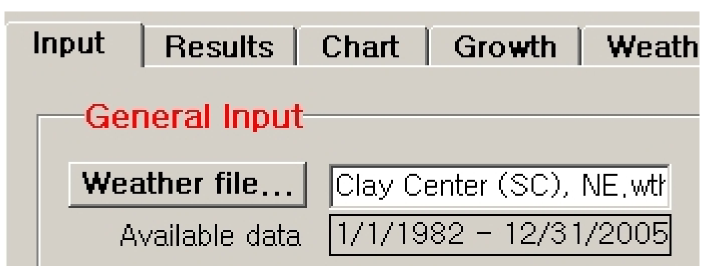
Retrieve defaults | Modification allowed | Cancel | Save | Help

2.3.2. Weather Data

For each simulation run, a weather data file must be selected that best represents the site for which the simulation is intended. Clicking the button **Weather file...** in the panel **General Input** on the front page displays the file selection sub-window, and a file can be selected by browsing to the appropriate directory and file name.



The default directory (or folder) can be changed if necessary (go to **Settings → General options** or press **CTRL-O**). By default, only files with extension **.wth** will be displayed in the file list because **.wth** is the default extension for weather files. In case a weather file uses a different extension, select **all file** in the **List files of type** window in order to display the file. Clicking **OK** will select a file and close the sub-window. Now the selected weather file is displayed in the box next to the weather file selection button, and the box below shows the start and end dates of the which data.



2.3.2.1. Creating a Weather Data File

When simulating yield potential (i.e. under optimal water regime) but without the need to estimate irrigation water requirements, the Hybrid-Maize model requires three daily weather variables to run: total solar radiation, maximum temperature **(T-high)**, and minimum temperature **(T-low)**. When simulating growth under irrigated or rainfed conditions, or optimal water regime with estimated irrigation water requirements, three additional daily weather variables are required: relative humidity, rainfall, and reference evapotranspiration **(ET)**.

All weather data must be stored in a plain text file (so-called ASCII file) with the extension **.wth**. Below is an example of such a file for a site with daily weather data from January 1, 1990 to December 31, 2003:

```
BEATRICE NE   Lat.(deg)= 40.30  Long.(deg)= 96.93  Elev.(m)= 376.
40.30 (Lat.)
year   day   Solar   T-High   T-Low   RelHum  Precip  ET-NE   SoilT   WndSpd
             MJ/m2   ºC       ºC      %       mm      Mm      ºC      km/hr
1990     1   8.829   5.5      -9.8    68      0.0     1.7     -1.7    11.8
1990     2   8.797   10.5     -1.6    63      0.0     2.5     -1.0    13.7
1990     3   7.373   7.1      -8.0    82      3.1     1.2     -0.3    12.5
1990     4   9.143   4.0      -10.6   71      0.0     1.4     -0.2    10.6
1990     5   8.799   3.9      -11.0   67      0.0     1.4     -0.8    9.8
…..
…..
2003   360   1.212   11.2      0.7    84      0.0     1.3     0.9     21.0
2003   361   9.021   13.8     -0.5    57      0.0     3.9     5.0     20.8
2003   362   7.564   6.5      -4.9    62      0.0     2.1     1.9     13.6
2003   363   9.326   5.5      -4.4    63      0.0     2.1     1.2     14.1
2003   364   7.829   9.8      -4.5    53      0.0     3.1     0.7     15.1
2003   365   8.509   4.7      -7.1    60      0.0     1.7     0.6     11.2
```

It is important that all data are in the appropriate metric units, and are placed in a row in the order as shown above. Detailed specifications for the weather file format are:

Row 1: Site information (location, latitude, longitude, elevation). All text in this row will be copied as ‘site info’ to the output file of a simulation run, but is not used in the simulation itself.

Row 2: Latitude of the site (in decimal degrees). If the program can’t find a value at the beginning of the second row, a warning message will pop up and the simulation will abort. For the southern hemisphere, this value must be negative. Any other text in this row must be separated by one or more spaces or a tab, and will be ignored when the program runs.

Row 3: Names of variables. Variables should be in the exact order shown. From left to right the variables are: year, day (ordinal day of the year, 1-365 or 366 for leap year), solar radiation, T-high (maximum temperature), T-low (minimum temperature), RelHum (humidity), precip (rainfall), and ET-NE (reference ET calibrated under Nebraska conditions). The example above shows two additional variables that are often available--soil temperature and wind speed--but they are not used in the current version of Hybrid-Maize and will thus be ignored by the program when it runs.

Row 4: Measurement unit (metric) for each variable. Solar radiation = MJ/m^2, temperature = ^{o}C, relative humidity = %, rainfall and ET = mm. If the data obtained are in other units, they must be converted to the appropriate metric units. If the data are in English units, daily solar radiation is often expressed in Langley (1 Langley=41.868 KJ m^{-2}), temperature in ^{o}F (1 ^{o}F=(1 – 32)/1.8 ^{o}C), and rainfall and ET in inch (1 inch = 25.4 mm).

Row 5 to end: One row represents one day. Within a row, values must be separated from each other either by space (one or more) or tab (one or more). Alignment is not important, and there is no limit to the number of decimals. If humidity, rainfall and ET are not available, the three variables must be entered as 0 (zero) and the model can only be used for simulating yield potential, not water-limited yield.

2.3.2.2. Sources of Weather Data

The Hybrid-Maize program package contains historical daily weather data obtained from the High Plains Regional Climate Center (HPRCC) for 21 selected locations in the western Corn Belt. (see the map and table below; data are provided until 12/31/2005).

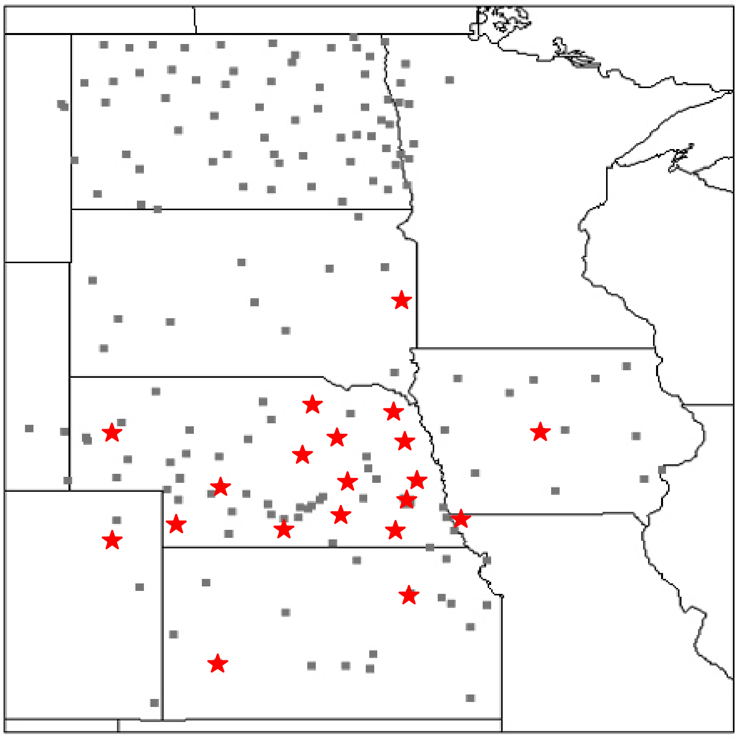


Figure 2.1. Sites of daily weather data included in the program package. The sites are part of the Automated Weather Data Network (AWDN) of the High Plains Regional Climate Center (HPRCC) of the University of Nebraska - Lincoln. The stars on the map show the locations of the sites included with your version of Hybrid-Maize; the gray squares show other weather stations in the AWDN database. We recommend that users who wish to actively use Hybrid-Maize to explore crop management options should purchase the expanded AWDN database on CD-ROM from the HPRCC or subscribe for specific sites to obtain up-to-date weather data for locations in closest proximity to the sites for which simulations are desired.

Site	County	State	Latitude	Longitude	Elevation (m)	Database period
Alliance West	Box Butte	NE	42°01’	103°08’	1213	5/88-12/05
Beatrice	Gage	NE	40°18’	96°56’	376	1/90-12/05
Central City	Merrick	NE	41°09’	97°58	517	9/86-12/05
Champion	Chase	NE	40°40’	101°72’	1029	1/82-12/05
Clay Center	Clay	NE	40°34’	98°08’	552	7/82-12/05
Concord	Dixon	NE	42°23’	96°57’	445	7/82-12/05
Elgin	Antelope	NE	41°56’	98°11’	619	1/88-12/05
Holdrege	Phelps	NE	40°20’	99°22’	707	5/88-12/05
Lincoln (IANR)	Lancaster	NE	40°82’	96°65’	357	1/86-12/05
Mead	Saunders	NE	41°09’	96°24’	366	5/81-12/05
North Platte	Lincoln	NE	41°05’	100°46’	861	9/82-12/05
O’Neill	Holt	NE	42°28’	98°45’	625	7/85-12/05
Ord	Valley	NE	41°37’	98°56’	625	7/83-12/05
Shelton	Buffalo	NE	40°44	98°45	614	1/91-12/05
West Point	Cuming	NE	41°51’	96°44’	442	5/82-12/05
Akron	Washington	CO	40°09’	103°09’	1384	10/83-12/05
Ames	Story	IA	42°01’	93°45’	309	7/86-12/05
Brookings	Brookings	SD	44°19’	96°46’	500	7/83-12/05
Garden City	Finney	KS	37°59’	100°49’	866	3/85-12/05
Manhattan	Riley	KS	39°12’	96°35’	320	6/84-12/05
Rock Port	Atchison	MO	40°28’	95°29’	268	1/91-12/05

For more precise location-specific simulations, and particularly for real-time simulations in the current growing season (see sections 3.1. to 3.4.), users must acquire weather data directly from available public or commercial sources through free or fee-based subscription or by purchasing data on a CD-ROM. Many weather station networks in the USA provide online access to weather databases, including daily historical records as well as daily records of the current growing seasons. Examples of such weather data sources include:

Center	Website	U.S. States
National Climatic Data Center (NCDC)	http://www.ncdc.noaa.gov	All
High Plains Regional Climate Center (HPRCC)	http://www.hprcc.unl.edu	NE, KS, IA, ND, SD, selected stations in other states
Midwest Regional Climate Center (MRCC)	http://mcc.sws.uiuc.edu	MO, IA, MN, IL, WI, KY, IN, OH, MI
Southeast Regional Climate Center (SERCC)	http://water.dnr.state.sc.us/water/climate/sercc	FL, SC, NC, GA, Al, MS, TN, VA, WV, MD, DE, KY
Northeast Regional Climate Center (NRCC)	http://www.nrcc.cornell.edu	CT, DE, ME, MD, MA, NH, NJ, NY, PA, RI, VT, WV
Western Regional Climate Center (WRCC)	http://www.wrcc.sage.dri.edu	AK, AZ, CA, CO, HI, ID, MT, NV, NM, OR, UT, WA, WY
Southern Regional Climate Center (SRCC)	http://www.srcc.lsu.edu	AR, LA, OK, MS, TN, TX
Illinois Climate Network	http://www.sws.uiuc.edu/warm/datatype.asp	IL
National Aeronautics and Space Administration (NASA)	http://earth-www.larc.nasa.gov/power/	Global

It is important to note that not all weather stations have complete weather data observations for long-term historical time periods and that spatial coverage varies. In particular, solar radiation data are often unavailable, except for more recent years and in the relatively new networks such as the AWDN at the HPRCC. Before subscribing or downloading data, check what data are available for a station located as close as possible to the location you wish to simulate and make sure that solar radiation is included. For simulating long-term yield potential using Hybrid-Maize, users should have at least 10 or more years of historical weather data. Also check the format and measurement units of the daily data that are available and how the data can be converted into the format shown above in section 2.3.2.1.

There will be cases when some of the essential weather data are incomplete. Hybrid Maize will malfunction if a weather file contains missing data. In many cases, individual missing cells can be filled by extrapolating a value from surrounding dates. In some cases, long stretches of missing data in historical weather files might be filled in by averaging the same time period from years with complete data. For locations where no weather station with complete records is available nearby, various data sources could be combined to generate a more location-specific data set. Except for mountainous and coastal areas, solar radiation and temperature vary less than rainfall over short distances. Therefore, obtaining solar radiation and temperature from a weather station located within about 20-100 miles of your location is often sufficient for reasonable yield potential simulations. More precise rainfall and temperature data can be measured directly on-site by using relatively inexpensive rain gauges and a max/min thermometer although both must be placed in an appropriate location.

2.3.2.3. Converting, Organizing, Updating, and Checking Weather Data

This version of **Hybrid-Maize** comes with a bundled utility program, **WeatherAid**, specifically for managing weather data, including downloading data from online sources, converting and reformatting the data for Hybrid-Maize use, and checking for erroneous data entries and missing data. To open **WeatherAid,** click **Utilities**, **WeatherAid** on the main menu, or click the icon  on the toolbar. Refer to **Help**, **Instructions** on **WeatherAid** main menu for detailed guide.

Alternatively, users can convert and format raw weather data manually according to the specifications in section 2.3.2.1. This can be done most efficiently in spreadsheet programs such as MS Excel. Once the units of the data are correctly entered and the data have been placed in the right columns with four rows of text on top, the file can then be saved as a **text** file. After this, the extension of the weather file needs to be changed from **.txt** to **.wth**. Updating a weather file can also be done in a spreadsheet (e.g., MS Excel) by opening the previously created **.wth** file and appending new data, then saving the file under the same name. Alternatively, **.wth** files can also be edited in any text editor. Hybrid-Maize includes the Notepad text editor for this purpose, which can be launched by clicking on **Utilities → Text editor** from the main menu of the program. New data, which must have correct units and order of variables, can then be appended as unformatted text to the end of the existing file.

NOTE: In text editors such as MS Wordpad, one has to use ***Paste special…*** *through the menu bar to select the unformatted text option for pasting when transferring text from MS Excel to a text file.*

For example, a raw data file downloaded from a network such as AWDN may look like this:

BEATRICE NE Lat.(deg)= 40.30 Long.(deg)= 96.93 Elev.(m)= 376.

a250629	T-High	T-Low	Rel Hum	Soil Tmp	WindSpd	Solar	Precip	ET-NE
date/time	F	F	%	F@4 in.	mi/hr	langleys	inches	inches
1 1 1990 2400	41.914	14.277	68.244	28.859	7.310	210.873	0.000	0.065
1 2 1990 2400	50.868	29.190	62.523	30.240	8.503	210.116	0.000	0.097
1 3 1990 2400	44.844	17.518	82.046	31.481	7.741	176.111	0.121	0.049
1 4 1990 2400	39.234	12.955	70.573	31.680	6.586	218.365	0.000	0.055

Manual data preparation includes the following steps:

1. Conversion of all English units to metric (S.I.) units *(*solar radiation MJ/m^2 = Langley/23.885; Temperature ^{o}C = 0.5556 x (^{o}F - 32); rainfall and ET in mm = inch x 25.4; Wind speed in km/hr = miles/hr x 1.609),
2. Conversion of month-day format (first two columns) into running day format (day 1 = January 1 in each year, day 365 = December 31 in each year or 366 in a leap year),
3. Re-arrangement of data columns to arrive at the appropriate finale file format:

BEATRICE NE Lat.(deg)= 40.30 Long.(deg)= 96.93 Elev.(m)= 376.
40.30 (Lat.)

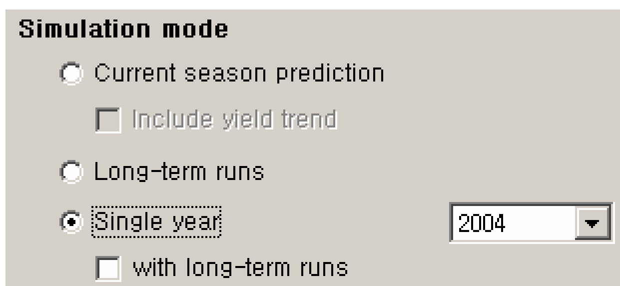
year	day	Solar	T-High	T-Low	RelHum	Precip	ET-NE	SoilT	WndSpd
		MJ/m2	oC	oC	%	mm	mm	oC	km/hr
1990	1	8.829	5.5	-9.8	68	0.0	1.7	-1.7	11.8
1990	2	8.797	10.5	-1.6	63	0.0	2.5	-1.0	13.7
1990	3	7.373	7.1	-8.0	82	3.1	1.2	-0.3	12.5
1990	4	9.143	4.0	-10.6	71	0.0	1.4	-0.2	10.6

4. Save the file as a tab delimited text file or MS-DOS text file (but not Unicode text file) with the extension **.wth**

2.3.3. Simulation Modes

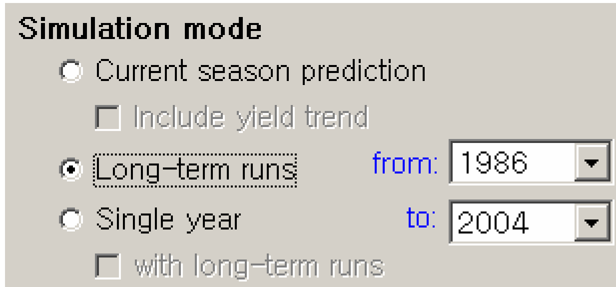
Single year: Simulation of growth in a single year (cropping season) is the default simulation mode. This mode is primarily used for analysis of past cropping seasons (see section 3.3.) to gain understanding of factors that may have caused yield loss or to estimate the size of the exploitable yield gap by comparing simulated yield potential with actual measured yields. The year of simulation is selected from the drop-down box on the right, which lists all available years in the weather file. Up to six individual single year runs can be made sequentially and their results can be compared, both numerically and graphically on the output pages. If more individual runs are attempted, the program will ask for permission to erase the results from previous runs before conducting a new run. Previous results can also be erased manually by clicking **Settings** on the menu bar and selecting **Erase current results**.

Single year with long-term runs: Single year simulation can be run in combination with long-term runs utilizing all available years of weather data. If this option is checked, a simulation will be run for every year in the weather file in addition to the selected year. This mode is useful for comparing a known year with the long-term site yield potential and understanding why yields in certain years were above or below normal and what climatic factors may have contributed to the observed results.



Results shown include the single year selected as well as the long-term simulation results. The latter are ranked based on grain yield. By default, simulated values are shown for the years with the maximum (best), 75% percentile (three out of four years have lower yields than this yield level), median (50% percentile), 25% percentile (three out of four years have higher yields than this yield level), and the minimum (worst) yield. The summary results table also displays the (long-term) mean and the coefficient of variance (CV, in %) calculated from simulations of all years. For result summary and bar chart plot, users can also choose to show all years of results by checking the option **Show all years** on the **Results** page or click the toggle **Five ranks / All years** on the Chart page. Whenever **with long-term runs** is selected, all previous run results, from single year mode or other modes, will be erased, and comparisons can only be made among years of the current long-term run.

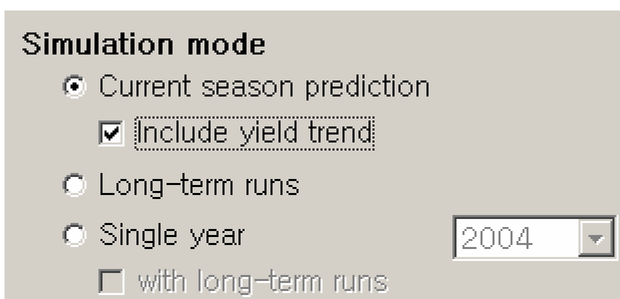
Long-term runs: This simulation mode is used for estimating the long-term yield potential or attainable water-limited yield at a given site, as affected by different choices of maize hybrid, planting date, and/or plant population. In other words, this mode can be used to explore how to exploit the available yield potential through management (see section 3.1.). When this mode is checked, a new box will appear on the right for the starting year. The start and end years for long-term runs must be specified, but a minimum of five years must be included to perform long-term simulations. By default, the first year and the last year of the weather file appear in the respective start/end boxes, and we recommend that as many years as possible be used for such analyses to ensure that the widest possible range of weather conditions are used in the simulation.



In this mode the model simulates maize growth in each year of the range selected. All runs (=years) are ranked based on grain yield. By default, simulated values are only shown for the years with the maximum (best), 75% percentile, median (50% percentile), 25% percentile, and the minimum (worst) yield. The summary results table also displays the numerical mean calculated from all simulations of all years, which is referred to as the long-term mean. For result summary and bar chart plot, users can also choose to show all years of results by checking the option **Show all years** on the **Results** page or click the toggle **Five ranks / All years** on the Chart page. It is important to remember that all runs (years) in this mode will display grain yields and other simulated data with respect to the same set of input data (e.g. planting date, GDD, etc).

*Note: Comparison of specific years where these input data vary from one year to the next is best carried out by multiple runs in the '**Single year**' mode.*

Current season prediction: This mode is used for in-season (or real-time) simulation of maize growth and forecasting the final yield before the crop matures (see section 3.4). Predictions are based on the up-to-date weather data for the current growing season, supplemented by the historical weather data for the rest of the season at the simulation location. To use this mode, the weather data file must contain at least ten years of reliable weather data for the site, in addition to updated real-time weather data for the current growing season.



When this mode is selected, the year selection box will be grayed out and the last year (i.e. the current year) of the weather file will be selected automatically as the year for which a prediction is to be made. For locations at which a growing season crosses into another year (such as in the southern hemisphere where crops are planted in September/October and harvested in the following year), the year when the current season starts will automatically be selected. Note that this mode will not run if the weather data for the current season are already available for the entire growing season. In this case, a message will pop up recommending the user to select the **Single year** mode.

In the current-season prediction mode, the model first uses the current year's weather data to simulate actual growth up to the current date, and then utilizes the climate data for each subsequent day based on the historical weather data from all previous years to simulate all possible growth scenarios until crop maturity. As with long-term runs, predictions are ranked according to grain yields and results are shown for the scenarios with the best, 75% percentile, median (i.e. 50% percentile), 25% percentile, and the worst yields.

In addition, for the current season prediction mode, the model also performs a complete long-term run using the same settings for GDD, date of planting, etc as specified for the current season. Results for the year representing the median grain yield from the long-term run are added to the overall model outputs displayed in the current-season prediction mode, along with the five ranks for the current-season prediction. This allows comparing growth in current ongoing growing season with growth in the median year, which may be useful for making management adjustments in real-time. The long-term median is used instead of the mean because it represents an actual year that has occurred in the past, whereas averaging historical climate data would cause 'smoothed' weather conditions that are unrealistic, particularly with regard to rainfall and temperature patterns.

The current-season prediction mode has an option **Include yield trend**. When this option is checked, the model will make yield predictions since emergence (or shortly after that) until the last day of the ongoing growing season in the weather file. The total number of predictions or the interval (in days) for the predictions are set through **Settings → General options** in the main menu. The results of yield trend are plotted in the output tab **Yield trend**. The data for plotting the graph can be saved through **Save results → Real time yield trend** on the main menu. Running the current-season prediction with **Include yield trend** allows analysis of how the yield predictions change during an ongoing growing season, i.e., whether a trend towards above- or below-normal yields exists. However, users should be aware that those simulations will take several minutes to complete.