Information Sheet

5 IRRIGATION

5.8 Irrigation Systems Selection

The aim of this information sheet is to present emerging factors and trends which must be considered in the context of irrigation system selection.

Introduction

A summary of the irrigation systems suitable to sugarcane production in South Africa is presented in Figure 1. The inherent performance capabilities such as irrigation system efficiency and uniformity of each system are described in Information Sheet 5.1.

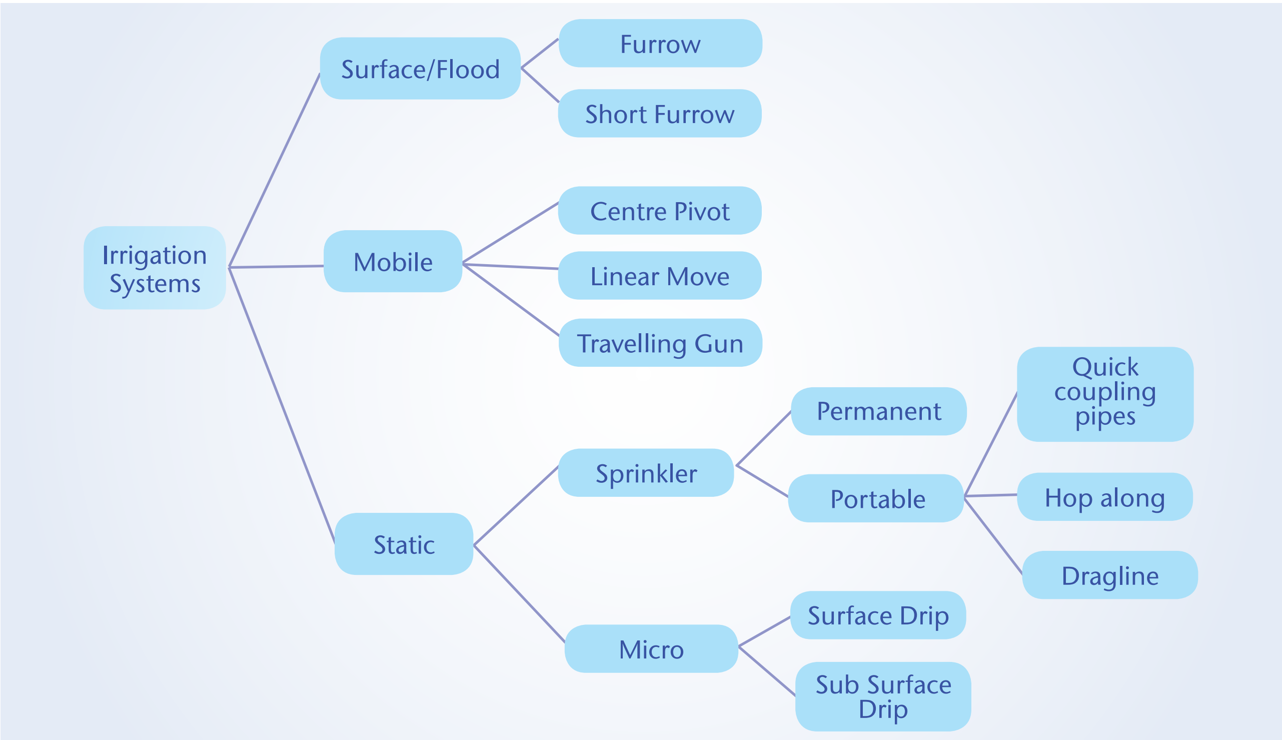

Figure 1. Summary of irrigation systems used in the SA sugar industry

Historically, when electricity was not readily available in rural areas, furrow irrigation was the prevalent method of applying water to the crop. Subsequent improvement in electricity supply allowed for portable sprinkler irrigation systems to become the dominant method of irrigation. The drive to modernise from furrow to sprinkler irrigation systems was attributed to the higher application uniformity attained by sprinkler systems, as well as reduced conveyance losses due to the piped supply. Despite sprinkler systems being cheaper, factors such as increasing water scarcity and electricity costs in recent years have led to micro irrigation systems and centre pivots gaining popularity.

Water, electricity, labour and the associated increasing burden

Due to the increasing competition for water, the imperative to use water more efficiently is constantly increasing. Similarly the surge in electricity and labour costs are greater than the long-term historical cost increases. Water, electricity and labour are major inputs in irrigation and the strengthening influence of such variables must be duly accounted for.

Firstly, independent of the choice of irrigation system, good design, installation, operation, monitoring and maintenance are all necessary, more so today, to ensure uniform and efficient irrigation. Secondly, irrigation system choice offers further opportunity to align to, or mediate the burden from the water, energy and labour variables. Different systems have different performance strengths and weaknesses. For example:

a. If water is limiting: Drip systems are noted for using the least amount of water while obtaining high crop yields. But effective drip systems require good design and rigorous management. Centre pivots also apply water uniformly but can be susceptible to high evaporative losses from a bare soil surface. Sprinkler irrigation, travelling big guns and furrow are less efficient systems if water is limited.

b. If cost of electricity is a concern: Furrow systems generally are gravity fed and have the lowest energy requirements, but are notorious for poor uniformities and require constant labour input. Drip and centre pivot systems are also relatively energy efficient systems (generally requiring 100 to 300 kPa pressure at the emitter/nozzle). Sprinkler irrigation systems typically require 250 to 400 kPa at the nozzle while traveling big guns have much higher energy requirements (400 – 900 kPa at the nozzle). Sprinkler irrigation and big guns are generally the most energy intense. Big guns can require up to 9 times the pressure that drippers require.

c. If labour is limiting: Centre pivot, permanent sprinkler and travelling big gun systems have the lowest labour requirements. Drip systems, when automated also have low labour requirements. If drip systems are not automated, they require constant attention especially if the quality of the water is average to poor. The labour skillset required for drip systems, can be high and a single mistake can be very damaging, with potential long-term negative impact on the crop. Portable sprinkler and furrow irrigation systems typically have the highest labour requirement.

End users should carefully assess the sensitivity of their farming operation to the water, energy and labour variables. These variables should then be used as determining factors regarding the selection of an appropriate irrigation system.

Capital versus operating costs – the link between longevity, maintenance and life cycle cost

The cost of an irrigation system can be divided into two components, capital and operating costs. Capital costs are generally the once off investment required to purchase and install the irrigation equipment. The operating costs represent the ongoing continuous costs payable over the lifespan of the irrigation system. In gravity fed surface irrigated systems, operating costs include factors such as labour, maintenance and water tariffs. In pressurised irrigation systems, however, operating costs include all of the above, plus the cost of electricity to run the pumps.

Traditionally, capital costs have been the main factor in deciding which irrigation system (or design option) to install, usually without considering operating costs. This explains, to some extent, why the relatively cheaper sprinkler irrigation, especially the dragline and hop along sprinkler systems have been the most widely used systems in South Africa. These systems have been installed even though they can have a high operating cost over the long-term.

Table 1. Typical ballpark costs for the different irrigation systems

Irrigation systems		Capital Cost Estimates (R/ha x 1000)	Operating Cost Factors			
			Life expectancy (years)	Labour (ha/field worker)	Annual maintenance costs (% of capital costs)	Pressure requirements at emitter (kPa)
Overhead sprinkler	Dragline	11 – 13	10	25	4	250 – 400
	Semi-permanent	10 – 14	12	25	2	250 – 400
	Permanent	24 – 26	15	50	1	250 – 400
	Centre Pivots	18 – 21	15	100+	5	150 – 300
	Linear Move	15 – 18	15	100+	6	150 – 300
	Travelling Big Guns	9 – 11	10	25	6	400 – 900
Drip	Surface Drip	10 – 12	2 - 5	20	30	100 – 250
	Sub Surface Drip	19 – 24	10	25	3	100 – 250
Surface/Flood	Furrow (earth canals)	N/A*	10	15	5	0

Following the ARC Irrigation design manual (updated in 2015).
Note: The estimated capital costs exclude the costs of the pump station, supply system and distribution system and installation of the equipment.
*N/A – Costs not available at this stage

While affordability and capital costs are still important, the rapidly increasing electricity tariffs and labour costs have made the operating costs of the irrigation system a crucial consideration. As a result of these considerations, farmers are recognising the value of higher capital cost systems (or design options) that have lower operating costs over the life cycle of the system. Hence, the expensive, but more accurate, automated, low pressure and water efficient systems such as centre pivots and drip irrigation systems are becoming popular.

The benefit of investing in high capital systems, however, is very dependent on the longevity of the irrigation systems. For this reason, monitoring and preventative maintenance to maximise the life span of the irrigation systems is very important. Even when unable to invest in expensive drip or centre pivot systems, systems which are easier to maintain and promise increased longevity, are preferred. For example, large areas of dragline irrigation systems are currently being replaced with portable hop along sprinkler systems. Draglines have become less popular due to theft of and damage to hoses, labour not placing the sprinklers in the correct positions, and high replacement costs of the dragline system.

System performance and its dependency on skilled operators and management

Irrigation hardware is always accompanied by specific operating rules. As a result of both the hardware and the operating rules, the different irrigation systems are associated with differing performance capabilities. The skills and operational requirements specifically needed for a system can dictate the performance of hardware for all irrigation systems i.e. poor management can override good irrigation design and excellent management may make a poor design workable. Therefore it is essential to match the irrigation system (and hardware) with an appropriately skilled and knowledgeable management team.

Many farms make use of more than one irrigation system. For example, centre pivots may be the preferred option but hop along sprinklers or drip may have to be used on outfall (corner) areas outside the pivot circle. Alternatively, the more affordable hop along sprinklers are preferred but certain fields with shallow soils or low water holding capacities can only be irrigated with drip. In such instances, it is important to understand that by making use of a variety of irrigation systems, each with its own set of operating rules and labour requirements, the skill set and knowledge for irrigation operation and management needs to be appropriately diverse and care must be taken not to compromise operations due to diluted management and skills. For example, it is conceivable that several blocks of 3 or 4 ha of drip or hop along sprinkler systems distributed across the farm on pivot corners will leave both the labour and irrigation management team spread thinly on the ground. Time and attention will have to be divided between managing the centre pivots and the outfall systems, with a tendency to favour one or the other system. Such dilution can result in neglect of an aspect which in turn will lead to costly poor irrigation performance. This poor performance is then a result of inefficient management and is not a true reflection of the irrigation systems capability. Great care must be taken to ensure that the skillset of irrigators is aligned to the specific needs of each irrigation system. This is an equally important consideration whether installing new or converting old irrigation systems.

Interaction of irrigation systems with agronomic practices

Finally, consider the suitability of an irrigation system to specific agronomic practices. For example, drip irrigation is only partially effective when germinating crops for green manure fallows because it delivers its water along a row and does not wet the entire soil surface. Drip systems, also, cannot be used to wash herbicide or fertiliser into the soil after manual application. Drip, similar to centre pivots, however, is precise enough for application of chemicals through the irrigation systems (chemigation) which reduces the need for infield traffic. Furrow irrigation with an open channel supply, on the other hand, may prove limiting for practising controlled traffic while hop along sprinkler systems are not uniform enough for chemigation.

In conclusion, careful consideration must be given to a number of factors when selecting the best irrigation system for a particular farming context. Selection criteria should include: capital and, more importantly, operating costs, maintenance requirements, after-sales support and long-term availability of spare parts, labour requirements, operational and management skill, irrigation uniformity and efficiency of water use relative to water costs and water availability and ensuring that the chosen irrigation system is compatible to agronomic practices such as planting green manure fallow crops, chemigation, control traffic or land preparation.

Finally, a decision-making template for selecting an appropriate irrigation system is proposed in Table 2.

Table 2. Proposed decision making template when selecting an irrigation system

Description of item		Weighting[a]	System 1:		System 2:	
			SCORE	Weighted Score	SCORE	Weighted Score
Annualised Capital Costs		9				
Life expectancy		7				
Operating Costs		9				
Management and maintenance	Costs	7				
	Skill/expertise	6				
	Time	6				
Aftersales support		7				
Irrigation efficiency and uniformity		8				
Energy Use		9				
Labour requirement		8				
Soil compatibility	Infiltration	7				
	TAW	7				
Agronomic considerations:	Field size and shapes	4				
	Compatibility with harvesting system (Controlled traffic)	5				
	Cutting fronts relating to varying age of cane in irrigation blocks	4				
	Fertigation and Chemicagation requirements or benefits (herbicide, ripening, insecticide, etc.)	5				
	Land preparation requirements	4				
	Suitability for green manure crops	4				
Other						
Total scores						

[a]Weighting – A guideline weighting factor is provided in the weighting column above. Users are welcomed to alter the weighting factors according to local needs. For consistency, weighting factors should be between 1 and 10 (1 being least important and 10 being most important).

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