WHAT INTEREST OF DRIP IRRIGATION FOR CASH CROPS IN FRANCE?

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Presentation outlines

1. Introduction
2. Cost comparison of drip and sprinkling irrigation for cash crops
3. Water, energy and labour savings
4. Others benefits and risks
5. Questions and experimental approaches
6. Conclusions
Introduction

Share of irrigation techniques in France (Source: Agreste)

<table>
<thead>
<tr>
<th>Year</th>
<th>Sprinkling Irrigation</th>
<th>Micro-Irrigation</th>
<th>Gravity Irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>2,500,000</td>
<td>97,300</td>
<td>-</td>
</tr>
<tr>
<td>2003</td>
<td>2,250,000</td>
<td>111,100</td>
<td>-</td>
</tr>
<tr>
<td>2005</td>
<td>2,250,000</td>
<td>107,400</td>
<td>-</td>
</tr>
<tr>
<td>2007</td>
<td>2,100,000</td>
<td>103,500</td>
<td>-</td>
</tr>
<tr>
<td>2010</td>
<td>1,950,000</td>
<td>109,500</td>
<td>-</td>
</tr>
</tbody>
</table>
Introduction

Irrigated areas (ha) of cash crops + silage maize

France 2010

1 575 600 ha total irrigated crops

1 200 000 ha irrigated cash crops + silage maize

Source: Agreste and FNPSMS
Introduction

Drip irrigation for cash crops

• Difficult to estimate up-to-date drip irrigated areas
• Mainly used in arboriculture and market gardening
• A few hundred hectares of cash crops in 2012, mainly Potatoes, Seed maize, Grain maize, Tobacco

• Farmers are interested by potential advantage of drip irrigation:
  ✓ More uniformity in water distribution
  ✓ No evaporation or drift losses
  ✓ Limited soil evaporation loss
  ✓ Possibility to irrigate with strong winds
  ✓ Adaptation to irregular plots contours
  ✓ Energy savings due to lower pressure requirement
  ✓ Labour savings during irrigation season when automated
  ✓ Easier use of fertigation to improve nitrogen efficiency
Cost comparison of drip and sprinkling irrigation for cash crops

Center-pivot

Mobile-gun (hose-reel)

Sub-surface
Flat dripper

On-surface reusable cylindrical dripper

On-surface reusable flat-dripper

On-surface disposable tape
Cost comparison of drip and sprinkling irrigation systems on a schematic 30 ha plot of grain maize

- **Technical dimensions for each system to deliver**
  - 3,000 m$^3$.ha$^{-1}$.year$^{-1}$
  - 6 mm/day maximum flow

- **Costs calculation**
  - Based on 2,000 m$^3$.ha$^{-1}$.year$^{-1}$ as interannual average summer water amount applied, common to all systems in a first hypothesis
2 mobile guns on 15 ha working simultaneously

Hose-reels 90/270 – nozzle 25 mm + turntable

Needs: 6 mm/day
Q = 90 m³/h
P = 8 bar
Pump power = 30 kW
Buried pipes = 950 m
Linear pressure losses
623 m Ø160 (inner 150) = 0.7 bar
327 m Ø140 (inner 130) = 0.6 bar
Singular pressure losses
2 elbows at 90° \( \Rightarrow \) 0.01 bar
Check valve \( \Rightarrow \) 0.09 bar
Pressure loss hose reel
PE 260 m Ø90 = 2 bar
Turbine = 0.5 bar

Pump hydraulic efficiency = 0.75
Electrical efficiency = 0.9

Pressure losses calculated by Hazen-Williams formula

Working time of mobile gun: 20 h/day
Center-Pivot and sprinkler solid-set system for edges

**Needs:** 6 mm/day

**Q =** 75 m³/h

**P =** 6 bar

**Pump power =** 18.5 kW

**Buried pipes =** 490 m

**Linear pressure losses**
490 m Ø140 (inner 130) = 0.9 bar

**Singular pressure losses**
1 elbow at 45° + check valve $\rightarrow$ 0.1 bar

**P = 5 bar**

Pressure losses calculated by Hazen-Williams formula

**Working time 24 h/day**
On surface drip system

4 sectors of 7.5 ha

Needs: 6 mm/day
Q = 75 m³/h
P = 4 bar
Pump power = 12 kW
Buried pipes = 950 m

Linear pressure losses
950 m Ø160 (inner 150) = 1 bar
Singular pressure losses
2 elbows at 90° ➞ 0.01 bar
Check valve ➞ 0.09 bar
Filtration = 0.6 bar

Pressure losses calculated by Hazen-Williams formula
Working time 24 h/day

Pump hydraulic efficiency = 0.75
Electrical efficiency = 0.9

Water supply line for 4 sectors
Flexible pipe 5”

Between dripperlines: 1.6 m
Between drippers: 50 cm
Dripper flow rate: 0.8 L/h
Sub surface drip system
4 sectors of 7.5 ha

Needs: 6 mm/day
Q = 75 m³/h
Pressure = 4 bar
Pump power = 12 kW
Buried pipes = 950 m

Linear pressure losses
950 m Ø160 (inner 150) = 1 bar
Singular pressure losses
2 elbow at 90° ➞ 0.01 bar
Check valve ➞ 0.09 bar
Filtration = 0.6 bar

Between dripperlines: 1.2 m
Between drippers: 50 cm
Dripper flow rate: 0.6 L/h
Flat drippers pressure compensating and anti-siphon mechanism

Pump hydraulic efficiency = 0.75
Electrical efficiency = 0.9

Pressure losses calculated by Hazen-Williams formula
Working time 24 h/day
Cost comparison of drip and sprinkling irrigation systems on a schematic 30 ha plot of grain maize

Investment and elements for cost calculation

<table>
<thead>
<tr>
<th>Equipment type</th>
<th>drip-irrigation</th>
<th>Sprinkling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sub-surface</td>
<td>on-surface</td>
</tr>
<tr>
<td></td>
<td>reusable</td>
<td>disposable</td>
</tr>
<tr>
<td></td>
<td>Flat dripper</td>
<td>cylindrical dripper</td>
</tr>
<tr>
<td>Total investment (equipment, pipes, pump, well) (€/ha)</td>
<td>3 450</td>
<td>3 600</td>
</tr>
<tr>
<td>operating annual time for 2000 m³.ha⁻¹.year⁻¹ (hours/year)</td>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td>Labour during the season (hours/ha/year)</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Labour setting and removing equipment (hours/ha/year)</td>
<td>4*</td>
<td>10</td>
</tr>
</tbody>
</table>

* annual allocation of cost of the operations of setting and removing equipment

Labour cost: 17 €/hour  
Electricity cost: 0.104 €/kWh  
Water Agency fee: 0.0083 €/m³
Cost comparison of drip and sprinkling irrigation systems on a schematic 30 ha plot of grain maize

DRIP IRRIGATION FOR WATER SAVING: THE WINNING FORMULA?

- **Sub-surface flat dripper**: €659/ha/year
- **On-surface reusable cylindric dripper**: €798/ha/year
- **On-surface reusable flat dripper**: €856/ha/year
- **On-surface disposable tape**: €861/ha/year
- **Mobile gun (hose-reel)**: €405/ha/year
- **Center-pivot**: €321/ha/year
## Water savings and uniformity

### Saving evaporation in the air and wind drift

<table>
<thead>
<tr>
<th>Equipment type</th>
<th>conditions</th>
<th>application efficiency Water received by crop and soil / water at the outlet of the equipment</th>
<th>spatial uniformity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile gun</td>
<td>good conditions</td>
<td>85% to 95%</td>
<td>++</td>
</tr>
<tr>
<td></td>
<td>windy conditions</td>
<td>75% to 85%</td>
<td>+</td>
</tr>
<tr>
<td>Center-pivot, spray line, spray line on hose reel</td>
<td>good conditions</td>
<td>90% to 95%</td>
<td>+++</td>
</tr>
<tr>
<td></td>
<td>windy conditions</td>
<td>80% to 90%</td>
<td>+++</td>
</tr>
<tr>
<td>sprinkler solid set system</td>
<td>good conditions</td>
<td>80% to 95%</td>
<td>++</td>
</tr>
<tr>
<td></td>
<td>windy conditions</td>
<td>70% to 80%</td>
<td>+</td>
</tr>
<tr>
<td>drip irrigation</td>
<td>new equipment</td>
<td>90% to 95%</td>
<td>++++</td>
</tr>
<tr>
<td></td>
<td>ageing, clogging</td>
<td>60% to 90%</td>
<td>++</td>
</tr>
</tbody>
</table>

(according Granier and Deumier, 2013)
Water savings and uniformity

Reducing soil water evaporation after irrigation

• Irrigation water losses by soil water evaporation
  ➢ Mainly significant in the 1\textsuperscript{st} stages of maize cycle when soil is not covered by the canopy
  ➢ Decrease when LAI increase

• Drip irrigation benefit
  Mainly expected in dry spring years with early irrigation

Estimated total water savings of drip irrigation versus mobile gun

• Water: 10\% - 20\%
• Reduction of operating cost: 3 - 7 €.ha\textsuperscript{-1}.year\textsuperscript{-1}
• Reduction of fixed annual cost: 20 €.ha\textsuperscript{-1}.year\textsuperscript{-1}
  (enlarging technical depreciation period)
Energy savings (case study)

Pressure requirement
- Hose-reel inlet: 5 to 8 bars
- Center-pivot: 5 bars
- Drip system: 3 to 4 bars

Pump power
- Mobile-gun: 30 kW
- Center-pivot: 18.5 kW
- Drip irrigation: 12 kW

kWh / m³
- Mobile gun: 0.34
- Center-pivot: 0.28
- Drip system: 0.16

€ / ha (2000 m³ ha⁻¹ year⁻¹)
- Mobile gun: 70
- Center-pivot: 58
- Drip system: 33

Coexistence of drip irrigation and sprinkling irrigation (mobile gun to irrigate at crop emergence)
- Often in the field on the same pumping station ⇒ no energy savings
- To save energy, requiring a speed variator
Labour savings

• During the season, drip irrigation with automation needs small workloads:
  ✓ Drip: 1.4 hour/ha/year
  ✓ Mobile gun (hose-reel): 4.6
  ✓ Center-pivot: 1.2

• Needs high workloads to set and remove every year on-surface drip irrigation: 9 – 13 hours/ha/year

* annual allocation of cost of the operations of setting and removing equipment
Benefits

- Splitting water and nitrogen application (fertigation) could improve water and nitrogen productivity and limit risk of drainage and nitrogen leaching.
- Reducing weed growth by limiting wetted soil surface
- Not wetting leaves by irrigation can reduce risk of foliar disease development (mildew of potatoes, mildew and sclerotinia of tobacco)
- Facilitating traffic in the field during season because of dried inter-rows
- Improving precocity for the beginning of tobacco harvest
Other benefits and drawbacks of drip irrigation for cash crops

Risks and drawbacks

- Clogging risk require
  - an efficient filtration system (automatic flushing advised)
  - monitoring along season difficult to identify losses in uniformity,
  - Not adapted when iron water content is too high,
  - injection of acids to destroy precipitates and biofilms.

- Birds, rodents and insects (wireworms, corn borer) may damage on-surface drip lines but also sub-surface systems

- Increasing risk of damage by acarian on maize in the south of France or common scab on potatoes

- Sub-surface irrigation
  - needs fully irrigated crop rotations: maize monoculture not potatoes or tobacco
  - inadequate to stony soils because installation constraints and associated cost
  - minimum tillage is recommended to avoid crashing the lines
  - risk of damage in case of harvest in wet conditions

- Need a complementary equipment to irrigate for spring crops emergence
Questions and experimental approaches

Field experiments on maize are in progress in France:
- Mediterranean climate (Montpellier) by IRSTEA
- Poitou-Charentes region and Rhône-Alpes region by ARVALIS
- Midi-Pyrénées region by CACG

to deal with following issues:
- With on surface or sub-surface drip irrigation, can grain yield be equal or higher than with sprinkling irrigation when water resource is abundant or scarce?
- What can be expected in terms of water savings from drip irrigation in dry year and in wet year? Is sub-surface drip irrigation the best water saving equipment?
- Which method and sensors can be used to optimize surface or sub-surface drip irrigation management depending on water resource availability?
- How to manage nitrogen fertigation to get the best productivity? Does it allow to reduce nitrogen quantity?
Conclusions

- **Overcost of drip irrigation** systems compared to sprinkling irrigation: first limiting factor for cash crops in France.
- **Life span** issue is very important: studying ageing mechanisms on surface and sub-surface drip irrigation.
- **Experiments in progress**
  - quantification of cost – benefice ratio
  - precise their domain of interest in the future
- Increase of farms and plots size will promote center-pivot.
- Sub-surface drip irrigation may replace sprinkler solid set system to irrigate edges of center-pivot.
- Automation is required in installation / remove of annual drip irrigation systems.
Thank you for your attention