

2.4. Model Outputs

Once a simulation run has completed, a beep will sound and the **Result** page will show subsequently. Other output pages, including **Chart**, **Growth**, **Weather**, **Water**, and **Yield trend**, can be viewed by clicking on the page tabs.

2.4.1. Results

The display of simulation results differs depending on the mode of simulation. In **Single year** mode without long-term runs, results are shown on one page (use the scroll bar to view the lower part). In other simulation modes, the **Results** display can be toggled between **Individual run** or **Across-run summary** by clicking the appropriate radio button at top left of the results page.

By default, results are for viewing only although it is possible to edit them on-screen by checking the option **Allow editing** on the top right of the **Results** window. The editing option allows users to add notes to the result page, rearrange the data columns, or delete specific data columns for printing. The results can also be opened in MS Excel or Corel Quattro Pro by clicking the button **Upload to spreadsheet**, provided that either program is installed on the user's computer.

Individual run display: The results begin with a summary of the year, location, and water regime specified for the simulation run. Key predicted dates for emergence, silking, and maturity, yields and harvest index, summarized weather statistics, and user-specified input settings are provided. Scrolling down on this page reveals the simulated daily model predictions for key crop growth variables. If long-term runs were also simulated, individual runs for the best yield, 75%, median, 25% percentile, and worst yield years can be displayed by selecting those runs from the pull-down list of the run selection box.

The screenshot shows the Hybrid-Maize software interface. The title bar is "Hybrid-Maize". The menu bar includes "Settings", "Save Results", "Print", "Utilities", and "Help". The toolbar contains icons for file operations and simulation settings. The main window has tabs for "Input", "Results", "Chart", "Growth", "Weather", and "Water". The "Results" tab is active, showing the "Individual run" radio button selected. A dropdown menu shows the year "2003". There is a checkbox for "Allow editing" and a button for "Upload to spreadsheet". The "Result Summary" section displays the following information:

Simulation year: 2003
Site: CLAY CENTER(SC) NE Lat.(deg)= 40.57 Long.(deg)= 98.13 Elev.(m)= 552.
Weather file: Clay Center (SC), NE.wth
Water condition: Rainfed.

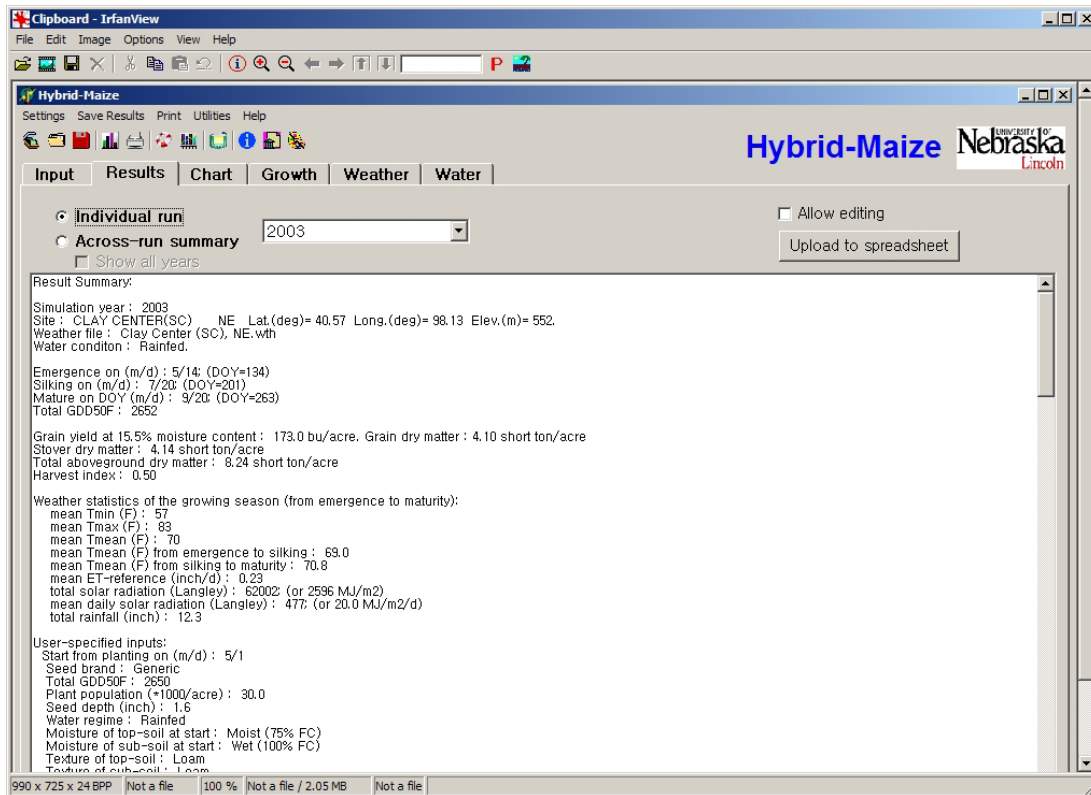
Emergence on (m/d): 5/14 (DOY=134)
Silking on (m/d): 7/20 (DOY=201)
Mature on DOY (m/d): 9/20 (DOY=263)
Total GDD50F: 2652

Grain yield at 15.5% moisture content: 173.0 bu/acre. Grain dry matter: 4.10 short ton/acre
Stover dry matter: 4.14 short ton/acre
Total aboveground dry matter: 8.24 short ton/acre
Harvest index: 0.50

Weather statistics of the growing season (from emergence to maturity):
mean Tmin (F): 57
mean Tmax (F): 83
mean Tmean (F): 70
mean Tmean (F) from emergence to silking: 69.0
mean Tmean (F) from silking to maturity: 70.8
mean ET-reference (inch/d): 0.23
total solar radiation (Langley): 62002 (or 2596 MJ/m2)
mean daily solar radiation (Langley): 477 (or 20.0 MJ/m2/d)
total rainfall (inch): 12.3

User-specified inputs:
Start from planting on (m/d): 5/1
Seed brand: Generic
Total GDD50F: 2650
Plant population (*1000/acre): 30.0
Seed depth (inch): 1.6
Water regime: Rainfed
Moisture of top-soil at start: Moist (75% FC)
Moisture of sub-soil at start: Wet (100% FC)
Texture of top-soil: Loam
Texture of sub-soil: Loam
Bulk density of top-soil: 1.3

At the bottom, there is a status bar with the text "Code of this run = Clay Center (SC), NE, 2005, 2" and "Weather folder = C:\Program Files\Hybrid-Maize2006\Weather data\".



Predicted or measured variables in the daily output section are (first unit: English; second unit: Metric):

Date	month/day
DOY	day of year (ordinal day number)
GDD	cumulative growing degree days from emergence, GDD50F or GDD10C
LAI	leaf area index, m^2/m^2
Stover	stover dry matter (leaves, stalks, cobs), lb/acre or kg/ha
Grain	grain dry matter, lb/acre or kg/ha
Total	total aboveground dry matter (leaves, stalks, cobs, grain), lb/acre or kg/ha
Root	total belowground dry matter (roots), lb/acre or kg/ha
GAssi	daily gross assimilation, lb CH_2O /acre/d or kg CH_2O /ha/d
Resp	daily total respiration (growth and maintenance respiration of all organs), lb CH_2O /acre/d or kg CH_2O /ha/d
Rain	rainfall, inches or mm
Irri	irrigation, inches or mm
ETref	reference evapotranspiration for a closed canopy (weather station), inches or mm
ETmax	maximum predicted evapotranspiration for actual canopy coverage, inches or mm
ETact	predicted evapotranspiration for actual canopy and soil moisture status, inches or mm. If $ETact < ETmax$, crop moisture stress occurs.
v/v	volumetric soil water content in 0-1 ft, 1-2 ft, and >2 ft depths, fraction
Stress	Crop water stress coefficient (0=no stress; 1=full stress)
Drain	Leaching beyond the maximum rooting depth, inches or mm

Across-run summary: When this display option is selected, the results are summarized for different years selected from among the years simulated in the historical weather database. Simulated values for yield and various phenological stages are shown for the years with the maximum (best), 75% percentile, median (50% percentile), 25% percentile, and the minimum (worst) grain yield. The summary results table also displays the long-term mean and associated coefficients of variance (CV, in %) calculated from simulations of all years and of a single year chosen for comparison (only in **Single year with long-term runs** mode). Climate parameters that influence crop growth, development, and yield are also shown for each of year in this display.

Results of 2003 along with long-term runs using historical weather data from 1982 to 2005

Rank	Year	Gr.Y	Gr.DM	Stover	tDM	HI	vDays	rDays	tDays	V+R	tSola	Tmin	Tmax	Tmean	vTmean	rTmean
Best yield	1996	274.0	6.49	5.19	11.68	0.56	66	87	153	67223	55.4	77.9	66.7	69.5	64.5	64.5
75% percentile	1997	222.5	5.27	4.68	9.95	0.53	67	89	126	61758	58.9	82.4	70.7	69.2	72.4	72.4
Median yield	1982	187.9	4.45	5.13	9.98	0.46	75	68	143	65930	57.9	78.4	68.1	67.4	68.9	68.9
25% percentile	2004	158.3	3.75	4.99	8.73	0.43	73	66	139	64107	56.6	80.6	68.6	67.6	69.8	69.8
Worst yield	1983	104.2	2.47	3.15	5.62	0.44	74	47	121	63569	59.2	83.7	71.4	67.2	78.0	78.0
Long-term mean		186.1	4.41	4.52	8.93	0.49	68	60	127	62633	58.5	82.4	70.5	69.2	72.0	72.0
Long-term CV, %		25	25	22	21	10	11	16	11	3	3	3	3	5	5	5
Task-run	2003	173.0	4.10	4.14	8.24	0.50	68	62	130	62002	57.1	82.5	69.8	69.0	70.8	70.8

Overall probability of frost occurrence during grain filling (%): 8

Note:
 The ranking is based on GRAIN yield.
 Gr.Y is grain yield in bu/acre at 15.5% moisture content, Gr.DM, Stover and tDM are dry matter for grain, stover and total aboveground biomass in short ton/acre.
 The long-term means are the numerical averages of all years.

Abbreviations:
 HI : harvest index, i.e., the ratio of grain dry matter to total aboveground dry matter
 vDays : days from emergence to silking (i.e., vegetative phase)
 rDays : days from silking to maturity (i.e., reproductive phase)
 V+R : days from emergence to maturity
 tSola : total solar radiation from emergence to maturity (Langley)
 tRain : total rainfall from emergence to maturity (inch)
 Tmin, Tmax, Tmean and ETref : mean daily Tmin, Tmax, Tmean, and ET-reference, respectively, from emergence to maturity (F)
 vTmean, rTmean : mean daily Tmean from emergence to silking (i.e., vegetative phase) and from silking to maturity (i.e., reproductive phase), respectively (F)
 tTm : total irrigation (inch)

User-specified inputs:
 Weather file : Clay Center (SC), NE, with
 Start from planting on (m/d) : 5/1 (DOY=121)
 Seed brand : Generic
 Total GDD50F : 2650
 Plant population (*1000/acre) : 30.0
 Seed depth (inch) : 1.6

Code of this run = Clay Center (SC), NE, 2005, 2 Weather folder = C:\Program Files\Hybrid-Maize2006\Weather data\

Users can also choose to include results of all simulated years by checking the option **Show all years**. The results of all years are added to the lower part of the table.

Seed depth (inch) : 1.6
 Water regime : Rainfed
 Top-soil Water at start : Moist (75% FC)
 Sub-soil Water at start : Wet (100% FC)
 Texture of top-soil : Loam
 Texture of sub-soil : Loam
 Bulk density of top-soil : 1.3
 Max root depth (inch) : 40

Note that all GDD values refer to the starting time of planting

Run on 3/6/2006, 8:00:21 PM

Results of all selected years

Run	Gr.Y	Gr.DM	Stover	tDM	HI	vDays	rDays	tDays	tSola	Tmin	Tmax	Tmean	vTmean	rTmean	ETref	tRain
1982	187.9	4.45	5.13	9.98	0.46	75	68	143	65930	57.9	78.4	68.1	67.4	68.9	0.22	19.0
1983	104.2	2.47	3.15	5.62	0.44	74	47	121	63569	59.2	83.7	71.4	67.2	78.0	0.26	11.3
1984	138.4	3.29	4.53	7.91	0.42	68	59	127	66625	59.0	81.9	70.4	69.0	72.1	0.24	13.2
1985	158.2	3.75	3.66	7.41	0.51	77	69	146	68445	54.1	77.5	65.8	66.7	64.8	0.25	19.2
1986	207.2	4.91	5.22	10.12	0.49	67	60	127	64805	58.8	81.9	70.4	69.3	71.5	0.23	18.8
1987	193.5	4.73	5.39	10.11	0.47	63	55	118	63677	59.7	84.1	71.9	70.3	73.7	0.27	15.4
1988	163.9	3.88	2.95	6.83	0.57	58	48	106	58795	60.8	87.9	74.4	72.0	77.2	0.31	7.5
1989	256.5	6.08	5.25	11.33	0.54	67	64	131	64060	58.2	81.4	69.8	69.3	70.3	0.22	23.9
1990	204.6	4.84	6.32	11.77	0.41	62	54	116	61877	60.2	84.4	72.3	70.6	74.2	0.24	17.8
1991	104.4	2.47	3.41	5.88	0.42	56	52	108	53969	60.9	86.9	73.9	72.9	74.9	0.25	9.5
1992	234.5	5.55	4.94	10.49	0.53	82	76	158	70560	53.3	78.5	65.9	65.8	65.9	0.22	22.5
1993	261.0	6.18	4.99	11.17	0.55	74	75	149	63303	56.3	78.2	67.3	67.6	67.0	0.20	29.0
1994	202.3	4.79	4.87	9.66	0.50	60	61	121	61617	59.4	83.5	71.5	71.7	71.2	0.25	12.2
1995	149.1	4.53	3.59	7.06	0.50	69	55	124	58616	59.3	82.5	70.9	68.5	73.9	0.23	9.5
1996	274.0	6.49	5.19	11.68	0.56	66	87	153	67223	55.4	77.9	66.7	69.5	64.5	0.19	20.7
1997	222.5	5.27	4.68	9.95	0.53	67	59	126	61758	58.9	82.4	70.7	69.2	72.4	0.22	15.5
1998	230.5	5.46	4.60	10.06	0.54	64	52	116	55910	61.3	83.3	72.3	70.2	74.3	0.22	19.5
1999	198.1	4.63	4.76	9.46	0.50	72	59	131	64172	58.6	80.9	69.8	68.2	71.6	0.22	16.5
2000	187.9	4.45	5.35	9.80	0.45	68	51	119	61905	59.7	84.0	71.8	69.1	75.5	0.25	14.3
2001	164.3	3.89	4.08	7.97	0.49	68	50	118	67138	60.1	83.8	71.9	69.0	76.0	0.27	9.6
2002	235.4	5.91	5.33	10.56	0.58	52	52	110	52726	61.1	85.9	73.5	72.0	75.1	0.28	5.7
2003	173.0	4.10	4.14	8.24	0.50	68	62	130	62002	57.1	82.5	69.8	69.0	70.8	0.23	12.3
2004	158.3	3.75	4.99	8.73	0.43	73	66	139	64107	56.6	80.6	68.6	67.6	69.8	0.23	17.6
2005	159.9	3.79	4.42	8.21	0.46	65	54	119	60422	59.3	84.3	71.8	69.7	74.4	0.26	10.5

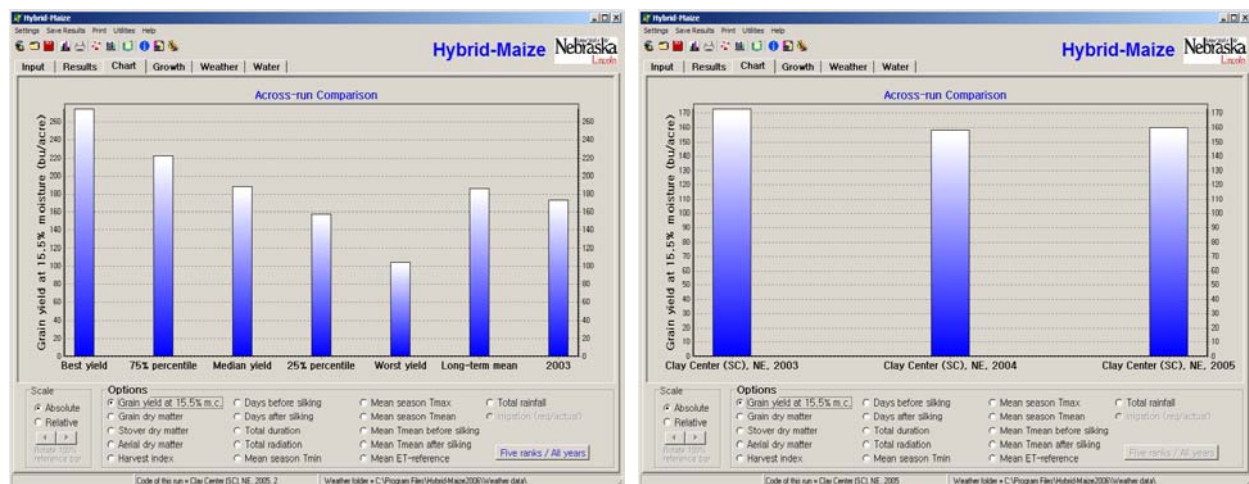
Code of this run = Clay Center (SC), NE, 2005, 2 Weather folder = C:\Program Files\Hybrid-Maize2006\Weather data\

Gr.Y	grain yield at 15.5% moisture content, bu/acre or Mg/ha
Stover	stover dry matter (leaves, stalks, cobs), short ton/acre or Mg/ha
tDM	total aboveground dry matter (leaves, stalks, cobs, grain), short ton/acre or Mg/ha
HI	harvest index = grain dry matter/total aboveground dry matter
vDays	days from emergence to silking (i.e., length of vegetative phase)
rDays	days from silking to maturity (i.e., length of reproductive phase)
V+R	days from emergence to maturity (i.e., total length of growing period)
tSola	total cumulative solar radiation from emergence to maturity, Langley or MJ/m ²
Tmin	mean daily minimum temperature from emergence to maturity, °F or °C
Tmax	mean daily maximum temperature from emergence to maturity, °F or °C
Tmean	mean daily average temperature from emergence to maturity, °F or °C
vTmean	mean daily average temperature from emergence to silking, °F or °C
rTmean	mean daily average temperature from silking to maturity, °F or °C
ETref	mean daily reference evapotranspiration from emergence to maturity, inches or mm
tRain	total rainfall from emergence to maturity, inches or mm
tIrri	model estimated or actual total irrigation water, inches or mm

NOTE: First unit: English, second unit: Metric option are selected under **Settings** → **General Options**.

2.4.2. Chart

This view of the results provides bar graphs of 17 variables. Depending on the simulation mode chosen, this can be a single bar graph for single-year run, a comparison of up to 6 different runs made sequentially, or the five ranked simulations and the long-term mean (with or without an extra single year) in a long-term simulation. These bar graphs are useful for quick visual evaluation of model results, particularly comparisons of various model runs using different settings for input variables. The variables to choose from include grain and stover yields, total aboveground biomass, harvest index, duration from emergence to silking and from silking to physiological maturity, as well as the total season length and mean weather statistics for climate variables. The variable **Irrigation required** is disabled if there is a mixture of runs with and without the **Estimate Irrigation Water Requirement** option checked on the input page. Two examples are provided below:



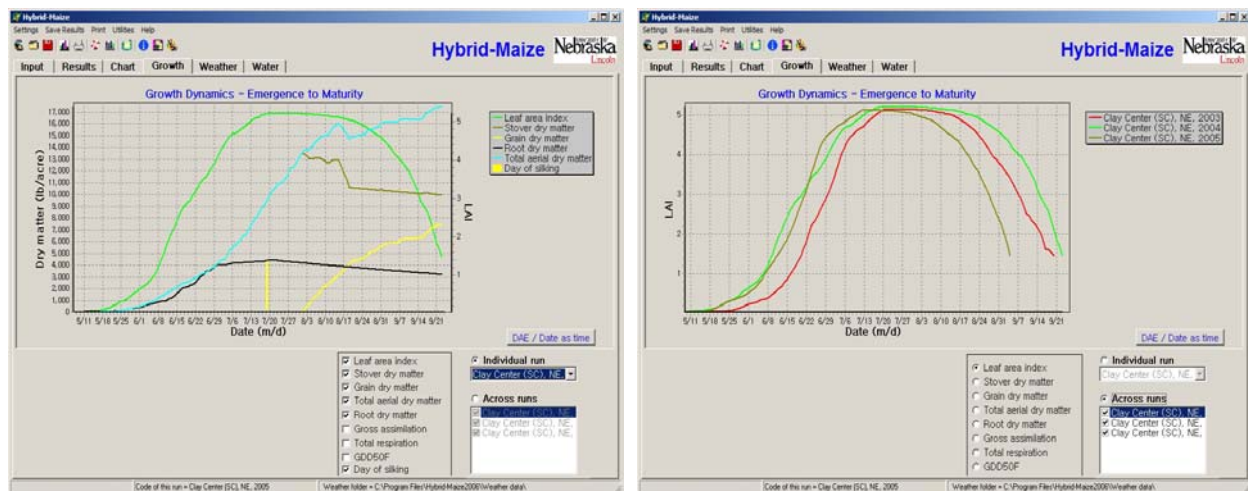
For simulations with long-term runs, results of all simulated years can be shown in the bar chart by clicking the **Five ranks / All years** toggle button.

2.4.3. Growth

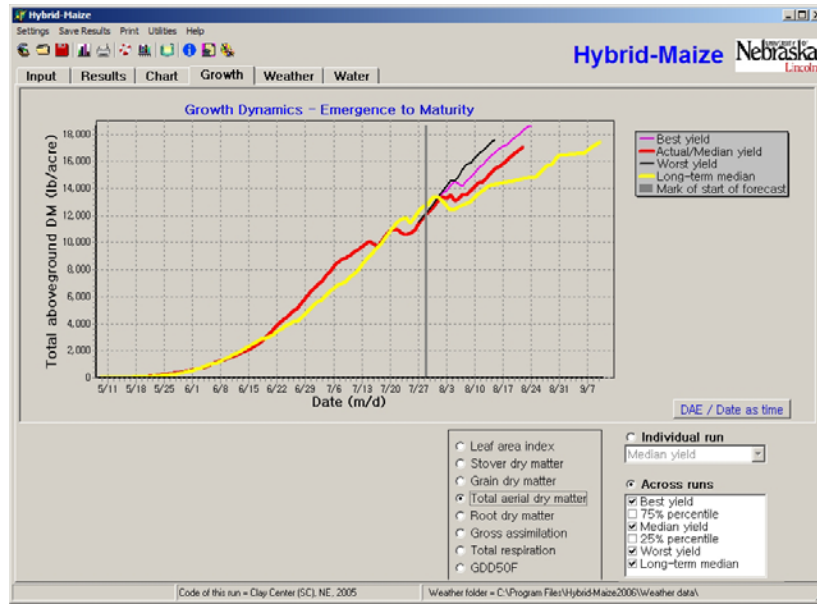
This page displays the growth dynamics of the maize crop from emergence to maturity. Eight variables can be displayed: leaf area index (LAI), dry matter of stover, grain and total aboveground biomass, gross assimilation, total respiration, and GDD accumulation. Each of these variables can be plotted for an individual run (default) or across runs. Click the button **DAE / Date on X-axis** to toggle the time scale on the x-axis between days after emergence (DAE) or calendar date

Individual run: For single runs, most of the variables can be plotted simultaneously. The dry matter variables utilize the left axis, whereas other variables utilize the right axis. Because LAI has a different scale than the other three variables that use the right axis (i.e., assimilation, respiration and GDD), LAI cannot be plotted simultaneously with these other variables. A warning message will pop up when the user attempts to do so. The day of silking is marked by a short yellow bar and can be removed by deselecting it from the variable list.

Across runs: One variable at a time is plotted for the selected runs.

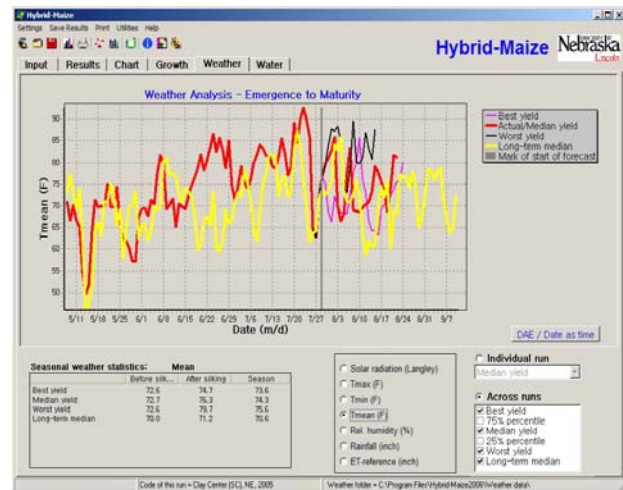
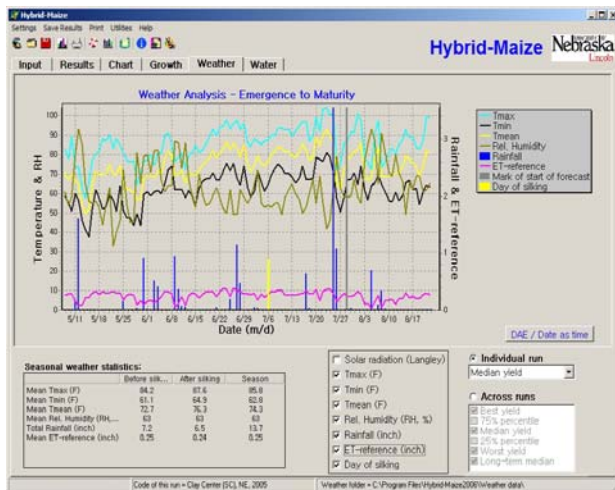


When running in **Current season prediction** mode a vertical gray bar marks the end of the actual weather data (date on which the real-time simulation is done) and the start of the forecasting phase for the remainder of the growing season. Predictions are shown for the different ranks of all scenarios calculated as well as for the long-term median for the entire growth period (yellow line). Actual growth and the various forecasts shown can be compared with the long-term median growth to evaluate whether an ongoing growing season is above or below normal conditions (see section 3.4. for an example).



2.4.4. Weather

This page displays seven daily weather variables from emergence to maturity: solar radiation, maximum, minimum and mean daily temperatures, relative humidity, rainfall and reference evapotranspiration (ET-reference). In addition, seasonal weather statistics are also shown in a table for quick visual reference. This page works in the same manner as the graphics on **Growth** with regard to individual (default) and multiple simulation run comparisons, and the x-axis can be toggled between days after emergence or calendar date. Due to the difference in scale, rainfall and ET-reference use the right axis while the other five variables use the left axis when plotting for single runs. When running in **Current season prediction** mode a vertical, gray bar marks the end of the actual weather data (date on which the real-time simulation is done) and the start of the forecasting phase for the remainder of the growing season.



2.4.5. Water

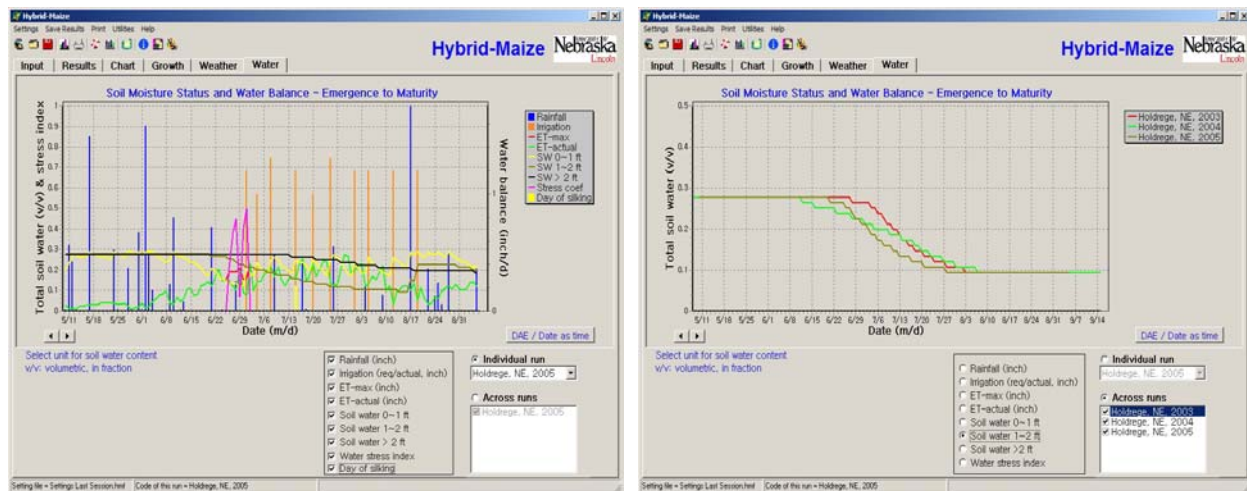
This page only appears when running the model for **Rainfed/irrigated** water conditions. It displays the seasonal dynamics of eight variables that define the water regime: rainfall, amount of irrigation (when there are irrigation events) or estimated irrigation requirement, maximum evapotranspiration (ET-max), actual evapotranspiration (ET-actual), volumetric soil water content at three depths, and water stress index for maize crop. Rainfall, irrigation, ET-max and ET-actual use the right axis, while soil water content and water stress coefficient use the left axis. The water stress index is estimated by:

$$\text{Water stress index} = 1 - \text{ET}_{\text{actual}} / \text{ET}_{\text{max}}$$

Any time the water stress coefficient is >0, the crop is assumed to experience water stress, which is shown as bright pink line in the Water graphs on this page.

As on the **Growth** and **Weather** pages, these graphs can display multiple variables for individual years or one variable across runs. The X-axis can be toggled between DAE and date. For soil water content on the Y-axis, one of the six (in the English system) or four (in the Metric system) units can be selected by clicking the bi-direction arrows. The units are: volumetric, gravimetric, and inch per foot soil. Each of those can be displayed as *total water content* or as *available water content*. The latter only includes crop-available soil water, i.e., water held between field capacity and permanent wilting point. For most practical applications, this is the water variable of greatest interest. The two units with inch per foot soil are not available in the Metric system.

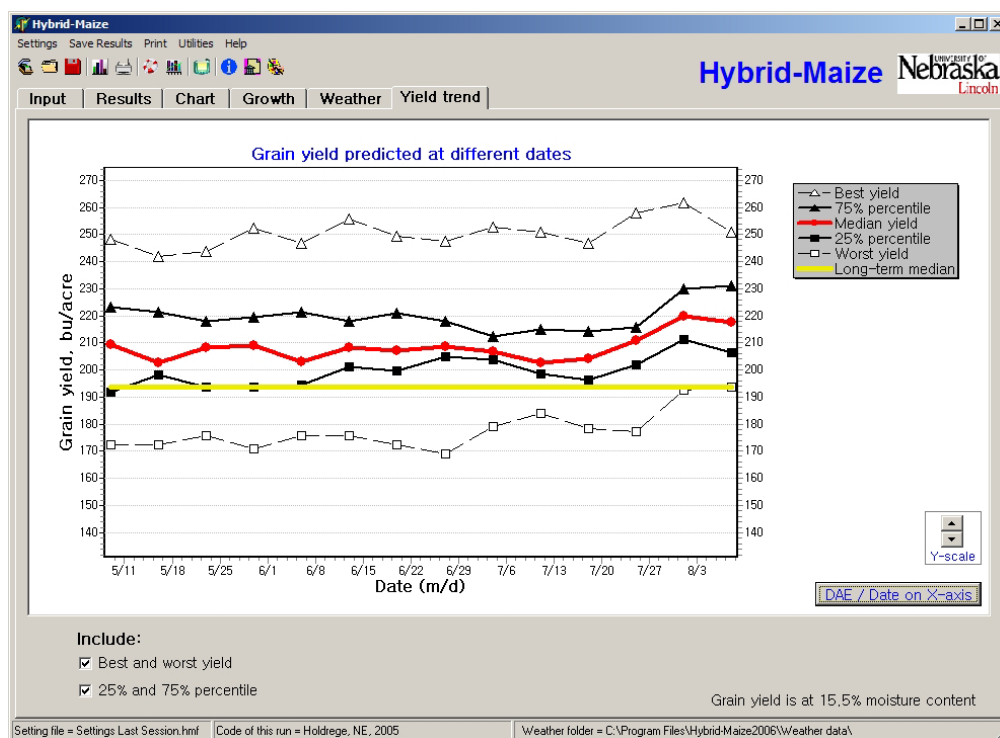
When running the **Current season prediction** mode under irrigated conditions using the option of **Assume no water stress in the forecast phase**, ET-actual and soil water content of the three soil layers are only plotted up to the date of the simulation in the current season, which is marked by a vertical, gray bar. Forecasting of soil moisture dynamics beyond this date is not done.



2.4.6. Yield trend

When running **Current season prediction** mode with **Include yield trend** selected, the **Yield trend** output tab becomes available, showing a graph of the yield forecasts made at previous dates during the ongoing growing season. The median yield forecast is shown as a bold red line and can be compared with the long-term median (bold yellow line) to assess whether there is a trend towards normal or above-/below-normal yields in the current growing season. In addition,

the minimum-maximum yield predictions and the 25% and 75% percentiles are shown. The area between the 25% and 75% percentiles represents the most likely yield range (50% of all predictions).



2.4.7. Saving and Printing Results

Numerical results can be directly opened in MS Excel or Corel Quattro Pro by clicking the button **Upload to spreadsheet** on the **Results** page, provided that either software program is already installed in your computer. After working in Excel or Quattro, the user needs to specify an appropriate format when saving the results, because the results are still in plain text format. Alternatively, click on **Save Results** → **Numerical results** on the main menu, then specify a file name and folder to save the results. The default extension for the saved file is **.xls** for the sake of easy opening in Excel.

All graphs can be saved as one of three graphic formats: bitmap, Windows meta file and Windows enhanced meta file. Click on **Save Results** → **Graph on display** on the main menu, then specify a file name, a folder and select a format.

All output pages can be printed; For individual run results, only the top part of the numerical results (i.e., the summary) will be printed. For across-run summaries, the whole page will be printed. To print, click **Print** on the main menu, and select the appropriate option. The user can select a printer or set up a printer through this menu. When printing graphs, the user may need to adjust the margins as needed.

