ICID2015
26th ERC & 66th IEC

WHAT INTEREST OF DRIP IRRIGATION FOR CASH CROPS IN FRANCE?

Bernard LACROIX
b.lacroix@arvalisinstitutduvegetal.fr

Marc Berrodier
Sophie Gendre
Bruno Fontaine
Alain Bouthier

ARVALIS Institut du végétal

Bruno Molle
Cyril Dejean

irstea

Jean-Marc Deumier

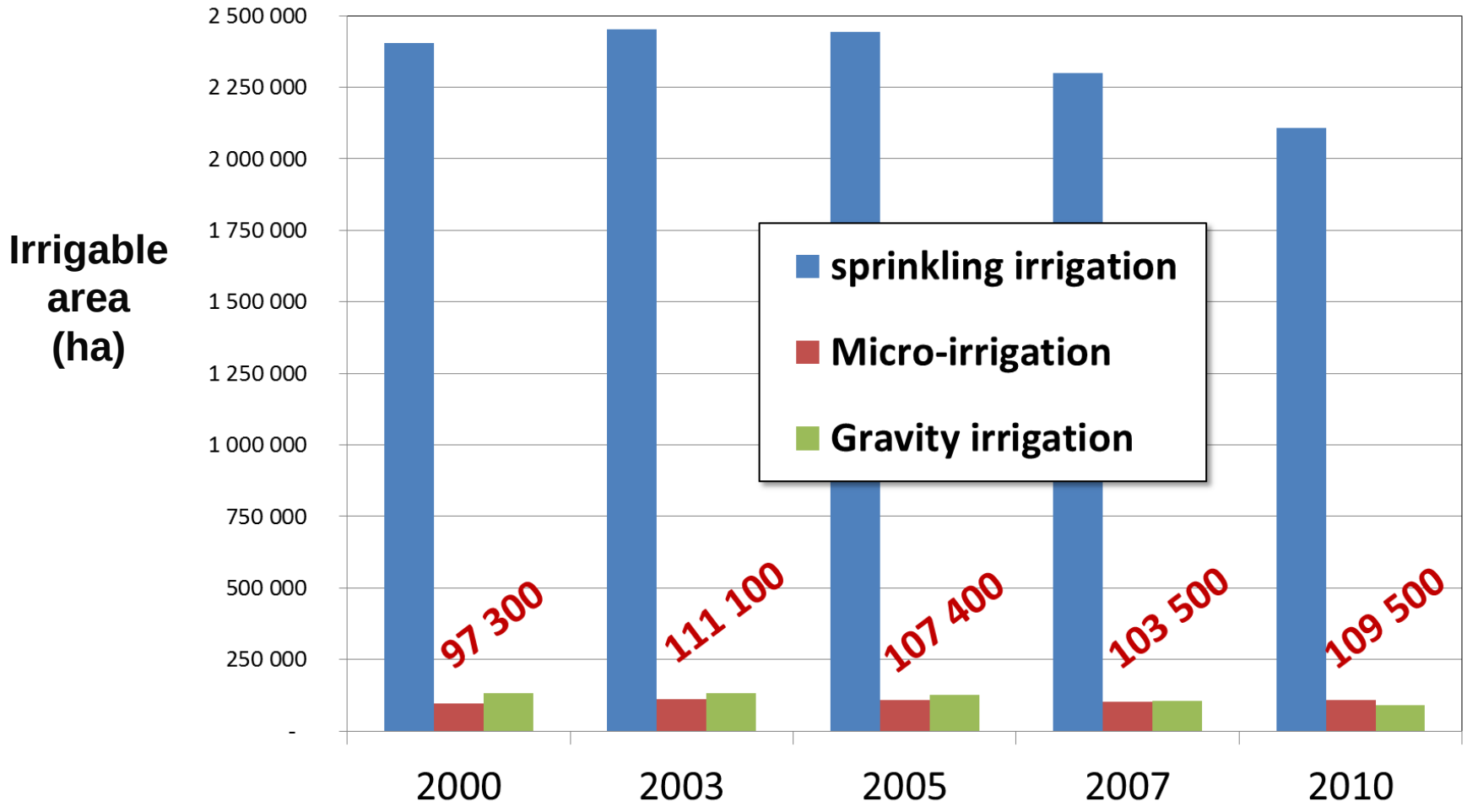
ICID2015
26th ERC & 66th IEC

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)



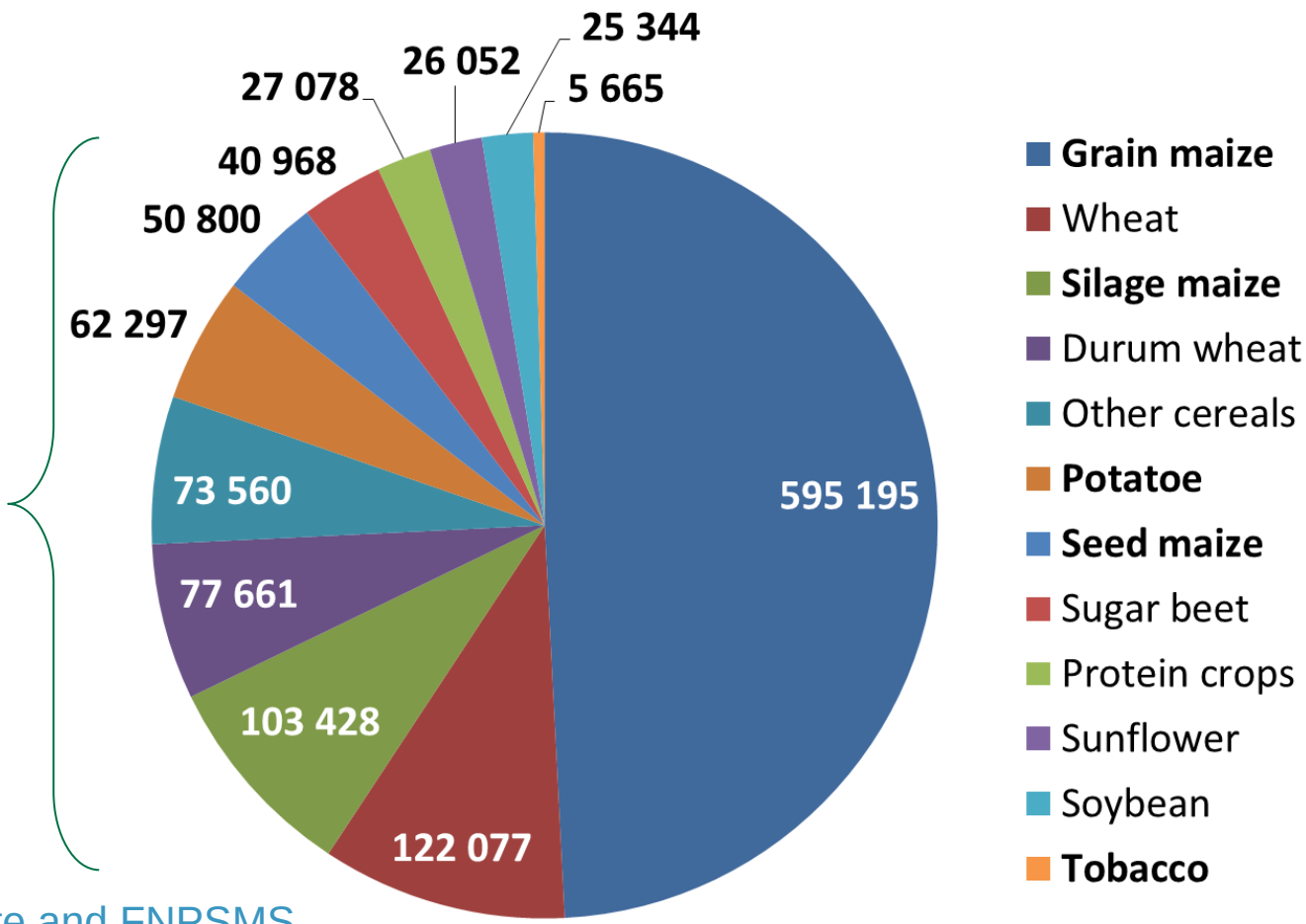
Introduction

France 2010

1 575 600 ha total irrigated crops

1 200 000 ha irrigated cash crops + silage maize

Irrigated areas (ha) of 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)

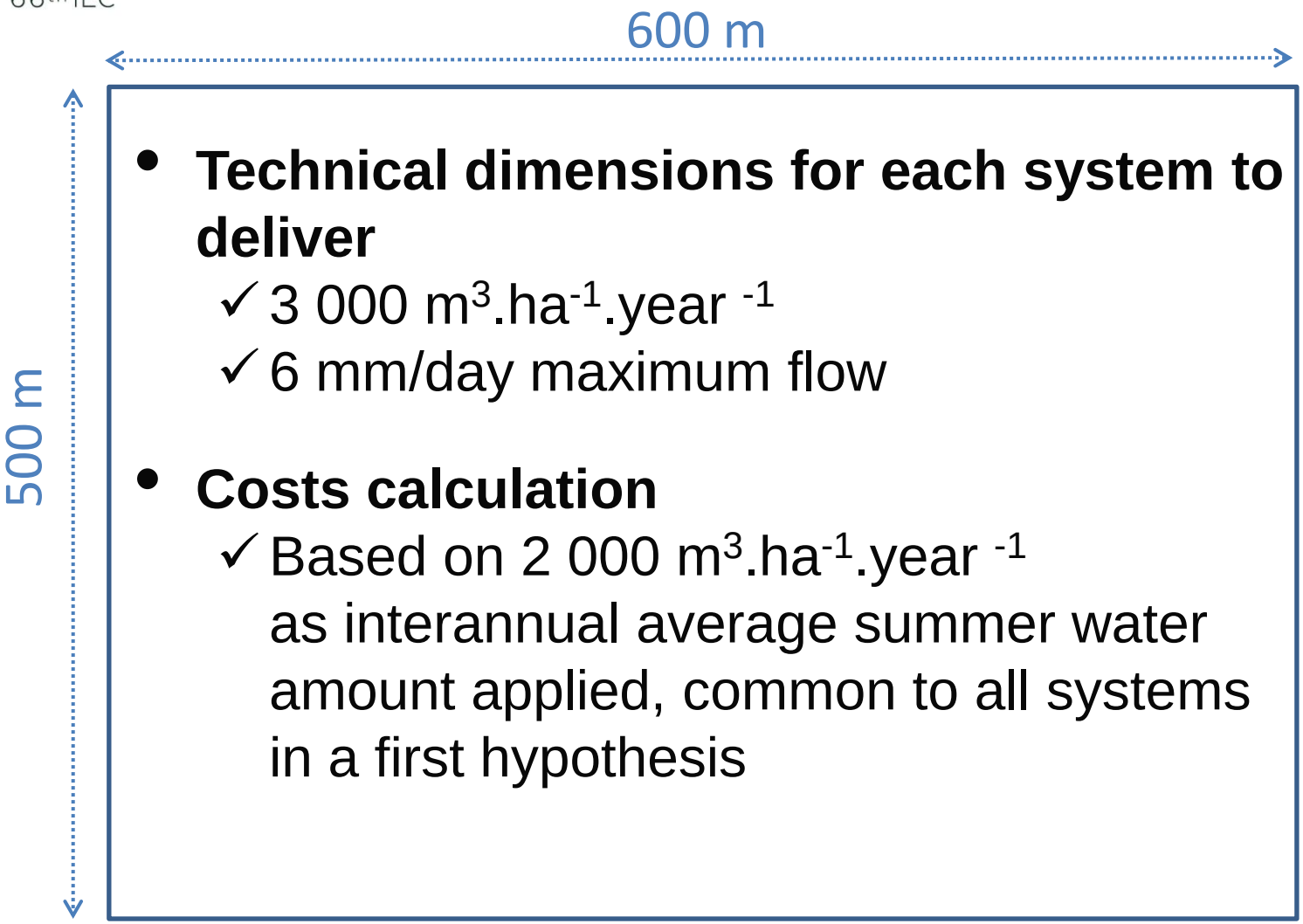
Sub-surface Flat dripper

On-surface reusable cylindric dripper

On-surface reusable flat-dripper

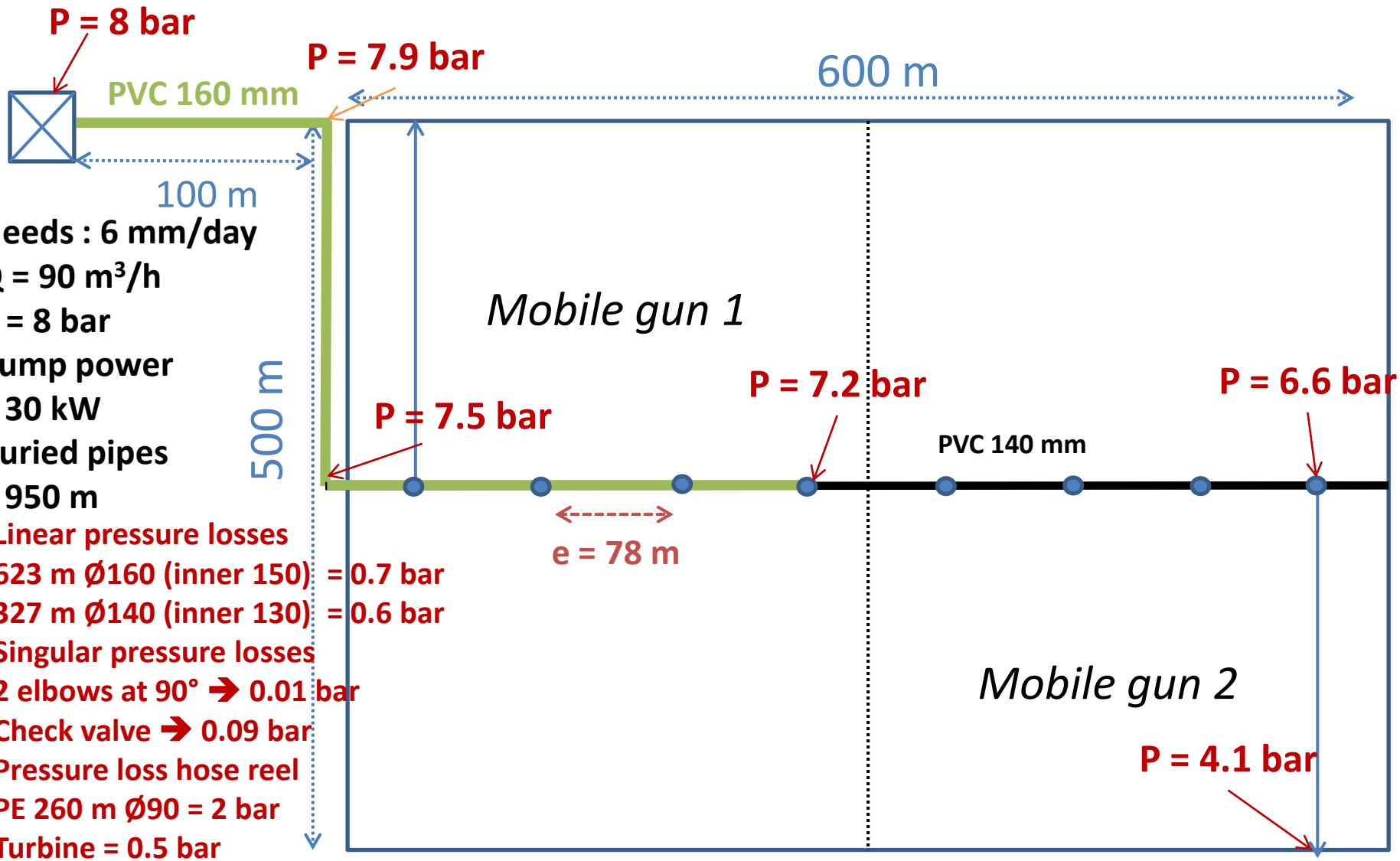
On-surface disposable tape

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



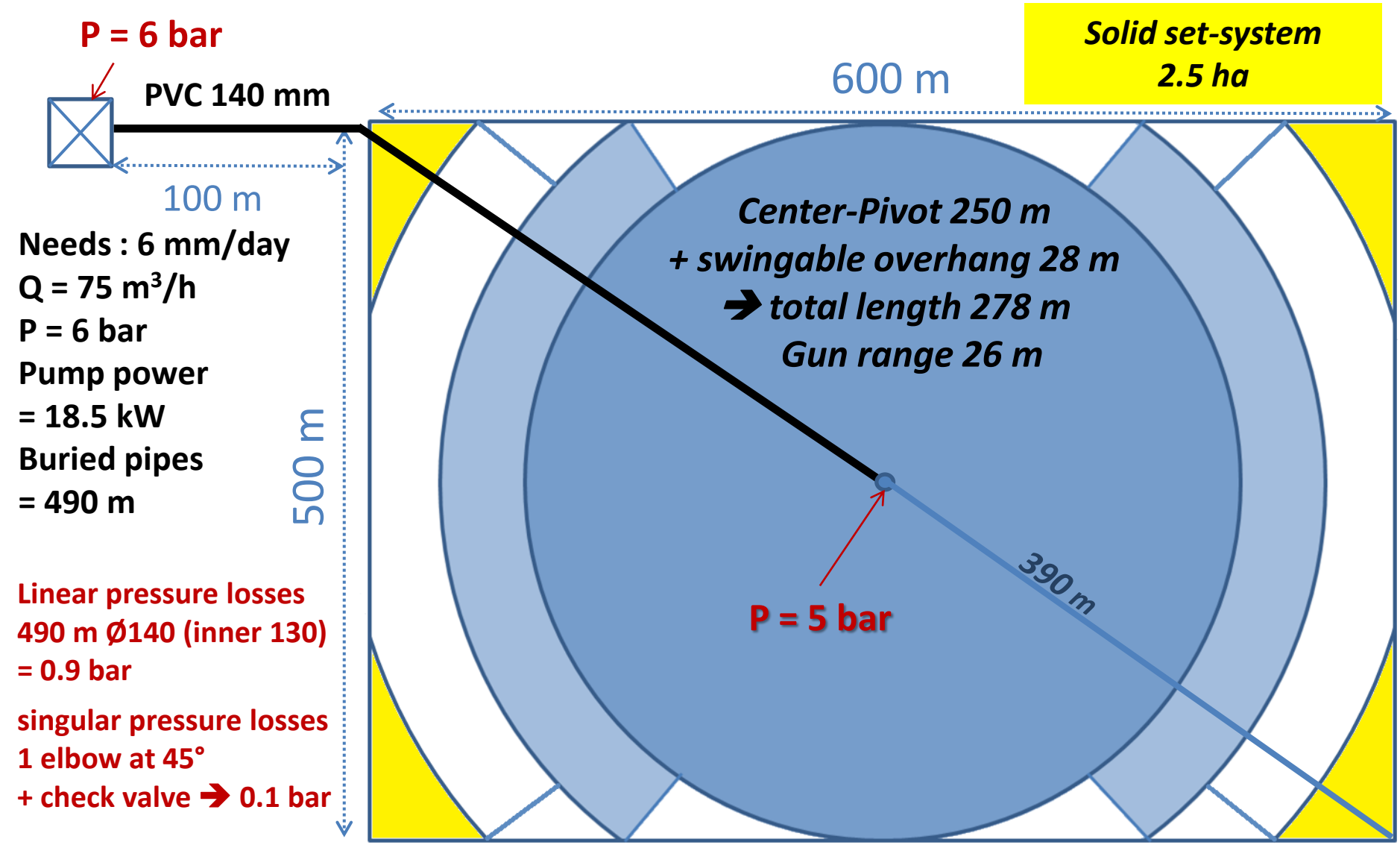
Needs : 6 mm/day
Q = 90 m³/h
P = 8 bar
Pump power = 30 kW
Buried pipes = 950 m

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° ➔ 0.01 bar
Check valve ➔ 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



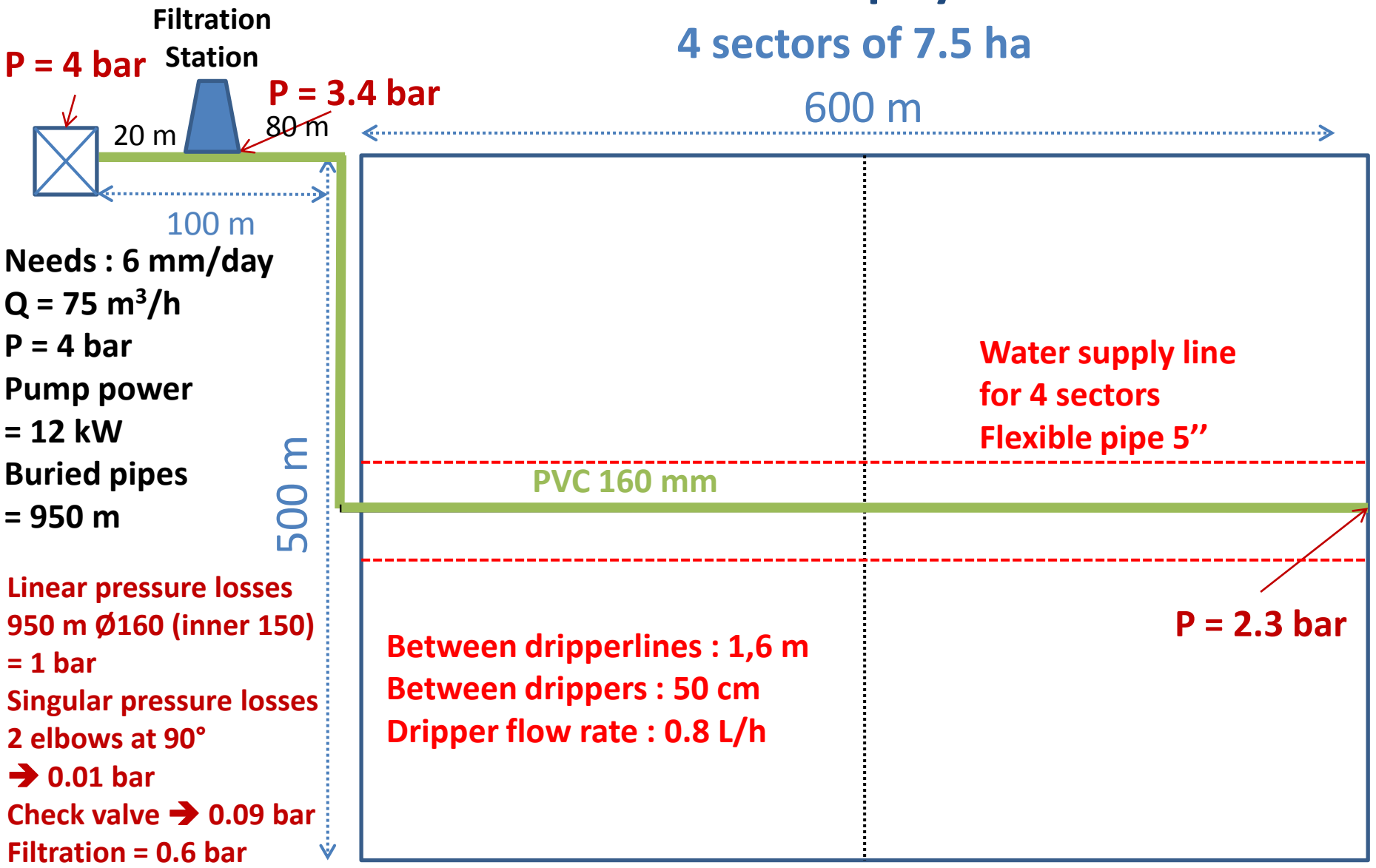
Pump hydraulic efficiency = 0.75
Electrical efficiency = 0.9

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

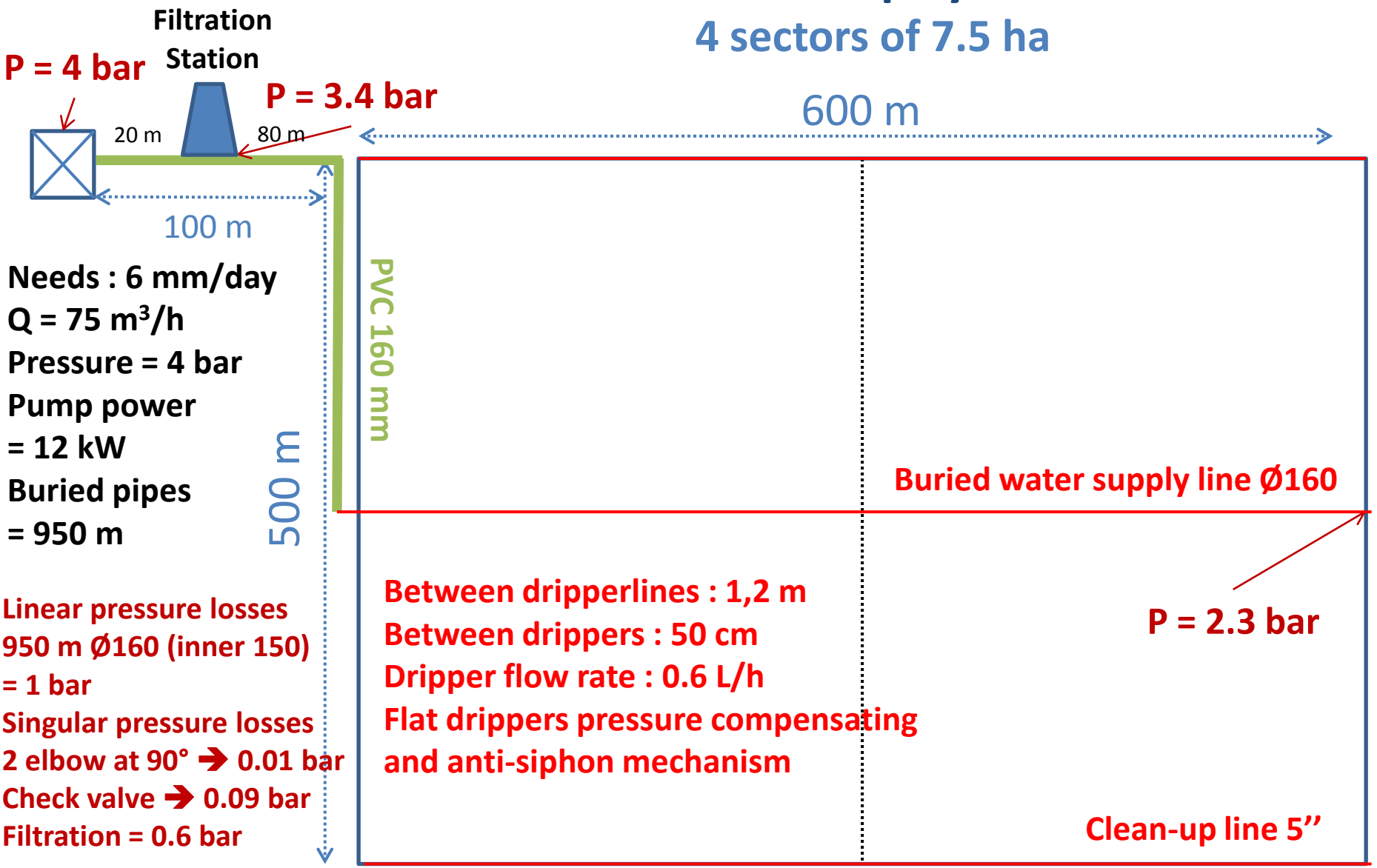
Pump hydraulic efficiency = 0.75
Electrical efficiency = 0.9

Pressure losses calculated by Hazen-Williams formula

Working time 24 h/day

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

ICID2015
26th ERC & 66th IEC

Cost comparison of drip and sprinkling irrigation systems on a schematic 30 ha plot of grain maize

Investment and elements for cost calculation

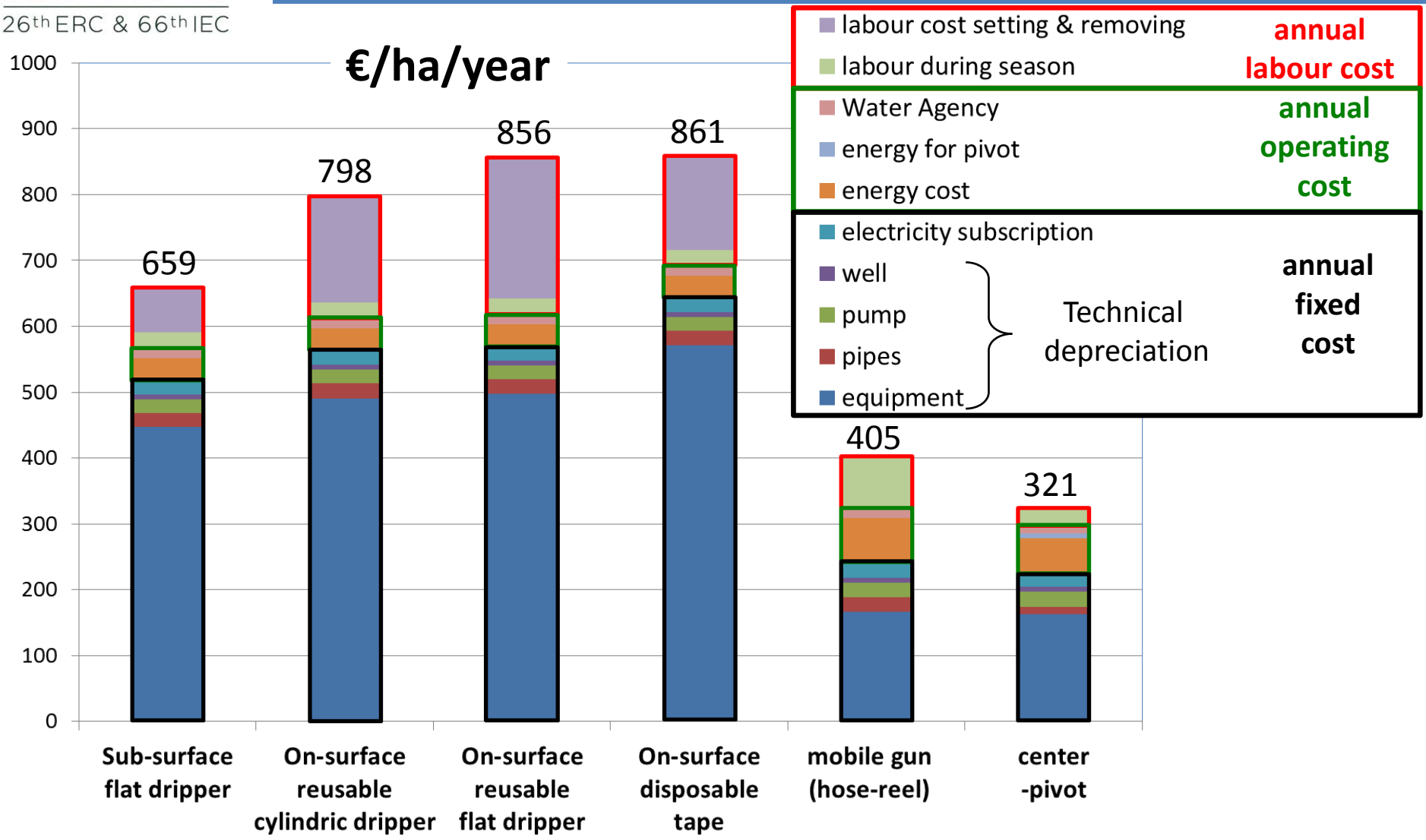
Equipment type	dripperlines				Sprinkling	
	Sub -surface	on-surface			Mobile gun (hose-reel)	center -pivot
		reusable		disposable		
	Flat dripper	cylindric dripper	flat dripper	tape		
Total investment (equipment, pipes, pump, well) (**€/ha**)	**3 450**	**3 600**	**1 570**	**1 420**	**1 790**	**2 015**
operating annual time for 2000 $m^3.ha^{-1}.year^{-1}$ (**hours/year**)	**800**	**800**	**800**	**800**	**667**	**810**
Labour during the season (**hours/ha/year**)	**1.4**	**1.4**	**1.4**	**1.4**	**4.6**	**1.2**
Labour setting and removing equipment (**hours/ha/year**)	**4***	**10**	**13**	**9**		

*** 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 €/m^3**

ICID2015
26th ERC & 66th IEC

Cost comparison of drip and sprinkling irrigation systems on a schematic 30 ha plot of grain maize



Water savings and uniformity

Saving evaporation in the air and wind drift

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

(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 1st 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^{-1}.year $^{-1}$
- Reduction of fixed annual cost : 20 €.ha^{-1}.year $^{-1}$

  (enlarging technical depreciation period)

ICID2015
26th ERC & 66th IEC

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 $m^3.ha^{-1}.year^{-1}$)

- 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

Other benefits and drawbacks of drip irrigation for cash crops

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

ICID2015
26th ERC & 66th IEC

Thank you
for your attention