

3.4. Current Season Simulation of Maize Growth and Yield Forecasting

Corn production fluctuates significantly from one year to another due to temporal and spatial variation in weather conditions, soils, and the availability of irrigation water. The interaction of these factors makes it difficult to make timely and reliable predictions of corn yield and total production in both irrigated and dryland fields. Forecasting of crop yields is important for several reasons. First, producers can use such predictions for evaluating drought risks, helping to guide in-season adjustments to crop management, and to provide additional information to crop marketing decisions. Major grain users, such as feedlots and ethanol plants, can utilize yield forecasts to refine grain purchasing plans. Politicians, insurance agencies and financial institutions may wish to predict farm income. At present, most information on expected maize production in the U.S. is obtained from the USDA crop reports, which are based on monitoring systems that mainly rely on field scouting, climatic data and empirically defined indices. Use of a crop simulation model provides an additional source of information. However, it is important to note that predictions from crop models, like other forecasting approaches, should not be considered infallible and will deviate from actual values. Therefore, crop model predictions should be used along with other sources of information and common sense and experience to guide management and marketing decisions. **Do not make decisions solely upon the basis of predictions from the Hybrid-Maize model!**

Running the Hybrid-Maize model in **Current season prediction** mode allows real-time, in-season simulation of maize growth up to the date of the simulation run, and forecasting of the possible outcomes in final yield based on historical weather data for the remaining crop growth period. The prediction is based on the up-to-date weather data of the current growing season, supplemented by the previously collected historical weather data for the site (or the nearest weather station) for the remainder of the season. When the option **Include yield trend** is included, yield forecasts will be made for each specified interval since emergence (or shortly after that) until the last day of the current season in the weather file. The results will be plotted in the output page **Yield trend**. Knowing predicted yield trends for the current season helps adjusting water and fertilizer management.

To use the yield forecasting mode, we recommend that the weather data file contain at least ten years of reliable historical weather data for the site (or a nearby weather station), in addition to weather data for the current year. Management decisions derived from in-season simulations could include adjusting the yield goal during the growing season in comparison with normal years and making subsequent adjustments in fertilizer amounts (sidedress, fertigation), or to help make replant decisions. During grain filling, yield forecasting can provide additional information to help guide marketing decisions on marketing.

Example: In-season simulation of irrigated maize growth

Our site is a field on a deep silt loam in eastern Nebraska, near Mead. Corn following soybean is grown in a no-till system. The field is equipped with a center-pivot irrigation system and an injection pump for fertigation. A commercial corn hybrid with a relative maturity of 109-d and 2700 GDD50F (1500 GDD10C) from planting to maturity was planted on May 2, 2003 at a 30-inch (0.76 m) row spacing with a seed drop rate of 32,000 seeds/acre (79,000 seeds/ha). Emergence was observed to occur on May 12 and actual measurement of stand counts three weeks later indicated an average plant population of 31,000 plants/acre (76,600 plant/ha). The crop reached 50% silking on July 19.

The soil, a Tomek silt loam, has 3% organic matter, 4 ppm nitrate-N in the top 3 ft of soil (depth weighted average), 12 ppm available P (Bray-1), 395 ppm available K and a pH of 6.4. Soil texture is silt loam throughout the profile and there are no impediments to root growth. Initial soil moisture status in the topsoil represents a normal year, about 27% gravimetric water content. A weather station is located at Mead, NE, with daily climate data available since 1982. This station is within 5 miles of the field and rainfall data measured there are representative of the actual field location. Alternatively, more location specific rainfall data could be used to supplement the weather station data, i.e., by editing the weather data file (see section 2.3.2.)

We first evaluate the site yield potential (see section 3.1.) for corn planted on May 2 at a depth of 1.5 inch and a final plant stand of 31,000 plants/acre, using 1982-2002 weather data:

Model inputs for simulating the long-term site yield potential.

Simulations using long-term historical weather data from 1982 to 2002

Rank	Year	Gr.Y	Gr.DM	Stover	IDM	HI	vDays	rDays	V+R	tSola	Tmin	Tmax	Tmean	vTmean	rTmean	ETref	tRain	tlri
Best yield	1992	282.2	6.68	5.35	12.04	0.56	76	87	163	70585	52.5	78.4	65.4	67.1	63.9	0.19	16.7	0.0
75% percentile	1996	258.5	6.12	5.09	11.21	0.55	63	74	137	56317	58.5	80.0	69.3	70.7	68.1	0.18	14.3	0.0
Median yield	1991	233.0	5.52	5.82	11.34	0.49	55	55	110	53411	62.0	86.2	74.1	73.9	74.4	0.22	15.0	0.0
25% percentile	2001	224.9	5.33	5.84	11.17	0.48	67	51	118	58748	60.6	84.1	72.4	69.6	76.0	0.25	8.5	0.0
Worst yield	1983	193.8	4.59	6.20	10.79	0.43	71	44	115	59293	61.5	84.0	72.8	68.6	79.4	0.23	9.8	0.0
Long-term mean		239.2	5.66	5.65	11.31	0.50	66	58	124	60295	59.8	83.2	71.5	70.2	73.3	0.23	15.3	0.0
Long-term CV, %		10	10	13	7	8	8	17	11	8	4	3	3	2	5	14	35	0

Among the five years above, frost damage during grain filling occurred in:
1992

Overall probability of frost occurrence during grain filling (%) : 5

Average yield potential under optimal conditions is 239 bu/acre and risk of frost is low. To achieve the yield potential, we need to ensure sufficient water and nutrient supply during the growing season. Using the actual soil test results and assuming a yield goal of 239 bu/acre, the current fertilizer recommendation algorithms for corn (Shapiro et al., 2001) suggest the application of 150 lbs N and 40 lbs P₂O₅, with the nitrogen split into 90 lbs applied pre-plant and 60 lbs at the V6-stage of corn development. This is the nutrient management practice implemented in 2003. However, if the predicted in-season yield potential is substantially higher than the long-term average, it is possible to make a small additional N application through the pivot to ensure adequate N supply for a higher yielding crop. However, such a decision should be made no later than the V12 to R1 (silking) stage window.

The goal of this exercise is to conduct weekly simulations during the ongoing 2003 growing season, beginning about 1 month after emergence, to ensure that irrigation matches crop water needs. In addition, we wish to decide whether additional N topdressing should be applied through fertigation at later growth stages (in the V12 to R1 growth stages window). Therefore, we assume that no water stress occurs during the forecasting period and our simulation is mainly a prediction of in-season yield potential for the actual planting date, hybrid, and plant density used at the site. Weather data are obtained weekly from the HPRCC web site at <http://www.hprcc.unl.edu> (see section 2.3.2. and note that a subscription is needed for access to real-time climate data).

The following pages show selected outputs for real-time simulations conducted at different dates throughout the growing season, including some interpretation. See section 4.4.3 (below) for more examples and how yield forecasts converge as the growing season progresses. The screenshot below shows how the data were entered in the **Current season prediction** mode, in this case for the final simulation done near maturity stage, with all observed dates (emergence, silking) and all irrigation events entered.

Hybrid-Maize University of Nebraska Lincoln

Settings Save Results Print Utilities Help

Input Results Chart Growth Weather Water

General Input

Weather file... Mead210.wth
Available data 1/1/1982 - 7/29/2003

Simulation mode

- Current season prediction
 - Include yield trend
- Long-term runs
- Single year 2003
 - with long-term runs

Start from m/d

- Emergence 5 12
- Planting 5 2

Seed depth (inch) 1.5

Seed brand Generic

Maturity

- GDD50F 2700
- Date (m/d)
- Relative maturity (days)

Optional:

- Date of silking (m/d) 7 19
- GDD50F to silking

Population (x1000/acre) 31

Water

- Optimal
 - Estimate irrigation water requirement
- Rainfed / Irrigated
 - Assume no water stress in prediction phase

Irrigation schedule

Month	Day	Amount (inch)
7	2	1.2
7	12	1.2
7	17	1.2
7	23	1.25
7	31	1.4
8	4	1.4
8	7	1.4
8	11	1.4
8	14	1.4

Reset entries

Nitrogen

- Optimal

Last season residues incorporation Type

Quantity (Mg/ha)

Date

Soil Nmin at planting (lb/acre)

Soil organic C (%)

Fertilizer N (lb N/acre)

Soil

Max rooting depth (inch) 40

Texture Initial moisture status Bulk density

Top-soil (1 ft) Silt loam Wet (100% FC) 1.3 (g/cm³)

Sub-soil Silt loam Wet (100% FC)

English units

Run...

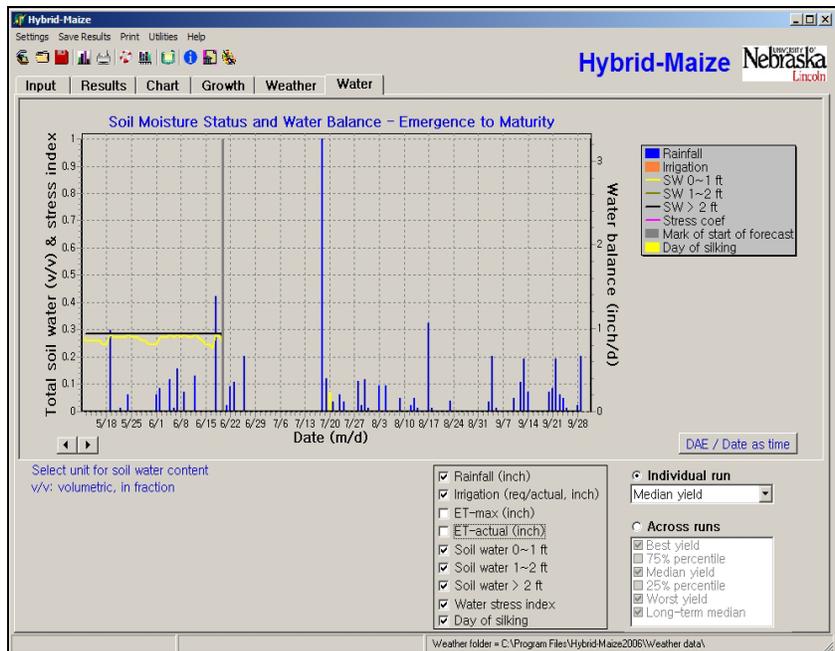
Weather folder = C:\Program Files\Hybrid-Maize2006\Weather data\

Simulation as of **June 20, 2003, about V6 (6-leaf) stage**

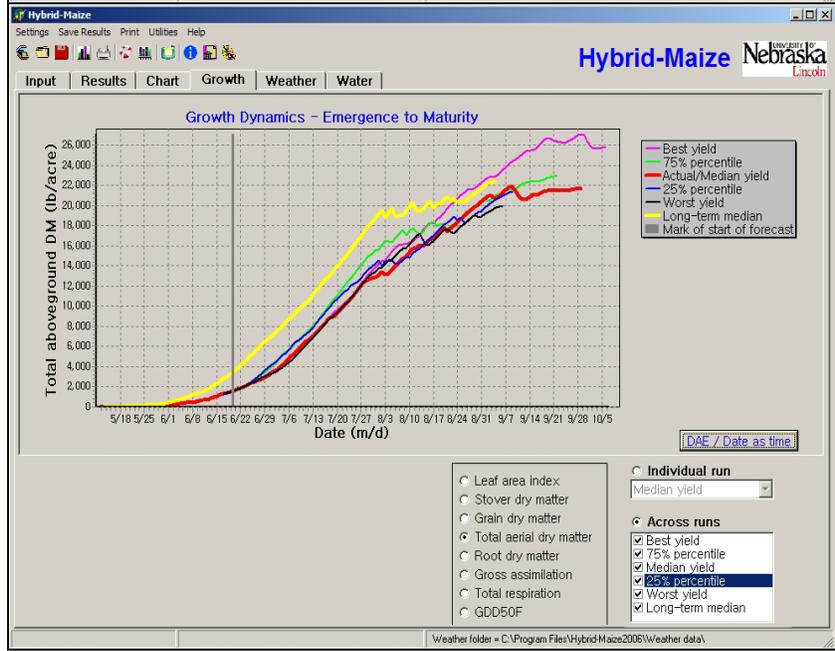
The weather file was downloaded on June 21. Model inputs included date of emergence (May 12) and GDD to maturity (2700) and silking (1370). No irrigation has occurred yet.

Real-time predictions of the current season

Rank	Gr.Y	Gr.DM	Stover	IDM	HI	vDays	rDays	V+R	tSola	Tmin	Tmax	Tmean	vTmean	rTmean	ETref	tRain	tIrr
Best yield	280.9	6.65	6.13	12.78	0.52	75	74	149	74509	55.8	79.4	67.6	67.6	67.6	0.21	16.7	0.0
75% percentile	261.9	6.20	5.33	11.53	0.54	78	81	159	69444	52.4	78.0	65.2	66.9	63.5	0.18	18.0	0.0
Median yield	240.7	5.70	5.08	10.77	0.53	71	70	141	64278	57.1	79.1	68.1	68.6	67.6	0.21	17.8	0.0
25% percentile	226.7	5.37	7.90	13.27	0.40	67	56	123	65897	57.8	84.8	71.3	69.5	73.4	0.26	9.5	0.0
Worst yield	197.9	4.69	5.31	10.00	0.47	71	47	118	57186	60.4	84.6	72.5	68.7	78.1	0.24	8.1	0.0
Long-term median	238.3	5.64	5.59	11.24	0.50	60	56	116	60945	60.6	84.8	72.7	72.0	73.4	0.25	18.4	0.0



Water tab. Several rainfall events occurred evenly spread throughout May and early June. Soil moisture in all soil layers is predicted to have remained at optimal levels and no water stress has affected crop growth so far (water stress coefficient = 0, no line visible). Note the vertical gray line, which marks the point at which historical weather data are used to extend the current season simulation into the future.



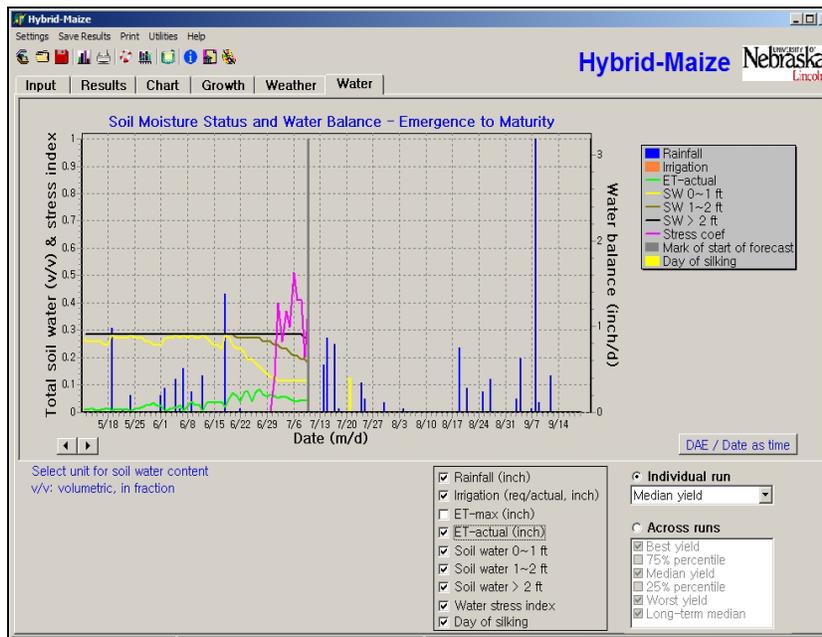
Growth tab. The long-term median growth scenario (yellow) is shown compared to the five rank years for the current growing season. 2003 appears to be a season with normal to slightly below normal biomass accumulation as of the simulation date (June 20). Because only one month of actual growth has occurred, predicted final yield potential varies widely (198-281 bu/acre). Median forecasted yield potential is 241 bu/acre, which is similar to the long-term median of 238 bu/acre (see Results table).

Simulation as of July 10, 2003, about V12 stage

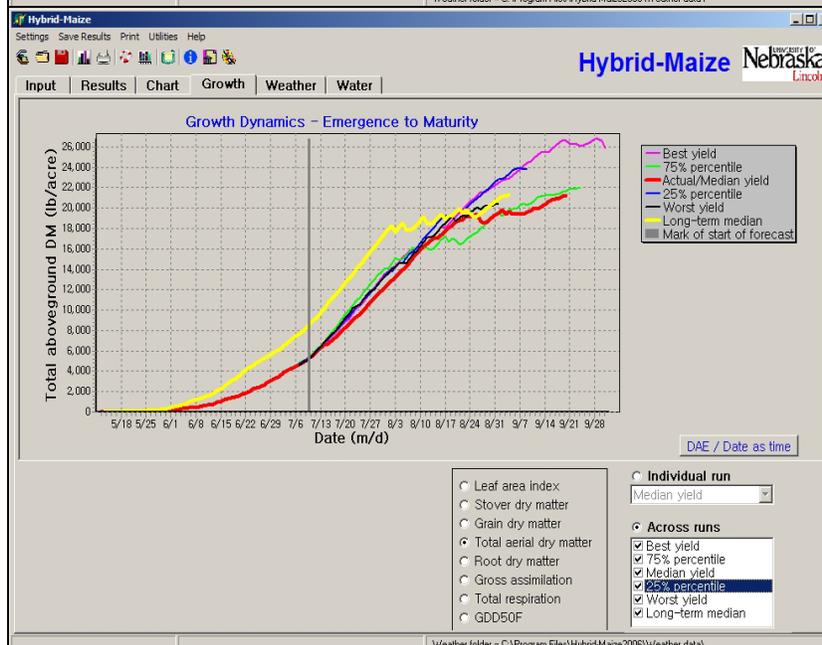
One irrigation event occurred on July 2 (1.2') and was entered under **Irrigation schedule** in the **Water** panel of the **Input** page. The weather file was downloaded on July 11 to extend the climate data for the current year up to July 10.

Real-time predictions of the current season

Rank	Gr.Y	Gr.DM	Stover	IDM	HI	vDays	rDays	V+R	tSola	Tmin	Tmax	Tmean	vTmean	rTmean	ETref
Best yield	293.1	6.94	5.99	12.93	0.54	72	72	144	71804	56.2	80.4	68.3	68.3	68.2	0.22
75% percentile	260.8	6.18	4.77	10.95	0.56	72	73	145	62962	56.6	79.7	68.2	68.4	68.0	0.19
Median yield	247.8	5.87	5.05	10.92	0.54	70	71	141	63207	57.6	78.9	68.3	68.9	67.7	0.20
25% percentile	231.6	5.49	6.00	11.49	0.48	70	55	125	61573	59.1	83.2	71.2	68.7	74.3	0.23
Worst yield	194.6	4.61	5.97	10.57	0.44	69	44	113	58206	61.4	85.1	73.3	69.2	79.6	0.24
Long-term median	241.7	5.72	5.08	10.81	0.53	60	56	116	60945	60.6	84.8	72.7	72.0	73.4	0.25



Water tab. No rain fell since June 17 and soil moisture in top two layers is predicted to have declined. A brief, minor water stress occurred, but was alleviated quickly by the first irrigation on July 2. Water stress is beginning to appear again, which indicates that the field may need another irrigation (see section UNL NebGuides on scheduling irrigations).



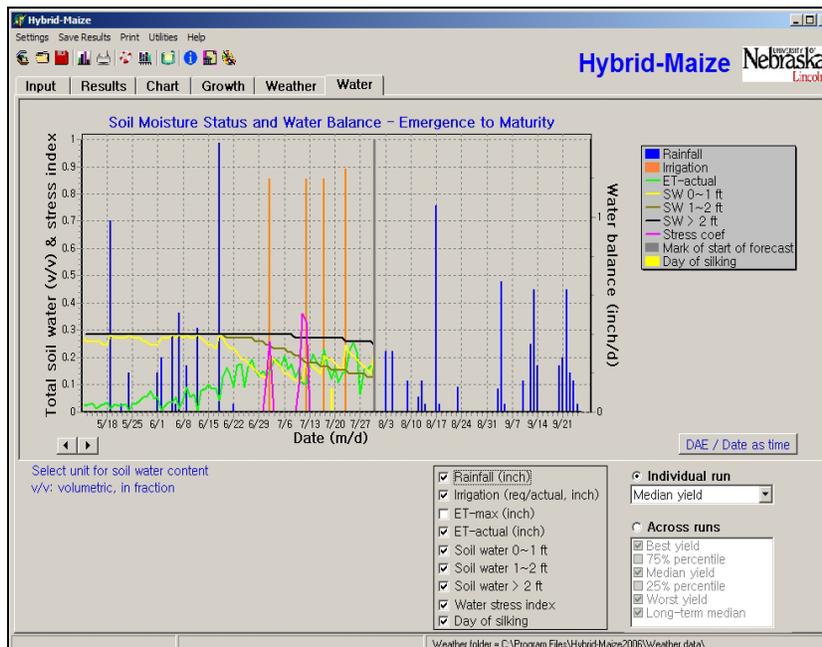
Growth tab. Growth up to July 10 has lagged the long-term median due to cooler temperatures. Silking is forecasted for July 19-20, so management must ensure that no stress occurs in upcoming two weeks. Median forecasted biomass and yield are projected to be similar to the long-term median. Because the median scenario projects a yield similar to the yield goal used in calculating the N amount that was applied, there is no need for an additional N topdressing in the V12 to R1 window.

Simulation up to **July 30, 2003, about 10 days after silking**

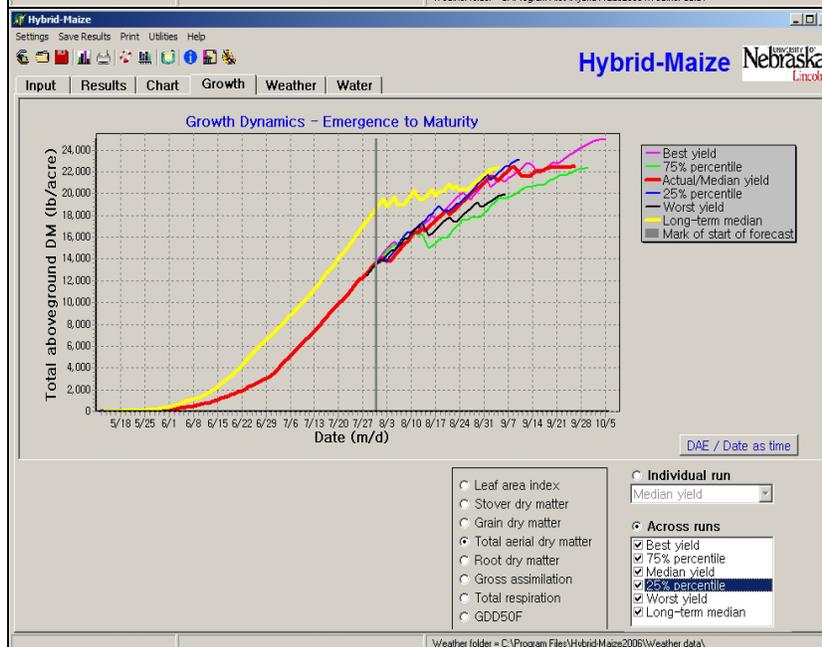
Four more irrigation events have occurred since July 10 (1.2 to 1.4 inches). The weather file was downloaded on July 31. Other model inputs included date of emergence (May 12), the observed date of silking (July 19), and GDD to maturity (2700).

Real-time predictions of the current season

Rank	Gr.Y	Gr.DM	Stover	IDM	HI	vDays	rDays	V+R	tSola	Tmin	Tmax	Tmean	vTmean	rTmean	ETref
Best yield	309.0	7.32	5.17	12.49	0.59	69	79	148	69963	54.7	80.9	67.8	68.7	67.1	0.21
75% percentile	262.0	6.21	5.00	11.21	0.55	69	71	140	64074	57.2	80.5	68.9	68.7	69.1	0.21
Median yield	253.5	6.00	5.24	11.24	0.53	69	58	127	62487	58.3	83.1	70.7	68.7	73.2	0.23
25% percentile	234.6	5.56	6.45	12.01	0.46	69	54	123	63037	58.7	84.2	71.4	68.7	74.9	0.25
Worst yield	202.4	4.79	5.15	9.94	0.48	69	50	119	57690	60.1	84.1	72.1	68.7	76.8	0.24
Long-term median	241.7	5.72	5.08	10.81	0.53	60	56	116	60945	60.6	84.8	72.7	72.0	73.4	0.25



Water tab. Unseasonably dry weather continues. No rain fell since June 17, but the frequent irrigations are simulated to have prevented crop water stress. Topsoil moisture is predicted to be increasing, whereas subsoil moisture is predicted to continue to decline, now also in the 2-3 ft depth.



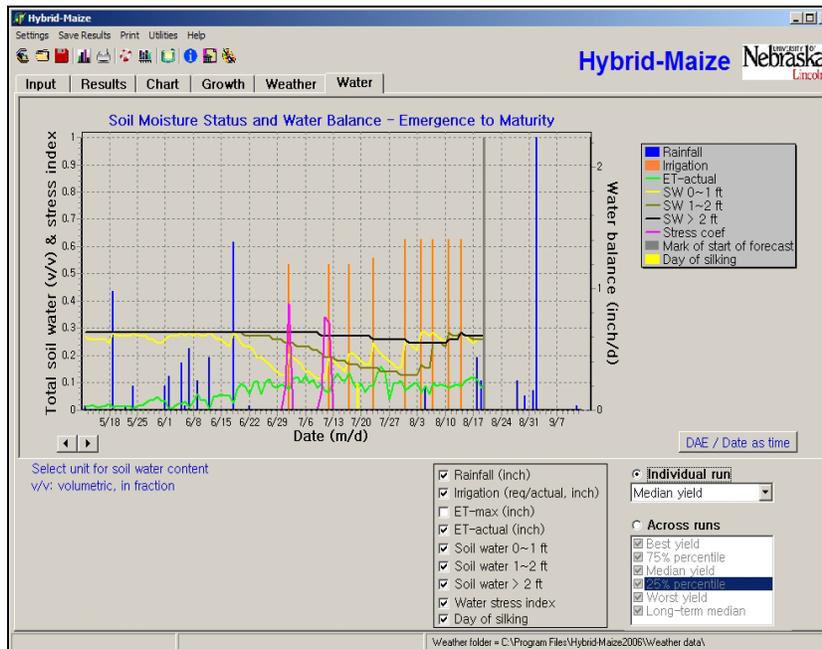
Growth tab. Actual biomass accumulation has approached the long-term median due to warmer than normal weather during the past three weeks. We are still on track for a normal or above normal yield, provided that sufficient water can be supplied. All scenarios suggest that maturity will be reached from 1 to 4 weeks later than normal (see 'V+R' column). Median forecasted yield potential has increased to 254 bu/acre, but the range of possibilities still remains quite large (202 to 309 bu/acre).

Simulation up to August 20, 2003, about R3 stage

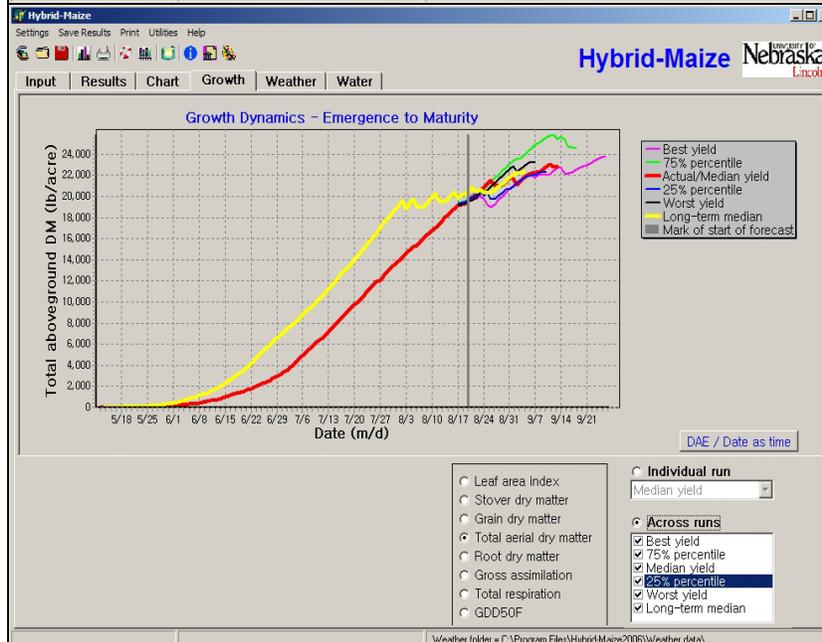
Five more irrigation events have occurred since July 30 (1.4 inches each) because it remained very dry. The weather file was downloaded on August 21. Other model inputs included date of emergence (May 12), the observed date of silking (July 19), and GDD to maturity (2700).

Real-time predictions of the current season

Rank	Gr.Y	Gr.DM	Stover	tDM	HI	vDays	rDays	V+R	tSola	Tmin	Tmax	Tmean	vTmean	rTmean	ETref
Best yield	285.2	6.75	5.17	11.92	0.57	69	70	139	66633	56.5	81.7	69.1	68.7	69.5	0.22
75% percentile	258.2	6.11	5.15	11.26	0.54	69	62	131	62573	57.6	82.6	70.1	68.7	71.8	0.21
Median yield	247.6	5.86	5.85	11.71	0.50	69	57	126	63001	58.0	83.8	70.9	68.7	73.6	0.24
25% percentile	238.1	5.64	5.50	11.14	0.51	69	54	123	60920	58.6	84.3	71.4	68.7	75.0	0.23
Worst yield	217.3	5.15	6.45	11.60	0.44	69	50	119	60356	59.3	85.2	72.2	68.7	77.2	0.24
Long-term median	241.7	5.72	5.08	10.81	0.53	60	56	116	60945	60.6	84.8	72.7	72.0	73.4	0.25



Water tab. Dry weather continues. Only traces of rain fell since June 17, but the frequent irrigations are simulated to have largely prevented crop water stress. Moisture is predicted to be increasing in all three depths to levels at the beginning of the growing season. We probably could have saved money by irrigating somewhat less.



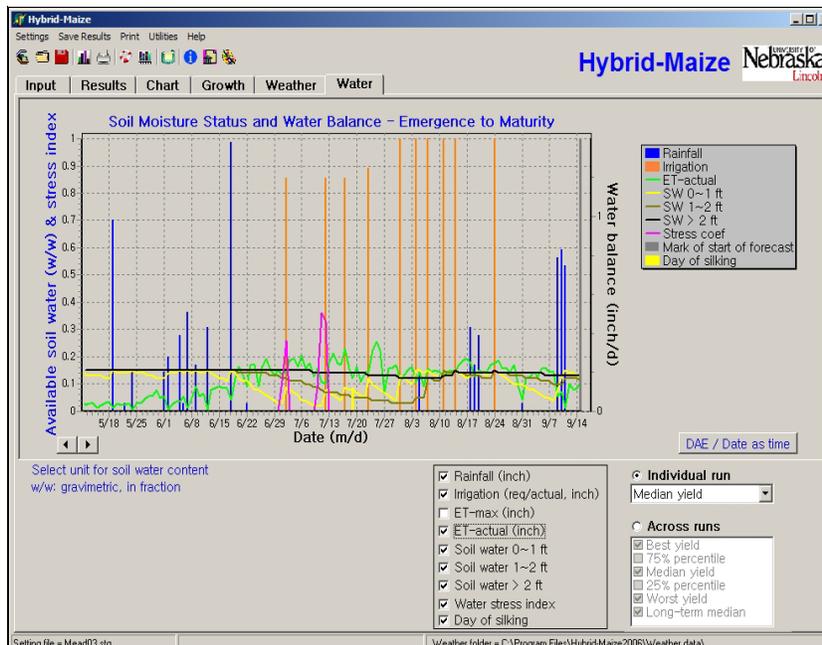
Growth tab. During the past three weeks, maximum temperature has largely been above normal (on 'Weather' tab, not shown here). Biomass accumulation is simulated to be slightly above the long-term median but still on track for a normal yield. All scenarios suggest that maturity will be reached from 1 to 3 weeks later than normal. Due to the hot, dry weather, median forecasted yield potential has decreased to 248 bu/acre and the range has narrowed to 217 to 285 bu/acre.

Simulation up to September 15, 2003, near physiological maturity (R6)

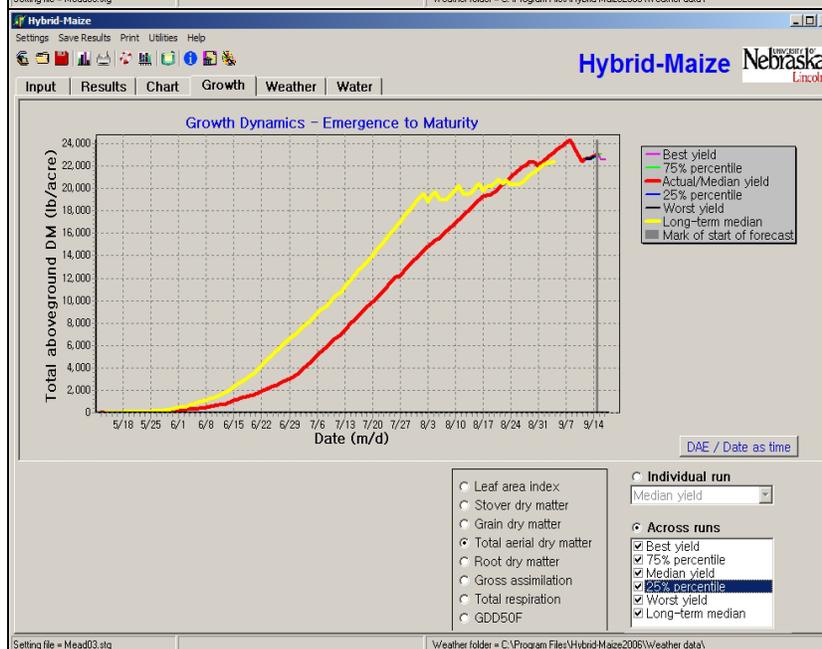
One final irrigation was applied on August 24. The weather file was downloaded on September 16. Other model inputs included date of emergence (May 12), the observed date of silking (July 19), and GDD to maturity (2630).

Real-time predictions of the current season

Rank	Gr.Y	Gr.DM	Stover	tDM	HI	vDays	rDays	V+R	tSola	Tmin	Tmax	Tmean	vTmean	rTmean	ETref
Best yield	255.4	6.05	5.63	11.67	0.52	69	61	130	64068	57.0	83.6	70.3	68.7	72.1	0.23
75% percentile	250.9	5.94	5.51	11.45	0.52	69	59	128	63158	57.4	83.9	70.6	68.7	72.9	0.23
Median yield	250.4	5.93	5.23	11.16	0.53	69	59	128	62786	57.4	83.8	70.6	68.7	72.8	0.23
25% percentile	249.8	5.92	5.31	11.22	0.53	69	59	128	62826	57.4	83.7	70.6	68.7	72.8	0.23
Worst yield	248.8	5.89	5.67	11.57	0.51	69	59	128	63206	57.2	83.8	70.5	68.7	72.7	0.23
Long-term median	241.7	5.72	5.08	10.81	0.53	60	56	116	60945	60.6	84.8	72.7	72.0	73.4	0.25



Water tab. A period of hot, dry weather in late August was followed by cooler weather in September, favoring grain filling. Water supply is simulated to have kept pace with crop demand. A total of 11 inches of irrigation water was applied during the growing season.



Growth tab. All scenarios suggest that maturity will be reached within the next 1 to 3 days. Median forecasted yield potential is 250 bu/acre, ranging from 249 to 255 bu/acre.

For comparison, measured final yield in a field experiment treatment that exactly represented the crop management followed in this real-time simulation was 251 bu/acre.