WATER CONSERVATION TECHNICAL BRIEFS

TB 8 - Use of Drip Irrigation

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WATER CONSERVATION

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TB 4 - Use of Drip Irrigation

Adopting more efficient techniques, such as using drip irrigation systems, can help ensure that farmers use water more efficiently. Drip irrigation systems normally place the water directly into the soil, or onto the soil surface, reducing the risk of runoff and thereby improving water application efficiency. Drip irrigation systems can be classified as traditional drip irrigation system, subsurface drip irrigation and low cost alternative systems. For a well designed, installed, and maintained irrigation system, application efficiencies can be up to 90 % for the area irrigated.

The structure of the technical brief is as follows: Sections 1 and 2 describe drip irrigation systems. Section 3 sets out the key issues needed to work out before the farmer decides whether a drip irrigation system is right for a particular farm. Section 4 presents a step-by-step decision tree for the sustainable improvement of water efficiency at a farm level. Section 5 outlines two case studies on drip irrigation implementation in Almeria, Spain and Greece. Section 6 outlines a set of KPI to monitor drip irrigation efficiency. Finally, Section 7 recommends some further reading.

Contents

Section 1: What is Drip Irrigation?

The use of drip irrigation enhances irrigation efficiency relative to conventional techniques (such as gravity systems, which include flood irrigation of entire fields, and furrow irrigation using shallow channels or ditches to carry water to the crop). With proper management, application efficiencies for a well designed, installed, and maintained irrigation system can be in the range of 80 to 90 % for the area irrigated. Without proper water management, they are typically 55 to 65 %.[1] Drip irrigation can reduce exposure to water risks and input costs making an agribusiness operation more resilient, profitable and solvent.

Section 2: Drip Irrigation systems

Drip irrigation systems can be classified as traditional drip irrigation system, subsurface drip irrigation (SDI) and low cost alternative systems.

A **traditional drip irrigation system** contains a main line and sub-main lines/header (to carry water to drip lines), laterals or drip lines (to distribute water to the outlets at base of plants), emitters (outlets to plants), a pump or pressure source, a control valve (to turn system on and off), a check valve (to prevent backflow into water source), a fertilizer injector (to apply fertilizer directly into irrigation water), a filter and a pressure regulator. More sophisticated system can include air vents, meters, timers, controllers and/or drains.

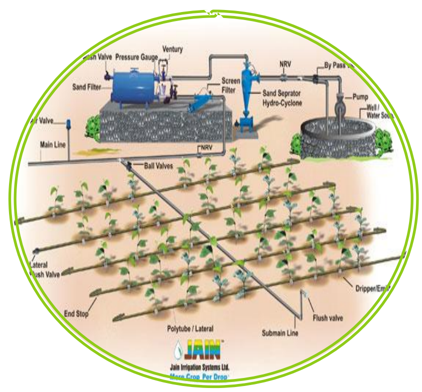

Figure 1: Drip Irrigation System Example

A **subsurface drip irrigation system** is similar to the system described above; however the irrigation of crops is conducted through buried plastic tubes containing embedded emitters located at regular spacings. This system is less vulnerable to damage during cultivation or weeding and it is unaffected by wind. In addition, places water close to the rooting zone (limiting evaporative loss). [2] SDI is most widely used for the irrigation of annual row and field crops in the United States. In Israel, SDI is widely used for the irrigation of permanent crops. Subsurface drip irrigation has been used in Arizona for at least 25 years. However, its adoption has proceeded slowly for a high initial capital and the intensive management needed.[3]

Lastly, there are **low cost alternative drip irrigation system**. One of these is called Pepsee and is used in India. It does not require micro tubes or emitters to place water directly to the root zone instead the lateral.[4] However, this system has a limited life period, cannot withstand high pressure of flow of water and supply an unequal distribution of water. In Rajasthan and Gujarat, local NGOs began promoting low cost drip irrigation among cotton growers. Farmers saw that by using pipes and microtubes, they can water an acre of cotton even with this restricted pumping time. Drip irrigation reduces the cost of cultivation, weed problems, soil erosion and increases water use efficiency as well as electricity use efficiency, besides helping reduce the overexploitation of groundwater. Recent times have seen a veritable revolution in farmers adapting drip irrigation as a survival mechanism.[5] Yet in spite of having many economic and other advantages, the growth of area under micro-irrigation has not so far been appreciable compared to the total potential.[6]

Drip irrigation was invented in Israel in 1959 as a way of using more efficiently the scarce resource. Since then, Israeli farmers have refined and automated the process, linking data on temperature, radiation, humidity and soil-water content to not only control where water is released, but when, and how much is needed to meet a plant's need for transpiration.

SECTION 3: THINGS TO CONSIDER BEFORE INSTALLING A DRIP IRRIGATION SYSTEM

The key issues needed to work out before the farmer decides whether a drip irrigation system is right for a particular farm are:

- Quantity of water used for irrigation
- Irrigation efficiencies
- Water quality
- Crops cultivated
- Topography and physical site characteristics,
- Source of the water supply

- Energy available
- Operation and management skills
- Farming equipment
- Environmental concerns,
- Costs.

The choice of the most suitable type of drip system depends mainly on the soil type (light or heavy soil; infiltration rate, lateral moisture movement), topography (slope), crop, water quality. Drip irrigation systems, however, are not suitable for all crops and soil types. Drip irrigation is well suited to multi-season cropping such as soft and top fruit. Where it has been used for field scale arable row crops or vegetables, the cost and practical issues of pipe installation and retrieval currently challenge its more widespread adoption.

Unilever has successfully applied drip irrigation system in tomato, gherkin and tea crops in different part of the World. The use of drip irrigation in Brasilian tomato crops has cut water use by 30%, boosted yields and also has helped to reduce inputs of insecticide and fungicide. In India, a drip irrigation trial in India produced a water saving of 40% and also cut chemical inputs in the gherkins

Water quality is an equally important consideration when determining whether a drip irrigation system is feasible. Surface water can contain organic debris, algae, moss, bacteria, small creatures, weed seeds, and soil particles that can clog the emitters. Clogging is the most serious technical problem in drip irrigation systems. However, properly designed and maintained filtration systems generally protect the system from most clogging. In general, adequate filtration, line flushing, and chemical treatment prevent most clogging.

In addition, not all conventional fertilisers, herbicides, fungicides, and pesticides are compatible with drip irrigation. Farmers need to consider alternative products and/or, preferably, integrated pest management practices.

For drip irrigation to improve water efficiency use on farms, it is crucial to provide regular system maintenance. This will include checking visually the system and the emitter discharge, removing and cleaning the filters and valves, checking the pressure system and the water flow rates. An Australian study showed that more sophisticated irrigation systems and scheduling tools do not necessarily lead to better irrigation performance. However, frequent maintenance is essential to keep drip irrigation functioning at design flow.

SECTION 4: A PATHWAY TO IMPROVE IRRIGATION EFFICIENCY

Water application efficiency is the ratio between the water used by a crop and the total amount of water delivered to that crop, indicating how well an irrigation system performs in transporting water to the plant roots. A strong contrast is apparent when comparing furrows with sprinkler and drip systems, with the former having an efficiency of around 55 %, sprinklers 75 % and drip systems 90 %[7].

To improve water use efficiency, farmers need to consider multiple factors, and the importance of each will depend on the operation's particular circumstances.

Figure 2 illustrates a step-by-step decision tree for the sustainable improvement of water efficiency on farms. Each factor is described in more detail below.

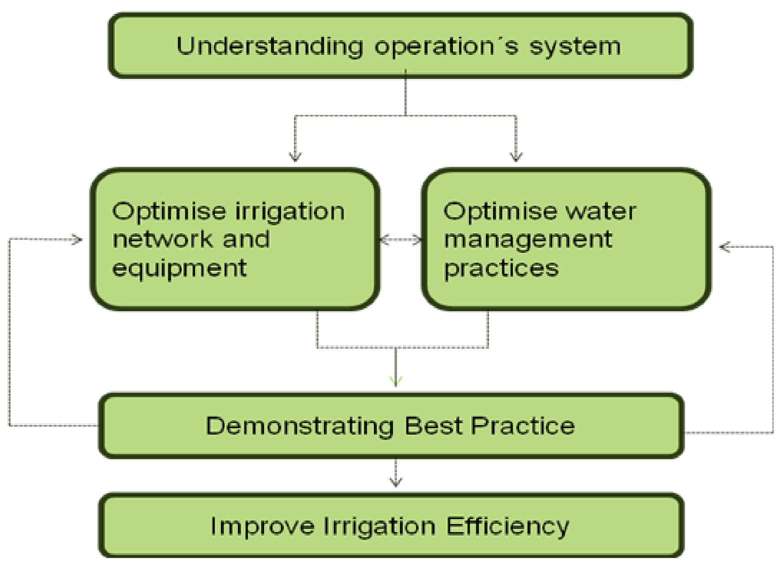

Figure 2: Step-by-step decision tree

A. Understanding the operation´s system

Understanding the operation's system and specific circumstances is the critical starting point on the pathway to improving water management practices and is key to identifying the best suited irrigation equipment. Section 3 (above) lists the key factors famers need to consider. In addition, it is also important to consider the cost of equipment, filtration, control, and numerous laterals needed.

B. Optimise the irrigation network and equipment

To optimise the irrigation network and equipment is necessary to control pressure, water use and uniformity. The most widespread problem is low pressure, often the result of extending irrigation schemes without paying sufficient attention to the impacts of increased demand on pump capacity, the distribution network and equipment performance. The result is poor application uniformity with knock-on effects on crop yield and quality. As discussed above, proper maintenance and regular checks are needed on pressure and volumes of water delivered to particular fields for comparison with manufacturer's guidelines for pumps and in-field equipment. In-field tests using catch-cans can be used to check that correct equipment settings (e.g. sector angle, lane spacing etc), water pressures and flow rates are being translated into a uniform application of water across the field.

A sustainable drip system must be reliable and able to save water, increase yields, manage salts, allow for crop rotation, and needed tillage operations.

C. Optimising the water management practices

This hinges on ensuring that water applications are managed (scheduled) according to crop water requirements without unnecessary waste, i.e. avoiding over-irrigation and/or surface run-off.

Most irrigators rely on their subjective experience to determine when it is right to irrigate, usually by walking the crop and taking soil auger samples. However, to optimise water use efficiencies, farmers should be encouraged to adopt a mix of both subjective and more scientific scheduling techniques.

D. Demonstrating best practice

The final step on the pathway is to demonstrate 'best practice.' Some of the best practices that have proved over time to lead to more efficient irrigation are listed below.

- Calculate the plant water requirements and record the evaporation rate loss to calculate the drip systems application
- Rate irrigation highly within the operation's management system
- Know the farm soils – from an irrigation perspective
- Design and maintain irrigation systems correctly
- Monitor all aspects of each irrigation event

- Use objective monitoring tools to schedule irrigation
- Use more than one method to schedule irrigation
- Retain control of irrigation scheduling
- Remain open to new information

SECTION 5: CASE STUDIES

Case study A: Primaflor Lettuce Farm, Spain

Primaflor farm, located in Almeria, produces different varieties of lettuces. To ensure that irrigation is undertaken in the most efficient manner, the farm has integral soil moisture meters within the growing crop to monitor soil moisture levels. These have sensors which monitor moisture levels over the time in order to adjust irrigation amounts from the pre-determined target levels. Any rise in moisture levels recorded at the shows that the crop has been over irrigated and the technician will reduce the subsequent applications of water to address this.[8]
It can be 25% more efficient than other methods of irrigation as it does not incur the losses through evaporation that topical applications of water are subject to.
The farm has gone one step further with the introduction of a pressure compensated drip irrigation system, which is more expensive to purchase than the convention drippers but provides a higher degree of accuracy over the conventional system.[9]

Case study B: Greece

Greece has the highest population dependent on agriculture in Europe. Between 33-40% of total agricultural area is under irrigation, mostly for crops (approximately 70%), vines (4%) and trees (25%). Water is often supplied through public networks. Within these networks, efficient irrigation technologies have not been widely adopted. While surface water irrigation accounts for 35-40% and irrigation with sprinklers amounts to 50-55%, drip irrigation remains at 10% only.
There is significant scope, therefore, to improve water productivity at the farm level by switching to more water efficient techniques or by improving current systems. In Greece, for example, a significant proportion of cotton is grown using flood irrigation, which requires 20000 litres of flood water to produce a kilogram of harvested crop due

to high levels of surface runoff and evaporation. Drip irrigation of cotton can require 7000 litres per kilogram of crop, although that is still seven times higher than the volume of water needed for the production of a kilogram of wheat.[10]

Section 6: Drip Irrigation systems KPI

Water use (m^3/Ton): Measure the water use of all irrigated water (water that is either taken from the mains or from the environment and directly irrigated or stored for future uses). A recording system should be implemented so efficiency can be measured by m^3 of water per ton of output.

Pumped water volume (m^3/ha): A recording system should be implemented so water pumped can be measured by m^3 of water per ha.

Field application efficiency (%): Field application efficiency is the ratio between the water used by a crop and the total amount of water delivered to that crop, indicating how well an irrigation system performs in transporting water to the plant roots.

Total length of irrigation supply channel (each of lined and unlined) (km): A recording system should be implemented to measure the length of irrigation pipe network in kms.

SECTION 7: REFERENCES AND FURTHER READING

Best Management Guidelines for Sustainable Irrigated Agriculture

http://www.maf.govt.nz/mafnet/rural-nz/sustainable-resource-use/irrigation/irrigation-best-management/finalwater05checked.pdf

This guide offers information about technical irrigation design and management factors. Also provides information on how to plan, to operate and review a new irrigation system.

USDA National Irrigation Guide

http://www.saiplatform.org/site_files/uploads/documenten/#16NationalirrigationguideUSDA(Handbook).pdf

This guide offers a comprehensive and technical guide on irrigation system.

Water management toolkit for field crop growers

http://www.ukia.org/defra.htm

The toolkit comprises a booklet and series of spreadsheets that allow farmers to schedule their irrigation more effectively.

Waterwise on the farm

http://www.environment-agency.gov.uk/static/documents/Research/geho0307blvhepweb_432285.pdf

Water Efficiency Tool

http://www.envirowise.gov.uk/uk/Our-Services/Tools/Water-Efficiency-Tool.html

A series of modules providing guidance and call to actions for water efficiency.

Drip Irrigation Design Tutorial

http://www.irrigationtutorials.com/index.htm#sprinkler

This tutorial provides a guide to design a simple drip irrigation system for small farms.

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[1] www.wsi.nrcs.usda.gov/.../Irrigation/National%20Irrigation%20Guide.pdf
[2] Irrigation Best Practice A Water Management Toolkit for Field Crop Growers. ww.defra.com
[3] http://ag.arizona.edu/crop/irrigation/azdrip/SDI.htm
[4] www.iwmi.cgiar.org/iwmi-tata_html/PM2003/PPT/.../Pepsee.ppt
[5] http://www.iwmi.cgiar.org/Publications/Water_Policy_Briefs/PDF/wpb03.pdf
[6] http://www.iwmi.cgiar.org/Publications/Other/PDF/Paper%2015%20of%20NRLP%20series%201.pdf
[7] EEA, Water resources across Europe, Confronting Water Scarcity and droughts http://www.eea.europa.eu/
[8] http://www.flagshipfarms.eu/downloads/case_lettuce.pdf

[9] http://www.flagshipfarms.eu/case5.php

[10] Chief Liquidity Series - Issue 1: Agribusiness (geography- and sector-specific water materiality briefings for financial institutions) http://www.unepfi.org/fileadmin/documents/chief_liquidity1_01.pdf