Irrigation Technologies and the Limits of Water Productivity

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Irrigation Technologies and the Limits of Water Productivity

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THE RECENT EXPANSION OF WORLD IRRIGATED AREA

Crops distribution (area)

- Cereals: 75%
- Other crops: 25%

Relative Water Productivity ($/m^3)

- Cereals: 40%
- Other crops: 60%

FAOSTAT, 2009

(Stanhill, 1986)
Evolution of irrigated area in Andalusia, Spain

**Irrigated area almost doubled over the last 20 years**

WITH THE SAME AMOUNT OF WATER!

Fereres et al., 2011, J. Ex. Bot. 62,
FLOOD IRRIGATION HAS BEEN PRACTICED FOR THOUSANDS OF YEARS
IN FLOOD IRRIGATION: THE SOIL CONTROLS THE INFILTRATION OF WATER

SOILS ARE INHERENTLY VARIABLE
PRESSURIZED SYSTEMS: THE SYSTEM CONTROLS THE INFILTRATION
IN DRIP IRRIGATION, CONTROL OF TIME AND SPACE
SURFACE IRRIGATION WENT FROM 90% TO 30% IN THIRTY YEARS

IN ANDALUSIA, DRIP IRRIGATION IS NEAR 70%

WHAT ABOUT ENERGY?

IRRIGATION METHODS IN SPAIN (2011)
Control, high uniformity, and ease of water application have been the key factors until now
Irrigation faces three challenges:

- Engineering
- Management
- Biological
THE YIELD GAP and HOW TO BRIDGE IT

Farm yields of processing tomatoes in California

La Mancha, Spain, Montoro et al., (2011)

Maize, Nebraska, USA, Grassini et al., (2011)
Focus on measuring the magnitude and causes of yield gaps

REMOTE SENSING

SIMULATION MODELS

AquaCrop: FAO simulation model of water-limited crop production

(Lobell, 2012)
Optimizing water use at the farm level

Develop a pre-season economic optimization model designed to optimize irrigation water management and cropping patterns at farm level

1. Simulation of crop-water production functions
2. Economic optimization model
3. Scenario analyses

UPSCALING MODELS TO IRRIGATION DISTRICTS AND REGIONS

(Garcia-Vila & Fereres, 2012)
DEVELOPMENT OF A REMOTE SENSING PLATFORM FOR IRRIGATION SCHEDULING

DEVELOPMENT OF A REMOTE SENSING PLATFORM FOR IRRIGATION SCHEDULING
Reduce risks by monitoring stress accurately and using precision irrigation where it is economically viable.
WHAT ABOUT THE BIOLOGICAL CHALLENGE (THE GENETIC OPTION) ?
WHY CROPS CONSUME SO MUCH WATER?
THE FUNDAMENTAL CONNECTION BETWEEN H$_2$O LOSS AND CO$_2$ ASSIMILATION

$WP = \frac{CO_2}{H_2O}$
MAIZE WATER PRODUCTION FUNCTION

YIELD (%) vs. CONSUMPTIVE USE (%)

- FAO I&D 33 (1979)
- Payero et al., (2009)

1:1 relationship indicated.

Source: Payero et al., 2009
Monsanto to Introduce Genuity Droughtgard Hybrids in the Western Great Plains In 2013 (one year too late) up to 6 bushel advantage over competitor hybrids (or 360 kg/ha).
ASSESSMENT OF WATER PRODUCTIVITY IMPROVEMENTS

THE BASIC RELATION BETWEEN YIELD AND CONSUMPTIVE USE, ETc, IS LINEAR FOR THE MAJOR CEREALS; i.e., WP IS CONSTANT
EVOLUTION OF WATER PRODUCTIVITY IMPROVEMENTS

From 70 to 90 % uniformity

The genetic option

Yield (%) vs Water input (%) graph showing water productivity improvements from 70 to 90% uniformity with different lines representing genetic options.
Optimizing the use of a limited water supply
BECAUSE OF Necessity
STRESS MANAGEMENT VIA DEFICIT IRRIGATION

CROP DEPENDENT

Yield (%) vs. Water input (%)

Water Productivity (kg/m³)

Water input (%)
In conclusion,

• Engineering advances were largely responsible for past increases in WP

• WP limits have largely been reached, but big gaps remain in most farming systems. Focus on measuring WP gaps and determining their causes

• Water supply limitations will force adoption of deficit irrigation. Opportunities for the optimization of limited supplies at scales from field to regions