Irrigation Scheduling Based on Crop Modeling

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Team of University of Nebraska (UNL)

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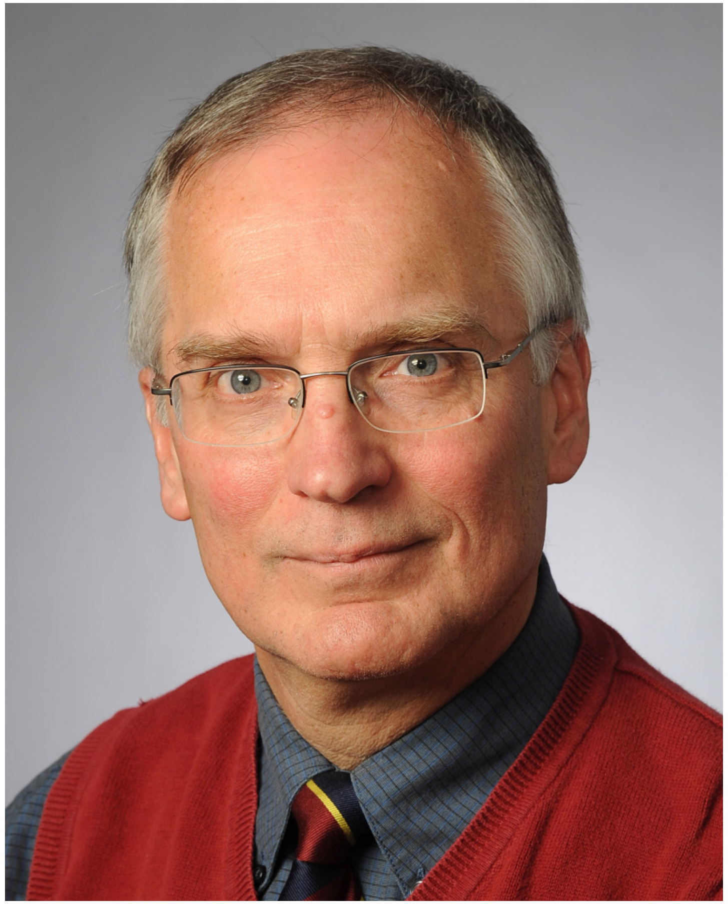


Roger Elmore, Professor,
Cropping System Specialist

Outline

- Crop modeling at UNL
- Irrigation scheduling based on crop models
- Remarks

Models for maize and soybean

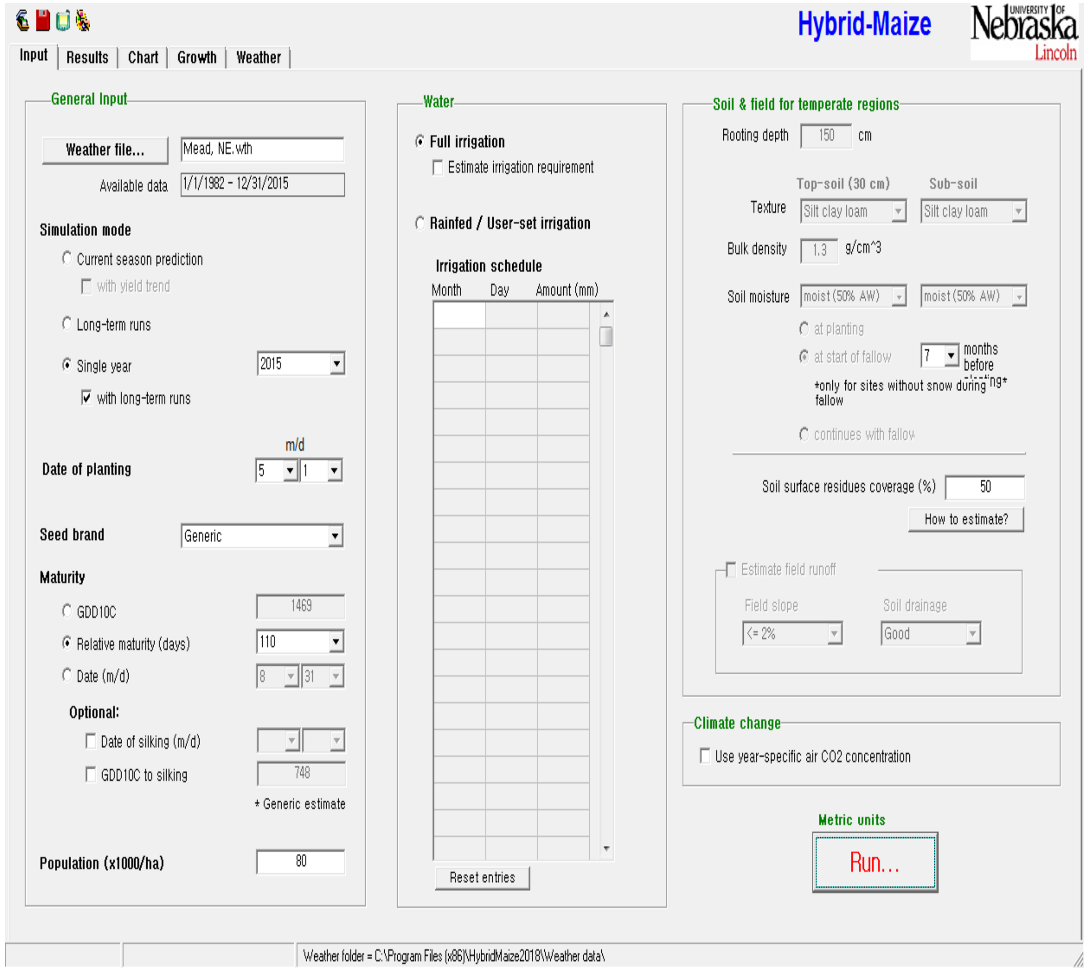
- Hybrid-Maize model (Yang et al, 2004, 2006, 2017)
- Maize-N model (Yang et al, 2008, Setiyono et al, 2011)
- SoySim model (Setiyono et al, 2010)
- CornSoyWater (Yang et al, 2016)

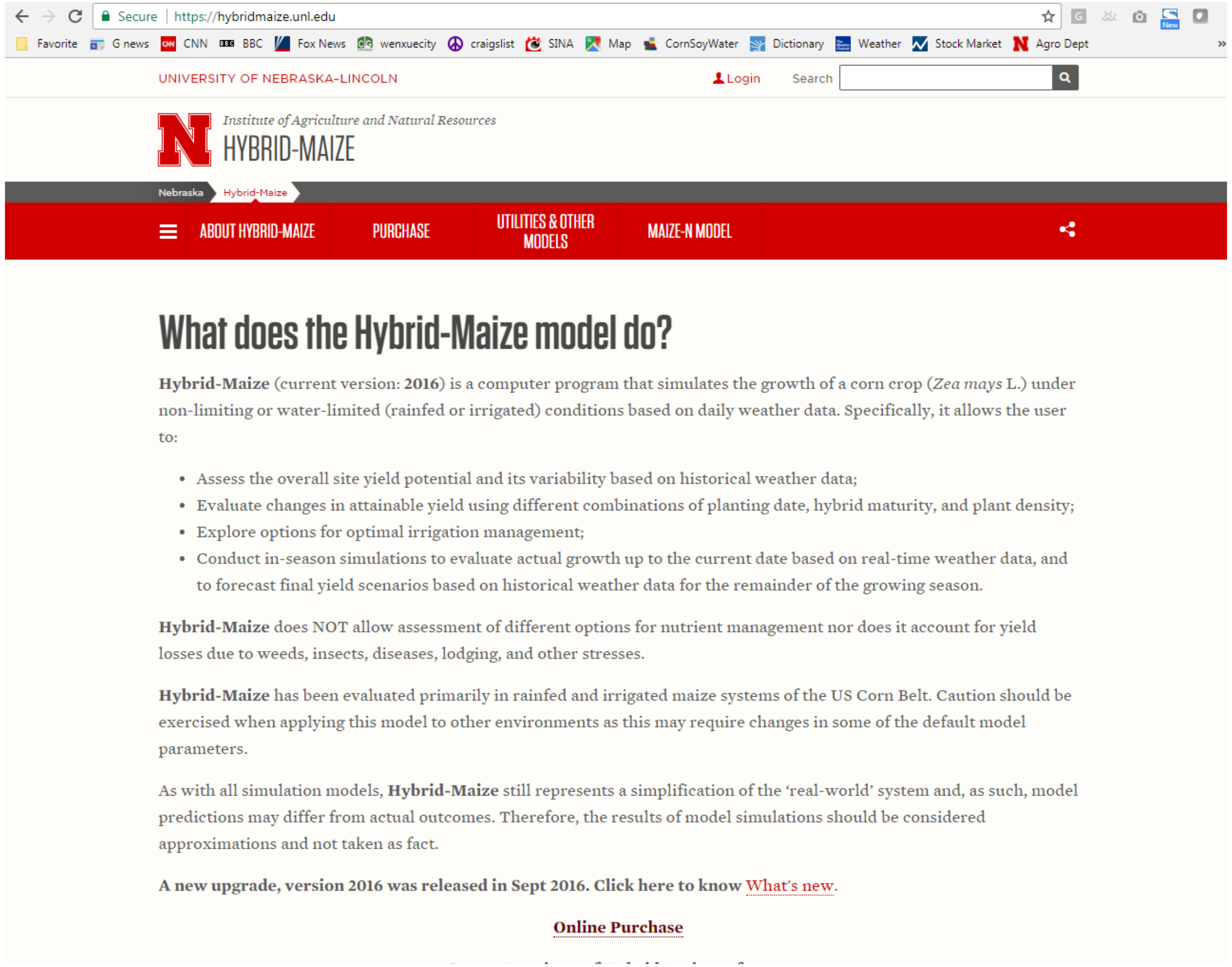
Common functions/features:

- Need no info farmers don't know
- Farmers can use them easily, while scientists find them very powerful.
- Simulate daily crop development, biomass growth, crop stage, and final yield.
- Produce both numerical results as well as graphs.
- Scientifically transparent on parameter settings, math functions, and references.
- Tested and validated in reviewed publications
- Complete documentation

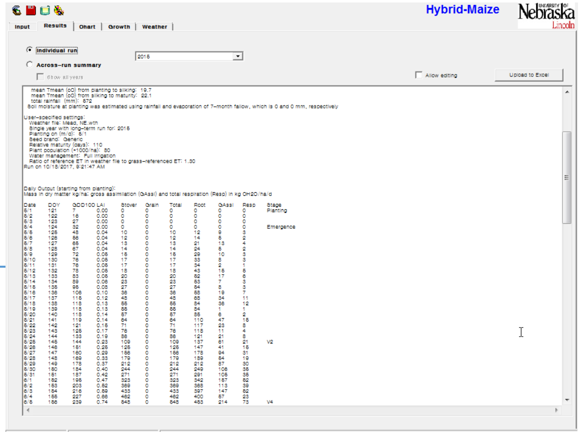
Hybrid-Maize model: growth and yield

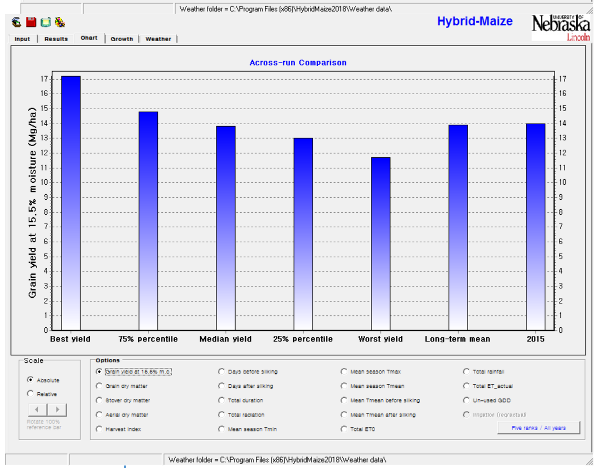
https://hybridmaize.unl.edu/

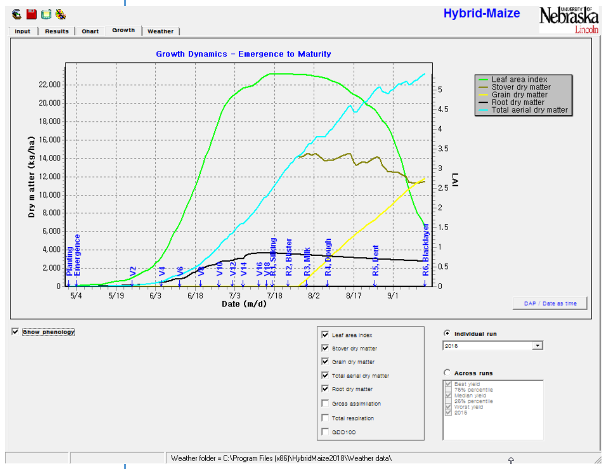




Hybrid-Maize model: inputs and outputs

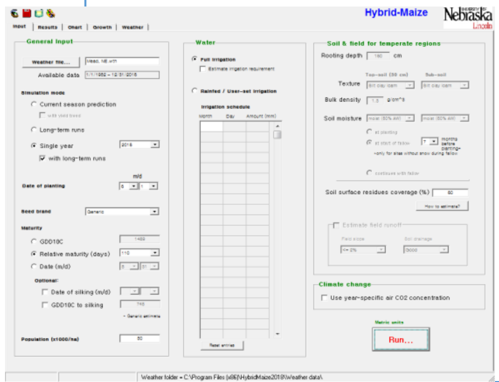






Inputs

- Daily weather data
- Hybrid maturity
- Planting date
- Plant population
- Soil properties (texture, rooting depth, residues, slop, drainage)

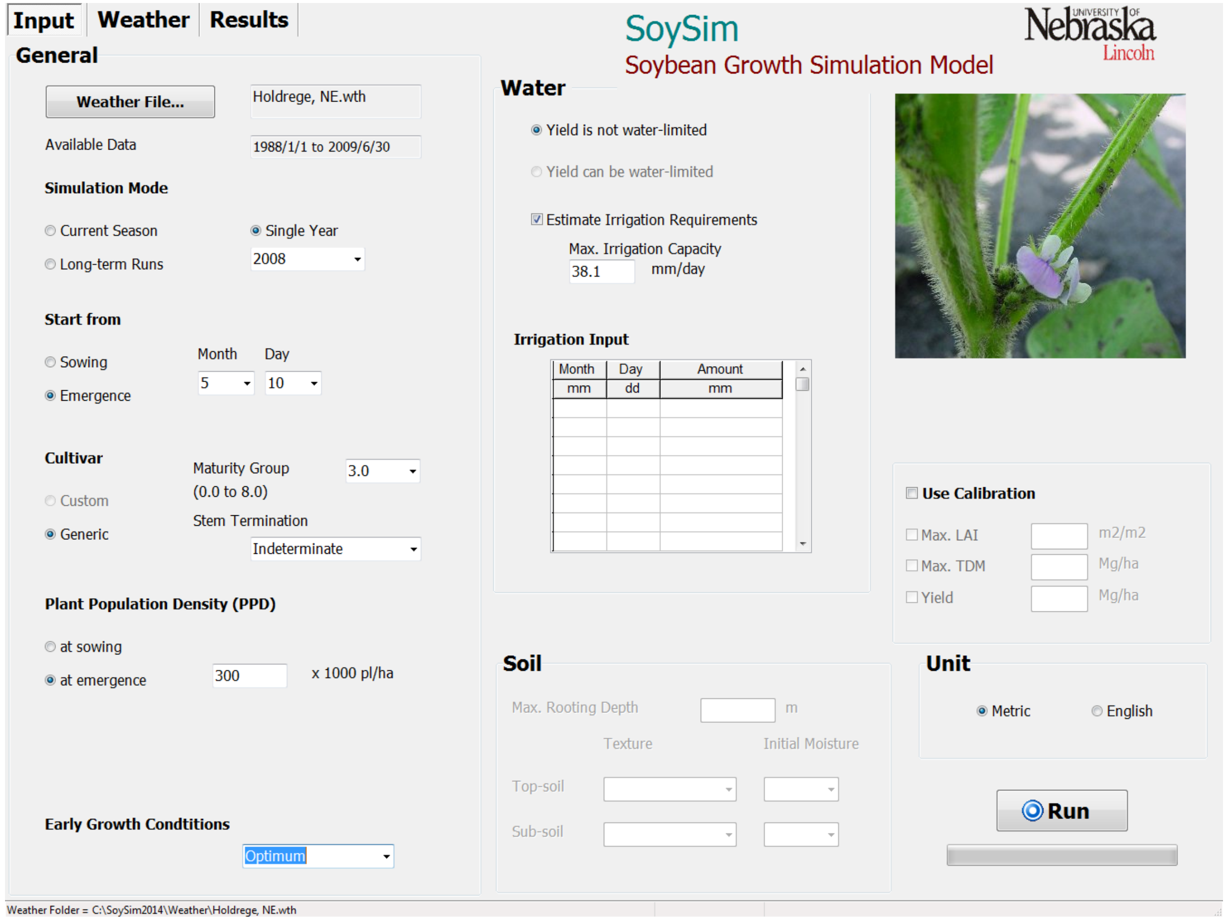


Outputs

- Daily values:
  - GDD (growing degree day)
  - Crop stage
  - Biomass accumulation
  - **LAI** (leaf area index)
  - **Root depth**
  - **Water use**
  - **Crop Water stress**
- End of season results:
  - Yield, stover biomass
  - Total water use
  - Water balance

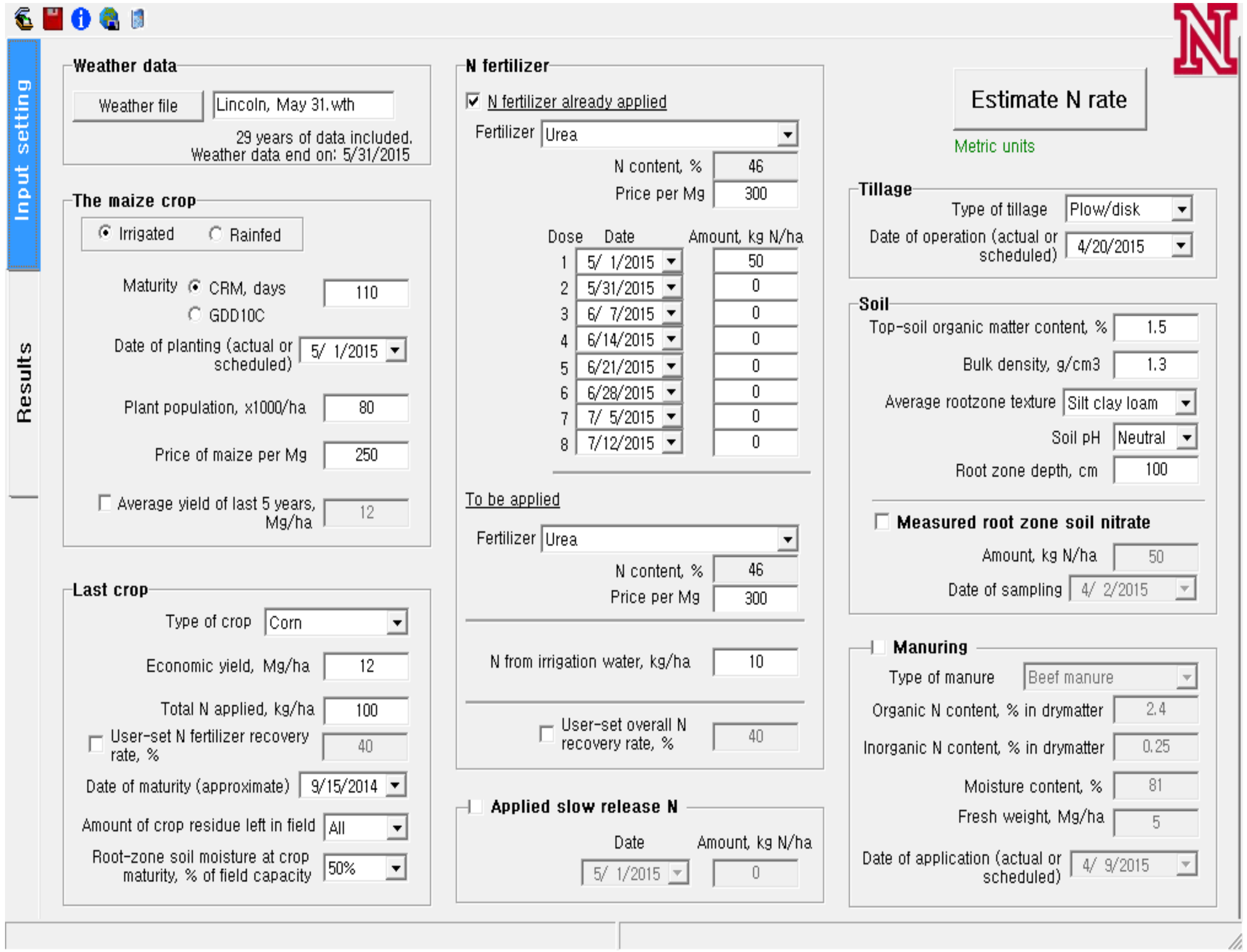
SoySim model: growth and yield

https://soysim.unl.edu/



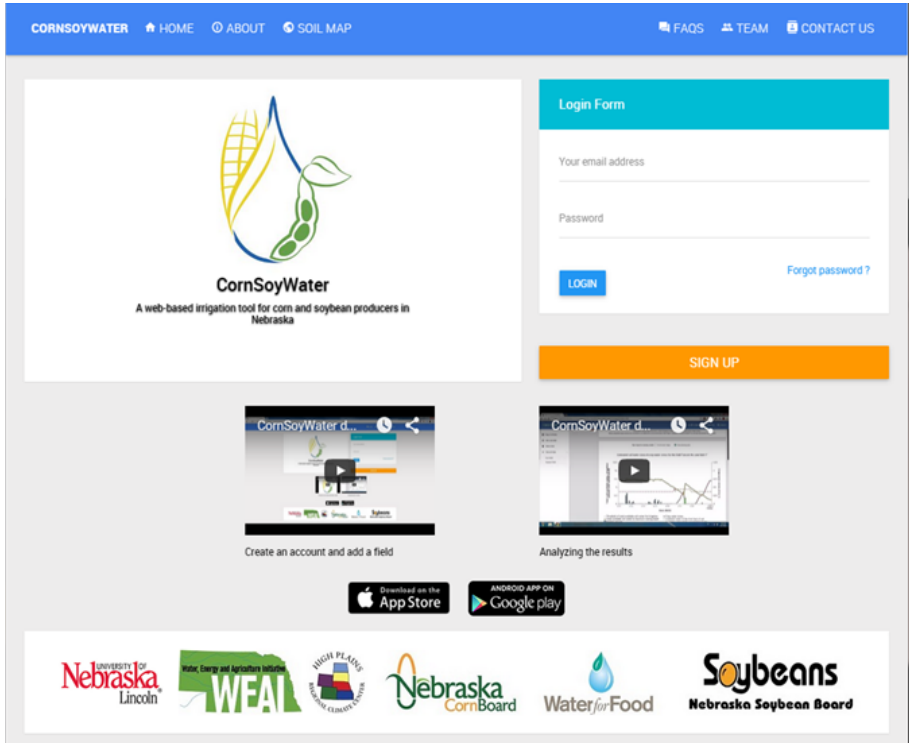
Maize-N: N fertilizer rate for maize

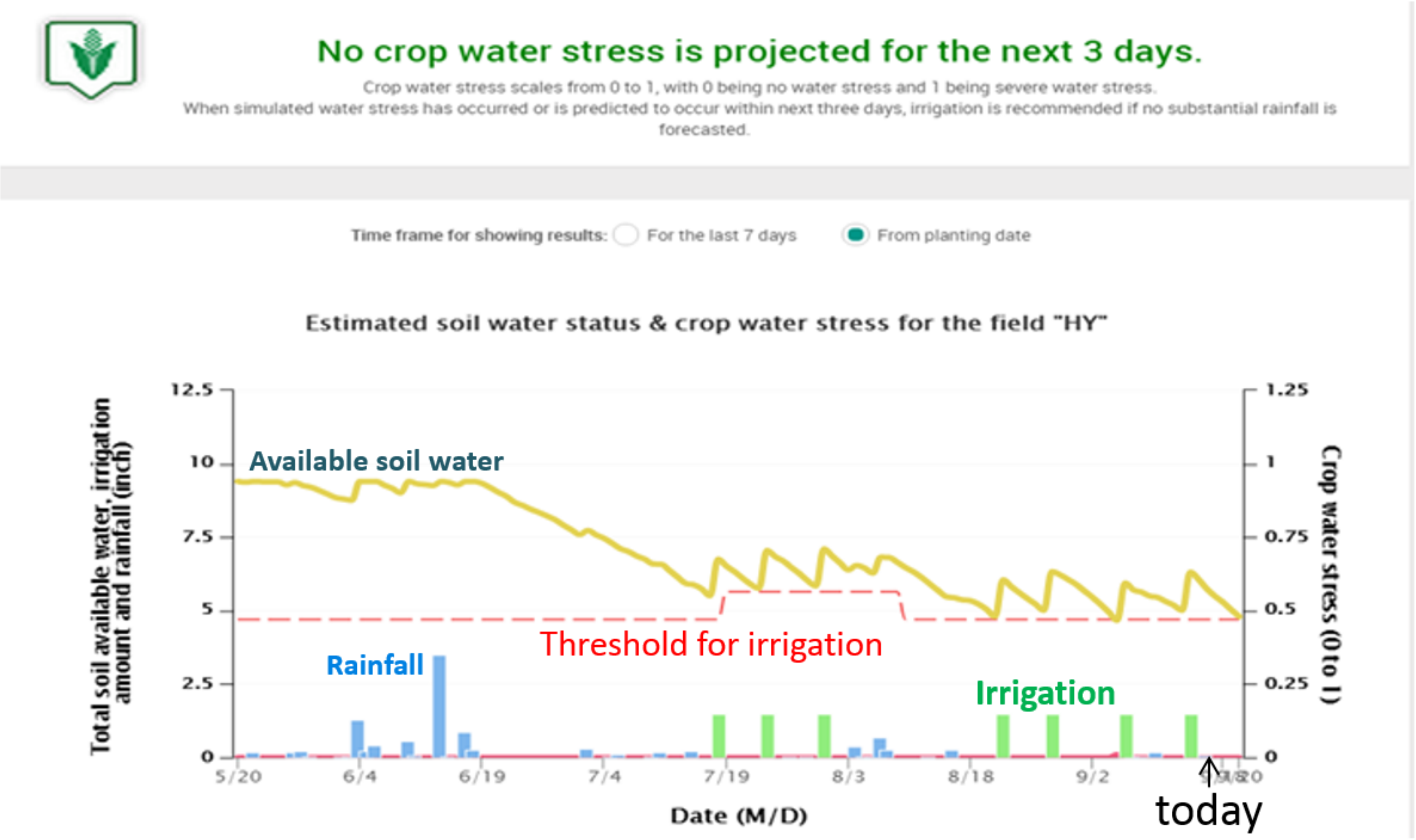
https://hybridmaize.unl.edu/Maize-N



CornSoyWater: irrigation scheduling for corn & soybean

cornsoywater.unl.edu





Irrigation recommendation is nothing but to know:

- How much water is current in the soil rooting depth
- Threshold of <u>water depletion </u>for starting irrigation
- How many days it can go before next irrigation

Routine for irrigation decision making

- Get up
- Check weather on TV or internet
- Dress up for field work.
- Fire up the pickup, and drive to the field……..
- Walk into the field…
- Check plants, soil; walk around, look around…
- Make a decision: irrigate or not

How farmers determine when to irrigate

Table 22. **Methods Used in Deciding When to Irrigate: 2013**

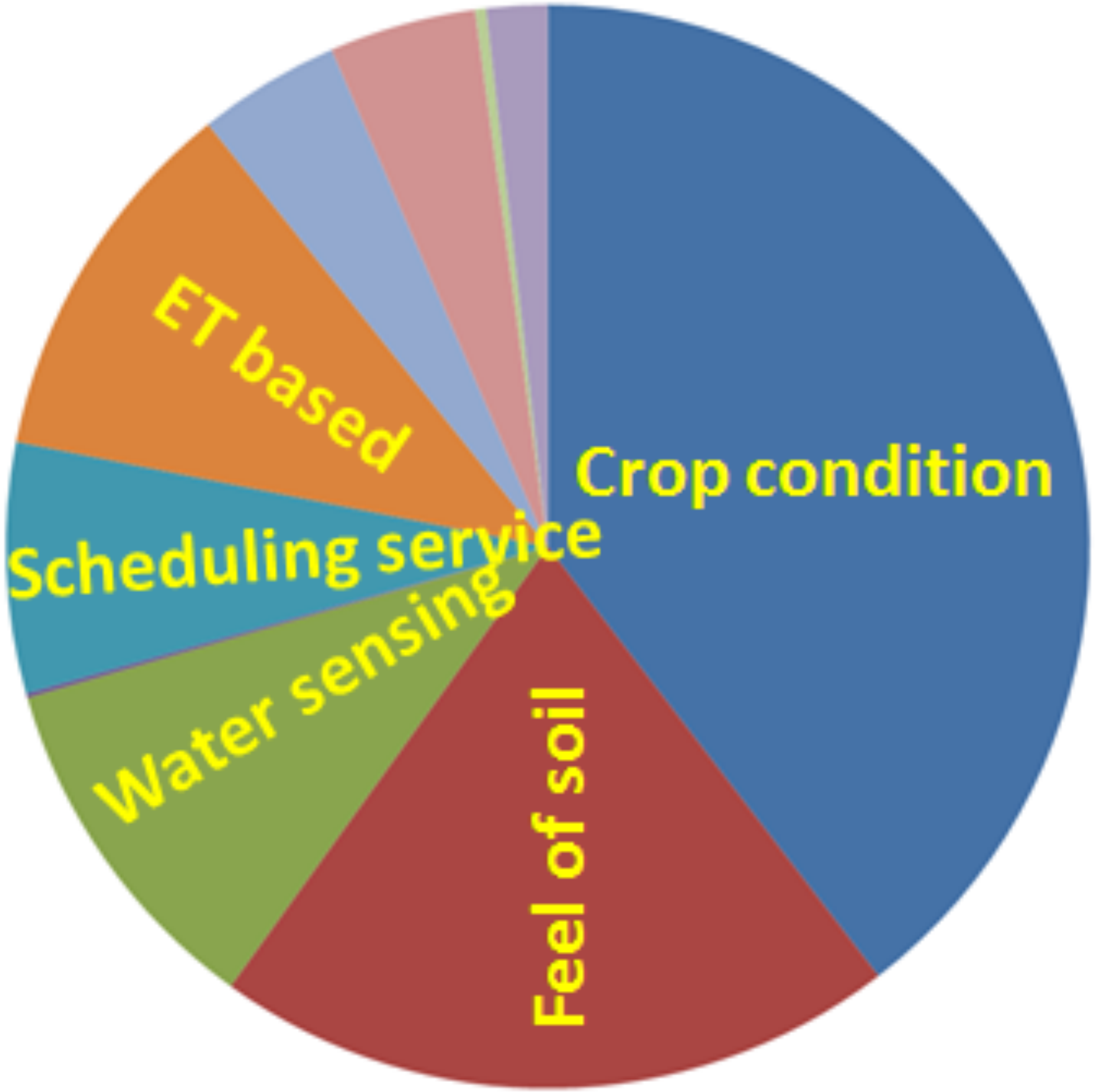
[Excludes institutional, research, and experimental farms. For meaning of abbreviations and symbols see introduc

Geographic area	All farms	Fa				
		Any method	Condition of crop	Feel of soil	Soil moisture sensing device	Plant moisture sensing device
United States	229,237	229,237	179,490	90,361	22,656	3,669
Alabama	1,022	1,022	919	426	70	1
Alaska	181	181	150	94	15	7
Arizona	4,380	4,380	3,171	1,964	174	21
Arkansas	4,212	4,212	3,978	1,452	222	53
California	44,347	44,347	33,163	18,097	7,429	2,127
Colorado	12,501	12,501	8,270	4,229	673	78
Connecticut	715	715	641	340	33	11
Delaware	396	396	354	192	60	10
Florida	8,120	8,120	6,865	2,971	803	181
Georgia	3,545	3,545	3,128	1,401	309	22
Hawaii	1,919	1,919	1,628	650	53	11
Idaho	14,092	14,092	10,025	5,867	521	61
Illinois	1,807	1,807	1,692	801	104	14
Indiana	1,893	1,893	1,770	845	151	29
Iowa	1,090	1,090	1,007	502	128	6
Kansas	5,243	5,243	4,340	1,646	596	50
Kentucky	1,212	1,212	1,046	465	80	9
Louisiana	2,130	2,130	1,936	695	62	17
Maine	946	946	818	352	19	11
Maryland	890	890	817	524	86	11
Massachusetts	1,398	1,398	1,233	739	122	-
Michigan	3,662	3,662	3,172	2,111	318	28
Minnesota	2,162	2,162	1,924	1,135	246	34
Mississippi	1,843	1,843	1,684	842	203	6
Missouri	2,569	2,569	2,436	1,159	162	22
Montana	7,384	7,384	5,674	2,393	446	26
Nebraska	15,747	15,747	13,491	6,957	3,599	45
Nevada	2,149	2,149	1,170	578	53	12
New Hampshire	528	528	483	262	32	1
New Jersey	1,255	1,255	1,118	569	175	36

Methods:

- Crop condition
- Feel of soil
- Soil moisture sensing
- Plant moisture sensing
- Scheduling service
- ET-based water use
- Personal calendar
- Computer model
- Look at neighbors

Nebraskan ways of determining when to irrigate



Challenge for making good decision on irrigation

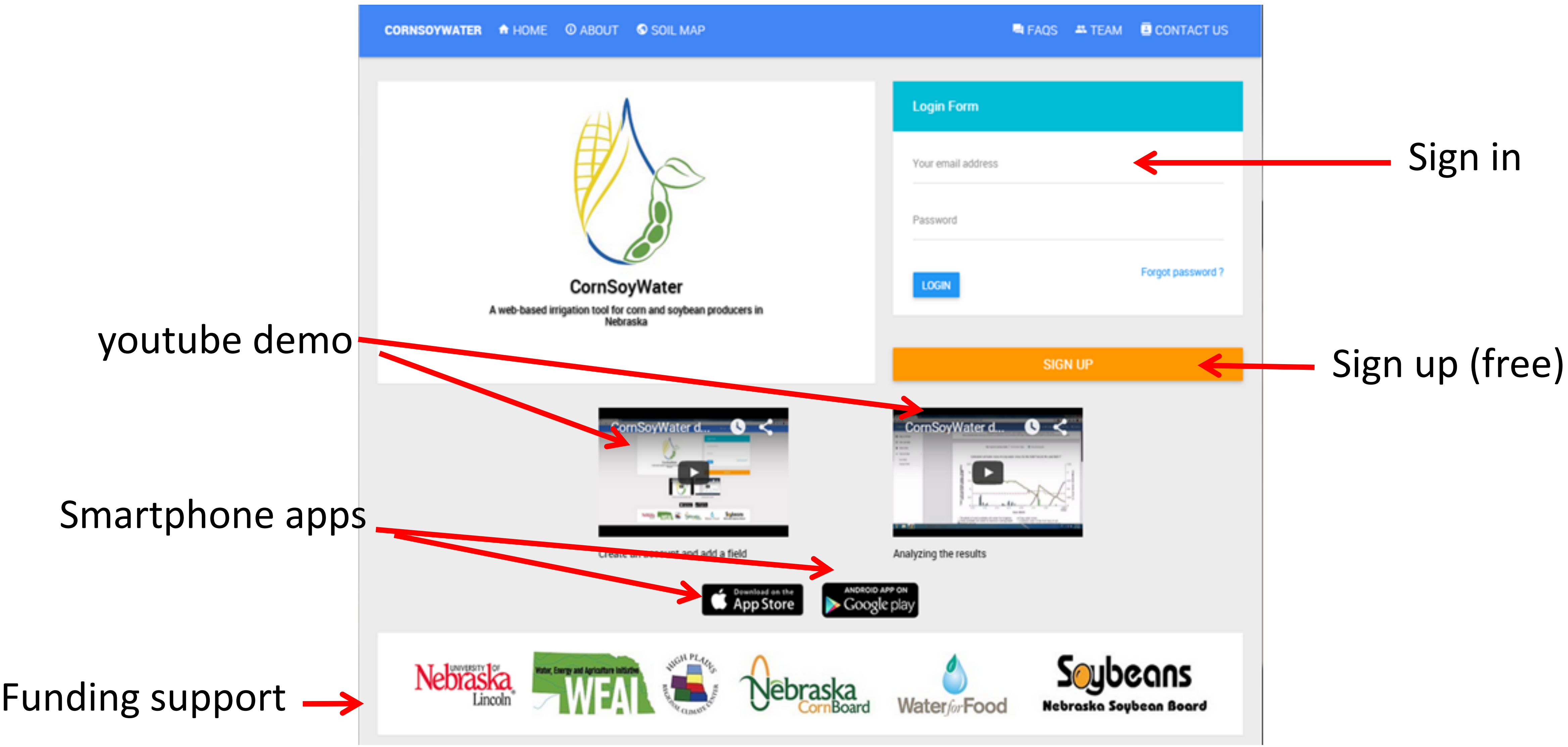

- Get to the field
- Know how many spots to check
- Have knowledge and experience of:
  - judging **available** water in soil and how many days it can carry on.
  - detecting early crop water stress
  - crop water use in relation to crop stage
  - blend weather forecast into the decision.


It is a challenge every day, every field, and every season!

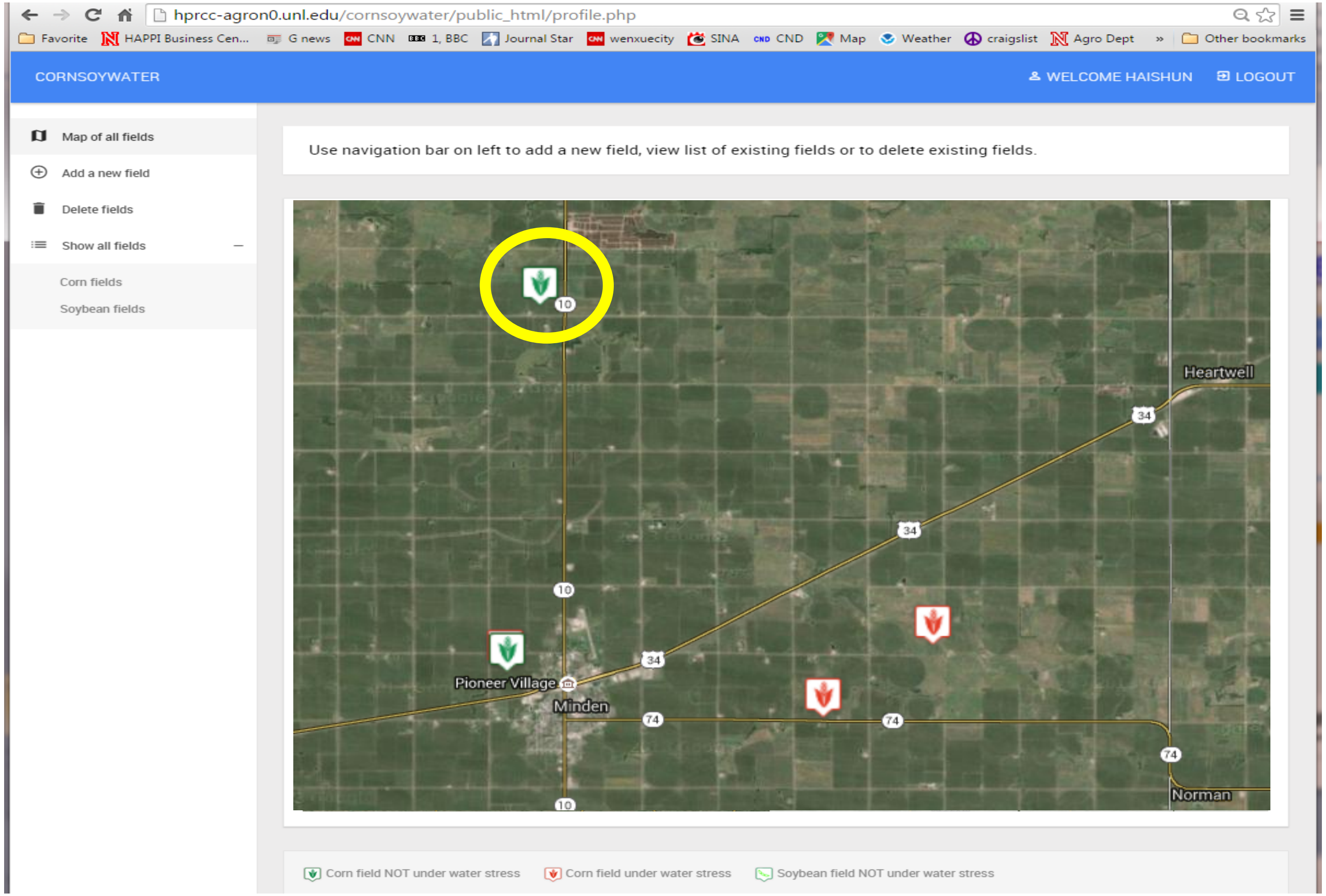
Conventional methods are:

- Empirical
- Not quantitative
- Depends much on experience
- Either too early, too much, or too late
- Time and label consuming, not fun!

CornSoyWater: model-based irrigation decision support for farmers



Upon log in: your fields are shown in green or red

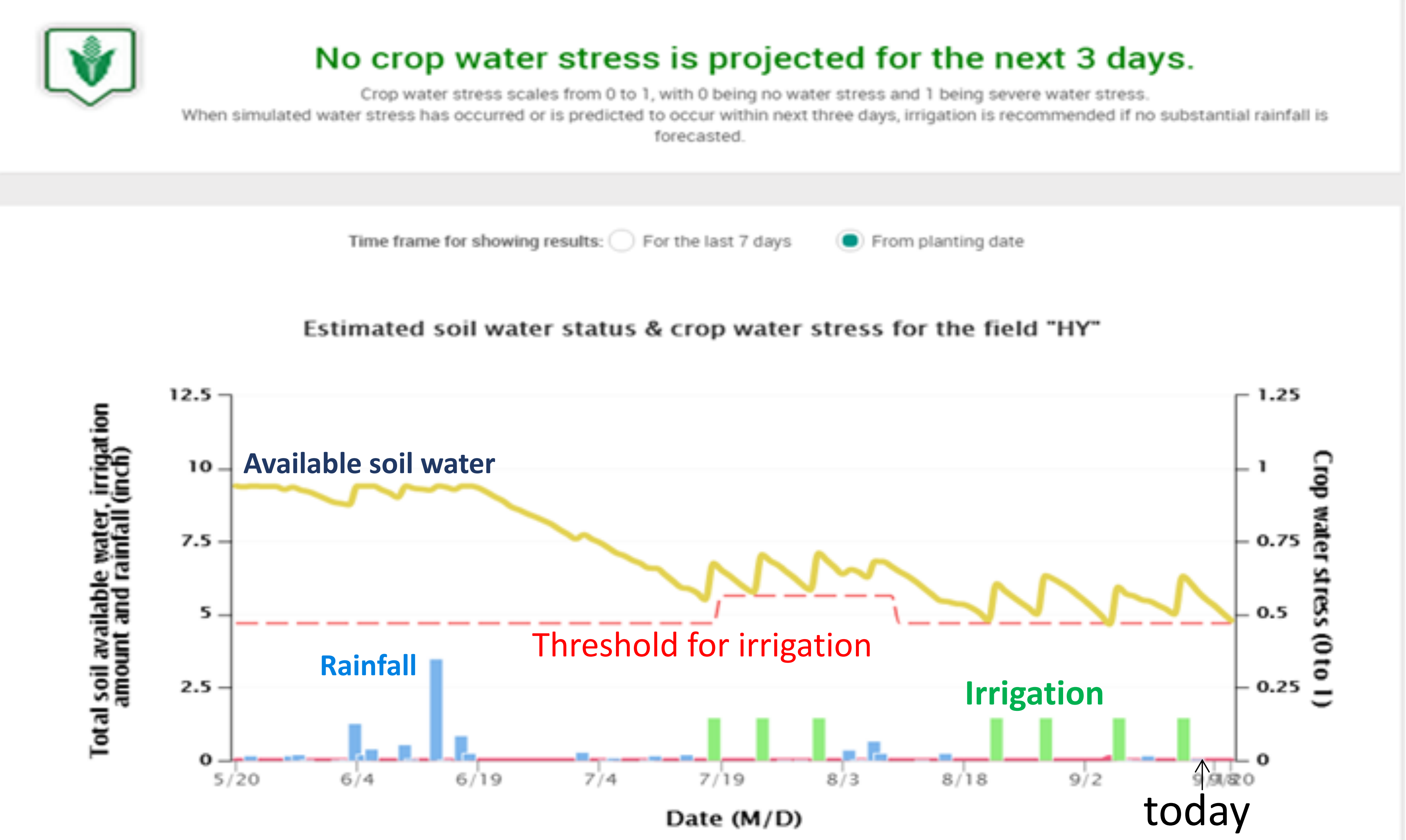


No need for irrigation

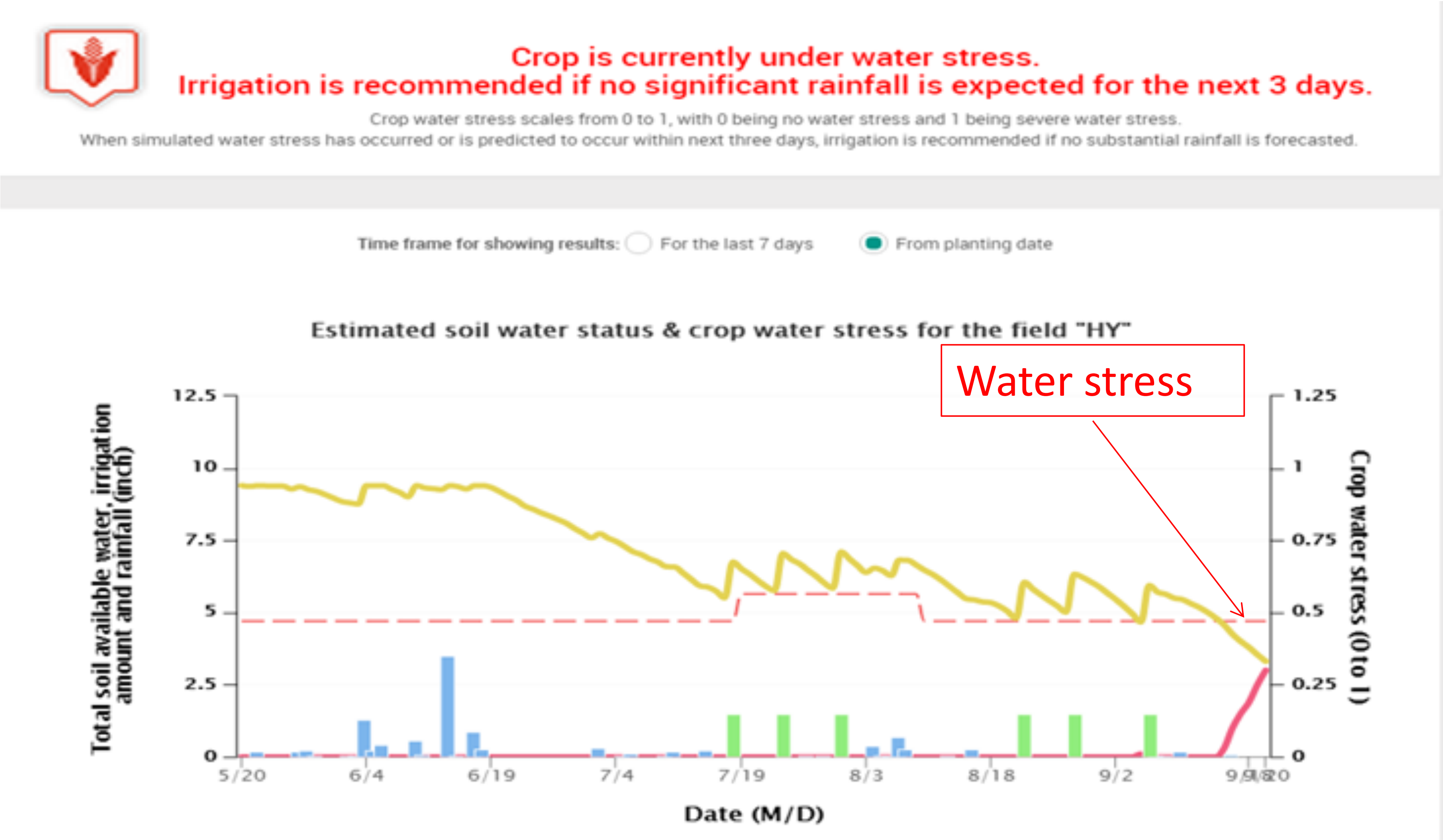
Need for irrigation

You know where you should go before leaving your home

Soil water and crop condition assessment



Irrigation is called if water stress is likely to occur



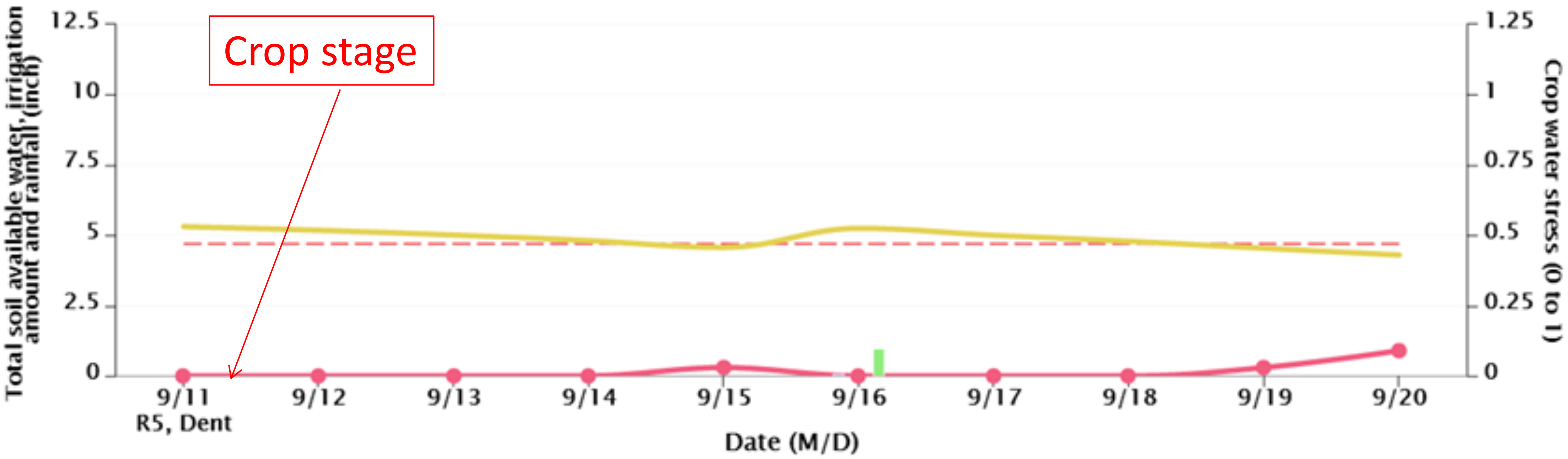
Current crop stage is also predicted

Crop water stress is projected for the next 3 days.
Irrigation is recommended if no significant rainfall is expected for the next 3 days.

Crop water stress scales from 0 to 1, with 0 being no water stress and 1 being severe water stress.
When simulated water stress has occurred or is predicted to occur within next three days, irrigation is recommended if no substantial rainfall is forecasted.

Time frame for showing results: For the last 7 days From planting date

Estimated soil water status & crop water stress for the field "HY"



Up-to-date soil water balance summary

Results Summary	
3.3	Current available water balance down to the maximum soil rooting depth (inch)
9.4	Initial available water down to the maximum soil rooting depth at planting (inch)
11.0	Total rainfall amount since planting (inch)
9.0	Total irrigation amount (inch)
20.0	Water consumption (i.e., total crop ET) since planting (inch)
6.0	Water losses, including canopy interception and drain below the maximum soil rooting depth (inch)

Don’t forget to enter your irrigation record!

Irrigation Events

Irrigation Date(MM/DD/YYYY)

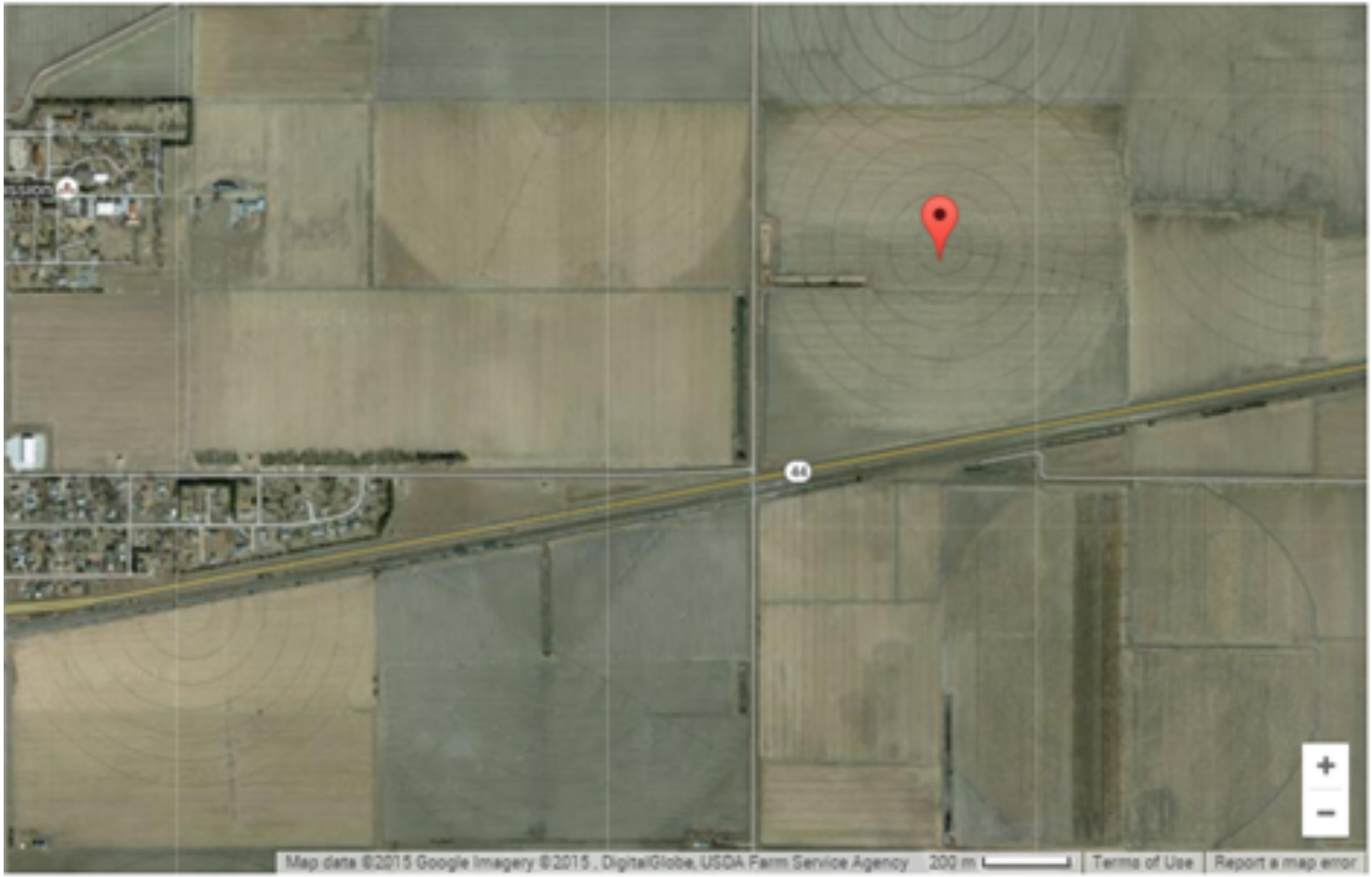
Irrigation Amount

ADD

Irrigation Date	Irrigation Amount
07/18/2015	1.5
07/24/2015	1.5
07/31/2015	1.5
08/22/2015	1.5
08/28/2015	1.5
09/06/2015	1.5

Free sign up, easy field registration for CornSoyWater

Registering a field: using the mouse to mark your field



Tell the program about your field & crop

Field Information	
HY	Field Name
5/20/2015	Date of Planting (MM/DD/YYYY)
115	Relative Maturity (Days)
34	Plant Population (x1000/acre)
60	Soil Rooting Depth (inch)
50	Soil Surface Residues Coverage (%)
1.3	Top Soil Bulk Density
Very wet (100% Available water)	Top Soil (1 foot) Moisture at Planting
Very wet (100% Available water)	Sub Soil (below 1 foot) Moisture at Planting
Loamy Sand	Top Soil (1 foot) Texture
Loamy Sand	Sub Soil (below 1 foot) Texture

- Hybrid maturity
- Date of planting
- Plant population
- Soil rooting depth
- Surface residues %
- Soil texture
- Soil moisture at planting

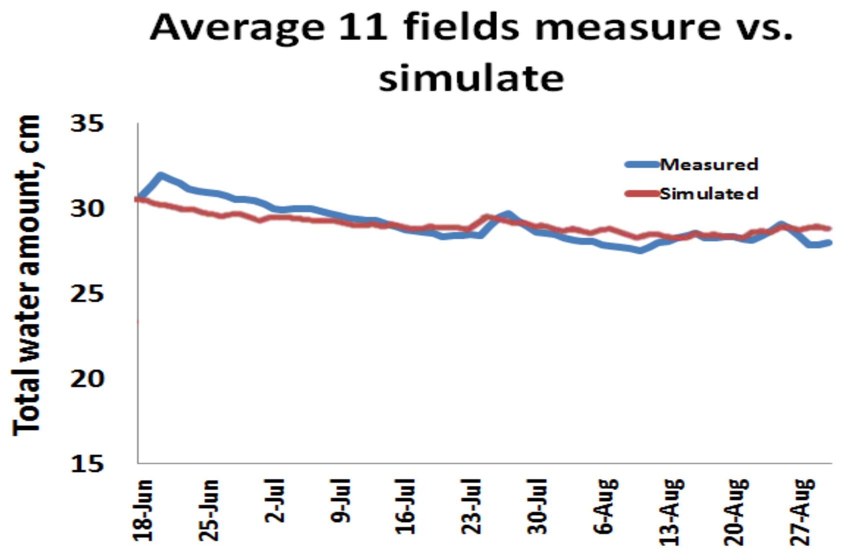
How CornSoyWater works

- It selects the nearest weather station for a field, and sets up simulation based on crop and soil info from user.
- Each time one logs in, it runs the model to simulate, in real time with 10-day projection:
  - Crop stage and growth (GDD, LAI, biomass, etc)
  - Crop water use
  - Soil water balance
  - Crop water stress

It calls for irrigation if water stress is likely to occur in coming days.

How good is the simulation?

CornSoyWater uses the Hybrid-Maize model (http://hybridmaize.unl.edu/, Yang et al 2004, 2006, 2014, 2016, 2017; Grassini et al, 2011, 2012; Liu et al, 2015, Meng et al 2015)



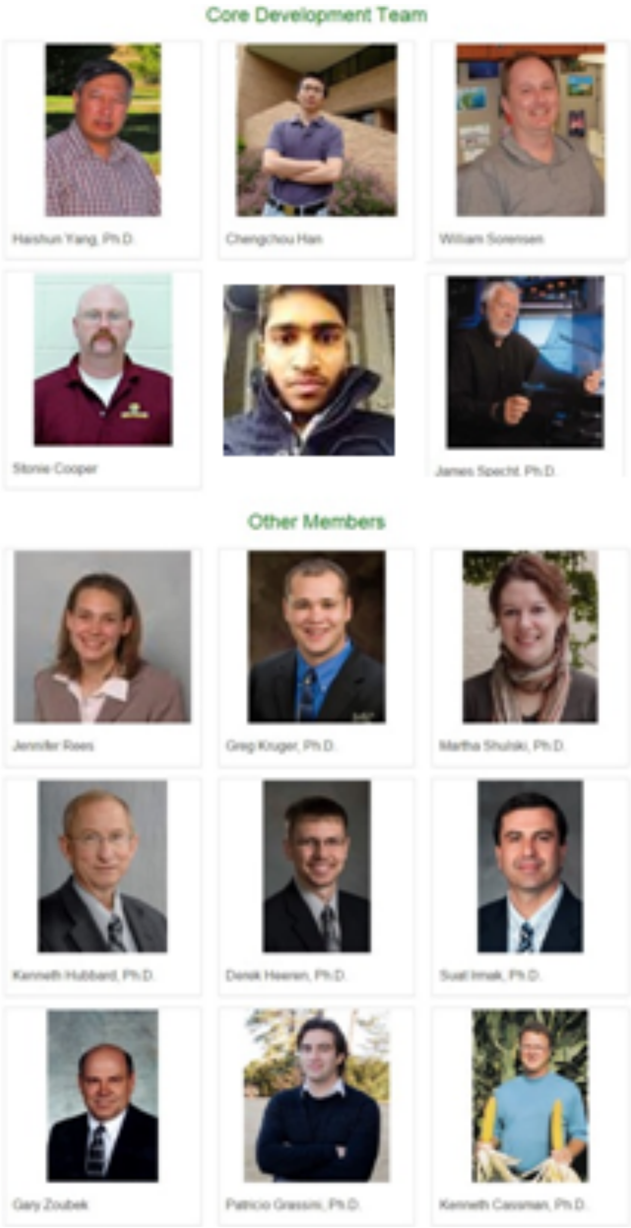
Key to good results

- Representative soil texture for the field
- Good rainfall data
- Good irrigation record.

However,

- **Don’t lose your common sense.**
- **We continue improving it to make it better every day!**

The CornSoyWater project team



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- Stonie Cooper, HPRCC server manager
- Dharmic Payyala, Rakesh Adloori, graduate students of Dept of Computer Sciences
- Greg Kruger (Co-PI), Assistant Professor, Dept of Agronomy & Horticulture
- Jenny Rees (co-PI), Associate Extension Educator
- Ken Hubbard, Professor, SNR and HPRCC.
- Derek Heeren, Assistant Professor, Dept of Biological System Engineering
- Group of senior students of Dept of Computer Sciences

Remarks: two challenges

- Accurate rainfall amount of a field
- Representative soil moisture content of a field

Thanks