Goals of the project

- Improve agricultural yield and water management in Sahel region through the use of a wireless sensor network
- What is its potential for Africa?
- Design of the most suitable drip irrigation system in Burkina Faso

Sensor-based irrigation

- Irrigation is triggered when the soil matrix potential (a way to measure the soil humidity) is below a defined value to avoid water stress
- Typically, water stress for the plant occurs when the soil matrix potential is around -30 to -60 kPa (depends on the plant type but independent of the type of soil)
- Soil matrix potential is monitored with sensors
- Light water stress may be allowed to save water given the cultivar

Material

Drip irrigation kits
- Water directly delivered to the crop through a dense network of low pressure pipes
- Water delivery efficiency 95% (in comparison: about 50% for conventional irrigation)
- Small scale, low-cost drip kit provided in Africa

Drawbacks:
- Still high investment
- Risk of clogging
- Good irrigation knowledge

Results

Model – Hydrus 1D
- 1D vertical simulation of water flow dynamic
- Transpiration: not to be restricted in order to maximize yield
- Evaporation: minimize as much as possible at the surface
- Leaks: negligible when matrix potential is below about -40 kPa

Beginning of growth: small irrigation depth (<10 mm) with higher frequency (2 days)

Mid-season: higher irrigation depth (>20 mm) and lower frequency (3-4 days)

Prediction for chilli pepper

<table>
<thead>
<tr>
<th>Days after planting</th>
<th>Threshold at 10 cm depth [kPa]</th>
<th>Irrigation</th>
<th>Minimum potential in root zone</th>
<th>Total irrigation amount per 250 m²</th>
<th>Water used/ETₚ₀</th>
<th>Bottom flux losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-20</td>
<td>-15</td>
<td>60</td>
<td>2.4 every 2 days</td>
<td>1.4</td>
<td>-60</td>
<td>17</td>
</tr>
<tr>
<td>21-60</td>
<td>-20</td>
<td>60</td>
<td>4.3 every 3 days</td>
<td>2.7</td>
<td>-50</td>
<td>38</td>
</tr>
<tr>
<td>61-150</td>
<td>-50</td>
<td>60</td>
<td>8.4 every 4 days</td>
<td>5.3</td>
<td>-55</td>
<td>110</td>
</tr>
</tbody>
</table>

Sensors – WSN Technology

- Two main manufacturers
  - Irrrometer (Watermark)
  - Decagon (MPS-2)

- Alimentation with solar panels
- Integrated in an autonomous wireless network

Precision:
- Sensors may fail about 5-10% of the time
- Sensors’ precision between ±10 kPa
- Minimum of 3 sensors per irrigation system

Costs

- Drip kit (Netafim™) 200 €
- Wireless sensor network 175 €
- Total (for 500 m²) 375 €

- High investment costs for Africa, but return on investment possible

Measurement

Traditional irrigation

- Irregular behaviour
  - Moisture too high: water losses
  - Moisture too low: yield losses

Sensor-based irrigation

- Regular behaviour: good water management

First harvest

- Sensor-based irrigation improves water management
- Traditional system may be efficient, but high variability

<table>
<thead>
<tr>
<th>Total harvest [kg]</th>
<th>Harvest vs. water</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>250</td>
</tr>
<tr>
<td>250</td>
<td>200</td>
</tr>
<tr>
<td>200</td>
<td>150</td>
</tr>
<tr>
<td>150</td>
<td>100</td>
</tr>
</tbody>
</table>

Water stress factor

- Good relationship between water stress and yield

Conclusion

- Good potential for West Africa, but still costly
- Requires more research in order to have more results
- Results depend on the plant type
- Difficulty: find the best thresholds for the plant

Contact: paul.cornioley@epfl.ch; tom.mueller@epfl.ch