Can we handle the variation in precipitation?

WATER MANAGEMENT UNDER CLIMATE CHANGE
FIVE REASONS FOR CONCERN

- Increasing productivity requires more water available for transpiration
- Shifts in seasonality in precipitation towards the spring are occurring across the Midwest
- Variation in precipitation increases the uncertainty in soil water supply
- Soils are becoming more degraded leading to decreased infiltration and increased erosion
- Increasing air temperature increases the atmospheric demand = more crop water use
Structure and practices are based on adequate summer rainfall
High productivity is associated with a favorable summer rainfall pattern
Good soils outyield poor soils in all years except when there is an “excellent” rainfall pattern
Production deficit to meet food needs for population increase

Translates to a water deficit since water use curve behaves as

PROBLEM
WATER REQUIREMENTS

Water Use Efficiency

Water deficit need 120 mm more water to grow 300 bu corn
SOIL WATER AVAILABILITY

Data Points
- Sand, AWC = 3.8 + 2.2 OM
- Silt Loam, AWC = 9.2 + 3.7 OM
- Silty clay loam, AWC = 6.3 + 2.8 OM

Hudson, 1994
ENERGY BALANCE SYSTEM
SOIL WATER USE RATES

Corn Water Use 2000

- Clarion Spring N (100 kg/ha)
- Webster Spring N (100 kg/ha)
- Clarion Fall N (200 kg/ha)
- Webster Fall N (200 kg/ha)
CROP YIELD VARIATION
DURATION OF PHOTOSYNTHETIC CAPACITY

Corn 2009

Yield (kg ha⁻¹)

1.29e+6 1.30e+6 1.31e+6 1.32e+6 1.33e+6 1.34e+6 1.35e+6

Data Points

Yield = -191558 + 0.15332 * Sum \( r^2 = 0.81 \)

Continuous Corn

Yield = -157666 + 0.1252 * Sum \( r^2 = 0.51 \)

Corn 2008

Yield (kg ha⁻¹)

3000 4000 5000 6000 7000 8000 9000 10000 11000

Data Points

Yield = -82200 + 0.06505 Sum \( r^2 = 0.89 \)

Corn 2010

Yield (kg ha⁻¹)

5000 6000 7000 8000 9000 10000 11000 12000 13000

Data Points

Yield = -93539 + 0.09377 * Sum \( r^2 = 0.87 \)
MAIZE YIELDS

Maize Production

Grain Yield (Mg ha⁻¹)

United States
Mexico
China

Year

US GRAIN PRODUCTION

US Corn Production

US Soybean Production

US Wheat Production
KANSAS CORN YIELDS

Kansas Maize Yields

Yield (kg ha\(^{-1}\))

- Irrigated Yields: \(Yield_i = -276878 + 143.8675 \times \text{Year}\) \(r^2 = 0.86\)
- Non-irrigated Yields: \(Yield_{ni} = -107358 + 56.524 \times \text{Year}\) \(r^2 = 0.29\)
IOWA COUNTY YIELDS

- **Floyd County**
  - Yield (kg ha⁻¹)
    - 2000
    - 4000
    - 6000
    - 8000
    - 10000
    - 12000
    - 14000

- **Story County**
  - Yield (kg ha⁻¹)
    - 0
    - 2000
    - 4000
    - 6000
    - 8000
    - 10000
    - 12000
    - 14000

- **Washington County**
  - Yield (kg ha⁻¹)
    - 0
    - 2000
    - 4000
    - 6000
    - 8000
    - 10000
    - 12000
    - 14000

- **Cass County**
  - Yield (kg ha⁻¹)
    - 0
    - 2000
    - 4000
    - 6000
    - 8000
    - 10000
    - 12000
    - 14000
The majority of the yield losses due to the weather are short-term stresses.
PRECIPITATION CHANGES

Linear trend of Annual Precipitation 1901-2006

Source: UDel.
US CORN PRODUCTION

Corn for All Purposes 2010
Planted Acres by County
for Selected States
REGIONAL DIFFERENCES IN SPRING PRECIPITATION
The increase in spring precipitation has decreased the number of workable field days in April through mid-May across Iowa by 3.5 in 1995 to 2010 compared to 1979-1994.
Des Moines Precipitation
Days per Year with More than 1.25 inches

Years having more than 8 days: 2

350% Increase

2010 through Sept 27: 7

41% Increase

3.7 to 5.2
PROJECTED CHANGE IN N. AMERICAN PRECIPITATION BY 2080-2090
CHANGE IN DRY PERIODS AND HOT NIGHTS

Change in Maximum Number of Consecutive Dry Days

Change in number of hot nights
CURRENT STATE OF AGRICULTURAL SOILS

- Time since cultivation
- Soil Organic Matter
- Soil Water Holding Capacity
- Soil Organic Matter Content

Graph showing the decrease in soil organic matter content over time since cultivation, with an increase in soil water holding capacity.
SOIL EROSION

Degrading the soil resource decreases the water holding capacity

Hudson, 1994

Organic Matter (%) vs. Available Water Content (%)

Data Points
- Sand, AWC = 3.8 + 2.2 OM
- Silt Loam, AWC = 9.2 + 3.7 OM
- Silty clay loam, AWC = 6.3 + 2.8 OM

Available Water Content (%) vs. Organic Matter (%)
WORLDWIDE LAND AREA

Worldwide Land Availability

Year

Land Area per Capita (ha)

0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50

1960 1980 2000 2020 2040

Year
VULNERABLE AREAS OF THE WORLD

Soil degradation

Philippe Rekacewicz, UNEP/GRID-Arendal
TEMPERATURE CHANGES

Projections of Surface Temperatures

2020 - 2029

B1

2090 - 2099

A2

(°C)

0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5
FIVE REASONS FOR CONCERN

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CHALLENGES

- Realize that our soils are fragile and increased productivity will only result from enhancing the soil and its ability to infiltrate and store precipitation
- Realize that we are now entering into a period in which stability in climate may not be the norm
- Realize that we have a wide range of options at our disposal and we need to be more creative in how we utilize this information