Design Project - SIE 2013

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Sensorscope

Info4Dourou 2.0: Irrigation support system for developing countries

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

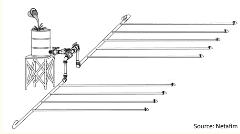
Experiment in Burkina Faso

- Long dry season (at least 6 months without precipitation)
- Dry season farming for food security and additional income
- **First experiment in Kombori:**
  - 6 experimental fields of 250 m²
  - Onion culture
  - Record of water use and harvests
  - Sensors indicate when to irrigate

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



Sensors – WSN Technology

- Two main manufacturers
  - Irrometer **(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

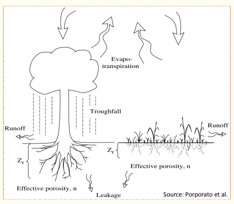
Drip kit (Netafim™)	200 €
Wireless sensor network	175 €
Total (for 500 m²)	**375 €**

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

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
- **Leakages**: negligible when matric potential is below about -40 kPa



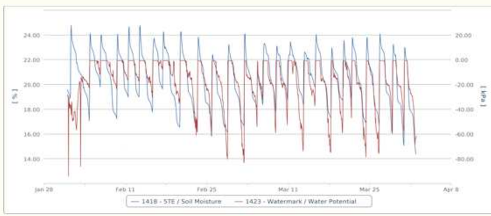
- **Beginning of growth:** small irrigation depth (<10 mm) with higher frequency (2 days)
- **Mid-season:** higher irrigation depth (>20 mm) and lower frequency (3-4 days)

Measurements

Traditional irrigation

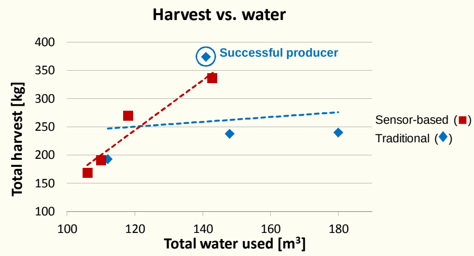
- Irregular behaviour
  - Moisture too high → water losses
  - Moisture too low → yield losses

Sensor-based irrigation

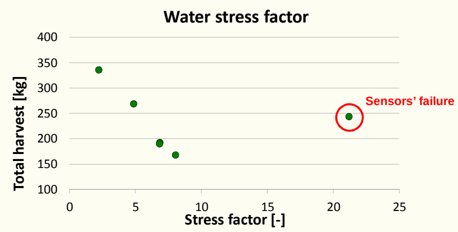


- Regular behaviour → good water management

First harvest



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



- Good relationship between water stress and yield

Prediction for chilli pepper

Days after planting	Threshold, at 15 cm depth	Irrigation				Minimum potential in root zone	Total irrigation amount per 250 m²	Water used/ ET_{max}	Bottom flux losses
[days]	[kPa]	Rate [mm/d]	Irrigation duration [h]	Irrigation frequency	Amount per irrigation [m³]	kPa	[m³]	%	[m³]
1-20	**-15**	60	2.4	every 2 days	1.4	-60	**17**	94.4%	1.5
21-60	**-20**	60	4.3	every 3 days	2.7	-50	**38**	90.9%	2.5
61-150	**-50**	60	8.4	every 4 days	5.3	-55	**110**	91.9%	2

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

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