2003

Growing Corn in a Computer: The Hybrid Hybrid-Maize Simulation Model and its Application to Production Agriculture

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[2003]

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The Hybrid-Maize Simulation Model and its Application to Production Agriculture

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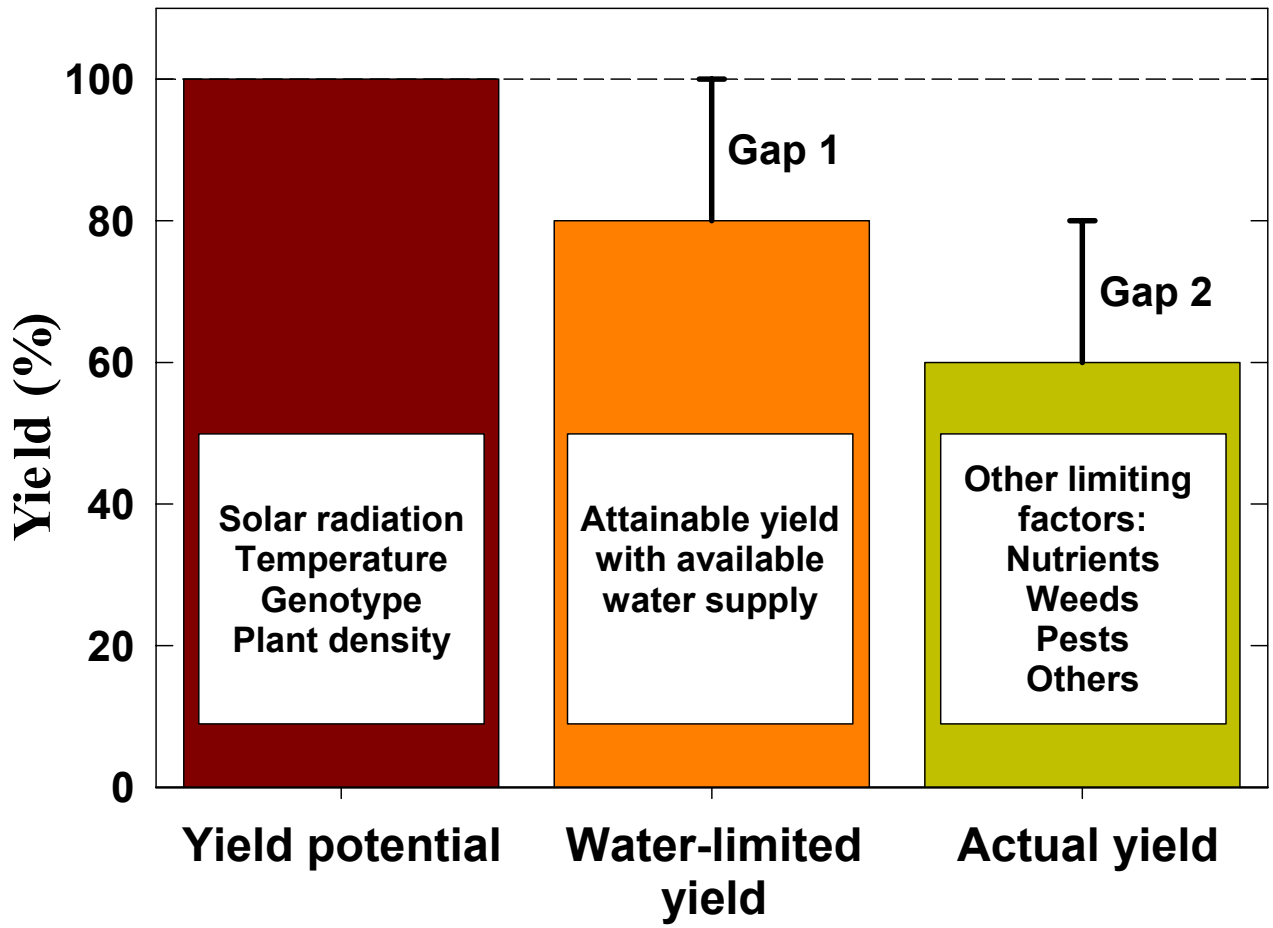
Outline

1. Definition of yield potential and yield gaps
2. Hybrid-Maize – model description and validation
3. Potential applications of Hybrid-Maize in corn management

Yield potential and yield gaps



To achieve yield potential of an environment:

- Utilize the entire growing season (= optimal planting date and variety choice)
- Optimize plant population
- Grow the crop with minimal possible abiotic and biotic stresses (nutrients, water, pests)

Hybrid-Maize model

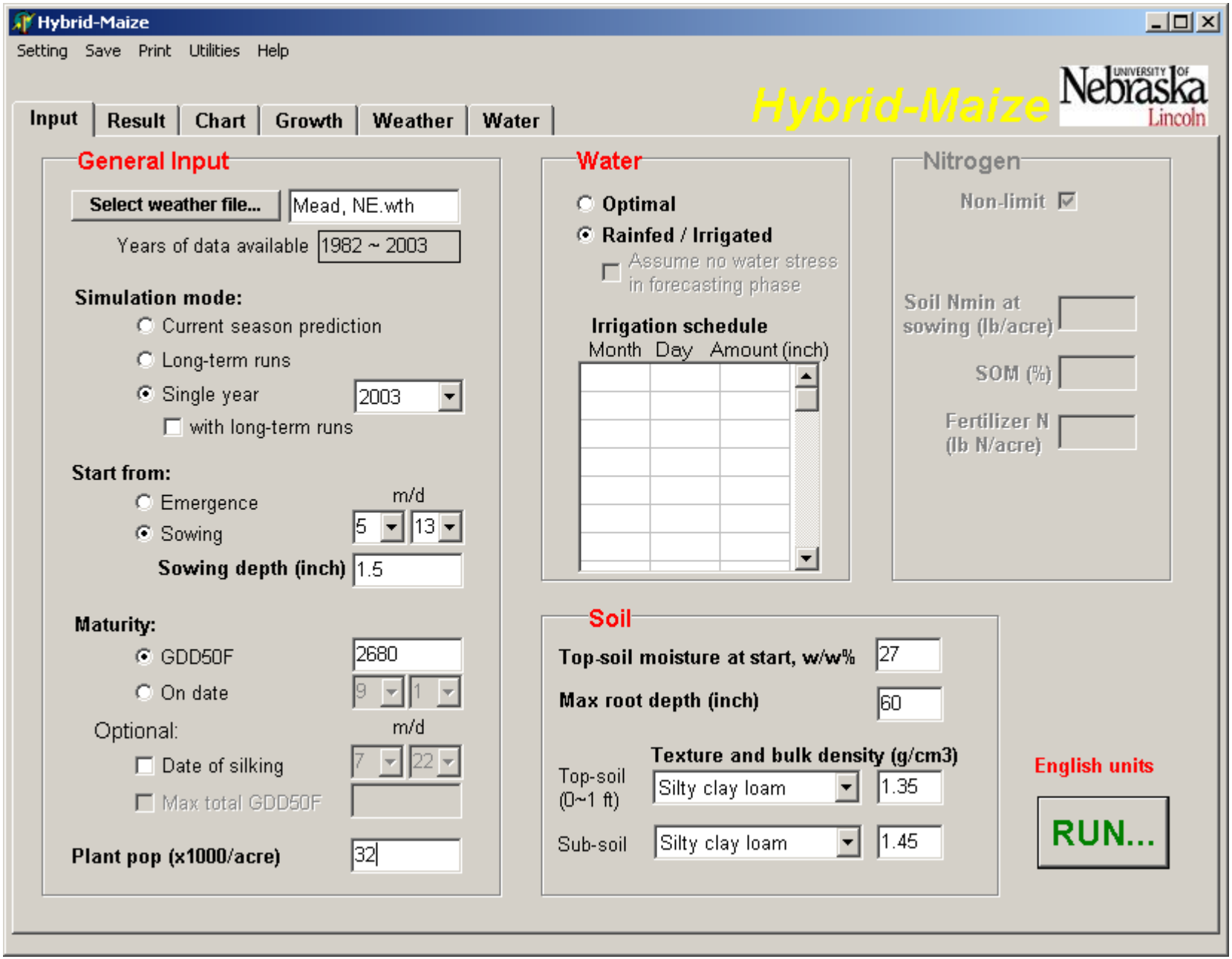
- Corn specific. Simulates growth and development of corn driven by light interception and temperature.
- Simulates corn yield potential and water-limited attainable yield. Nitrogen component is in work.
- Sources: Ceres-Maize, INTERCOM, own components & modifications.
- Predicts date of silking based on GDD for a corn hybrid.
- Allows simulating single growing seasons or long-term climate data.
- Easy import of online weather data.

Authors: H. Yang, A. Dobermann, K. Cassman, J. Lindquist, T. Arkebauer, D. Walters (UNL).

Hybrid-Maize model

Input data

- Daily weather (solar radiation, max. and min. T, rainfall)
- Crop management (date of planting, GDD for hybrid, plant density, sowing depth)
- For simulating water-limited yield: max. rooting depth, texture class and bulk density in topsoil and subsoil)
- Optional: change model parameters (model uses default values, but those can be changed)
  - Hybrid-specific crop coefficients
  - Soil physical properties for different soil texture classes
  - General model coefficients describing crop growth and development


Hybrid-Maize
Setting Save Print Utilities Help
Hybrid-Maize
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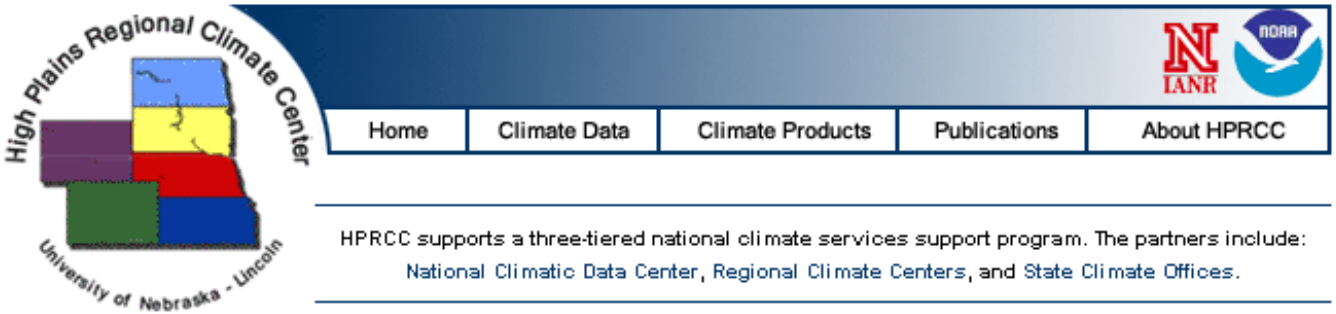
Input Result Chart Growth Weather Water
General Input
Select weather file...
Mead, NE.wth
Years of data available
1982 ~ 2003
Simulation mode:
Current season prediction
Long-term runs
Single year
2003
with long-term runs
Start from:
m/d
Emergence
Sowing
5
13
Sowing depth (inch)
1.5
Maturity:
GDD50F
2680
On date
9
1
Optional:
m/d
Date of silking
7
22
Max total GDD50F
Plant pop (x1000/acre)
32
Water
Optimal
Rainfed / Irrigated
Assume no water stress in forecasting phase
Irrigation schedule
Month Day Amount (inch)
Nitrogen
Non-limit
Soil Nmin at sowing (lb/acre)
SOM (%)
Fertilizer N (lb N/acre)
Soil
Top-soil moisture at start, w/w%
27
Max root depth (inch)
60
Texture and bulk density (g/cm3)
Top-soil (0~1 ft)
Silty clay loam
1.35
Sub-soil
Silty clay loam
1.45
English units
RUN...



Quick Links

- Climatic Impacts in the High Plains
- Southwestern U.S Drought of 2002
- HPRCC Archive of NWS Stations
- Automated Weather Stations Information
- Nebraska Weather and Climate Information
- Lincoln, NE Weather and Climate Information

About HPRCC

(mission, objectives, activities, highlights, personnel)

Climate Data

(online, full service, AWDN, NWS, digital, hardcopy)

Climate Products

(current maps , normals, atlas, historical, national)

Research Projects

(NE soil moisture, crop coefficients, wind energy)

Publications

(articles, books, reports, extension)

Weather and Climate Links

(state climatologists, government, education)

High Plains Regional Climate Center
University of Nebraska
236 L.W. Chase Hall, Lincoln, NE 68583-0728
Phone : 402-472-6706, Fax : 402-472-6614

www.hprcc.unl.edu

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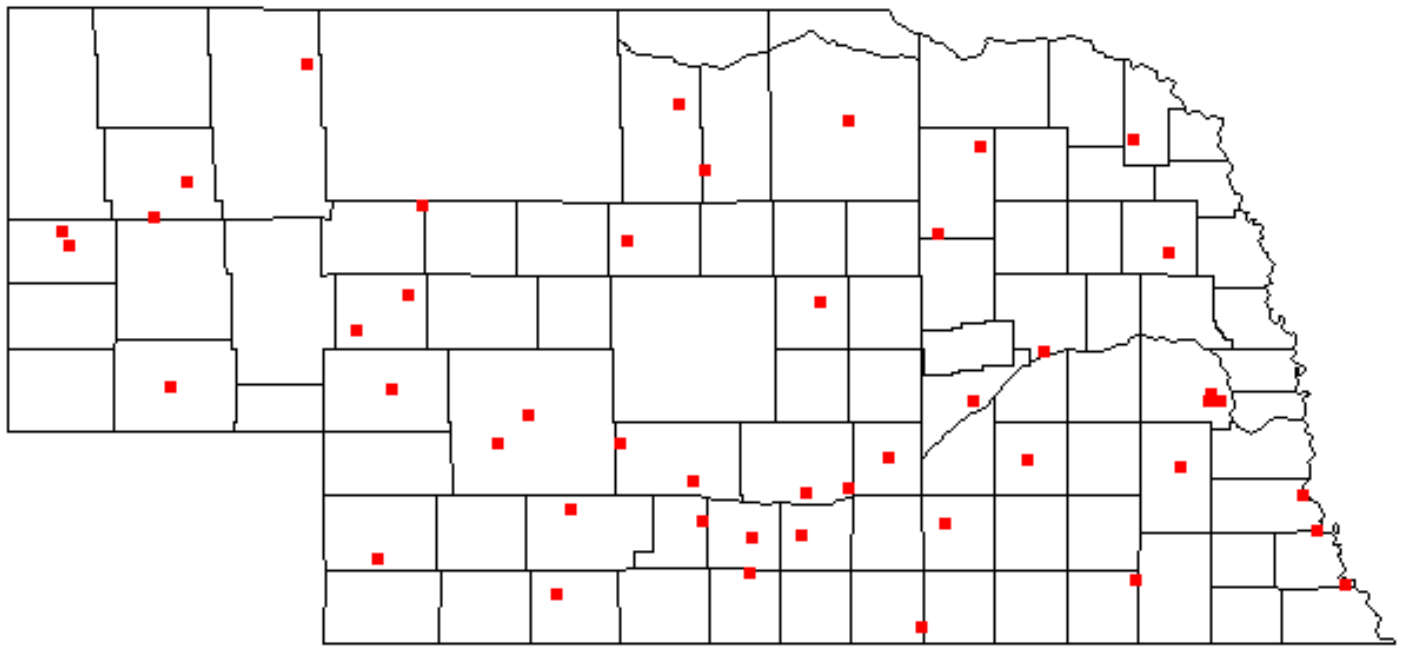
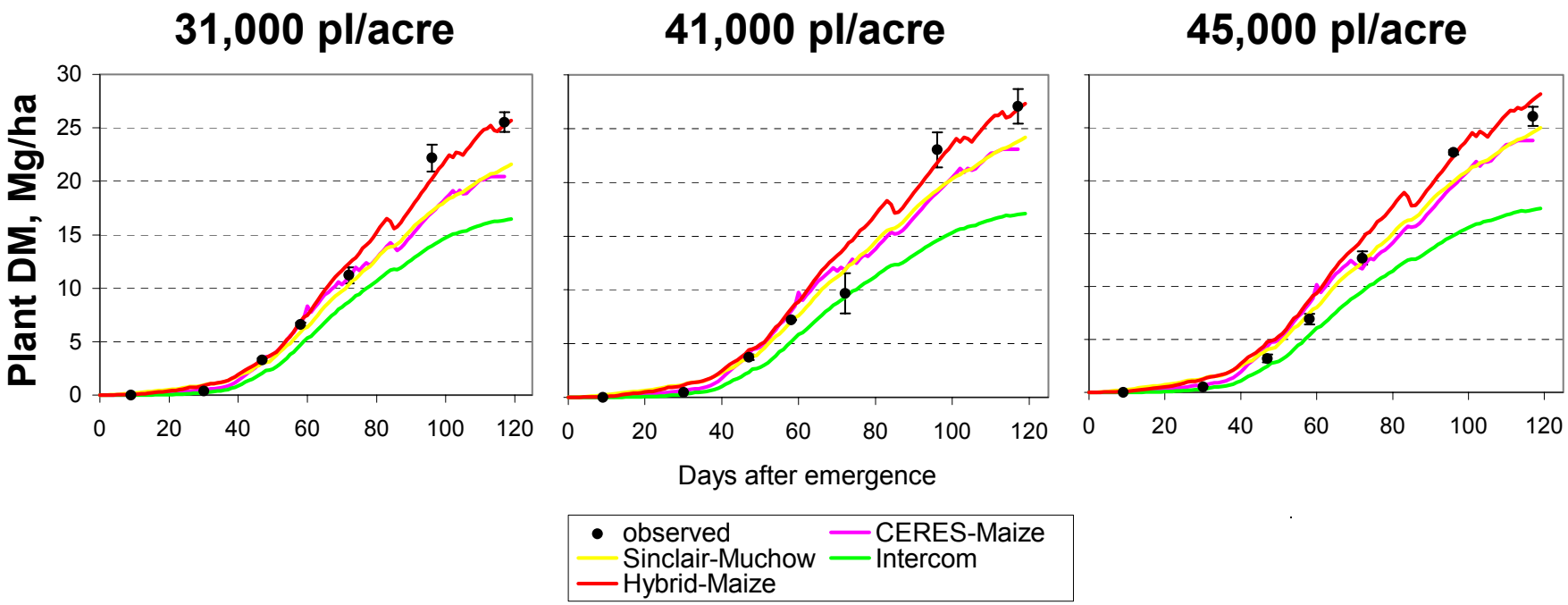
Select a station by placing the mouse cursor over a square and clicking.
Alternatively, use the table below to find a station.

Location: Move mouse over a station.



Location: Move mouse over a station.

Hybrid-Maize validation



Lincoln, NE, high-yield experiment, corn after soybean, intensive nutrient management, 2001.

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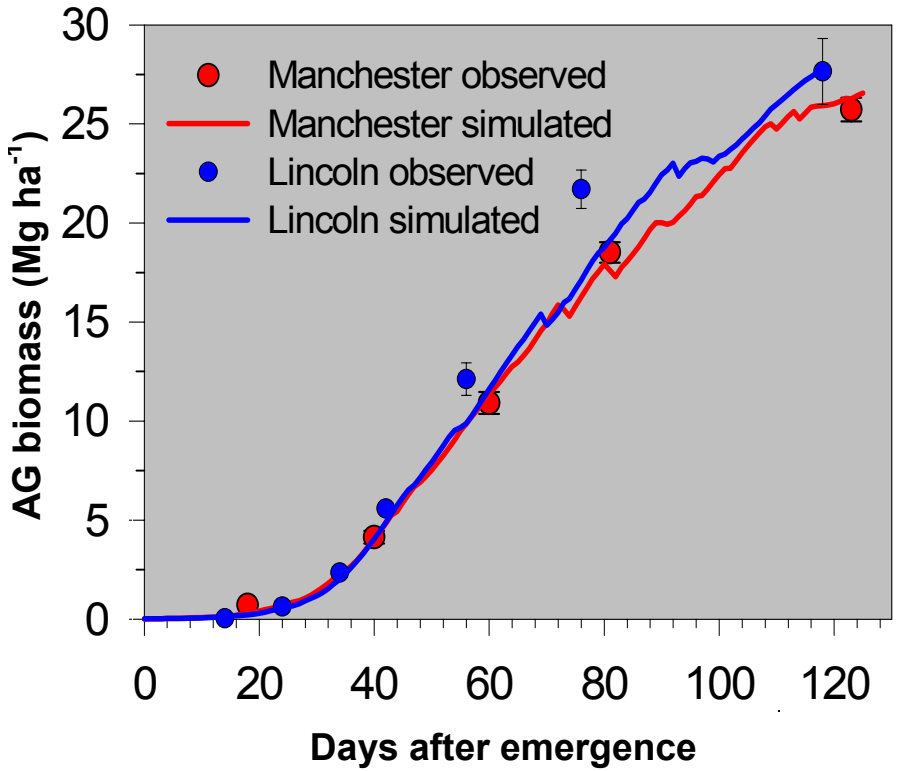
Hybrid-Maize validation



Total aboveground crop biomass growing season.
Manchester: Francis Childs farm, 2002, Pioneer 33P67, 34,000 plants/acre
Lincoln: High-yield experiment, 2002, Pioneer 33P67, 38,000 plants/acre

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Hybrid-Maize validation

Crop model	Grain	Stover	Total biomass	HI
	---------- Mg dry matter/ha ----------			
Measured	13.2	13.2	26.4	0.50
Ceres-Maize	12.4	11.0	23.4	0.53
Muchow-Sinclair	11.4	11.4	22.8	0.50
Intercom	9.7	9.0	18.7	0.52
Hybrid-Maize	13.1	13.2	26.3	0.50

Lincoln, NE, high-yield experiment, corn after soybean, 37,000 plants/acre, intensive nutrient management, averages of 1999-2001.

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Hybrid-Maize validation

Location	Manchester	Lincoln	Mead	C. Center
Plant density (plants/acre)	34,000	38,000	27,000	33,000
Simulated grain yield (bu/acre)	282	280	268	274
Measured grain yield (bu/acre)	248	242	247	266
Simulated total dry matter (lbs/acre)	24400	24700	23000	23600
Measured total dry matter (lbs/acre)	23000	24700	22100	23900

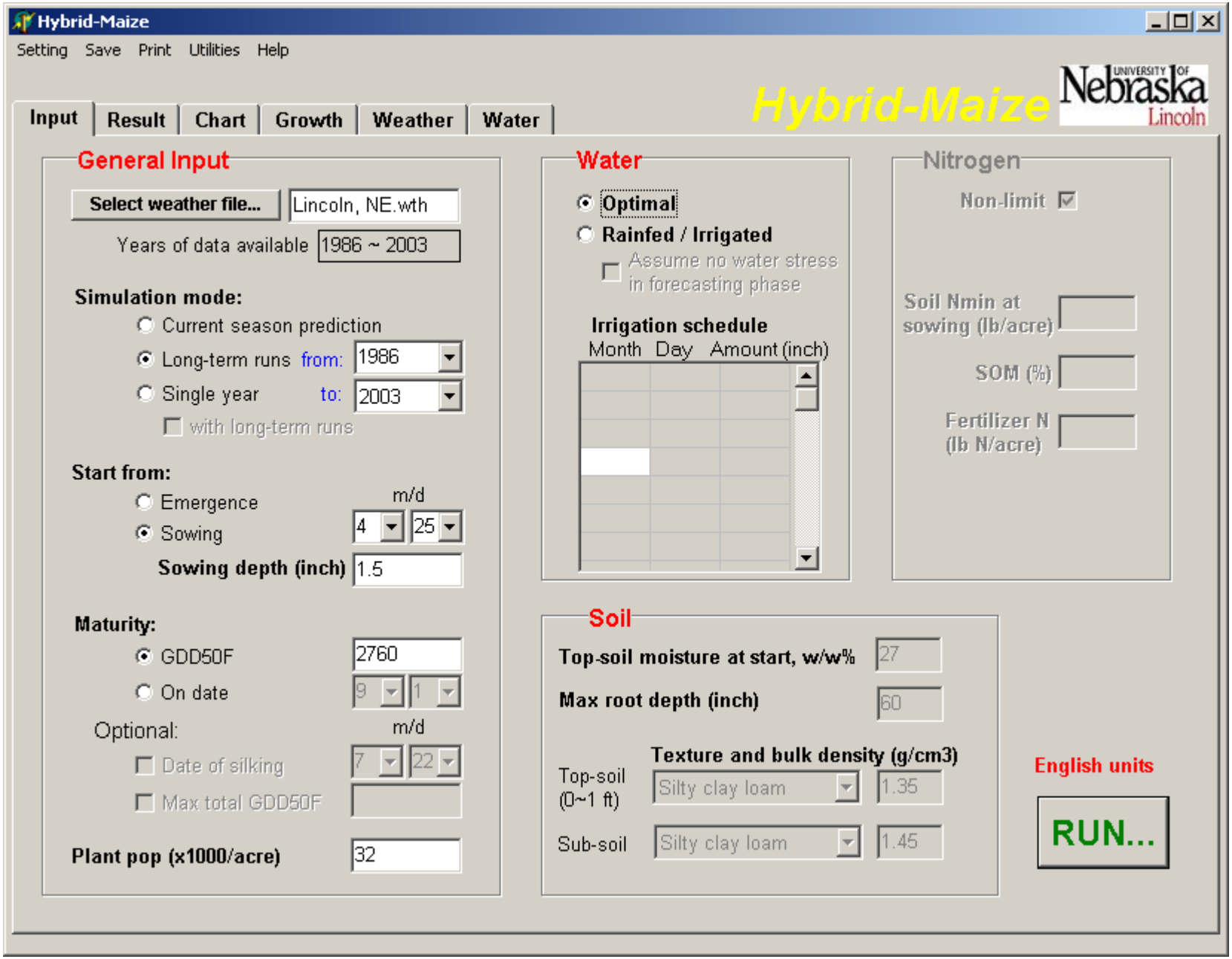
Manchester: Francis Childs farm, 2002, Pioneer 33P67, rainfed
Lincoln: High-yield experiment, 2002, Pioneer 33P67, drip-irrigated
Mead: NSFP trial, 2002, Pioneer 33P67, sprinkler-irrigated
Clay Center: NSFP trial, 2002, Pioneer 33P67, furrow-irrigated

Potential applications

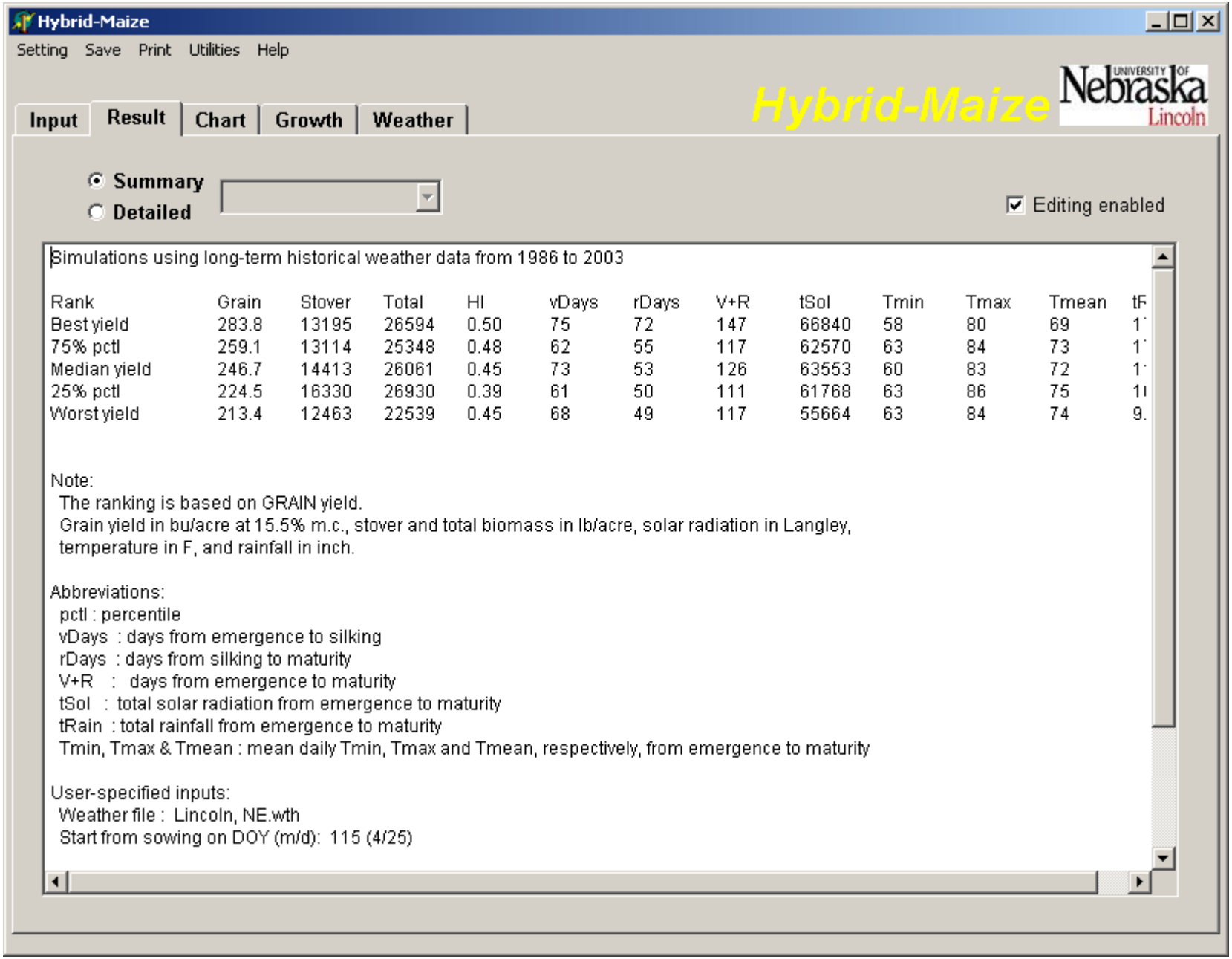
Using historical, long-term climate data for a site:

- Assess long-term yield potential and its variation among years (irrigated and non-irrigated).
- Assess change in yield potential due to varying planting date, hybrid choice, or plant density.
- Post-harvest analysis: what happened?

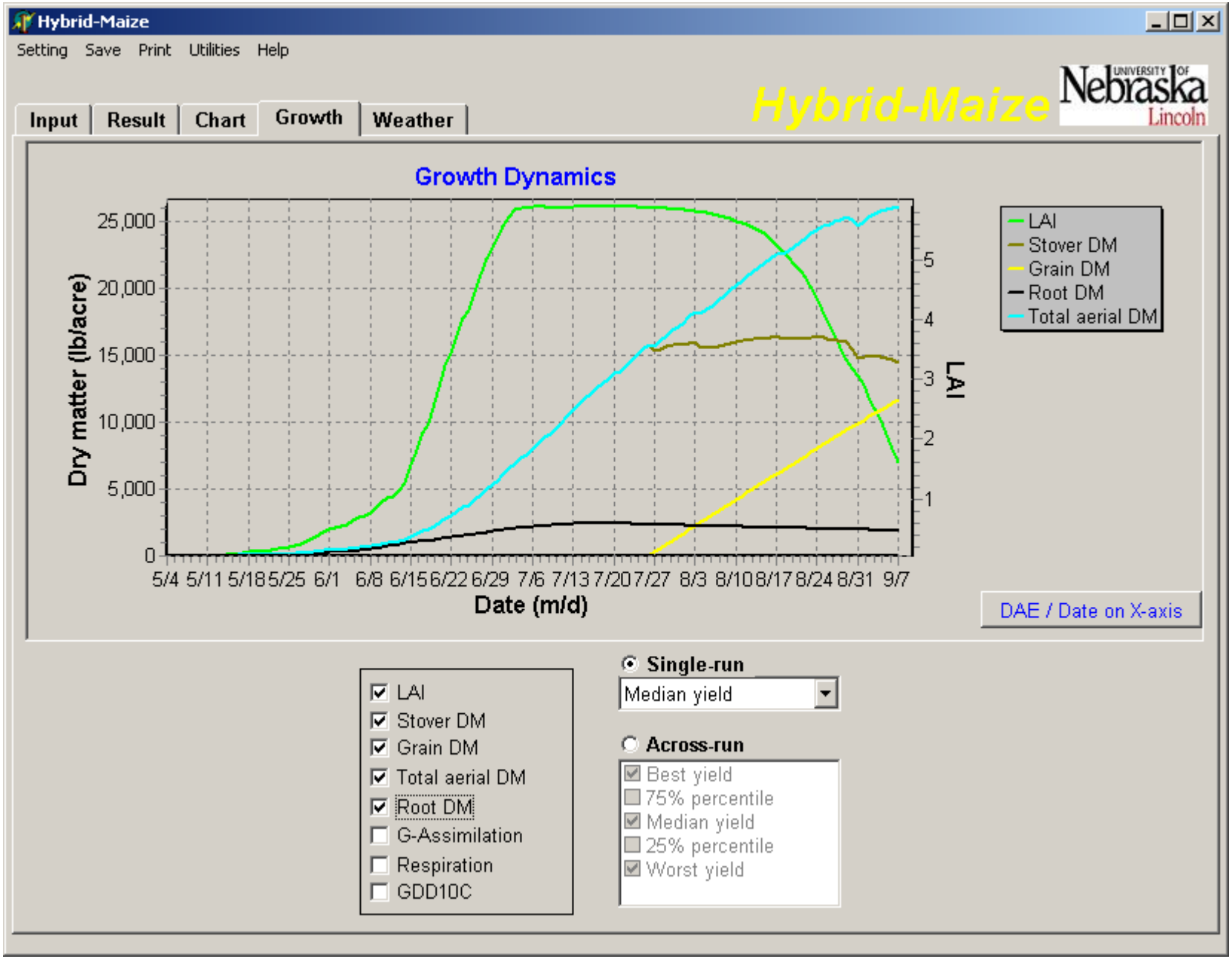
- Management decisions:
  - → set adequate yield goals
  - → determine optimal planting date (window)
  - → identify most suitable varieties/hybrids
  - → determine optimal plant density
  - → evaluate economics and risks of various scenarios.



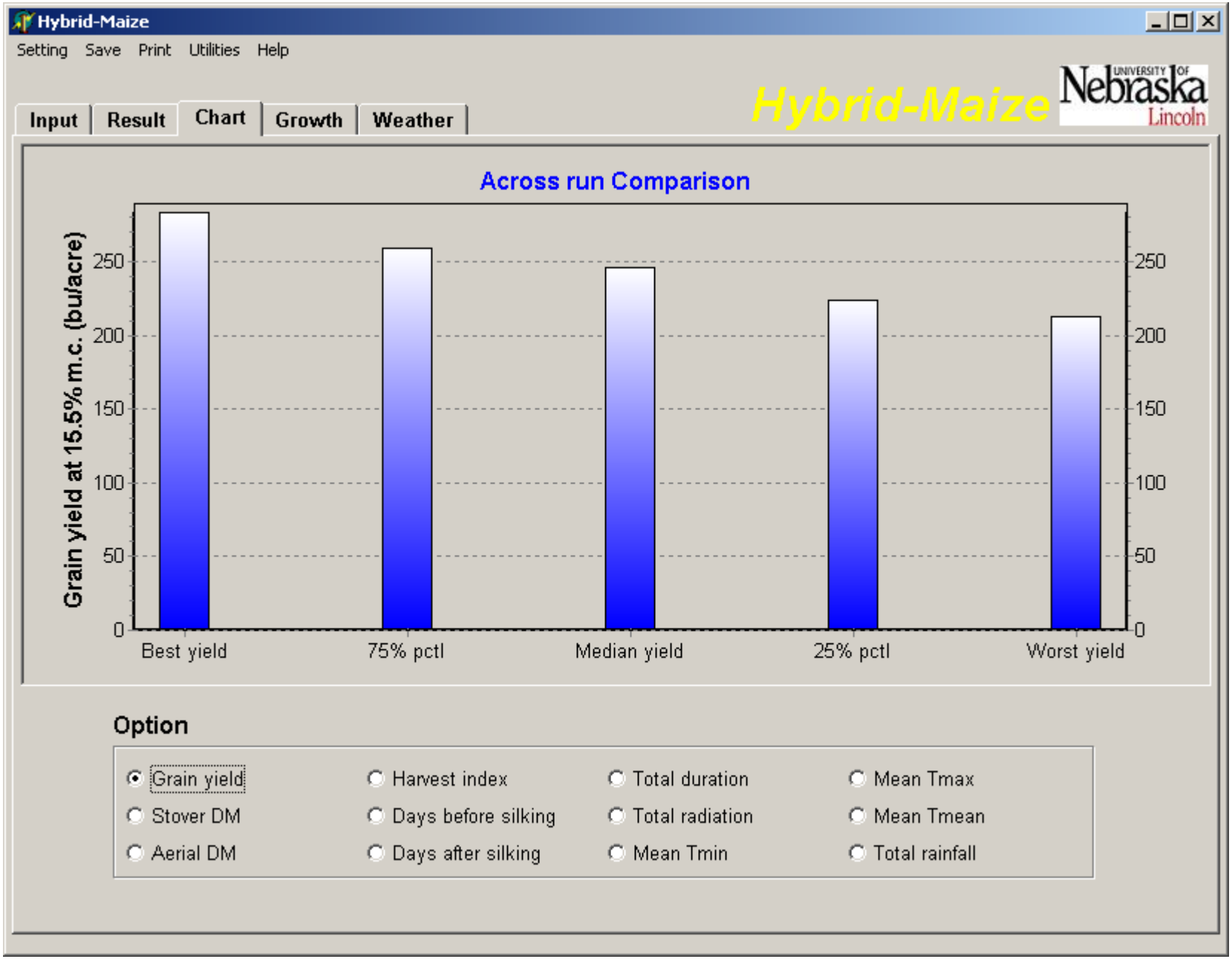
Irrigated corn at Lincoln, 114 d hybrid, Planted April 25



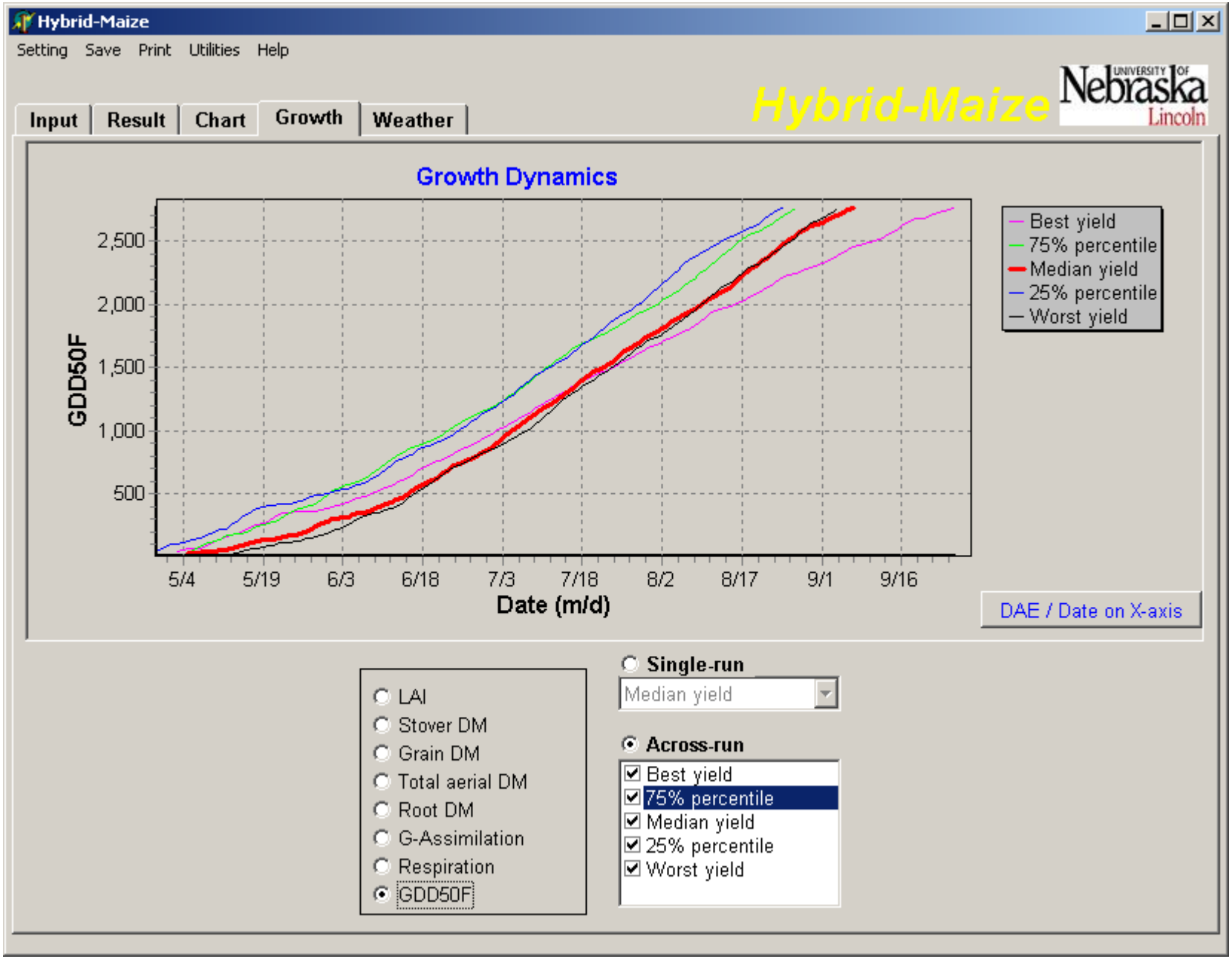
Irrigated corn at Lincoln, 114 d hybrid, Planted April 25



Irrigated corn at Lincoln, 114 d hybrid, Planted April 25



Irrigated corn at Lincoln, 114 d hybrid, Planted April 25



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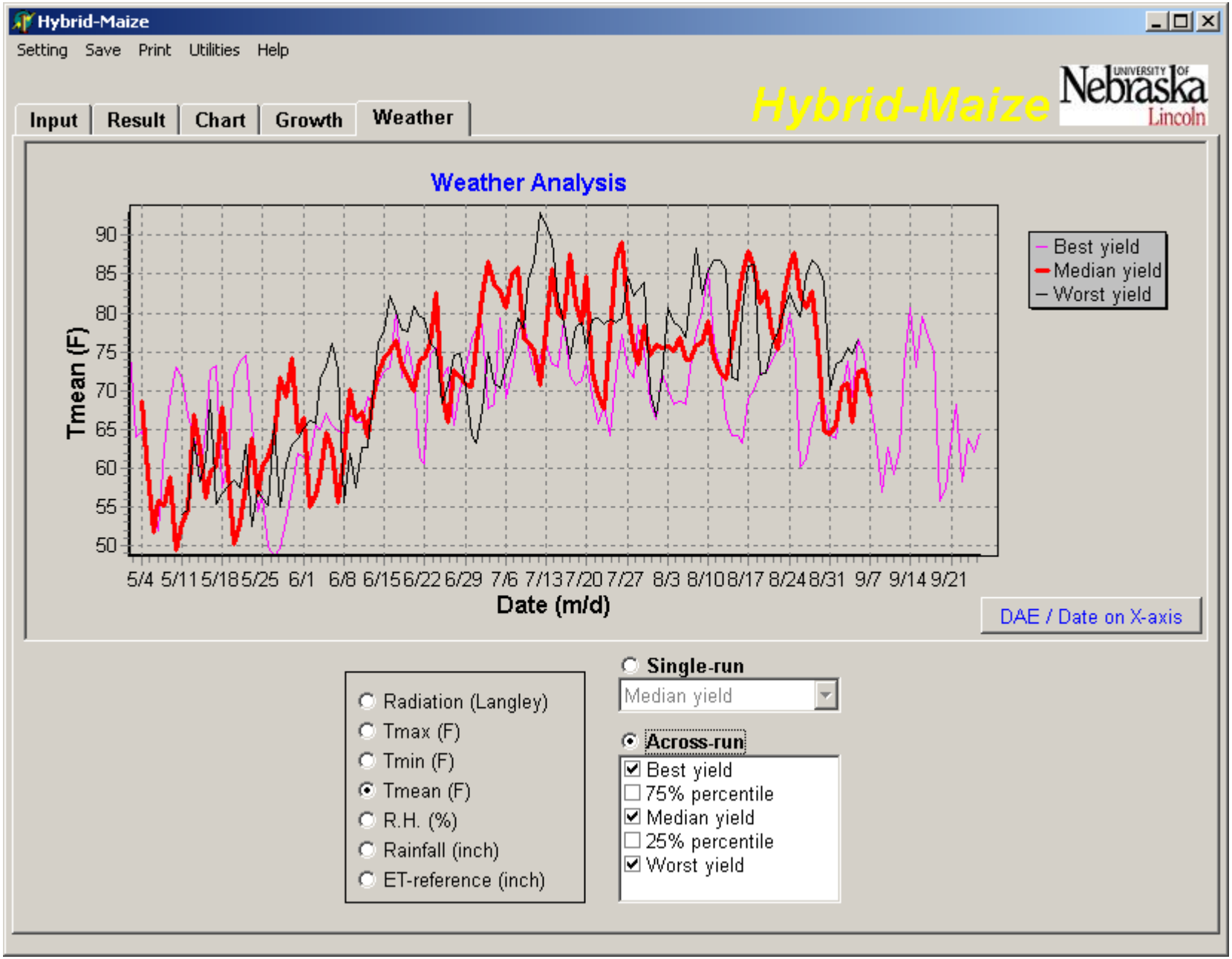

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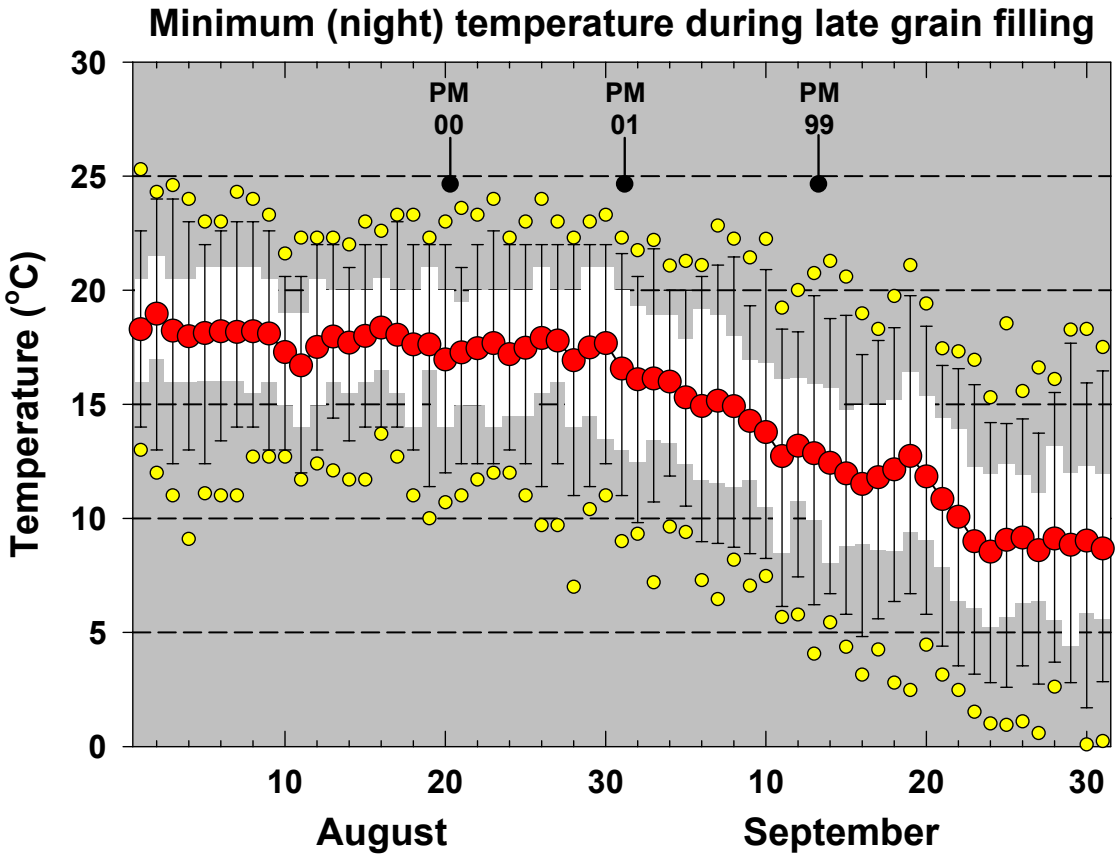
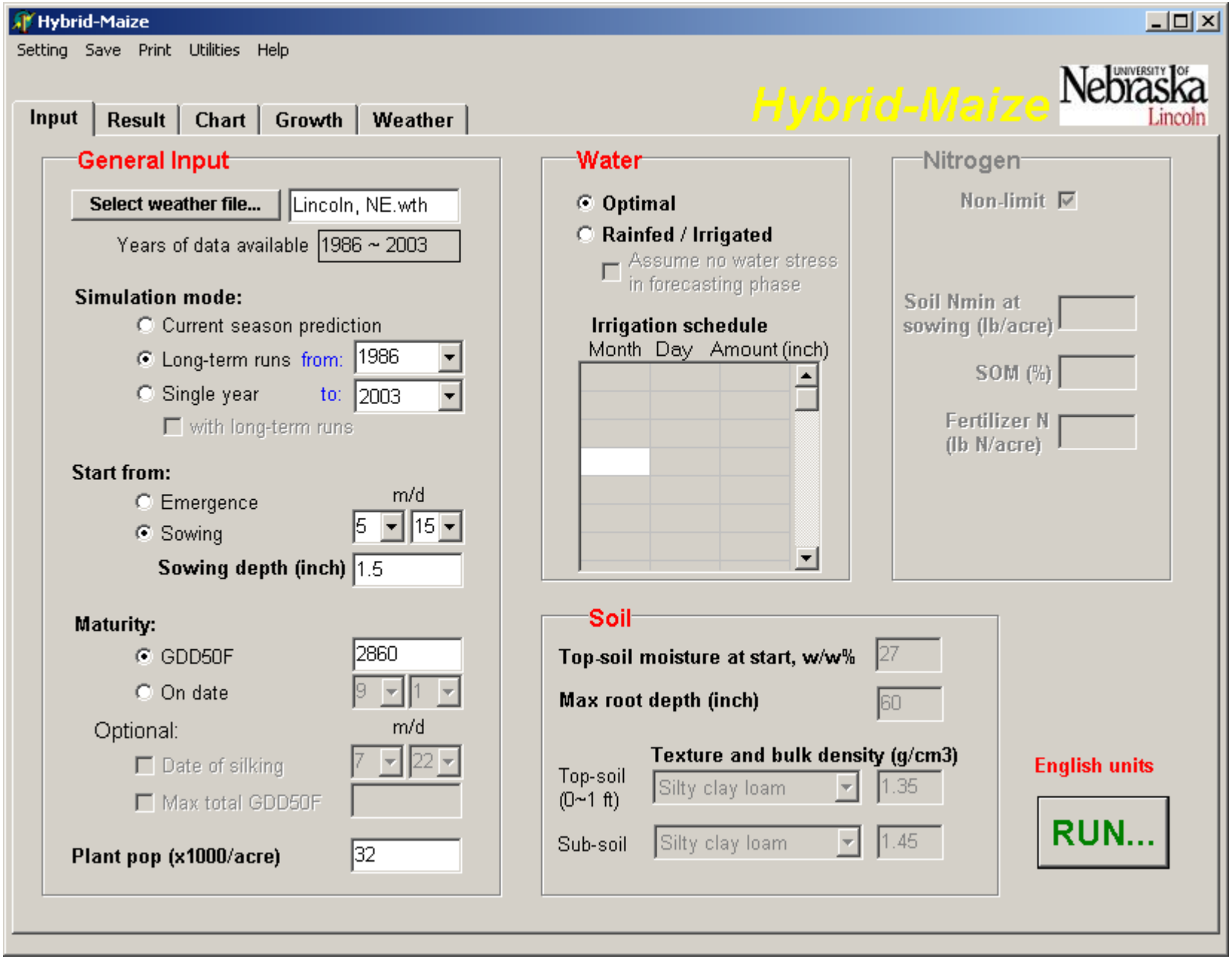


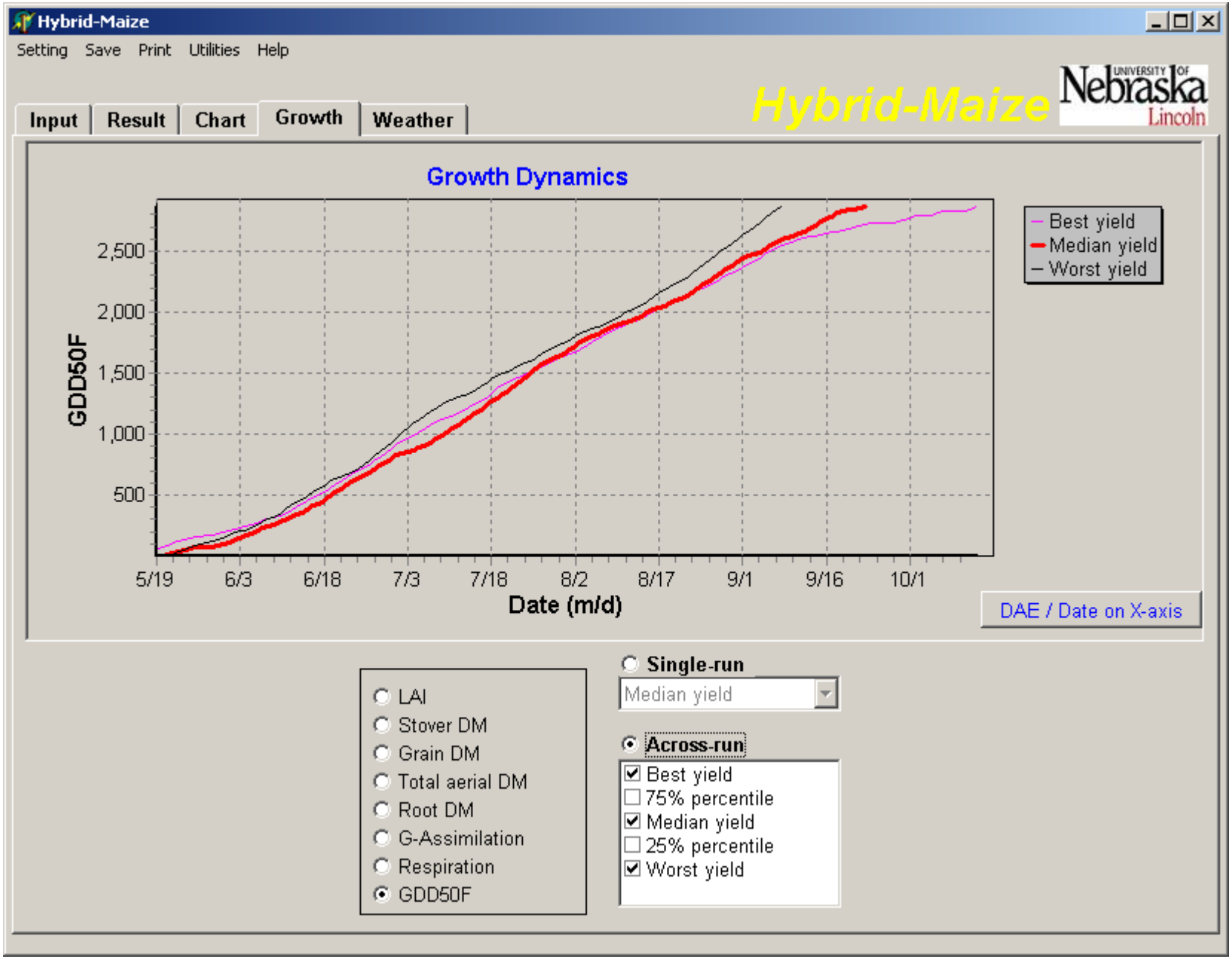
Lincoln, NE, based on long-term climate. At this site, high night temperatures during grain filling may cause early maturity of corn. Delaying planting or choosing a longer season hybrid could move grain filling into a period with lower night temperatures.

Can we exploit more yield potential at this site by shifting the grain filling to a cooler period?

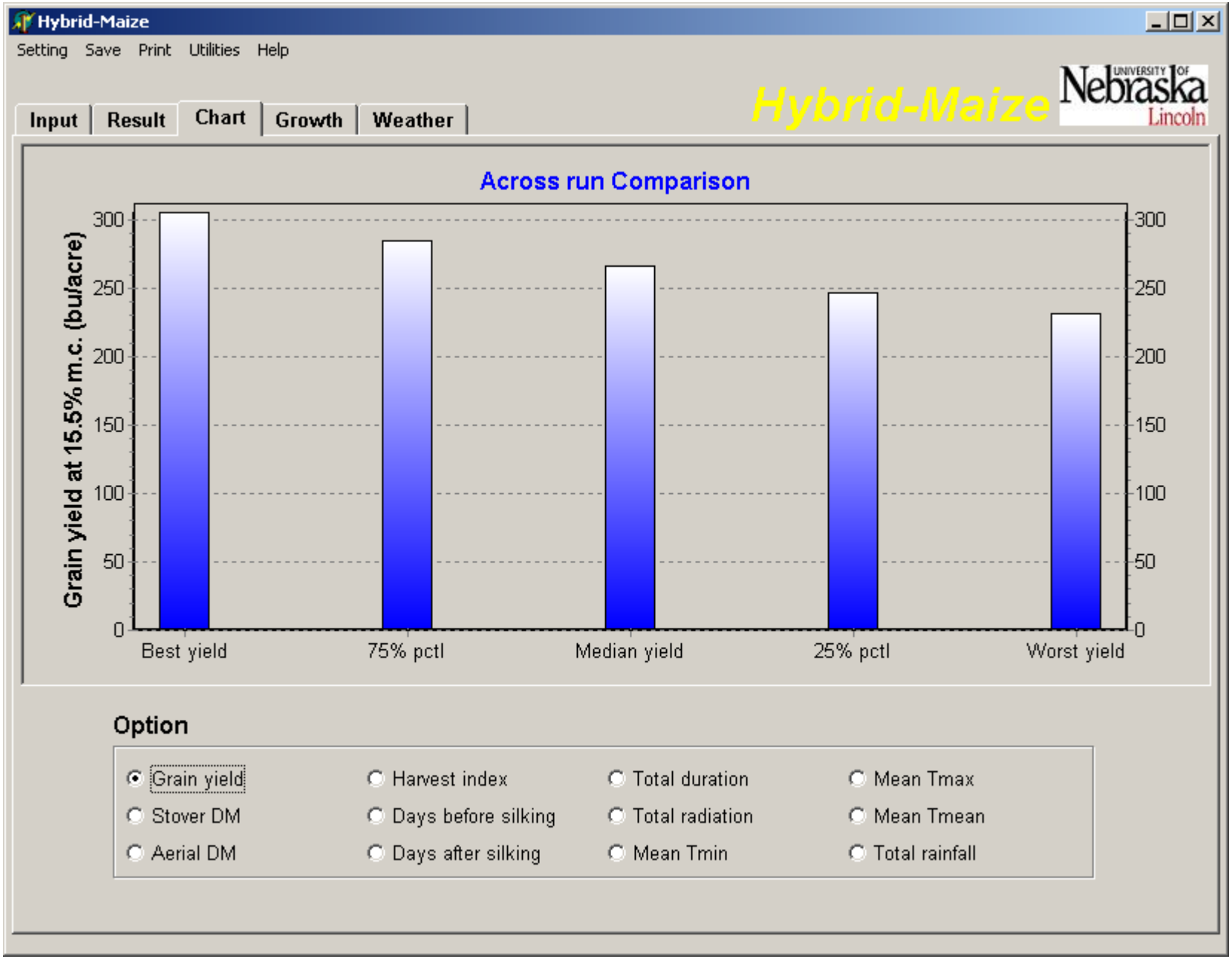
→ plant a full-season hybrid 2-3 weeks later than normal



Irrigated corn at Lincoln, 119 d hybrid, Planted May 15



Irrigated corn at Lincoln, 119 d hybrid, Planted May 15



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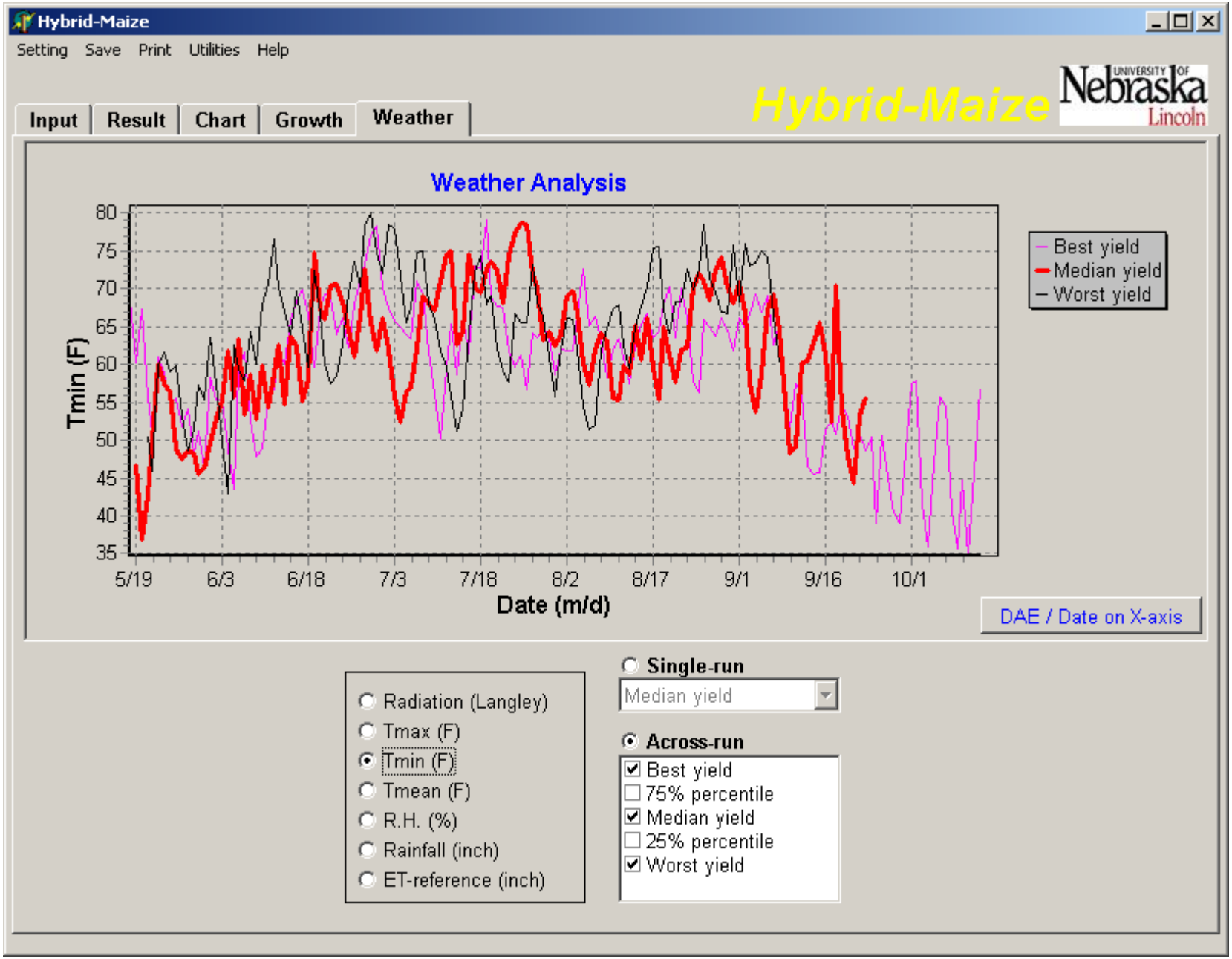

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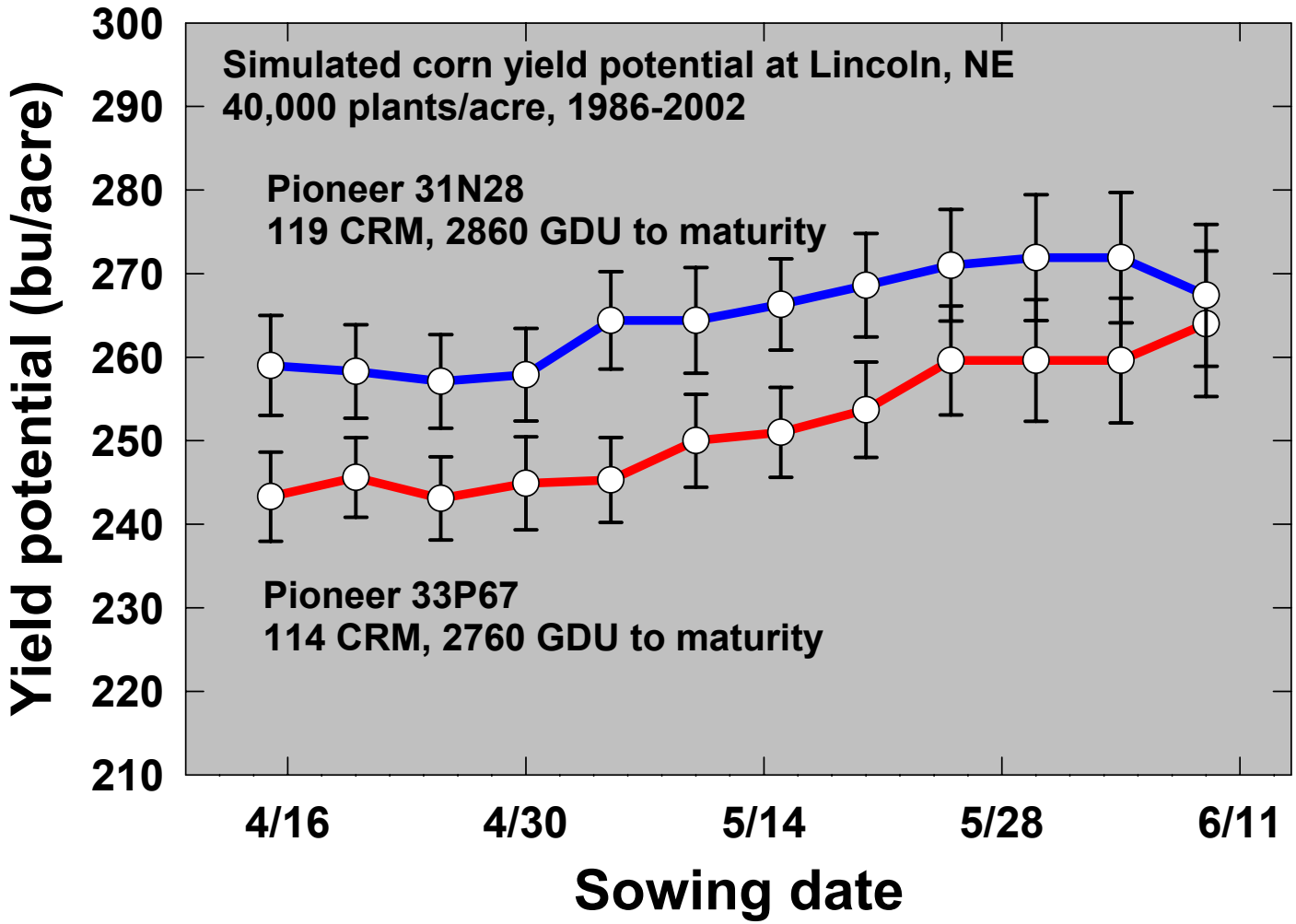
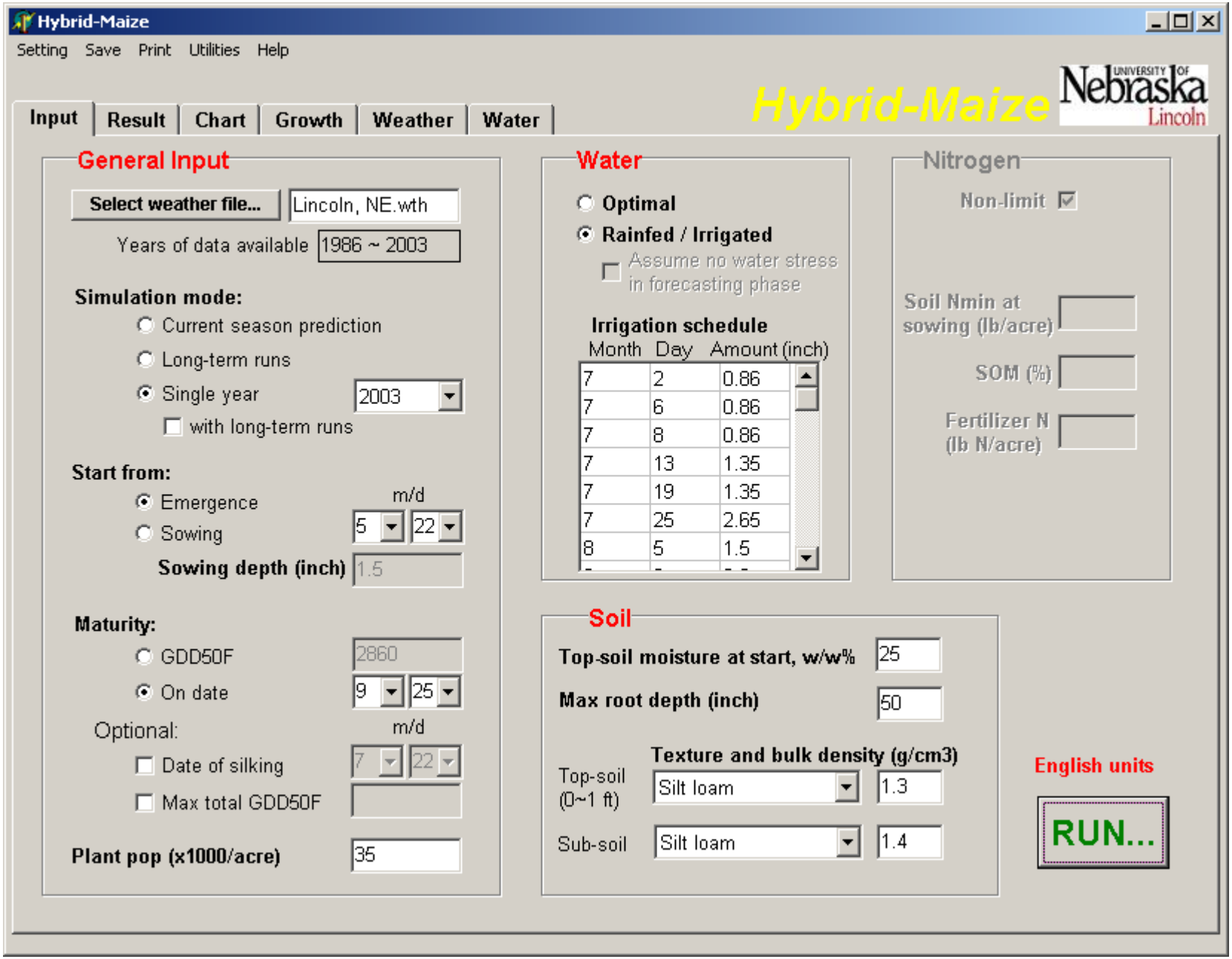

Simulated corn yield potential at Lincoln, NE
40,000 plants/acre, 1986-2002
Pioneer 31N28
119 CRM, 2860 GDU to maturity
Pioneer 33P67
114 CRM, 2760 GDU to maturity
Yield potential (bu/acre)
300
290
280
270
260
250
240
230
220
210
4/16
4/30
5/14
5/28
6/11
Sowing date

El Lincoln, NE: 2003 Yields

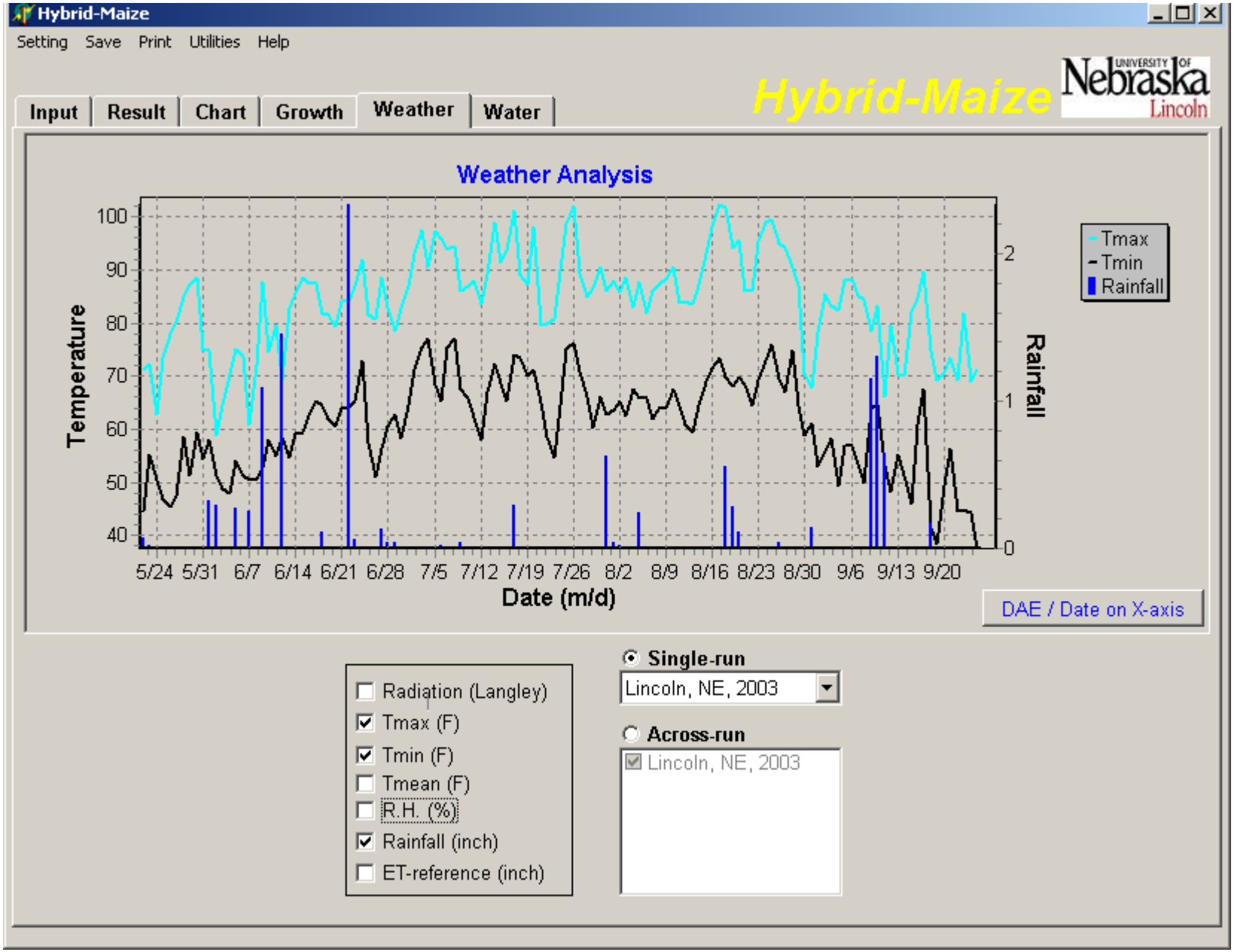
	Predicted	Actual
Silking date	23-Jul	22-Jul
Grain yield (bu/acre)	287.2	285.3

Lincoln, NE, 2003

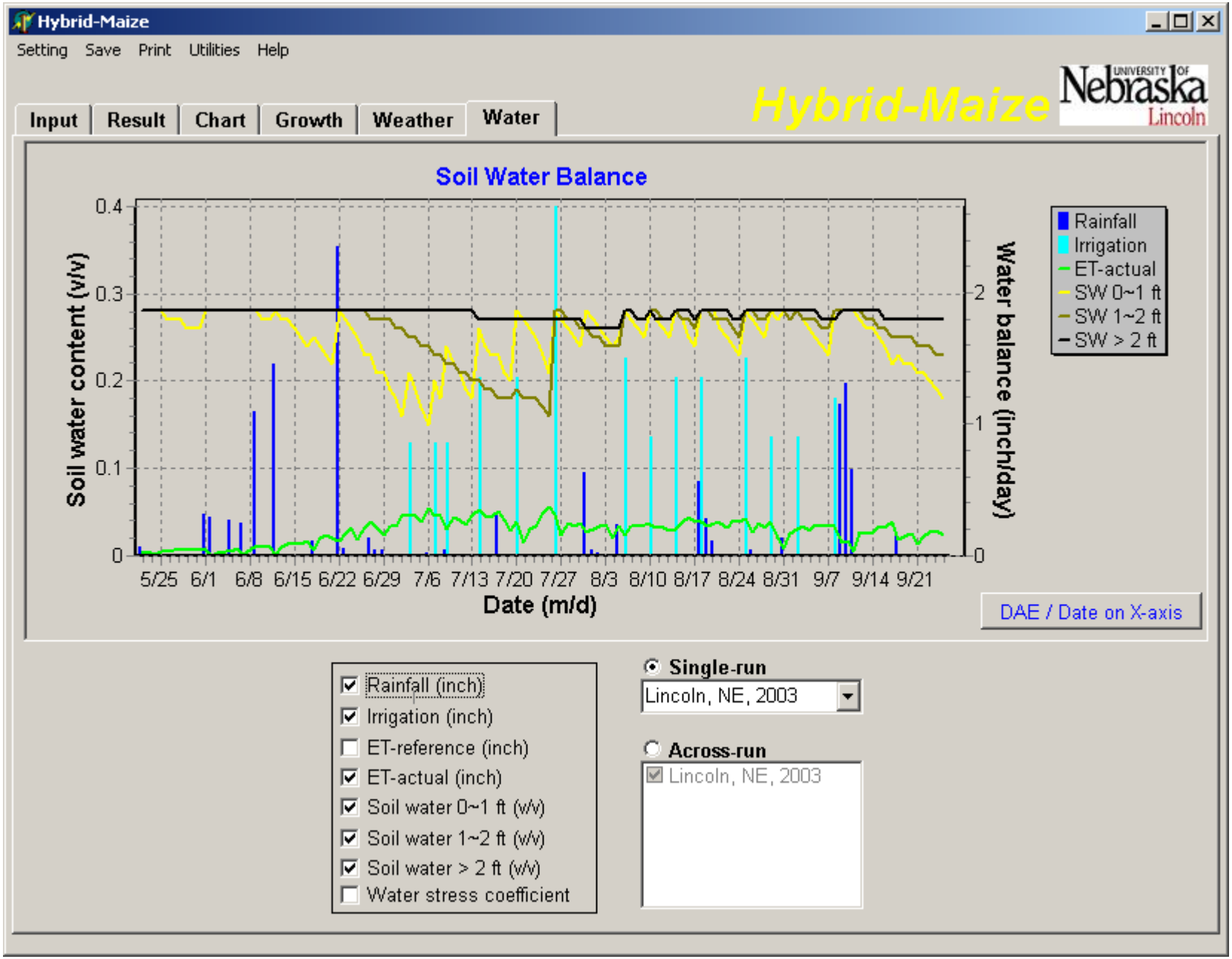
Treatment:	CS-P2-M2
Hybrid:	31N28 (119 d)
Plant density:	35,000 plants/acre
Planting:	13-May
Emergence:	22-May
Maturity:	25-Sep



Irrigated corn at Lincoln, 2003, Pioneer 31N28, Planted May 13



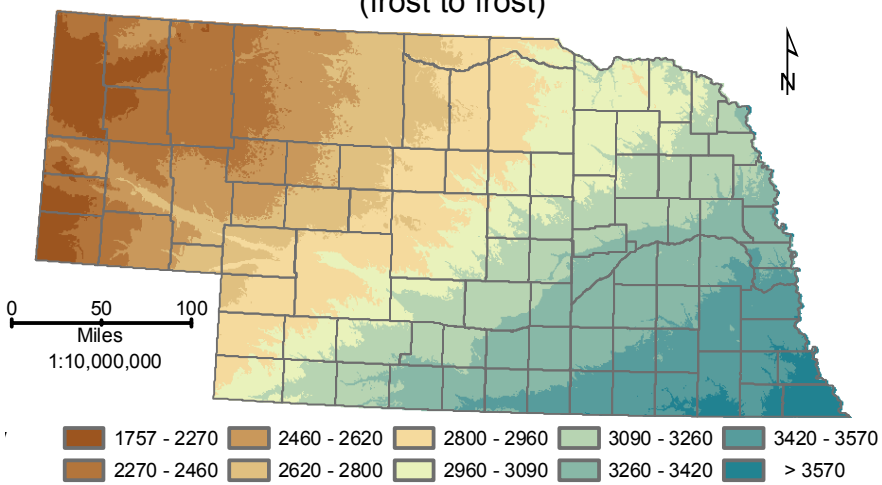
Irrigated corn at Lincoln, 2003, Pioneer 31N28, Planted May 13



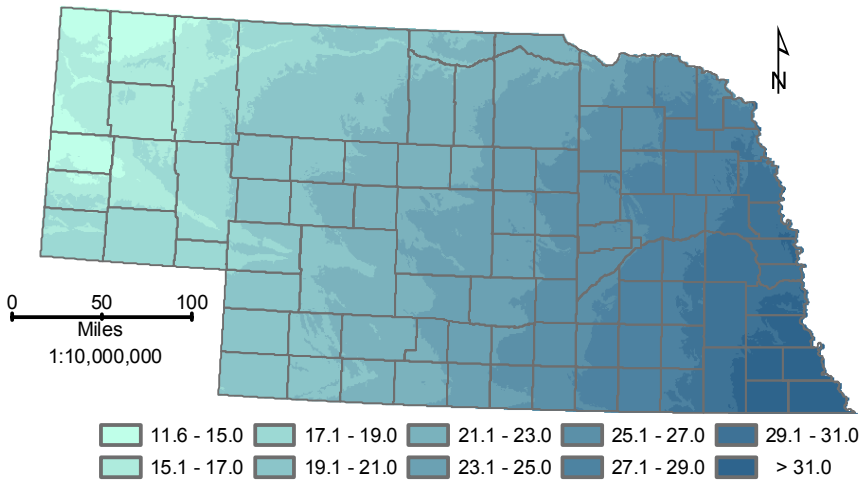
Irrigated corn at Lincoln, 2003, Pioneer 31N28, Planted May 13

What determines spatial variation in corn yield potential in Nebraska?

Mean Annual Growing Degree-Days
(frost to frost)



Mean Annual Precipitation (in)



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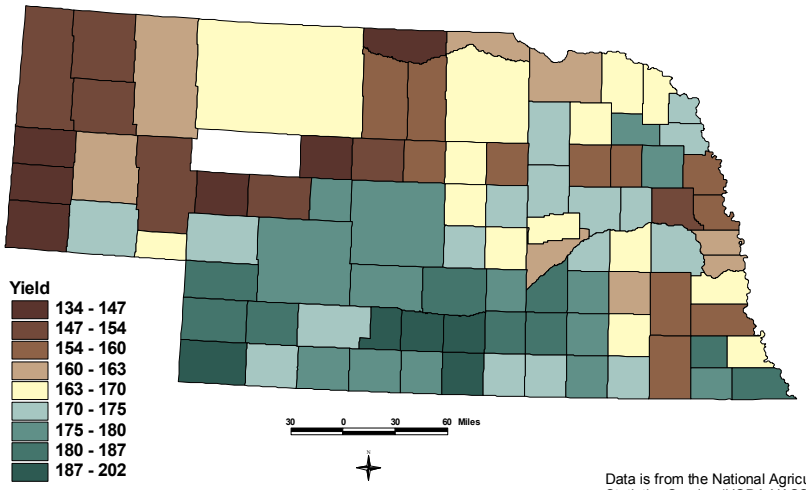
What determines spatial variation in corn yield potential in Nebraska?

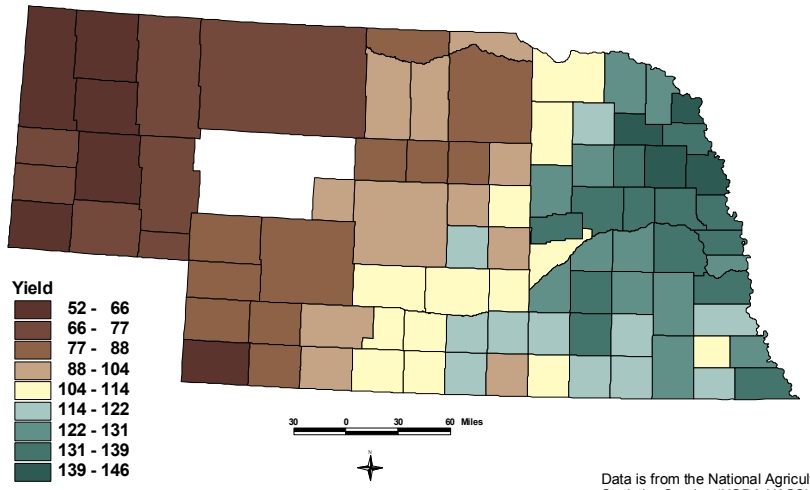
Maximum Irrigated Corn Yield (grain)
(1997 - 2001)



M. Milner (11-18-02)

Data is from the National Agricultural Statistics Service (USDA NASS).

Maximum Rainfed Corn Yield (grain)
(1997 - 2001)



M. Milner (11-18-02)

Data is from the National Agricultural Statistics Service (USDA NASS).

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Simulated attainable corn yields in different regions of Nebraska

			Irrigated corn (bu/acre) @30,000 plants/acre		Dryland corn (bu/acre) @25,000 plants/acre	
Region	Planting date	GDD (F)	Mean	Common range	Mean	Common range
Southeast-East	5-May	2650	245	230-270	195	155-215
Central	6-May	2600	250	235-270	170	135-215
South-Central	3-May	2650	255	240-275	190	145-215
Southwest	8-May	2550	235	220-260	115	80-155
Northeast	9-May	2550	240	220-260	170	135-200
North-Central	10-May	2400	220	200-245	120	90-140
Northwest	7-May	2250	205	195-225	85	65-105

Simulations based on weather data collected during the past 20 years at multiple locations in each district (High Plains Regional Climate Center online database). Assumes currently widespread cropping practices (planting date, hybrid maturity, plant density) as reported by NASS.

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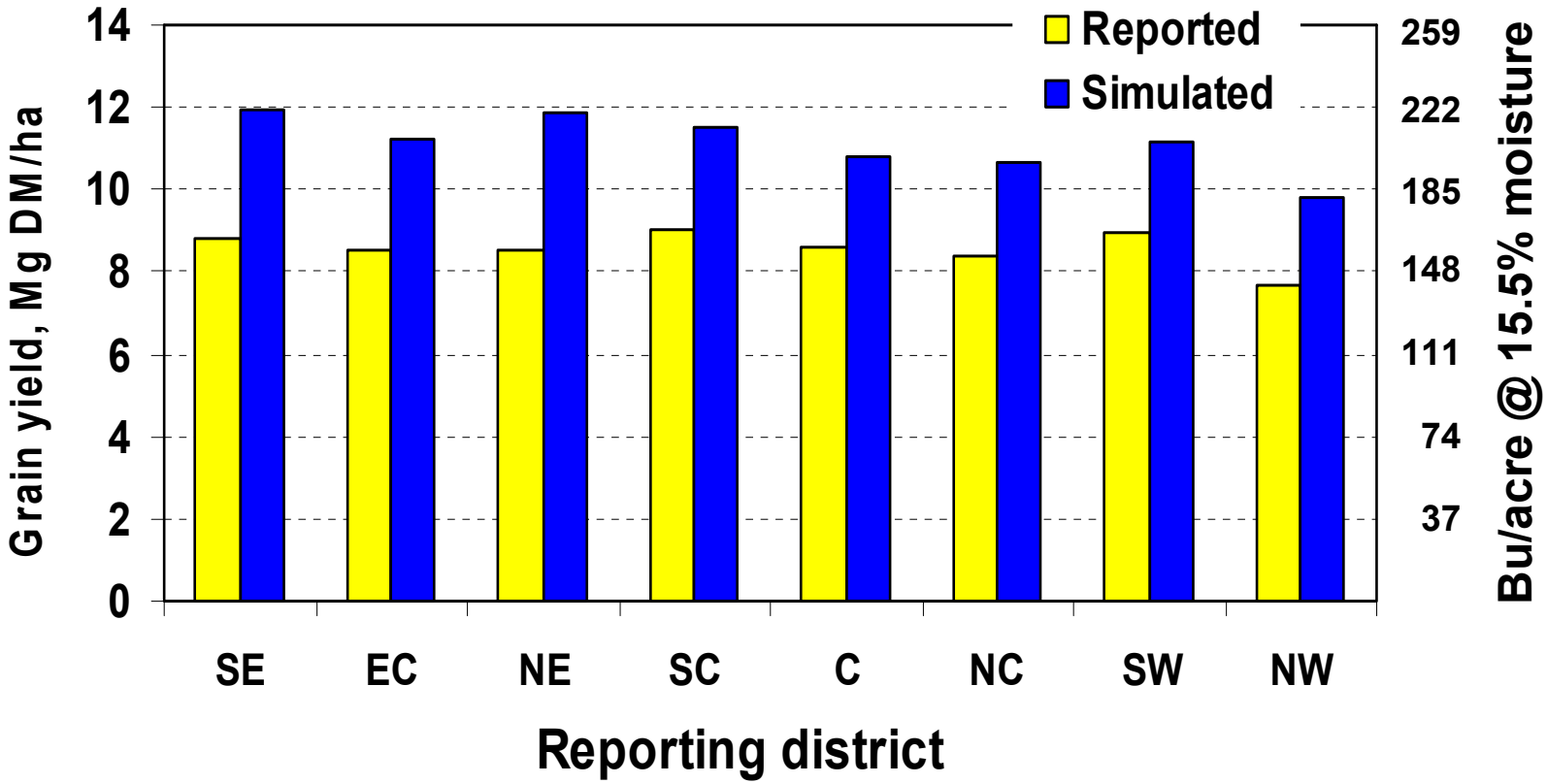
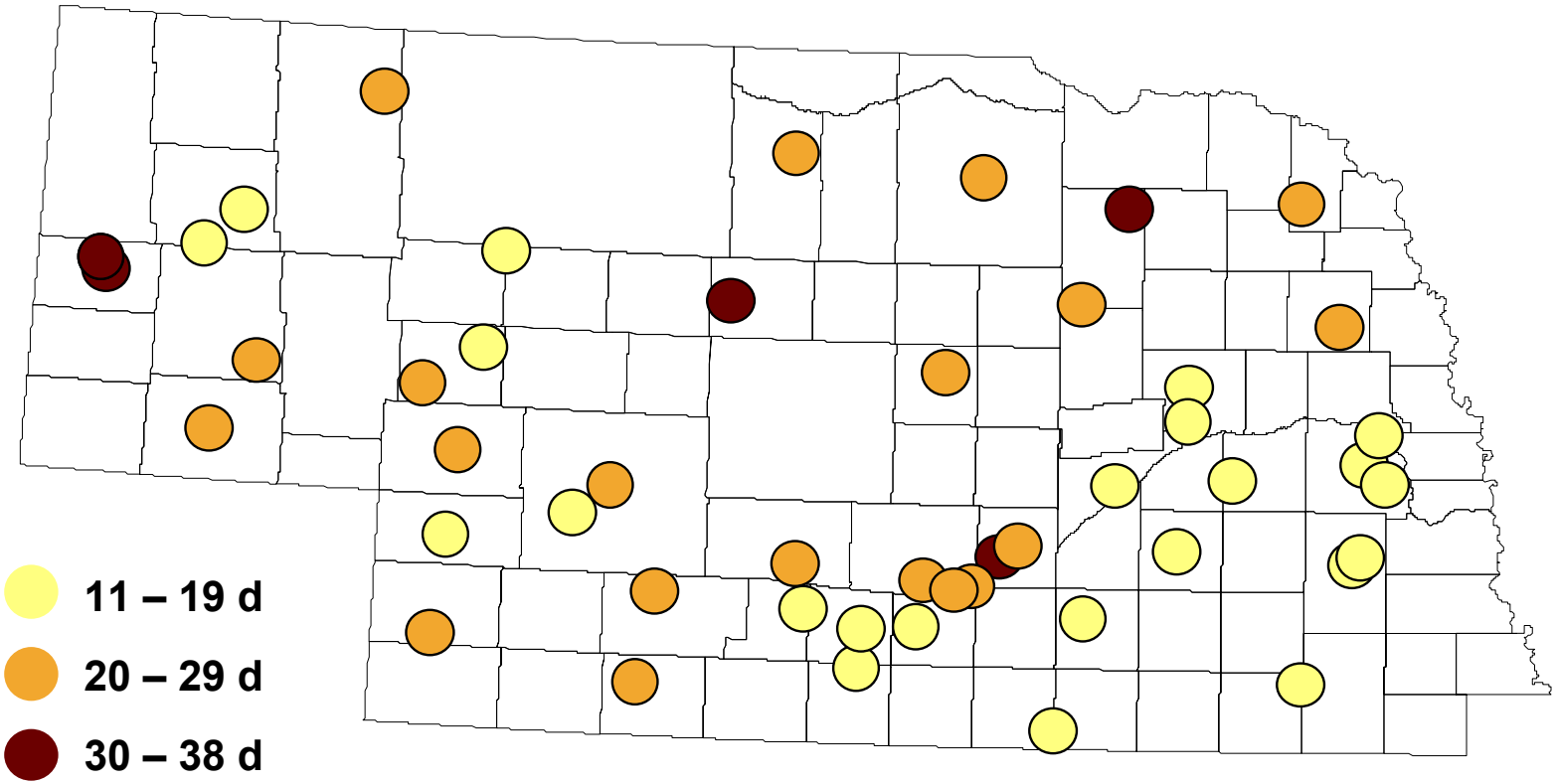
To achieve full climatic site yield potential, management requires:

- Identify optimal growing season duration: Hybrid-Maize model searches for optimal planting data and the date when grain filling stops.
- Select a corn hybrid that fully utilizes the optimal growing season duration (GDD).
- Use very high plant population (40,000 plants/acre).
- Grow under stress-free conditions.



Average irrigated corn yield in Nebraska by crop reporting district in the NASS database (1998-2002) and corresponding simulation of yield potential by the Hybrid-Maize model. Simulation is based on the current reported cropping practices (reported planting and maturity dates, 30,000 plants/acre).

Optimal management: *gain in season length*



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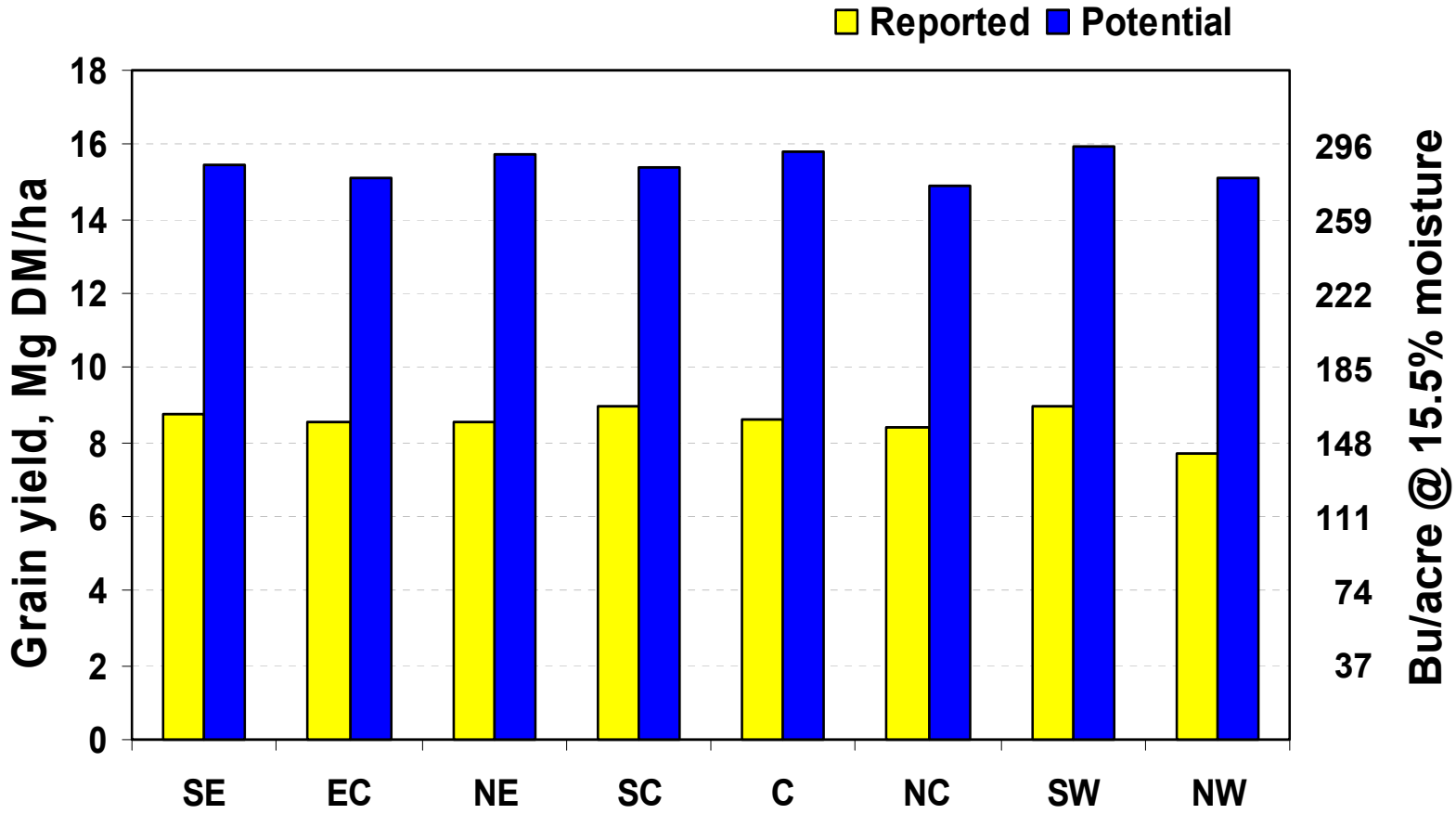

Simulated full-season corn yield potential across Nebraska in comparison with actual average yields of irrigated corn (means of 1998-2002). Simulation assumes full utilization of the available growing season (optimal planting and choice of corn hybrid, 40,000 plants/acre).

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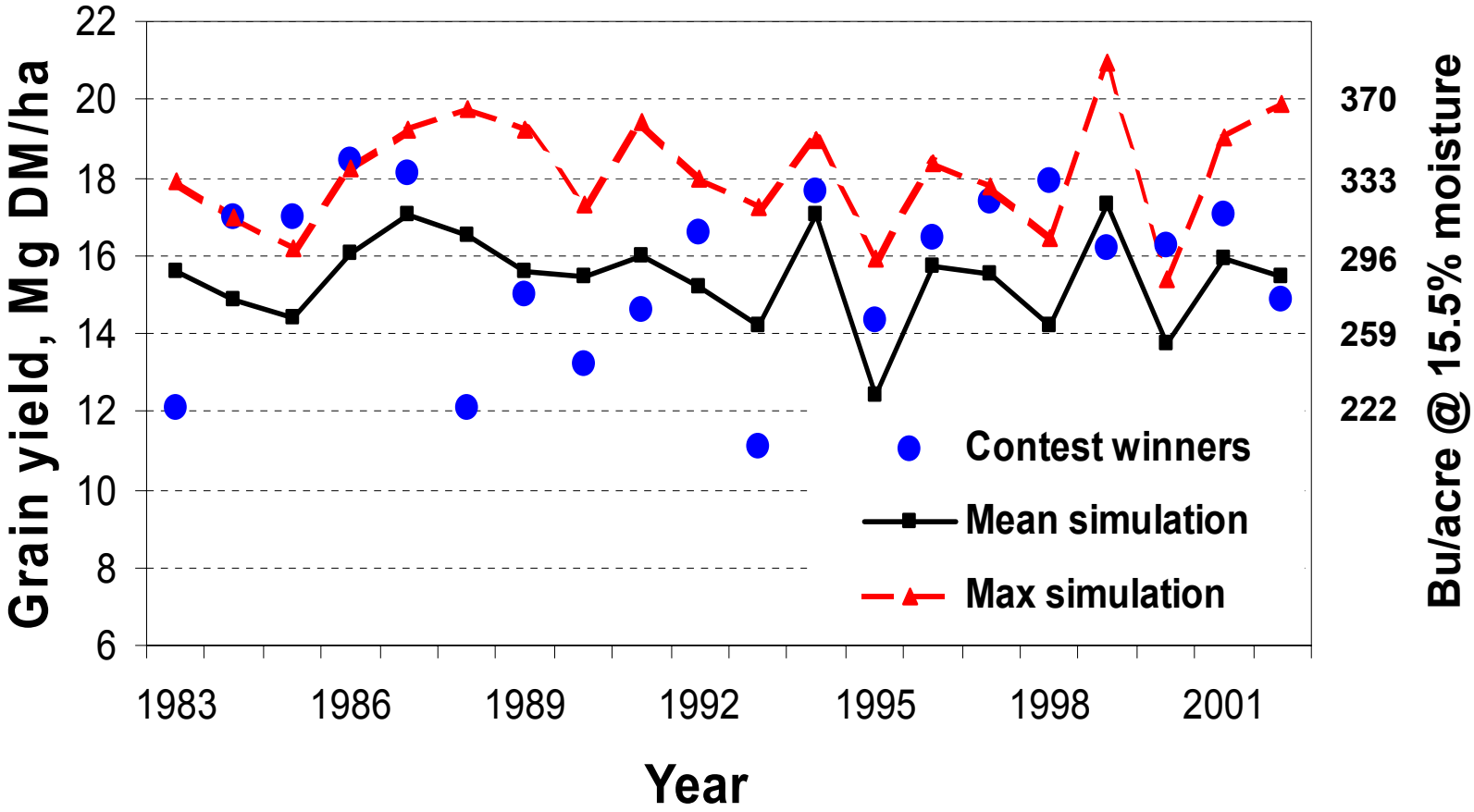

Full season maize yield potential simulated by Hybrid-Maize compared to the yield of Nebraska yield contest winners (irrigated corn category).

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Corn yield potential in 2003

Station	Mead	Beatrice	Concord	G. Island	C. Center	N. Platte	Alliance
Period	1982-2003	1990-2003	1982-2003	1995-2003	1982-2003	1982-2003	1988-2003
Planting date	4/25	4/25	5/1	4/25	4/25	5/5	5/5
Hybrid GDD(F)	2750	2750	2600	2750	2750	2650	2300
Simulated yield potential @ 32,000 plants/acre (bu/acre)							
Long-term maximum	323	321	309	312	327	331	276
Long-term median	**263**	**256**	**265**	**270**	**271**	**265**	**233**
Long-term minimum	225	240	151	231	197	166	162
2001	245	243	266	261	267	265	207
2002	250	240	254	268	246	251	237
2003	**273**	**256**	**285**	**312**	**325**	**302**	**262**

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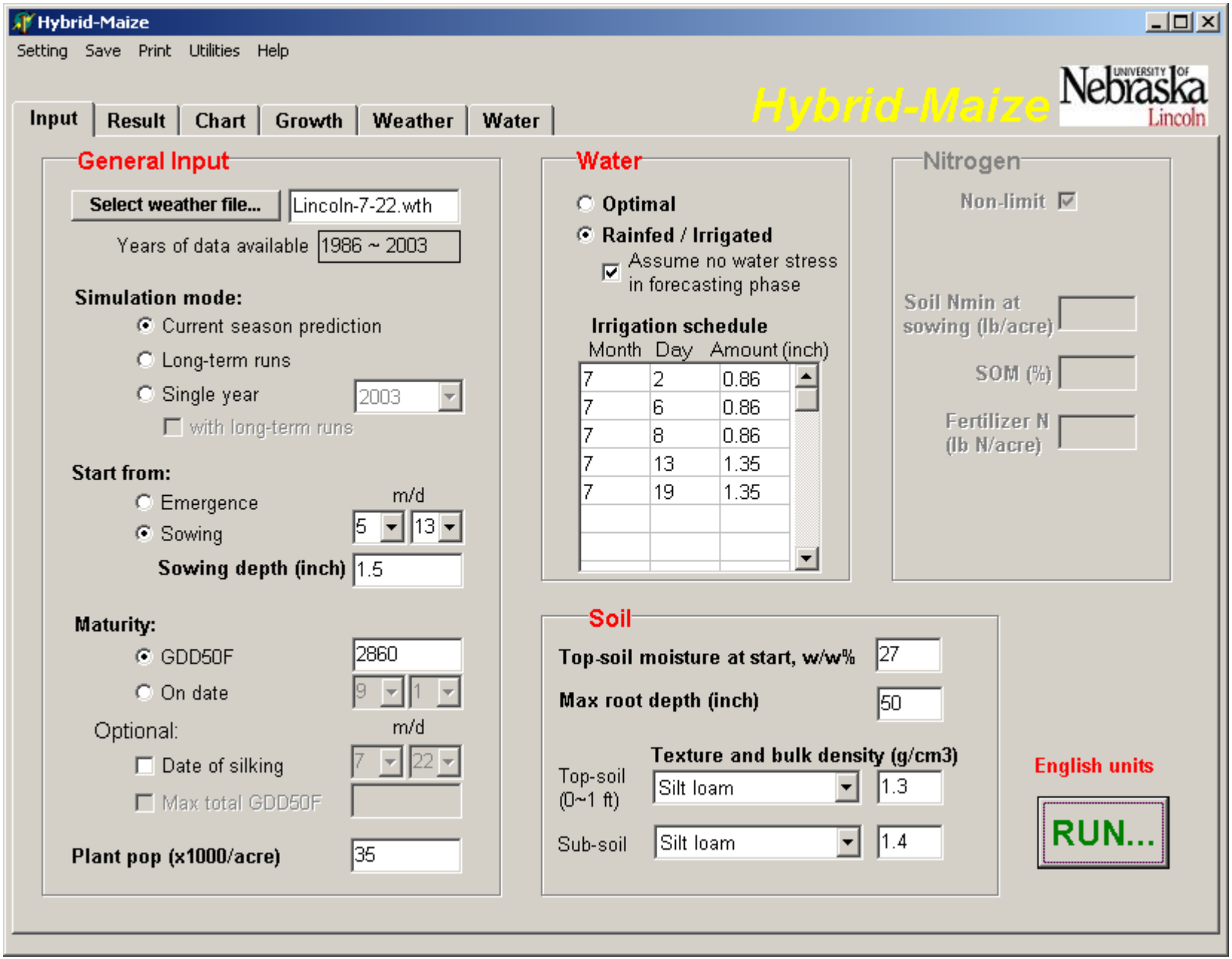
Potential applications

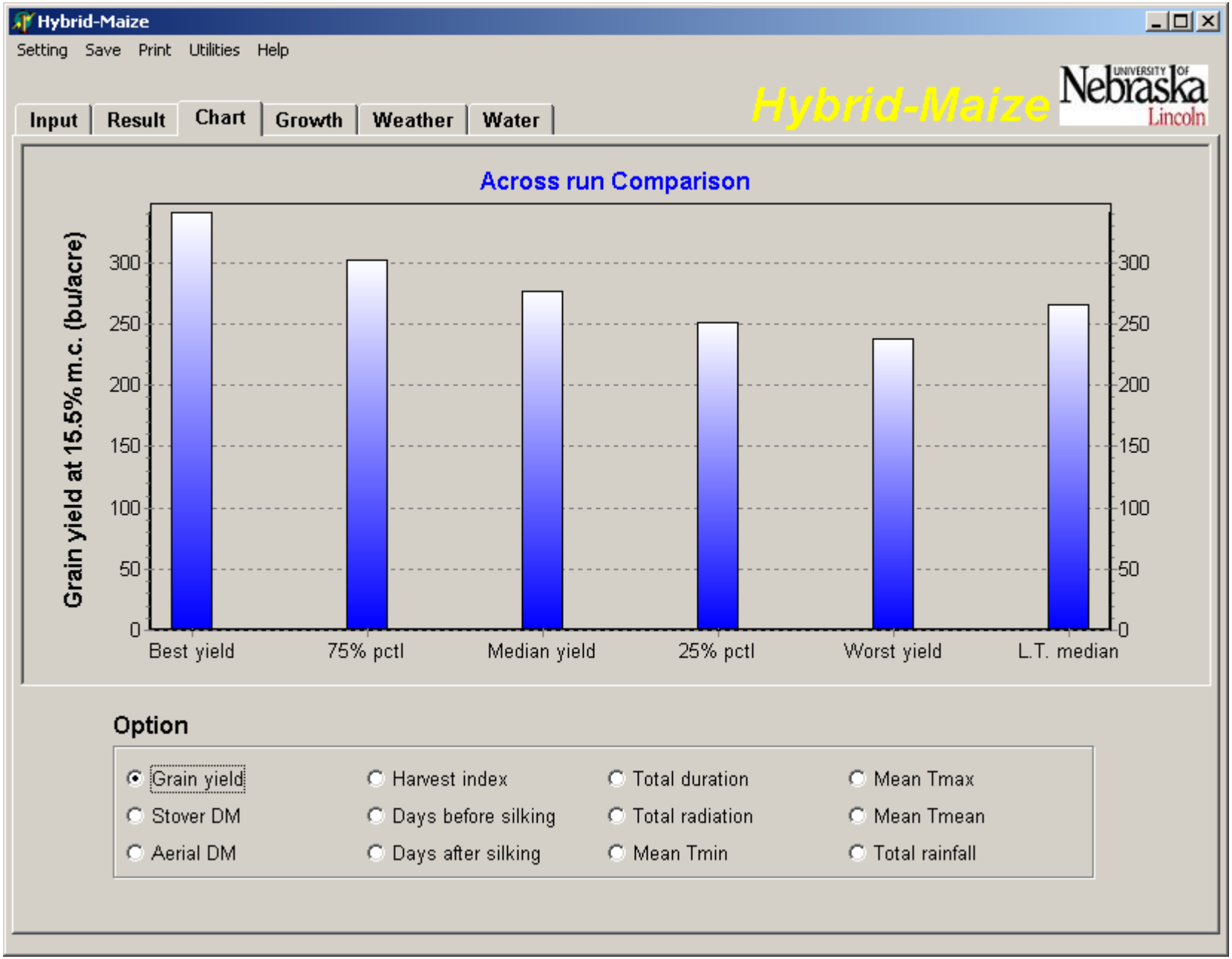
Using real-time climate data for a growing season :

- Estimate actual yield potential and water-limited attainable yield based on daily records of solar radiation, temperature, rainfall, and irrigation.

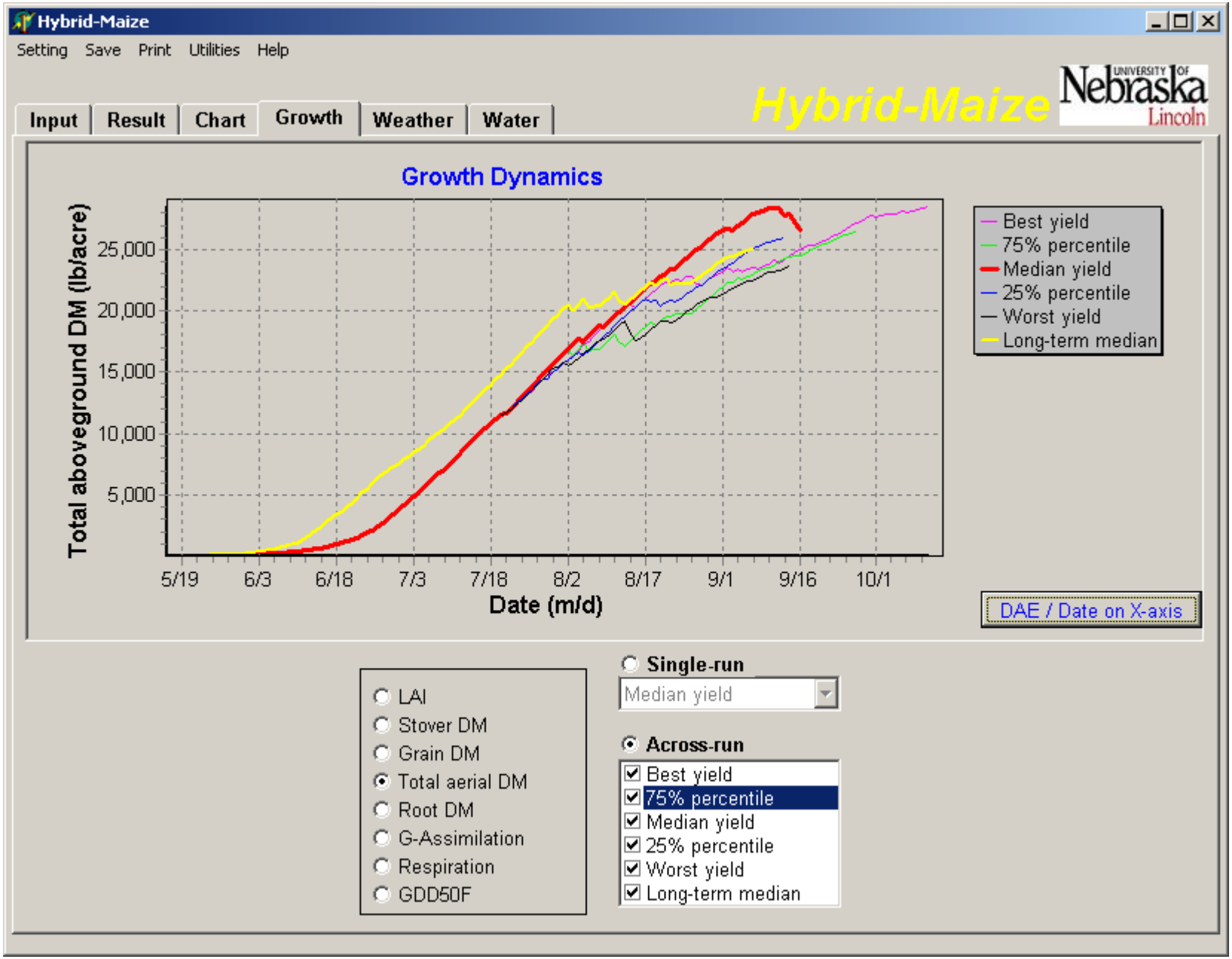
- Management decisions:
  - → adjust yield goal during the season and make subsequent adjustments in fertilizer amounts (sidedress, fertigation)
  - → evaluate moisture status and make decisions on irrigation.
  - → evaluate actual plant growth and soil moisture dynamics in comparison with normal years/other years.
  - → make decisions for next year.



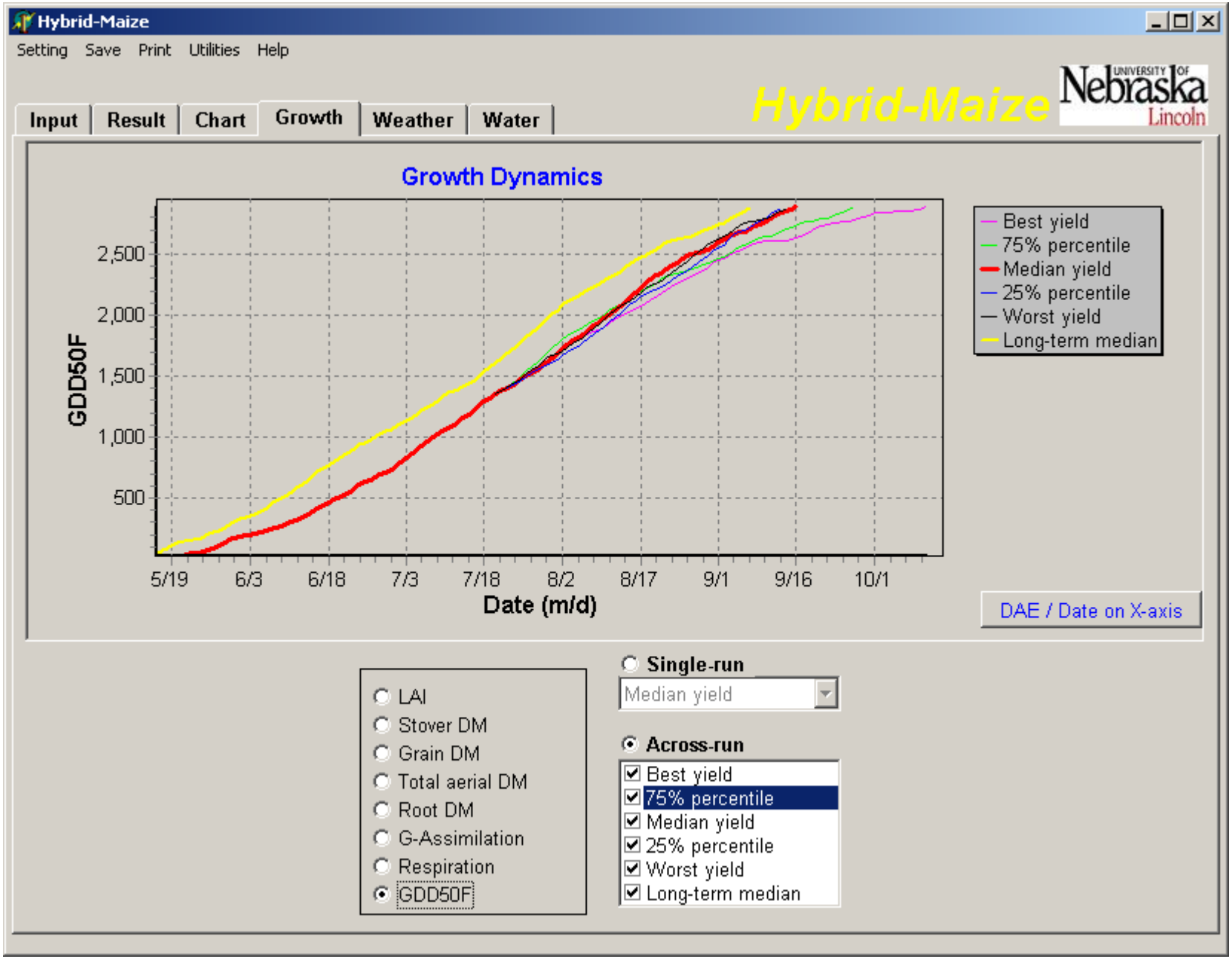
Irrigated corn, Pioneer 31N28, Lincoln 2003, actual weather until July 22



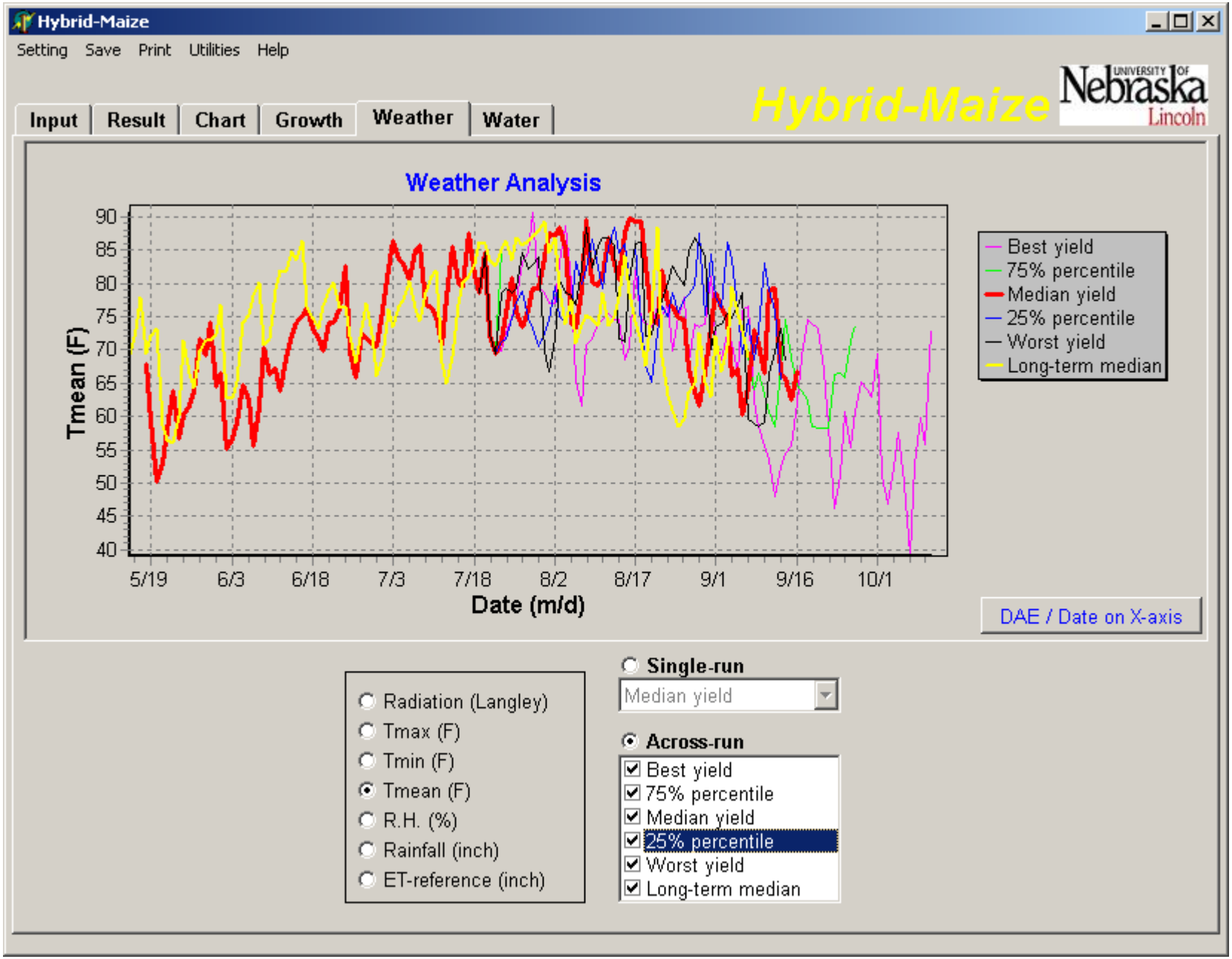
Irrigated corn, Pioneer 31N28, Lincoln 2003, actual weather until July 22



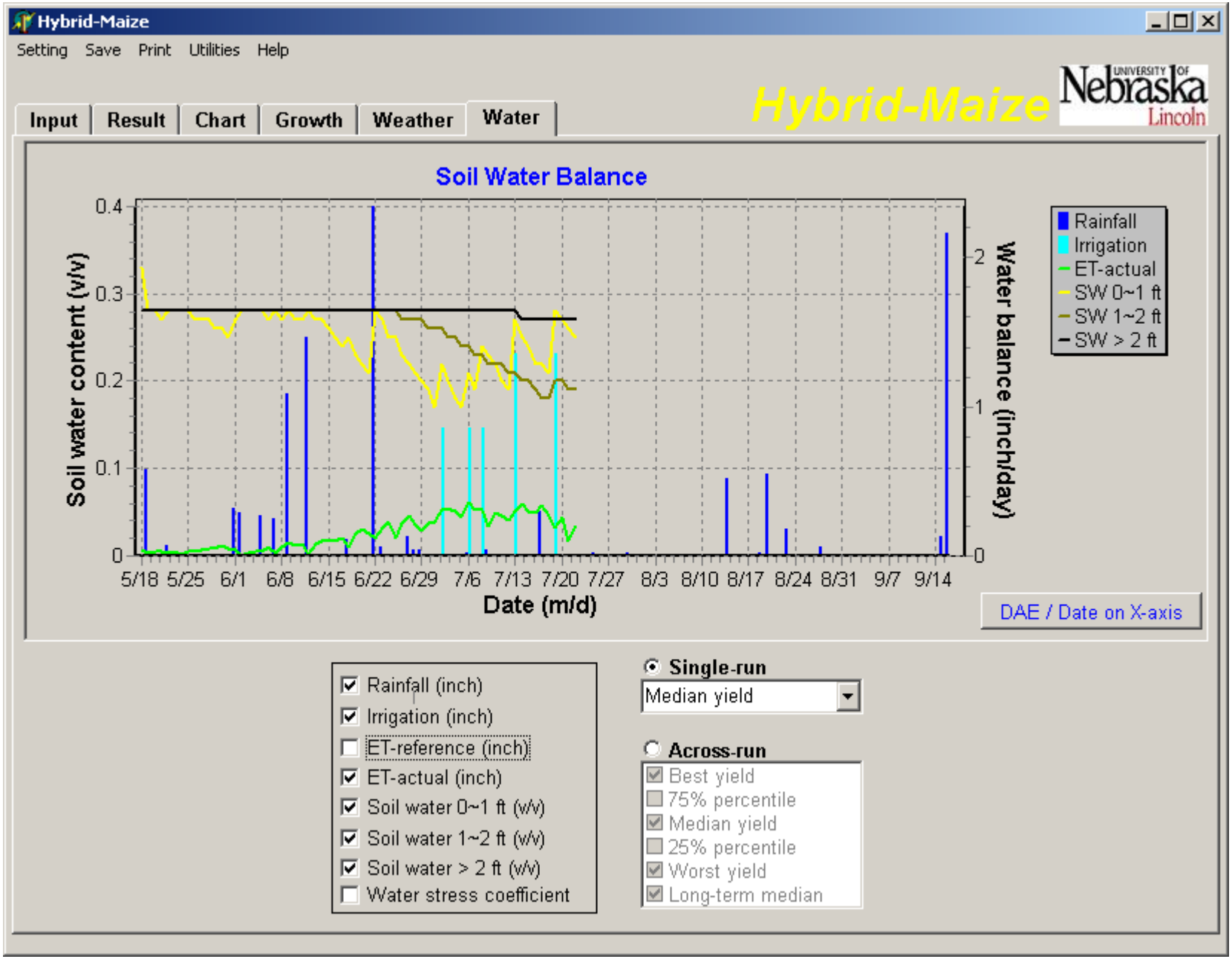
Irrigated corn, Pioneer 31N28, Lincoln 2003, actual weather until July 22



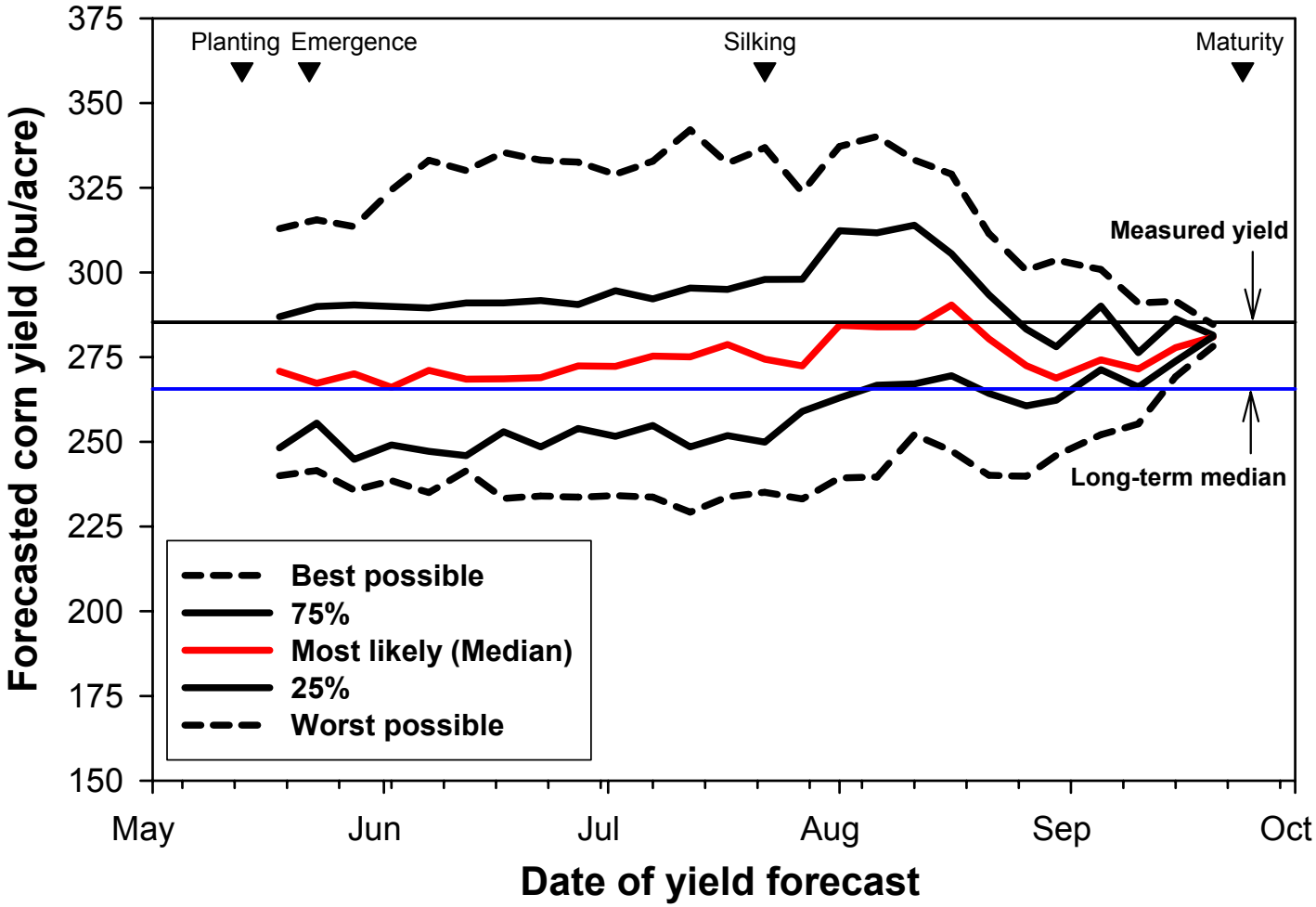
Irrigated corn, Pioneer 31N28, Lincoln 2003, actual weather until July 22



Irrigated corn, Pioneer 31N28, Lincoln 2003, actual weather until July 22



Irrigated corn, Pioneer 31N28, Lincoln 2003, actual weather until July 22



Real-time yield potential forecast at Lincoln, NE, 2003. Corn (Pioneer 31N28) was planted on May 13 @ 37,000 plants/acre. Beginning May 18, yield forecasts were made with Hybrid-Maize every 5 days. The red line shows the final yield measured (285 bu/acre).

Irrigated corn, Lincoln 2003

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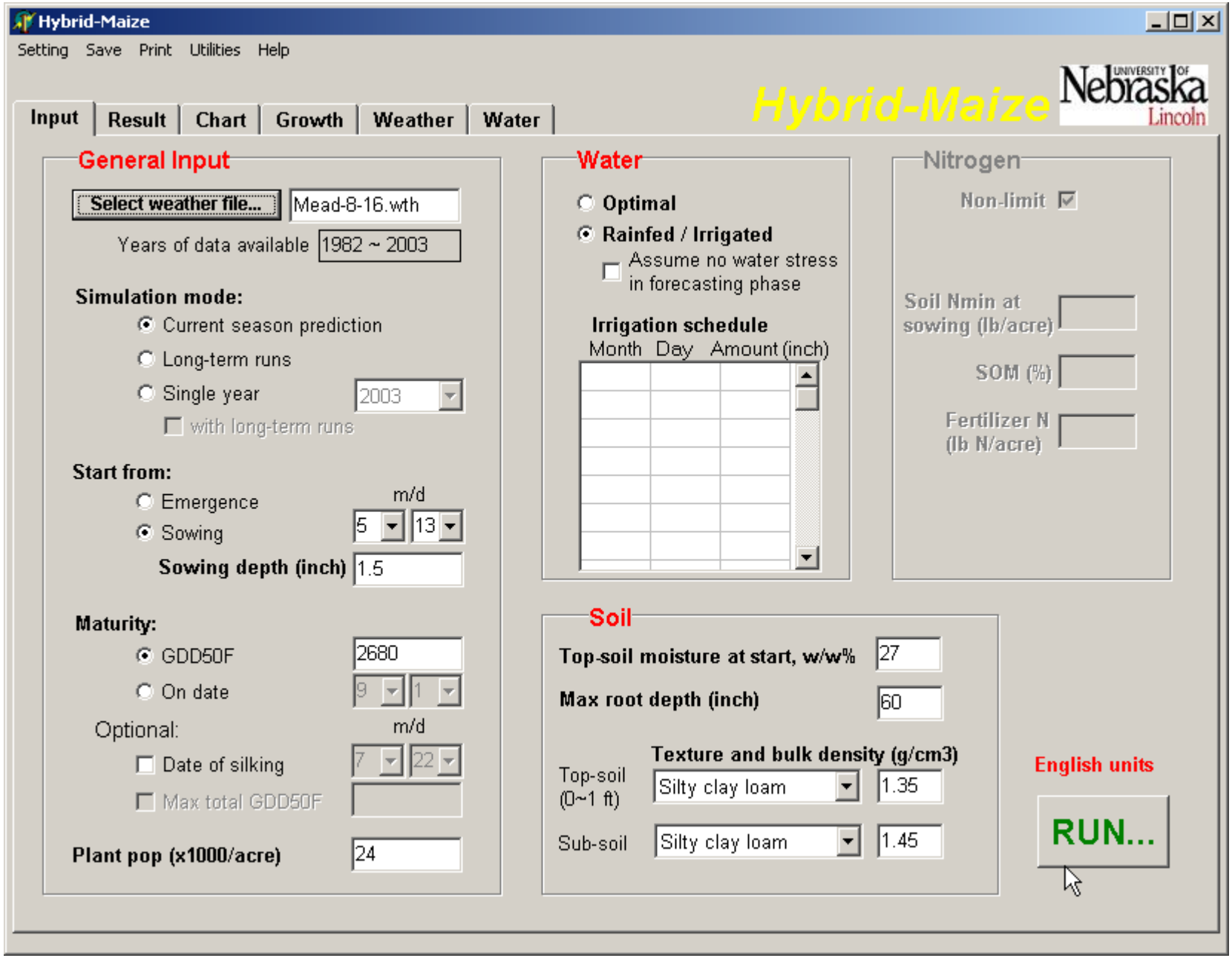
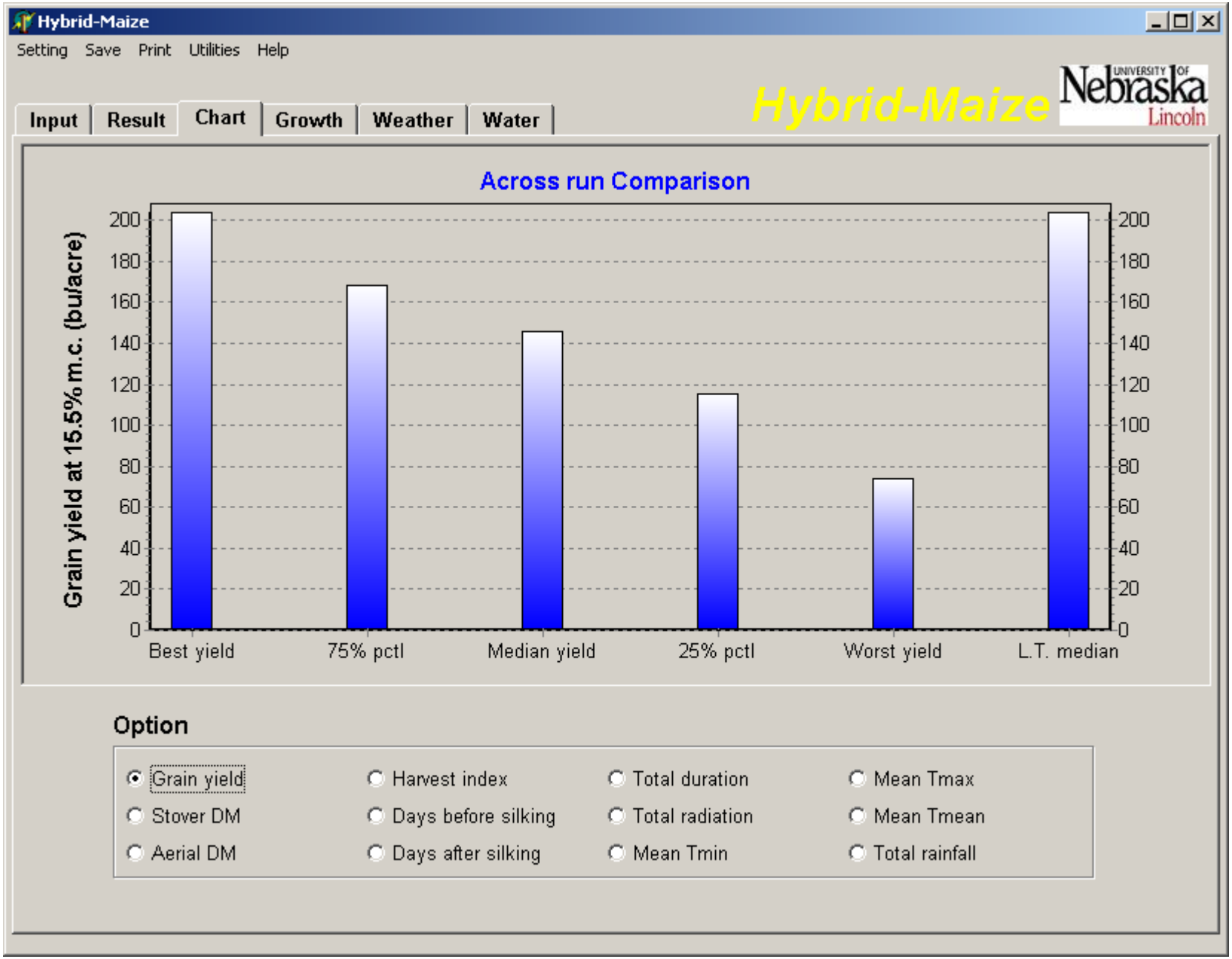
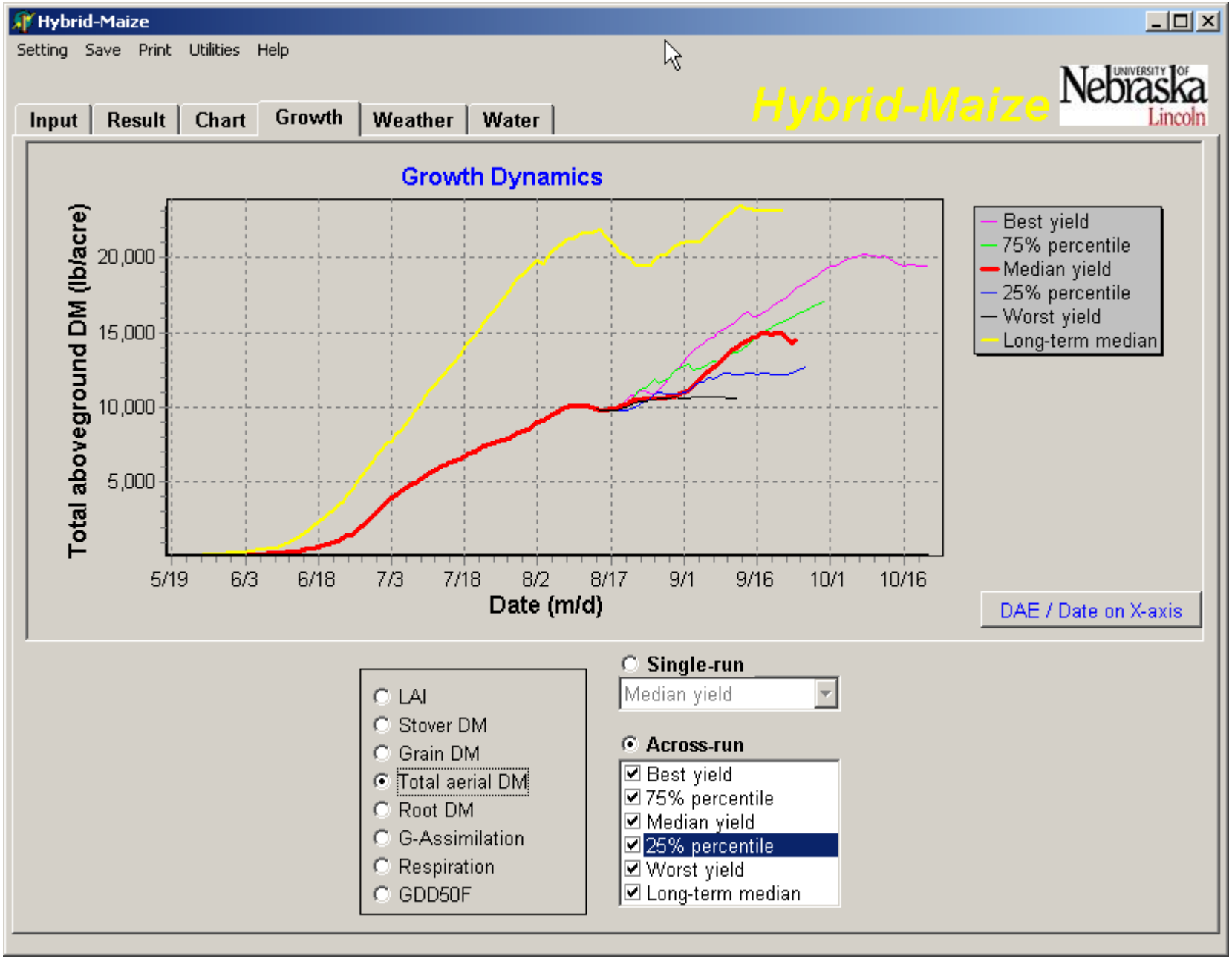


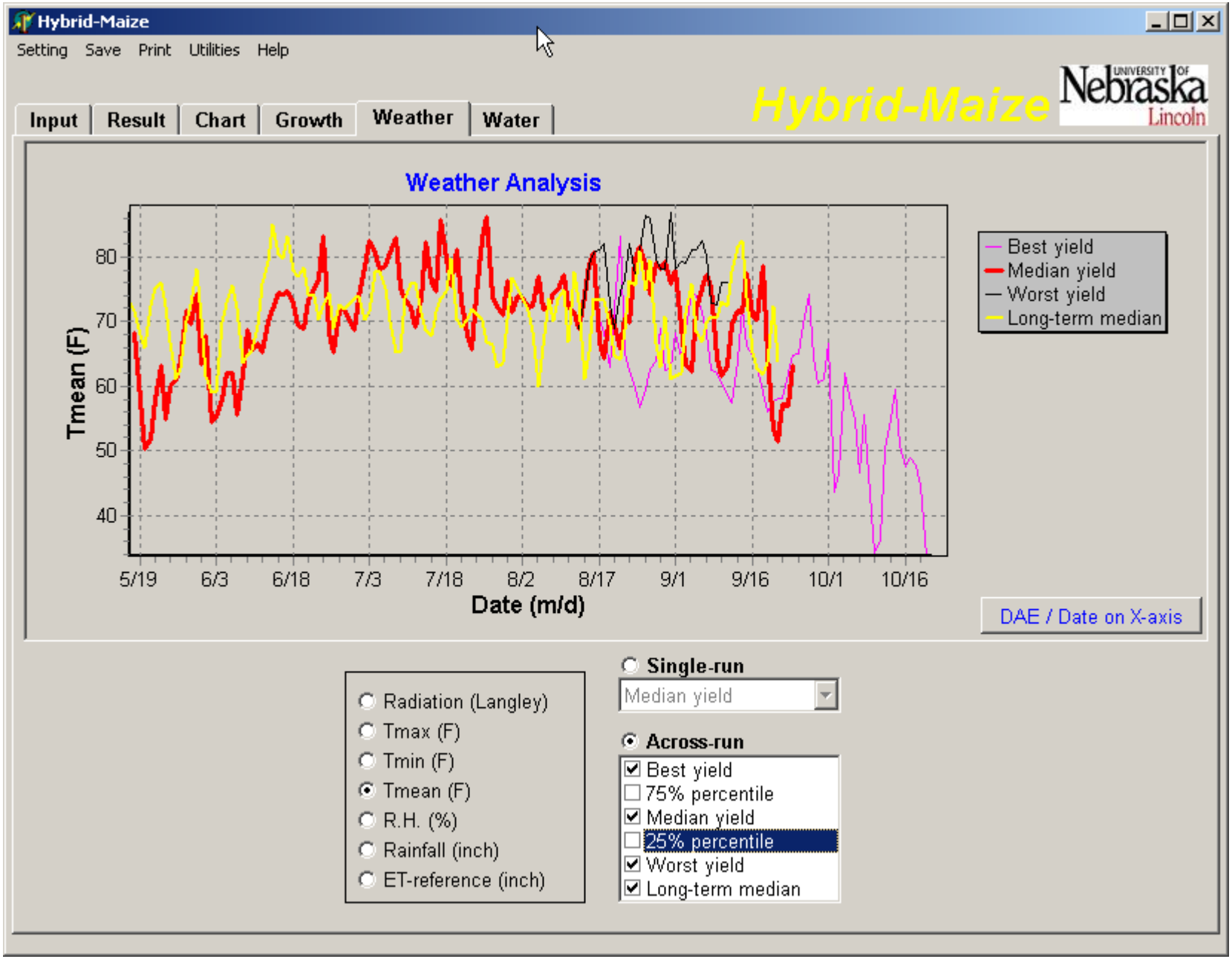
Dryland corn, Pioneer 33B51, Mead 2003, actual weather until August 16



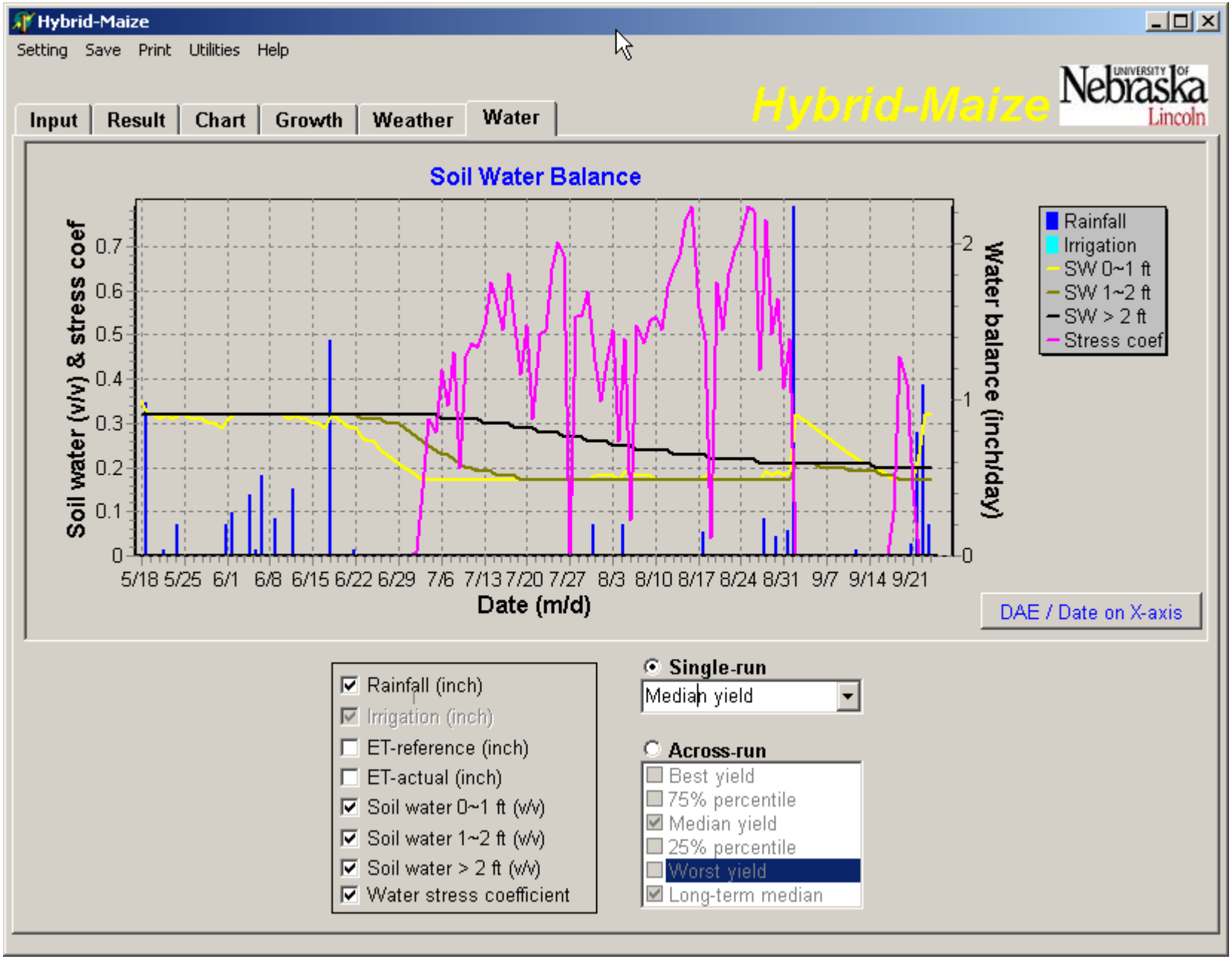
Dryland corn, Pioneer 33B51, Mead 2003, actual weather until August 16



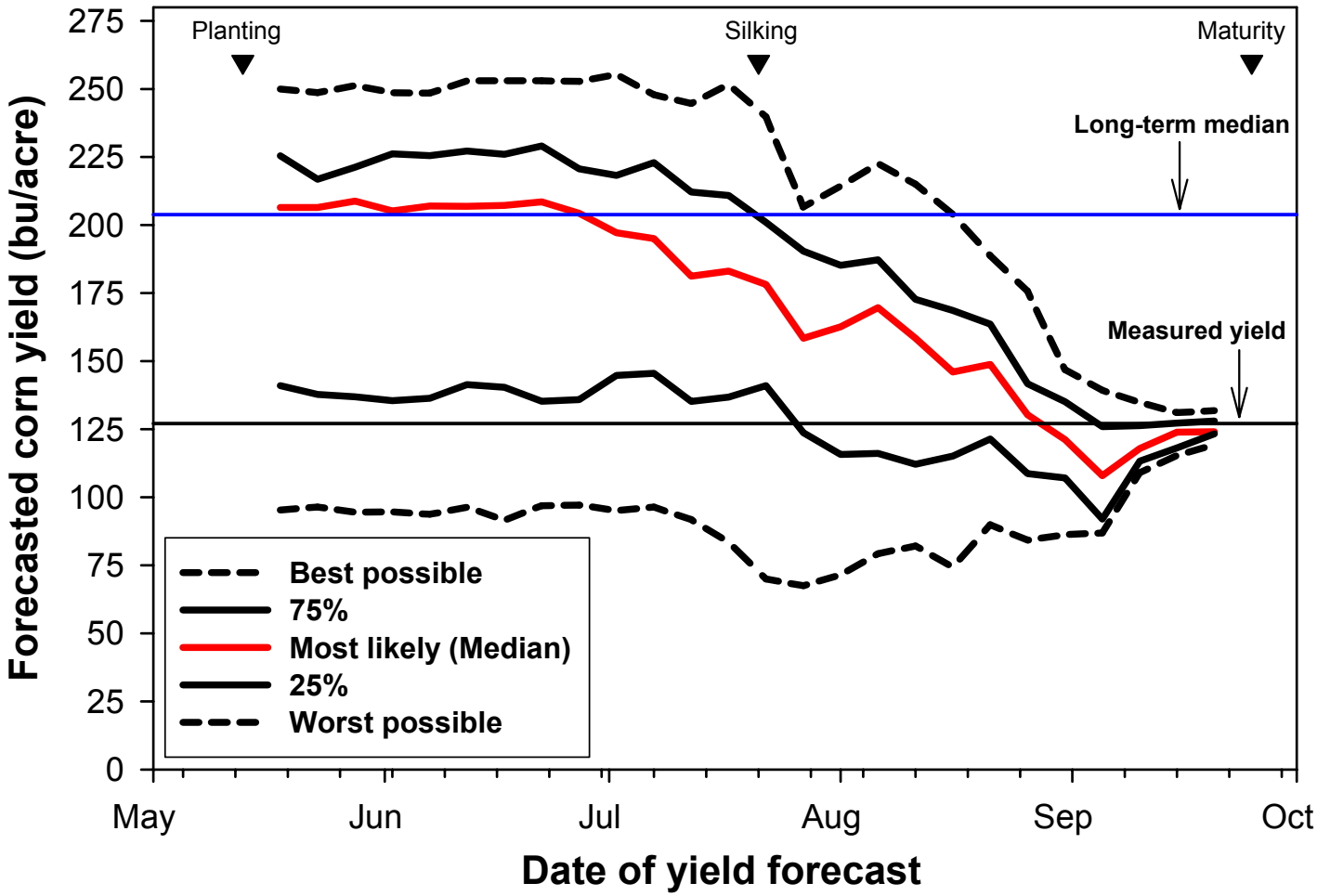
Dryland corn, Pioneer 33B51, Mead 2003, actual weather until August 16



Dryland corn, Mead 2003, actual weather until August 16



Dryland corn, Mead 2003, actual weather until August 16



Real-time yield potential forecast at Mead, NE, 2003. Dryland corn (Pioneer 33B51) was planted on May 13 @ final stand of 24,000 plants/acre. Beginning May 18, yield forecasts were made with Hybrid-Maize every 5 days. The red line shows the final yield measured (127 bu/acre).

Dryland corn, Mead 2003

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Summary

- Models are not perfect representations of the real world. They represent the current scientific understanding in relatively simple mathematical terms.
- Hybrid-Maize is a robust model for estimating corn yield potential under non-limiting and water limiting conditions.
- Model estimates allow evaluating different options for crop management.
- Hybrid-Maize has promising potential for in-season management decisions.

Outlook

- Do more validation at other sites and for dryland corn.
- Write user's manual and release software in early 2004.
- More testing in real-time field management.
- Incorporate nitrogen management module.