SWAZILAND SUGAR ASSOCIATION TECHNICAL SERVICES

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Irrigation Scheduling

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Irrigation Feature

In Swaziland irrigation is required to make up the deficit between crop water use and rainfall. In simple terms irrigation scheduling is deciding when to apply water, and how much water to apply.

Effective irrigation scheduling begins with irrigation system design parameters. Irrigation designers should consider the soil's ability to hold water and peak evaporative demand when choosing a cycle frequency and application amount for the system. The cycle frequency is the minimum number of days between irrigation cycles, whereas the application amount is determined by stand time (the number of hours a sprinkler remains in the same position) in the case of overhead irrigation systems, or the contact time (time water remains in contact with the soil) in the case of furrow irrigation systems (Figure 1).

Deciding when to irrigate depends on soil water content, which changes in response to water inputs in the form of rainfall and irrigation and water removal in the form of evaporation (from the soil surface) and transpiration (from crop surface).

A simple analogy is to think of the soil as a bucket. A soil can hold a maximum amount of water depending on its texture (% clay, silt, sand) and rooting depth. This is the soil's **field capacity.** The bucket is considered full at this point. At the soil's **permanent wilting point** the bucket is empty and the crop will effectively be dead. The plant will suffer stress long before soil moisture levels are depleted to this point and there is a practical lower limit above which the crop can extract water without experiencing any stress. This is the **readily available moisture capacity** of a soil. The difference between field capacity and permanent wilting point is the **total available moisture (TAM)**, and the difference between field capacity and readily available moisture capacity is the **readily available moisture (RAM).** Sugarcane can normally extract water to half TAM, or when the bucket is half full.

Moisture stress can be avoided by maintaining the soil moisture content between field capacity and readily available moisture capacity, or within the RAM. Irrigation can be scheduled by estimating soil water content directly (by feel or instrumentation). Developing the skills to determine water availability by feel requires experience and practice while the instrumentation required to do this accurately can be expensive and difficult to use. Alternatively, soil water content can be estimated by calculating a soil water budget and accounting for additions of water to the budget and water removal in the form of crop water use. Irrigation is scheduled once the estimated soil water content reaches a threshold level (at or above the RAM capacity)

The amount of water used by the crop depends on atmospheric demand (which varies during the year) and the stage of crop development (canopy size). There are two standards used to estimate atmospheric demand, the class-A pan (a direct measurement of evaporation) and the Penman-Monteith method which is a calculated estimate using meteorological inputs. Whereas the Class-A pan is easy to use the Penman-Monteith method is more accurate. The degree of canopy cover (canopy factor) can be estimated from a visual appraisal of the crop or from more objective calibrated tables and temperature driven estimates.

This water balance approach can be managed at any level of complexity. Large estates update daily soil water balances on a field-by-field basis using hand-written ledgers, computer spreadsheets and irrigation scheduling software. Smaller-scale producers tend to opt for simplified water balances using monthly mean demand estimates and pre-determined canopy factors depending on month of harvest (Table 1).

Irrigation scheduling can be simplified further by combining the average crop water use estimate with irrigation system design criteria to estimate the number of days delay between successive irrigation cycles. The number of days between irrigation cycles will depend on the current month (evaporative demand) and month of harvest (crop stage of development). For example, consider a system designed to apply 38 mm net with a minimum cycle time of 6 days at Mhlume (Table 2). For a crop harvested in August, irrigation should be delayed by 3 days between successive irrigation cycles during November. In January the following year, one irrigation cycle should follow the other without a delay for the same August-cut field.

This simple approach ignores rainfall and only accounts for the change in evaporative demand and stage of crop growth. Simple rules of thumb can be developed to cope with rainfall. The number of additional delay-days following a rainfall event can be estimated from the amount of rain that fell (Table 3).

Tables 1, 2 and 3 are shown overleaf. For further information, contact SSATS on 383 8998.

New Seedcane Price

Note that primary seedcane for the 2002 - 2003 season will cost E350.75/t delivered.

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Irrigation Scheduling (Contd.)

Harvest Month	Current month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Apr	1	1	1	0.4	0.4	0.6	1	0.9	1	1	1	1
May	1	1	1	1	0.4	0.4	0	0.5	0.8	1	1	1
Jun	1	1	1	1	1	0.4	0	0.4	0.5	0.8	1	1
Jul	1	1	1	1	1	1	0	0.4	0.4	0.7	1	1
Aug	1	1	1	1	1	1	1	0.4	0.4	0.6	0.9	1
Sep	1	1	1	1	1	1	1	1	0.4	0.4	0.7	1
Oct	1	1	1	1	1	1	1	1	1	0.4	0.4	0.8
Nov	0.8	1	1	1	1	1	1	1	1	1	0.4	0.5
Dec	0.5	0.8	1	1	1	1	1	1	1	1	1	0.4

Table 1: Canopy factors by harvest month for the Swaziland lowveld

Rainfall event	Action
< 5 mm	Ignore
5 - 10 mm	wait 1 day
10 -20 mm	wait 2 days
20 - 50 mm	wait 4 days
> 50 mm	wait 5 days

Table 3: Simple rules of thumb to cope with rainfall. These should be developed to suit soil moisture holding capacity - seek advice before using them.

Harvest Month	Current month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Apr	0	1	2	19	24	18	9	3	0	0	0	0
May	0	1	2	4	24	27	23	11	2	0	0	0
Jun	0	1	2	4	6	27	23	15	8	2	0	0
Jul	0	1	2	4	6	7	23	15	11	3	0	0
Aug	0	1	2	4	6	7	5	15	11	5	1	0
Sep	0	1	2	4	6	7	5	2	11	10	3	0
Oct	0	1	2	4	6	7	5	2	0	10	9	2
Nov	1	1	2	4	6	7	5	2	0	0	10	7
Dec	8	2	2	4	6	7	5	2	0	0	0	9

Table 2: Days delay between successive irrigation cycles for a system designed to apply 38mm net in six days at Mhlume

Figure 1: Furrow irrigation in the Swaziland lowveld. Effective scheduling begins with irrigation system design.

Irrigation Project Pitfalls

The number of new projects in the Swaziland sugar industry is increasing rapidly. With a projected expansion of approximately 18,000ha in the next 5 to 10 years, small-scale projects will soon constitute over 30% of the area under sugarcane. The success of these projects will largely depend on the installation of profitable and economically sustainable irrigation systems. The success of the irrigation projects will depend in turn on many factors including institutional support, socio-economic conditions, availability of good soils and careful planning and management. This article highlights the main activities that should be given careful attention to make a sugarcane irrigation project successful.

Figure 2: Commissioning a new irrigation system. This is an essential component of project implementation.

Irrigation project management

An irrigation project is comprised of two distinct stages. The first stage covers planning, financing, design, contracts management, installation, commissioning and training of farmers. A plan for implementing these activities to enable growers to plant on time

IRRIGATION PROJECT PITFALLS (CONTD.)

should be prepared and adhered to during the implementation of the project. This requires a high level of expertise in engineering design and project management. Growers should seek professional advice before they start a project to ensure that the technical feasibility of proposed designs and irrigation methods have been thoroughly checked. This first stage should logically follow the allocation of quota and should be co-ordinated by one institution. The second stage starts once sugarcane production has begun. It focuses on the day-to-day operation and management of the irrigation system and agricultural operations to achieve high yields and profit for the project.

Irrigation system selection

The irrigation system is the heart of a sugarcane project upon which the success of subsequent agricultural operations depends. Growers should therefore seek professional advice to select the most appropriate irrigation system that suits their water supply and quality, topography, soil type and financial position. Due to water supply and soil constraints, the choice of system on most new projects is limited to dragline, centre pivot, floppy and drip irrigation. The promise of high water use efficiency has resulted in some small-scale growers installing drip irrigation systems without a full understanding of its capital, water quality and management requirements resulting in disappointing performance. Growers should seek professional advice before selecting an irrigation system to avoid these problems. Once the wrong system or design has been selected and the system is installed, it is difficult and expensive to correct mistakes or make changes. Inappropriate systems will result in financial losses and do not last long enough to pay for the investment.

Irrigation system design

A properly designed irrigation system is the first step towards achieving efficient irrigation and an economically sustainable project. Starting with detailed topographic and soil maps, computer software can be used to produce detailed and highly energy efficient layouts. Such designs might not have the lowest capital cost, but they are the most effective option in terms of reducing running costs and enhancing long-term economic viability. Reputable irrigation design engineers with good design facilities and a sound track record should be contracted to design irrigation systems. The designer must analyse every aspect of the terrain, soils and other physical considerations to meet the requirements of a sustainable irrigation system. Given the long-term nature of investment in an irrigation system, a high level of technical input at the design stage lays the foundation for its ease of management, reliable operation and high yields from efficient application of water.

This is not always done, and the bad practice of selecting the cheapest quotation without a thorough analysis of the quality of design proposals is one of the major causes of problems currently experienced on new irrigation projects. Design-related problems include excessive power costs from oversized pumps and transformers, inferior equipment, frequent breakdowns and in some cases outright failure of irrigation systems. The promise of financial savings from cheap systems quickly turns to losses from delays to planting, high costs of correcting problems, unnecessarily high operating costs, inefficient use of other inputs and lower yields during the life of the project. It is important for growers to have designs thoroughly checked by Swaziland Sugar Association Technical Services (SSATS) or engineers from SKPE and the sugar mills.

Project implementation

This stage follows selection of the most suitable irrigation system and the optimal design for the project. It commences after funding has been secured. The main focus should be the management of contracts for equipment supply and installation to complete the project on time and to a high standard of workmanship. Great care and skill is required to prevent construction delays and cost overruns that could derail project budgets and economic viability. The traditional approach to developing irrigation projects is the client-consultant-contractor system developed for civil engineering projects. This approach has the advantage of the consultant protecting the interests of the client in dealing with the contractor. Under the present structure for servicing small-scale farmers, there is no institution fulfilling the role of consultant. Lack of close supervision of delivered materials and irrigation construction work is partly responsible for the poor workmanship and supply of inferior equipment on some projects.

Commissioning

Once installation is complete, the system should be commissioned before it is handed over to the farmers (Figure 2). Commissioning helps to ensure that farmers have received what they paid for and that the design is workable. In particular, the commissioning exercise should:

- Ensure that the contractor has fulfilled all his design, installation and supply obligations
- Demonstrate to the grower that the system works properly and that it meets the objectives of the farmers
- Provide the client with a complete set of documents and instructions on operating the system

SSATS have developed guidelines for commissioning irrigation systems and can provide assistance in this area.

Training of operators

An irrigation project is not complete until the end user has been sufficiently trained to understand the components of the irrigation system and how to operate it efficiently. Training should be an integral part of irrigation project development and should begin before construction of the project is completed. The training should involve farmers in the construction process so that they know how the system is put together and how the individual components combine to form a complete irrigation system.

Irrigation Services Available from SSA

SSATS has expanded its irrigation services to include :

- Checking soils to determine which irrigation system to use.
- Technical information on irrigation systems.
- Assessing water supply availability.
- Evaluating designs submitted by irrigation companies.
- Economic analysis of irrigation systems.
- Commissioning of irrigation systems.
- Irrigation system performance evaluation.
- Irrigation scheduling advice and computer software.
- Organising irrigation training courses.

Growers are encouraged to make full use of these services. Telephone 383 8998 for more information.

In Summary

This article has outlined some of the main activities that form the irrigation project management process and highlights the need to follow a planned and coordinated approach. Failure to follow a planned approach results in sub-optimal performance or outright collapse of the irrigation system. Preliminary observations show that as much as 800ha of recently installed drip irrigation systems are operating below the expected standard due to poor planning, design and installation. Examples are given overleaf (see "Irrigation System Performance") .

IRRIGATION SYSTEM PERFORMANCE TESTS

Centre pivots and drip irrigation systems are gaining popularity throughout the industry (see below). However, these systems are not foolproof and their success often depends on the quality of their design, installation and management.

Two new projects were evaluated during 2001 to demonstrate how these systems can perform under differing conditions. One was a 110ha sub surface drip (SDI) project while the other was a 110ha centre pivot project. Results will be used to assess the suitability of the two systems for future developments and to determine the training needs of growers.

The SDI system performed well below standard. A new drip system is expected to achieve application uniformity of 90% or better. Application uniformity in the measured blocks ranged from 56% to 80% (Figure 3). Such poor distribution of water could lead to low yields particularly in a dry season such as 2001/2002. Possible causes of this poor performance include inadequate filtration of water, poor operation of the system, poor quality of equipment and poor installation. Figure 4 shows the water application profile in a SDI field evaluated at a different site in the same year, where design, installation and operation of the system were optimal. The uniform water application (95%) translates to efficient water use and uniform crop growth, which will result in higher yields.

The centre pivot project performed satisfactorily, achieving 87% uniformity, which is comparable with other centre pivots evaluated throughout the industry. However, new centre pivots are expected to achieve 90% uniformity. Failure to achieve 90% in this case was attributed to clogging of sprinklers by sand as a result of drawing the water supply direct from a river. Growers pumping directly from a water source with a high silt load should consider installing filters to protect their systems and optimise performance.

These evaluations demonstrate the importance of measuring system performance to check whether growers are realizing the full potential of their irrigation. Drip irrigation can be recommended where filtration requirements are minimal and growers have been trained on how to run a drip irrigation system successfully. When properly matched to soils, centre pivots can perform well under most conditions, but skilled personnel should periodically check the system to ensure optimum performance.

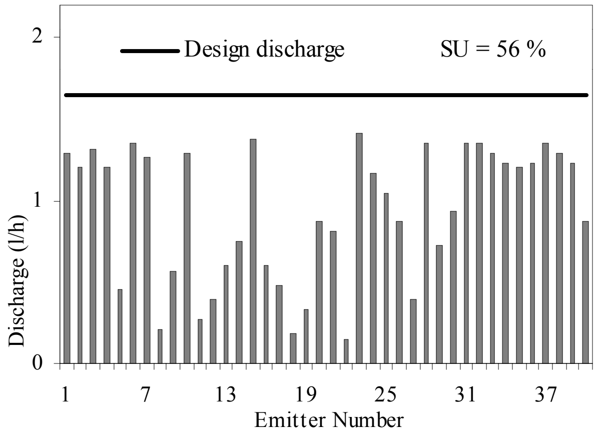

Figure 3: Application profile of sub-standard drip

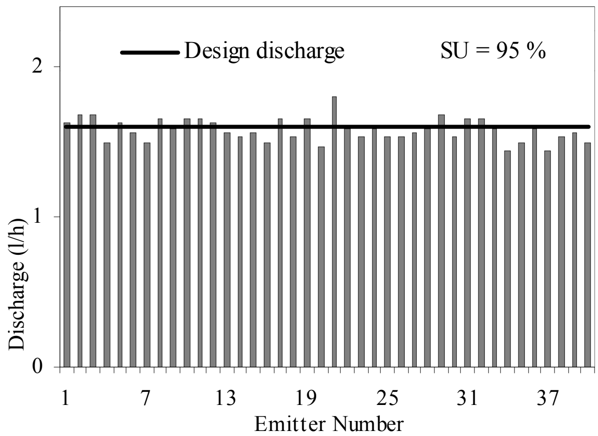

Figure 4: Application profile of well designed and well installed drip

IRRIGATION SYSTEM PREFERENCES

There has been a dramatic increase in the use of drip irrigation in the sugar industry since 1998. This has taken place both in re-development programmes and in the development of new areas of sugarcane (Figure 5). The total area under centre pivots has also increased markedly, but the percentage increase is masked by an increase in the total area under cane over the same period.

The trend follows the need for increased water use efficiency (tons cane per cubic meter of water) against rising labour and power costs. If properly designed and managed, centre pivot and drip systems apply water uniformly and efficiently with improved control over the amount of water that can be applied in a single irrigation event. It is important to note that compared to furrow and dragline systems, drip irrigation requires a high level of expertise to operate and manage properly. Its initial capital costs are higher and the dripper-lines have a relatively short life span (up to 10 years). Centre pivot systems are easy to operate but require skilled personnel to service electric motors, gear drives and control panels. Growers should seek advice from SSATS when considering installing these systems (Tel 383 8998).

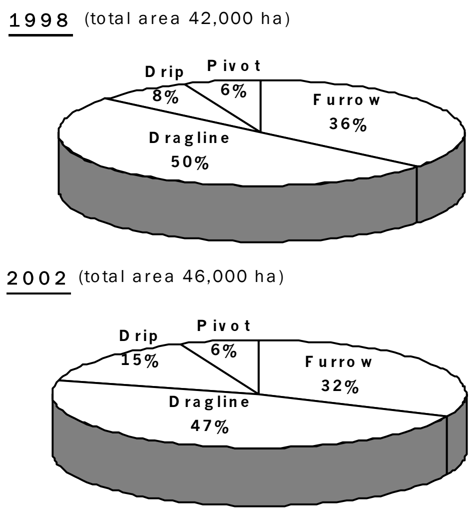

Figure 5: Irrigation systems in Swaziland, 1998-2002