WHAT INTEREST OF DRIP IRRIGATION FOR CASH CROPS IN FRANCE?

QUEL INTERET DU GOUTTE-A-GOUTTE POUR L'IRRIGATION DES GRANDES CULTURES EN FRANCE ?

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ABSTRACT

Sprinkling irrigation by mobile guns (hose-reel), center pivot systems and sprinkler largely dominate irrigated cash crops in France. However, French cash crop irrigators who look for water, energy and labour savings are interested by potential benefits of drip irrigation. Compared to sprinkling irrigation, drip irrigation claims for a more uniform water distribution, no evaporation or drift losses, limited soil evaporation loss , the possibility to irrigate in strong winds, its adaptation to irregular plots contours, energy savings due to lower pressure requirements, labour savings during irrigation season when automated, an easier use of fertigation to improve nitrogen efficiency. However, its cost is still very much higher than standard sprinkling irrigation. Field experiments are in progress to answer agronomic questions and to assess the place for these systems in the future for cash crops in France.

RÉSUMÉ

L'irrigation par aspersion par canon-enrouleur, pivot et couverture intégrale domine très largement les surfaces de grandes cultures irriguées en France. Cependant, les avantages potentiels du goutte-à-goutte intéressent les irrigants de grandes cultures en France qui sont à la recherche d'économie d'eau, d'énergie et de main d'œuvre. Par rapport à ces systèmes d'aspersion, le goutte-à-goutte revendique effectivement une meilleure homogénéité de répartition de l'eau, pas de perte par évaporation ou dérive, une limitation des pertes par évaporation de l'eau du sol, la possibilité d'irriguer même par vent fort, une adaptation à un parcellaire irrégulier, des économies d'énergie du fait d'une pression nécessaire plus faible, des économies de main d'œuvre en saison du fait de son automatisation possible, une plus grande facilité de pratiquer la fertigation dans l'objectif d'améliorer l'efficience de l'azote apporté. Cependant son coût reste beaucoup plus élevé que celui des systèmes d'irrigation par aspersion. Des travaux sont en cours pour répondre aux questions agronomiques posées et évaluer la place à venir de ce système dans les grandes cultures en France.

Keywords: drip irrigation ; water and energy savings ; irrigation system cost ; cash crops

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Introduction

In France, according to the last agricultural census (2010), sprinkling irrigation by mobile guns (hose-reel), center pivot systems and sprinkler largely dominate the 1 200 000 hectares of irrigated cash crops in France : grain maize, seed maize, silage maize, potatoes, wheat, barley, soybean, tobacco, sorghum. Micro-irrigation (all types, not only drip irrigation) equipped 25% of all irrigated farms but only 8% of irrigable areas, mainly in arboriculture and market gardening. However, French cash crop irrigators who look for water, energy, labour savings but also productivity improvement are interested by potential benefits of drip irrigation. Compared to sprinkling irrigation, drip irrigation claims for a more uniform water distribution, no evaporation or drift losses, limited soil evaporation loss, the possibility to irrigate in strong winds, its adaptation to irregular plots contours, energy savings due to lower pressure requirements, labour savings during irrigation season when automated, an easier use of fertigation to improve nitrogen efficiency. However we can't see a rapid development of this technique which equipped a few hundred hectares in 2012 (mainly on potatoes, seed maize and tobacco). We wonder if the cost is the main limiting factor and what are the technical questions. There is a lack of economic assessment to compare drip irrigation and sprinkling irrigation. On the other hand, it seems that conditions to access to the benefits of drip irrigation are not always fulfilled in the field. There are few serious comparative assessments between sprinkling irrigation and drip irrigation on water consumption and productivity in French conditions. There are still questions on life span and ageing particularly of sub-surface drip irrigation. In this study, we try to assess cost of drip irrigation systems comparatively to sprinkling irrigation and discuss its benefits and disadvantages.

1. Material and methods

1.1. Cost comparison of drip and sprinkling irrigation systems on a 30 ha plot of maize

On a schematic 30 hectares plot of grain maize as a theoretical case-study, six different irrigation systems have been compared: mobile gun (hose-reel), center pivot, on-surface drip irrigation (three different systems), and sub-surface drip irrigation. Each system complies with the hydraulic conditions specific to its type of irrigation. Equipment dimensions are adapted to deliver 3000 m^3/ha/year (6 mm/day). Figure 1 shows equipment details. Filtration system equips drip irrigation systems. Costs are calculated with a first hypothesis of an interannual average amount of water of 2000 m^3/ha/year, common to all systems. References for costs are from surveys of suppliers and farmers. The investments (replacement value) include all the installation from water resource to the plot. Fixed annual costs include technical depreciation (pump, pipes, filtration system and application equipment) and electricity subscription. Technical depreciation of equipment depends on annual use duration, obsolescence and life span. Our assumptions are given on table 1. Operating costs proportional to water amount applied include electricity consumption of pumps (at a cost of 0.104 €/kWh) and a charge due to Water Agency (at a cost of 0.0083 €/m^3). Labour cost is due to time to set the equipment, to handle and to move it during the season, and to remove it at the end of the season or re-equipment, at a cost of 17 €/hour.

Table 1 - Assumptions of life span, obsolescence and depreciation of different irrigation systems

Equipment type	dripperlines				mobile gun (hose-reel)	center -pivot
	sub-surface	on-surface pipes				
		reusable		disposable		
	flat dripper	cylindric dripper	flat dripper	tape		
Obsolescence (years)	15	15	3	2	15	20
Life span (hours)	3 000	3 000	600	400	15 000	30 000
Technical depreciation (years)	8	8	2	1	9	13

1.2. Assessment of benefits, disadvantages and constraints for drip irrigation use on a cash crops field

A survey was conducted in 2012 among 4 dripperlines manufacturers, 7 distributors, 11 experimenters and 33 irrigators. The aim was to assess extent and evolution of drip irrigation areas in the French different regions, the different types of systems, cash crops concerned, and benefits or disadvantages from the point of view of users: equipment setting, monitoring, removing, life span, risk of clogging, questions about irrigation management during the season, use of fertigation, water and energy savings assessment, place in cropping systems (Pagliarino et al., 2012).

This information has been completed by others interviews and observations since 2012.

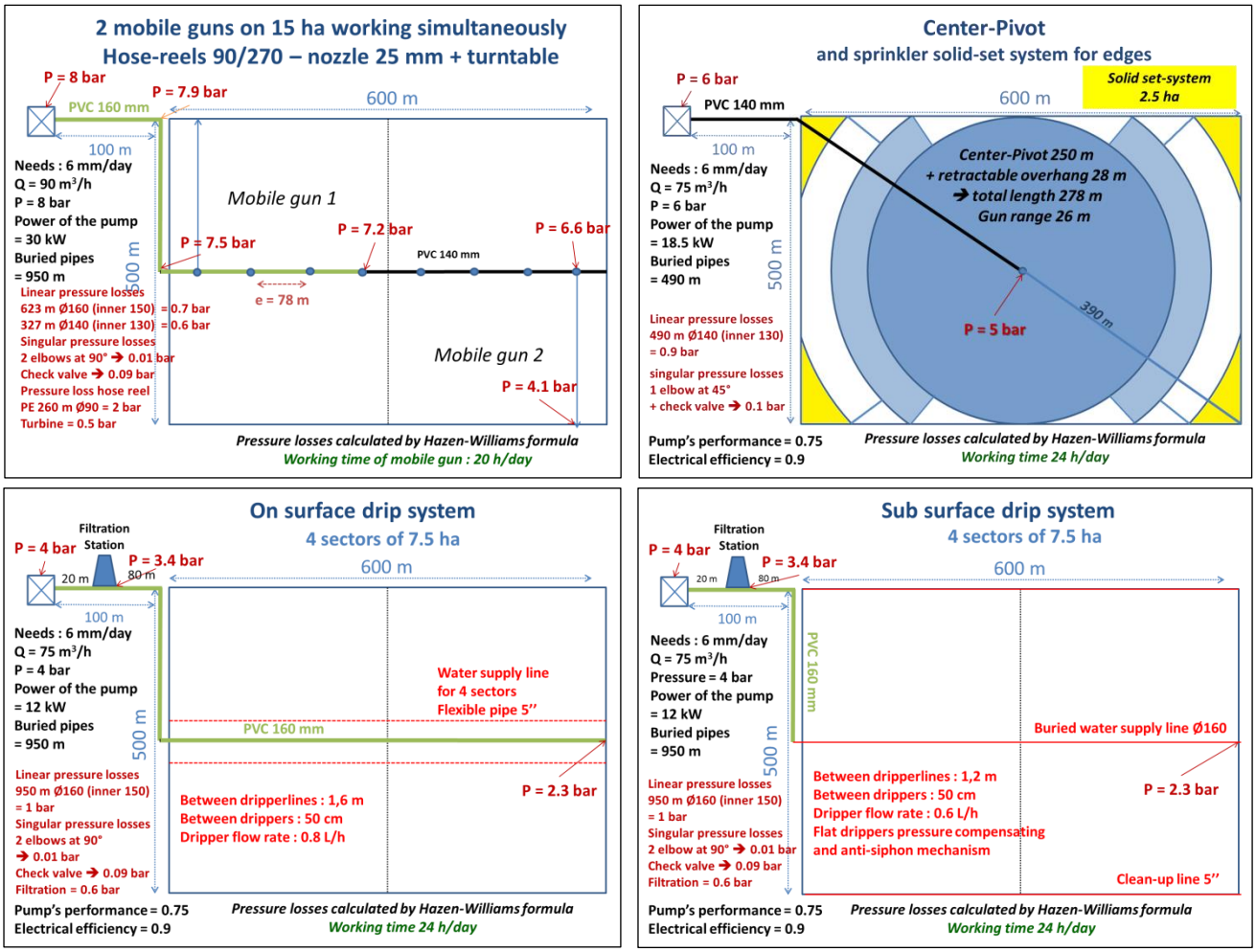

Figure 1 Characteristics of the different irrigation systems compared

2. Results and discussion

2.1. Cost comparison of different irrigation systems

Table 2 shows the study results.

Table 2 – Compared costs of 6 irrigation equipments based on the case study (30 ha maize plot)

Equipment type			Dripperlines				mobile gun (hose-reel)	center -pivot
			sub-surface	on-surface				
				reusable		disposable		
			flat drippers	cylindric drippers	flat drippers	tape		
Investment (replacement value)		€	103 500	108 000	47 000	42 500	53 500	60 500
		€/ha	3 450	3 600	1 567	1 417	1 783	2 017
Fixed annual costs, with technical depreciation of equipment		€/ha/year	518	563	570	643	240	226
Operating costs		c€/m³	2.5	2.5	2.5	2.5	4.4	3.8
		€/ha/year	50	50	50	50	87	75
Labour costs	during the season	€/ha/year	23	23	23	23	78	20
	setting and removal	€/ha/year	68*	162	213	145		
Total annual costs		€/ha/year	659	798	856	861	405	321

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

Based on our assumptions, drip irrigation annual costs appear very higher than sprinkling irrigation by center-pivot costs (overcost from 330 to 540 €/ha/year) or mobile gun costs (overcost from 250 to 450 €/ha/year); sub-surface drip irrigation appears significantly less expensive than on-surface drip irrigation.

Depending on dripper type, line thickness and space between lines, investment in drip irrigation system can be very variable. Drip irrigation equipment chosen in our case study come from actual cases and is only an example. With an high investment, cylindrical drippers are mainly used for perennial plants like arboriculture but it is possible to use them for cash crops due to important life span of lines which make them competitive in the long term. As well, sub-surface drip equipment needs high investment because, in addition to cutting and closing trenches, it needs thicker and more rigid lines to be more resistant to crushing. However with a fifteen years life span of lines against one to three years for on-surface disposable lines or on surface reusable lines with flat drippers, sub-surface equipment annual cost is less expensive. On-surface or sub-surface drip irrigation is not competitive against mobile gun (hose reel) or center-pivot, as a result of a very higher investment and a shorter life span. In addition, with drip irrigation equipment it is not possible to dispense with a mobile gun to irrigate for spring crops emergence in case of drought at spring. This point has not been taken into account in the table 2 results.

2.2. Water savings and irrigation uniformity

In sprinkling irrigation, evaporation and wind drift during flight in the air and evaporation from the soil during hours following irrigation can create water losses. Drip irrigation avoids these potential losses. Direct evaporation losses are estimated by minus of 10% (Ruelle et al., 2004, Molle et al., 2011). Wind drift losses concern especially windy conditions. In these conditions, benefit of drip irrigation is also a better uniformity and effective working time of equipment with good conditions (that are largely decreased by windy hours for a mobile gun and sprinkler solid set system). Table 3 gives performances of irrigation equipment on two criteria: application efficiency (water amount received by crop and soil / water amount at the outlet of the equipment (nozzle or drippers)) and spatial uniformity in good conditions or degraded conditions (wind or clogging). Performances of drip irrigation are better but with important degradation risk by ageing or clogging. In windy conditions, center-pivot and drip irrigation keep a good uniformity, that, compared to mobile gun and sprinkler solid set system, could improve productivity and/or water savings (with mobile gun, one can increase water applied to balance lack of uniformity).

Tableau 3 – Application efficiency and spatial uniformity of water by irrigation equipments (according Granier and Deumier, 2013)

Equipment type	conditions	application efficiency	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%	++

Irrigation water losses by soil evaporation are mainly significant in the first period of maize cycle when the soil is not covered by the canopy and decrease with leaf area index increase.

Therefore, drip irrigation benefit on these losses can be mainly expected in dry spring years with early irrigation. In a simulation study under Mediterranean climate, without rain on the whole cycle, water savings were estimated at 35 mm (Mailhol et al., 2009). In total, water savings by drip irrigation could vary from 10% to 20% compared to mobile gun (Mailhol et al., 2013) resulting in additional reduction of operating costs from 3 à 7 €/ha/year depending on the year, but also fixed annual costs (about 20 €/ha/year) by increase of depreciation duration.

2.3. Energy savings

Pressure requirement for drip irrigation (on-surface or sub-surface) before filtration station (about 3 to 4 bars) is significantly lower than pressure requirement at hose reel entrance (5 to 8 bars). Therefore it can work with a lower power pump (12 kW against 30 kW for mobile gun in the study case). It allows electrical consumption reduction over 50% compared to mobile gun and operating costs over 40% for similar water consumption. However, a mobile gun cannot work on the same pumping station to irrigate at crop emergence. In the field, pumping stations well-adapted to drip irrigation are rarely observed. Often, we can find coexistence of drip irrigation and sprinkling irrigation on the same pumping station. In these cases, there is no energy savings unless pumping station is equipped by a speed variator. On the other hand, fertilizer injection system for fertigation can lead to pressure loss (from 0.2 to 1 bar as measured in an experimental installation).

In total, operating costs savings (energy and water savings) due to a change from hose-reel to drip irrigation could be on average about 45 €/ha/year (35 €/ha/year on wet years to 72 €/ha/year on dry years).

2.4. Labour savings

During the campaign, drip irrigation with automation requires few labour, as center-pivot, which is not the case for mobile gun. However, setting and removing every year on-surface drip irrigation represent a lot of work, penalizing this system. It is probably one of the main causes to explain decrease of drip irrigation in potatoes after an increase at the end of the 1990s. Recent interest of farmers for sub-surface drip irrigation in cash crops is mainly due to the absence of every year

setting and removing equipment work, even if this work has to be done at the installation and for renewing equipment (Deumier, 2013). In total the advantage of center-pivot (a long life-span, moderate investment, small workloads) is clear by comparison to other irrigation equipments. This advantage increases with the size of the plot. In contrast, small plots with irregular shape can give advantage to drip irrigation, despite its cost, to reduce edge effects and well irrigate the whole plot.

2.5. Other benefits and disadvantages of drip irrigation for cash crops

Numerous other benefits and disadvantages, mentioned in the survey, must be listed here:

Benefits	Risks and drawbacks
• Splitting water and nitrogen application (fertigation) could improve water and nitrogen productivity and limit risk of drainage and 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	• Clogging risk require ✓ an efficient filtration system, ✓ monitoring along season not easy due to low visibility of lack of uniformity, ✓ not too rich in iron water, ✓ injection of acids to destroy precipitate and bleach for bacteria. • Birds, rodents and insects (wireworms, corn borer) damages risks of on-surface dripperlines but also on sub-surface systems • Increasing risk of damage by mites on maize in the south of France or common scab on potatoes • Sub-surface irrigation, as a fixed installation is cost-effective only with irrigated crop rotations therefore adapted to maize monoculture but not to potatoes or tobacco. It is inadequate to stony soils because of cost. Ploughing is not recommended to avoid damage on the lines if done in wet conditions. Risk of damage in case of harvest in wet conditions.

2.6. Questions and experimental approaches

Field experiments on maize are in progress in various conditions of soil and climate in France, conducted by IRSTEA in Montpellier under Mediterranean climate, by ARVALIS in Poitou-Charentes region (West of France) and near Lyon (South East) and by CACG in Midi-Pyrénées region (South-West). They aim to deal with the 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 water savings quantities 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 on-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?

Conclusion

Overcost of drip irrigation systems compared to sprinkling irrigation appears to be the first limiting factor for cash crops in France. May equipment cost decrease if the market is growing?

According to this overcost, life span issue is very important and ageing of sub-surface drip irrigation have to be studied.

Despite of this overcost, some farmers are interested by their potential benefits : labour savings particularly for sub-surface drip irrigation, improving yield, productivity of water and nitrogen in case of fertigation, insensitivity to wind, acceptability by society because its image of water savings, and funding opportunities.

Experiments in progress should provide quantification of these benefits and precise their place in the future. Increase of farms and plots size will rather promote center-pivot. Sub-surface drip irrigation could replace sprinkler solid set system to irrigate edges of center-pivot.

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