Changing Climate
Apocalypse or Politics?
“MORE CROP FOR THE DROP”

A Global Search for Drought Tolerant Soybeans via the USDA National Plant Germplasm System

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New Crop Varieties that Use Agricultural Water More Efficiently

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DRY WEATHER is the GREATEST GLOBAL BARRIER to FOOD PRODUCTION
Plants need water, a lot of it.

Even Weeds need water.
Comparison of irrigated and non-irrigated corn grown in Helena, AR.
A Law of Nature

Plants Must Lose Water to Grow

CO₂ \rightarrow \text{H₂O}
It takes about 500,000 gallons of water to grow an acre of crop.
This water tower holds about 300,000 gallons of water, enough for 3/5 of an acre.
Bean Economics

Only about 15% of soybeans are irrigated.
70 Million Acres of Soybean in the USA

About 115 Million water towers

We are heavily dependent on mother nature!

Acres:
- Not Estimated
- < 10,000
- 10,000 - 24,999
- 25,000 - 49,999
- 50,000 - 99,999
- 100,000 - 149,999
- 150,000 +

U.S. Department of Agriculture, National Agricultural Statistics Service
U.S. Soybean Yield – August Drought

Dry August

YIELD

YEAR


20 25 30 35 40 45 50

35.3
Future Rainfall - Intensified Swings

2030–2039

This map illustrates the potential for future drought worldwide, based on current projections of future greenhouse gas emissions. Source: University Corporation for Atmospheric Research.
Water Shortages in California
With limited arable land and a continuously growing world population, the available farmland per capita is expected to further decrease dramatically.
Land for agriculture in United States is decreasing
(USDA Economic Research Service, 2011)

Buy land.
They ain’t making any more of the stuff. – Will Rogers
During the Green Revolution in the 1970’s

World Food Stocks were 1 year Supply

Now:

3 months

Less room for mistakes-
Or Bad Weather
The Big Question....

How can we meet the challenge?
What Can We Do in Agriculture?

• Develop More Efficient Water Use Practices

• Develop Agricultural Crops That Use Water More Efficiently

• Simply Irrigating Crops is Not a long term Answer- it takes fossil fuel to pump water- And in many cases fossil water
How Do We Get More Crop for the Drop?

GM or Biotech Approaches have NOT Worked.

Desert Survival Does NOT Feed the World—Or make Agriculture profitable

Why not move cactus genes into crops?
Let’s Look at Existing Crop Variation in Other Countries in Dry Areas

• More Empirical than cactus-
  More likely to Work
• Approach based on a long history of success.
• But Never Applied to Drought
DOMESTICATION OF SOYBEAN

~1500 B.C.

BEIJING
Adaptation of Soybean To local Conditions Around The Globe

3000 Years of ‘On Farm’ Breeding

Adaptation of Soybean To local Conditions Around The Globe

Continual Rise and Selection of Favorable Mutants
3000 Years of On Farm Breeding
More than 20,000 Types of Soybean Developed by farmers - and Collected

By USDA
Early USDA Explorer  P.H. Dorsett
SANDHILLS Research Station, NC
USDA & N.C. State University
All Varieties are FAST Wilting
-- Some worse than others
Discovered 10 Slow wilting types

Spent 20 Years of R&D
Field Day in North Carolina

Proof of Concept

New USDA Drought Variety
# Drought Gene DISCOVERIES
(Arkansas, Georgia, USDA & others)

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<th>CHROMOSOME</th>
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Soybean Team Drought

An Example That Can be Repeated in other crops
Mechanisms of Drought Tolerance

Deeper roots

Unusual Stomatal Response to Drying Air

Sustained Nitrogen Fixation
How much water does it take?
Crop ‘Water Productivity’

Corn and Soybean Need a lot of Water

Corn ~4500 gallons per bushel

Soybean ~7000 gallons

Seed Yield

Seasonal Crop Water Use (mm)
Freshwater Withdrawals by Sector

- Freshwater Thermoelectric: 3%
- Agricultural Irrigation: 14%
- Industrial & Commercial: 6%
- Domestic & Public: 37%
- Livestock & Aquaculture: 41%
How can we make soy more stress tolerant?

- **Opportunity** (not apocalypse) for Public Funding -
- Public concern for agriculture & weather never so great as **Now**.
- We call this momentum
- Public Researchers have learned a lot & are Ready to Partner with private sector, thanks in part to USB

Future Funding & ADVANCES will depend in large part on enthusiasm of stakeholders - YOU
Why haven’t we made the soy crop stress tolerant already?

- Funding has always lagged for Public Research on weather stress.
- Not much to go on scientifically at First-Had to build a Knowledge Base.
- United Soy Board
- The main long term support of public research on weather stress-
- Critical factor over other crops.
Soybeans for a Changing Climate

• WHAT HAVE WE DONE IN THE PUBLIC Sector?

• WHERE DO WE GO?
Private Interest

Farmer Support
United Soybean Board

Pioneer
Brand Products

Monsanto

Syngenta
Thanks!
Crop Yields Decline under Higher Temperatures

- **Corn**
  - Change in Yield (tons per hectare) vs. Change in maximum temperature (°F)

- **Soybean**
  - Change in Yield (tons per hectare) vs. Change in maximum temperature (°F)
World Grain Area Harvested per Person, 1950-2011

Source: USDA, UN

Source: http://www.earth-policy.org/indicators/C54/grain_2012
Illinois corn yield and water use

- **Corn yield (bushels/acre)**
  - 0
  - 50
  - 100
  - 150
  - 200

- **March-September rainfall (inches)**
  - 0
  - 10
  - 20
  - 30
  - 40

- **Yield**
- **Precipitation**
- **gallons of water per bushel of corn**
  - 4100
  - 3250
  - 4690
  - 5020
  - 4470
  - 5140
  - 4800
  - 5260

**Legend**
- **Yield** data from Illinois Farm Reports (USDA National Agricultural Statistics Service)
- **Rainfall** data from NOAA / National Climatic Data Center

Rainfall data from NOAA / National Climatic Data Center

Yield data from Illinois Farm Reports (USDA National Agricultural Statistics Service)
Changings Climate or Politics?
Apocalypse or Politics?
Maybe An Opportunity?
The Green Revolution of the 70s
Most Soybean is **NOT** Irrigated -

Too expensive to run the pumps.
FAO Hunger Map 2010
Prevalence of undernourishment in developing countries

Source: FAOSTAT 2010 (www.fao.org/hunger)

Note: The map shows the prevalence of undernourishment in the total population of developing countries as of 2005-7 – the most recent period for which complete data are available. Undernourishment exists when caloric intake is below the minimum dietary energy requirement (MDER). The MDER is the amount of energy needed for light activity and a minimum acceptable weight for attained height, and it varies by country and from year to year depending on the gender and age structure of the population.

The designations employed and the presentation of material in the map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal or constitutional status of any country, territory or sea area, or concerning the delimitation of frontiers.

Prevalence of undernourishment in developing countries (2005-07)

- Very high (undernourishment 35% and above)
- High (undernourishment 25-34%)
- Moderately high (undernourishment 15-24%)
- Moderately low (undernourishment 5-14%)
- Very low (undernourishment below 5%)
- Missing or insufficient data
70 Million Acres of Soybean in the USA
Palmer Drought Index-
An On-Line State of the Drought

August 2011

National Climatic Data Center, NOAA
112 Years of Drought in the America’s Breadbasket
In 2012, Drought Was Severe

- Major areas account for 75% of the total production annually.
- Major and minor areas account for 99% of the total production annually.
Minnesota

Slow wilting type