FIGARO

FLEXIBLE AND PRECISE IRRIGATION PLATFORM TO IMPROVE FARM-SCALE WATER PRODUCTIVITY

Closure event,
7 September, 2016
Marginal cost curves for water footprint reduction in irrigated agriculture: a policy and decision making guide for efficient water use in crop production

A.D. Chukalla; M. S. Krol; A.Y. Hoekstra

UNIVERSITY OF TWENTE.
Water footprint of crop production

The diagram illustrates the water footprint of crop production, distinguishing between green and blue water footprints. Green water footprint (WF) includes rainfall, irrigation, evapotranspiration, and capillary rise, while blue water footprint includes soil moisture from capillary rise and irrigation. Drainage and runoff are also depicted as part of the water cycle.
Objective

To compare management packages with regard to their costs in reducing WF of irrigated crop.

To develop curves that help in estimating the cost and cost effective measures associated with a certain WF reduction target, e.g. towards a certain reasonable WF benchmark per ton of crop or WF permit per ha.
Research approach

- Quantify WFs and annualised costs
- Structure management packages along WF improvement paths
- Deduce marginal cost curve for WF reduction

\[ \text{Cost} = \text{Investment} + \text{O&M} \]
WFs and costs of crop production

<table>
<thead>
<tr>
<th>WF, m³ ha⁻¹</th>
<th>Cost, $ha⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>8000</td>
<td></td>
</tr>
<tr>
<td>7000</td>
<td></td>
</tr>
<tr>
<td>6000</td>
<td></td>
</tr>
<tr>
<td>5000</td>
<td></td>
</tr>
<tr>
<td>4000</td>
<td></td>
</tr>
<tr>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Sprinkler | Furrow | Drip | Subsurface drip

- Green WF
- Blue WF
- Investment cost
- Water cost
- Energy cost
- Labour cost
WF versus cost in irrigated crop production

Pareto optimal front for WF and cost improvement
WF reduction pathways in irrigation

- **FU** – Furrow
- **FI** – Full irrigation
- **NM** – No mulching
- **SP** – Sprinkler
- **DI** – Deficit irrigation
- **OM** – Organic mulching
- **SD** – Subsurface drip
- **SM** – Synthetic mulching

- **WF, m³ ha⁻¹ year⁻¹**
- **Cost, $ ha⁻¹ year⁻¹**

**Pathways:****
- **Furrow** to **deficit**
- **Full irrigation** to **No mulching**
- **to** **organic** **mulching**
- **to** **drip**
- **Drip** **Deficit irrigation** **Synthetic mulching**

**Furrow – Drip – deficit irrigation**
WF reduction pathways in irrigation

- **FU** – Furrow
- **FI** – Full irrigation
- **NM** – No mulching
- **SP** – Sprinkler
- **DI** – Deficit irrigation
- **OM** – Organic mulching
- **SD** – Subsurface drip
- **SM** – Synthetic mulching

**WF, m³ ha⁻¹ year⁻¹**

**Cost, $ ha⁻¹ year⁻¹**

- **Furrow Full irrigation No mulching**
- **to organic mulching**
- **to drip**
- **Drip Deficit irrigation Synthetic mulching**
WF reduction pathways in irrigation

- **FU** – Furrow
- **FI** – Full irrigation
- **NM** – No mulching
- **SP** – Sprinkler
- **DI** – Deficit irrigation
- **OM** – Organic mulching
- **SD** – Subsurface drip
- **SM** – Synthetic mulching

**Cost, $ ha\(^{-1}\) year\(^{-1}\)**

**WF, m\(^{3}\) ha\(^{-1}\) year\(^{-1}\)**
WF reduction pathways in irrigation

- **Furrow**
- **Full irrigation**
- **No mulching**

- **Sprinkler**
- **Full irrigation**
- **No mulching**

- **Drip**
- **Deficit irrigation**
- **Organic mulch.**

- **Drip**
- **Deficit irrigation**
- **Synthetic mulch.**

Cost, $ ha⁻¹ year⁻¹

WF, m³ ha⁻¹ year⁻¹
Marginal cost curve for WF reduction starting from furrow & full irrigation and no mulching

- Drip and synthetic mulching
- Organic mulching
- Deficit irrigation
Marginal cost curve for WF reduction starting from sprinkler & full irrigation and no mulching

- Synthetic mulching
- Drip and Organic mulching
- Deficit irrigation

WF in m$^3$ ha$^{-1}$

Cost of WF reduction, $\$, m$^3$

WF reduction, m$^3$ ha$^{-1}$

163
1176
1985

6377
6214
5201
4392
Policy and decision making based on information from the MCC for WF reduction

- WF benchmark (m$^3$ t$^{-1}$)
- WF permit (m$^3$ ha$^{-1}$) or WF cap (m$^3$ per basin)

- Incentive (market) based
- Non-incentive
Illustrative example

The WF in a basin, already exceed above the maximum sustainable level. Catchment with water scarcity of 120% → Need to reduce the water footprint by 20%

Irrigation of maize by sprinkler accounts for the major share of the water footprint

Current water footprint maize = 6900 m³ ha⁻¹ → Need to reduce the water footprint by 1380 m³ ha⁻¹

Conclusion
- Implement deficit irrigation and drip on all areas
- Implement organic and synthetic mulching on 75% and 25% of the area, respectively
- Total cost: -1.3*163 + 0 + 1.3*(1380-1176) = 53 $ ha⁻¹
Decision and policy makers can benefit from the comprehensive information in the MCC for WF reduction to apply incentive and non-incentive based instruments in managing water scarcity.

The information can be used to improve awareness and communication of the cost effective WF reduction measures/management packages among water managers, industries, producers and technology developers.
Thank You