SURVEY OF IRRIGATION SCHEDULING PRACTICES IN THE SOUTH AFRICAN SUGAR INDUSTRY

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Introduction

Effective irrigation scheduling is a prerequisite to optimising the use of expensive irrigation water for sugarcane production in South Africa. Accurate irrigation scheduling is not widely practised in the sugar industry despite the many scheduling tools available to sugarcane growers. This leads to very low water use efficiencies (WUE) of approximately 50% of what could be achieved theoretically (Olivier and Singels, 2003). Irrigation scheduling can be defined as a programme of irrigation determining the amount of water and timing of application. Schedules can be classified as fixed (amount and cycle fixed for entire growing season), semi-fixed (amount and cycle are changed a few times to accommodate rainfall and significant seasonal and crop age induced changes in water demand) or flexible (amount and cycle are changed daily or weekly according to calculated water budget based on recent crop and weather conditions). Scheduling methods aim to maintain the soil water content in the optimal range by direct monitoring of soil water content or by estimating the soil water content through water budgeting.

The objectives of this study were to determine (i) which irrigation scheduling methods and tools are being used within the industry and to what extent, (ii) reasons for adoption or non-adoption of specific scheduling methods and (iii) practical limitations that prevent the successful implementation of scheduling techniques. The information will be used to identify priorities for future research and technology transfer to improve irrigation water use efficiency.

Methods

Interviews were conducted with 10 growers in each of the major irrigation areas of Malelane, Komatipoort, Pongola and Mtubatuba.

A comprehensive questionnaire was completed that covered the following aspects:

- General farm information (irrigation system, system design and maintenance, water source and cost and computer skills).
- Scheduling practices (scheduling methods, scheduling tools used and reasons for use).
- Perceptions (irrigation scheduling, advice and training).

South African Sugar Association Experiment Station Extension Officers also completed a shortened version of the questionnaire to summarise the situation in each extension area. An Excel spreadsheet was used to run queries and analyse the data sets of both the individual and area questionnaires. Due to the small sample size of the study (Table 1), results from individual questionnaires (irrigation systems and scheduling methods and instruments) were compared with that of the area questionnaires to confirm trends.

Table 1. General information obtained from the questionnaires. Irrigation and crop water requirements were calculated using the Canesim crop model (Singels *et al*., 1998).

	Survey area				Industry totals
	Komatipoort	Malelane	Pongola	Mtubatuba	
Number of interviews					
Commercial	9	10	9	10	38
Small-scale	–	–	–	–	–
Number of growers					
Commercial	93	102	160	101	456
Small-scale	836	452	375	-	1 663
Irrigated cane (ha)					
Commercial	15 899	18 442	16 009	6 318	56 668
Small-scale	5 734	3 331	2 121	-	11 186
Average farm size (ha)					
Commercial	574	606	300	220	425
Small-scale	7	7	10	10	9
Average yield (t/ha)					
Commercial	105	97	103	95	100
Small-scale	80	70	70	65	71
Net irrigation requirement (mm/annum)	970	970	840	660	–
Crop water requirement (mm/annum)	1300	1300	1200	1100	–
Water quota (mm/annum) (Water source in brackets)	995 (Komati) 1300 (Crocodile) 850 (Lomati)	1300 (Crocodile) 1250 (Noord-Kaap)	1000 (Pongola)	No limit (Umfolozi) 1000 (Hluhluwe)	–
Water and electricity cost (R/ha/annum)	1640	1667	3048	632	–

Results

Although the questionnaires covered a vast number of issues related to irrigation scheduling, this paper highlights only the most relevant findings (Table 2).

Overhead dragline irrigation systems are used the most (67%), followed by drip irrigation (18%), centre pivot (12%), flood (3%) and floppy (1%), (Table 2). The Komatipoort area has less dragline irrigation than the other areas. Southern irrigated areas (Pongola and Mtubatuba) have less drip irrigation (18%) than the northern irrigated areas (Komatipoort and Malelane). These results were confirmed by the area survey. With larger farms and higher yield potentials in the northern irrigated areas (Table 1), growers are investing in automated irrigation systems such as drip.

The type of irrigation system being used largely determines the way irrigation is scheduled. Dragline irrigation systems are mostly (73%) irrigated according to a semi-fixed irrigation schedule, whereas centre pivot and drip systems are mostly (71%) scheduled according to flexible schedules (Table 2). Current dragline system practices suggest that flexible irrigation scheduling is impractical, due mainly to labour constraints and design limitations. In 95% of cases, schedules are adjusted for significant rainfall (>30 mm), 92% for season (winter and summer) and 55% for crop age.

Flexible schedules are used on 80% of centre pivot irrigation systems and 64% of drip irrigation systems (Table 2). Of the growers that make use of flexible schedules, 85% prefer direct soil water content monitoring and 15% prefer water budget calculations based on crop water use data (Figure 1).

Table 2. Number of growers (percentage given in brackets) that schedule irrigation according to a fixed, semi-fixed or flexible irrigation schedule for different irrigation systems and areas.

Irrigation system	Survey area				Industry totals
	Komatipoort	Malelane	Pongola	Mtubatuba	
Flood	0	0.25 (0.7%)	0.34 (0.9%)	0.4 (1.1%)	0.99 (2.6%)
-Fixed	-	0.25 (0.7%)	0.08 (0.2%)	-	0.33 (0.9%)
-Semi-fixed	-	-	0.26 (0.7%)	0.4 (1.1%)	0.66 (1.7%)
-Flexible	-	-	-	-	-
Dragline	4.18 (11.0%)	6.53 (17.2%)	7.21 (19.0%)	7.46 (19.7%)	25.38 (66.8%)
-Fixed	1.15 (3.0%)	2.04 (5.4%)	-	3.60 (9.5%)	6.79 (17.9%)
-Semi-fixed	3.03 (8.0%)	4.49 (11.8%)	7.21 (19.0%)	3.86 (10.2%)	18.59 (48.9%)
-Flexible	-	-	-	-	-
Floppy	0.03 (0.1%)	0.04 (0.1%)	0	0.22 (0.6%)	0.29 (0.8%)
-Fixed	-	-	-	-	-
-Semi-fixed	0.03 (0.1%)	0.04 (0.1%)	-	0.22 (0.6%)	0.29 (0.8%)
-Flexible	-	-	-	-	-
Centre pivot	2.36 (6.2%)	0.18 (0.5%)	1.38 (3.6%)	0.78 (2.1%)	4.70 (12.4%)
-Fixed	-	-	-	-	-
-Semi-fixed	0.57 (1.5%)	-	-	0.39 (1.0%)	0.96 (2.5%)
-Flexible	1.79 (4.7%)	0.18 (0.5%)	1.38 (3.6%)	0.39 (1.0%)	3.74 (9.8%)
Drip	2.43 (6.4%)	3.00 (7.9%)	0.07 (0.2%)	1.14 (3.0%)	6.64 (17.4%)
-Fixed	-	-	-	-	-
-Semi-fixed	0.41 (1.1%)	1.36 (3.6%)	-	0.60 (1.6%)	2.37 (6.2%)
-Flexible	2.02 (5.3%)	1.64 (4.3%)	0.07 (0.2%)	0.54 (1.4%)	4.27 (11.2%)
Total:	9 (23.7%)	10 (26.3%)	9 (23.7%)	10 (26.3%)	38 (100%)

The neutron water meter is used the most (75%) for direct soil water measurement, followed by tensiometers (9%) and the wetting front detector (1%) (Figure 1). Consultants mostly make use of a neutron water meter to provide a scheduling service. Growers are willing to pay for such a service. The neutron water meter is accurate, relatively easy to use and requires little maintenance compared with tensiometers. It should however be noted that the initial calibration of the neutron water meter and interpretation of data can be complicated and time consuming.

Water budgeting requires evapotranspiration (ET) data (mostly obtained from automatic weather stations) and crop water use coefficients (Singels *et al*., 1999). Real-time ET data is used more (10%) than long-term ET data (5%) (Figure 1). Computer availability (84%) and internet access (74%) are not limiting factors. However, appropriate crop coefficients are not readily available. Crop factors, meant for use with A-pan evaporation figures (George, 1988), are wrongfully being applied to Penman-Monteith reference ET figures. Appropriate crop coefficients have been calculated for all irrigated areas (Olivier and Singels, 2001) and will soon be available.

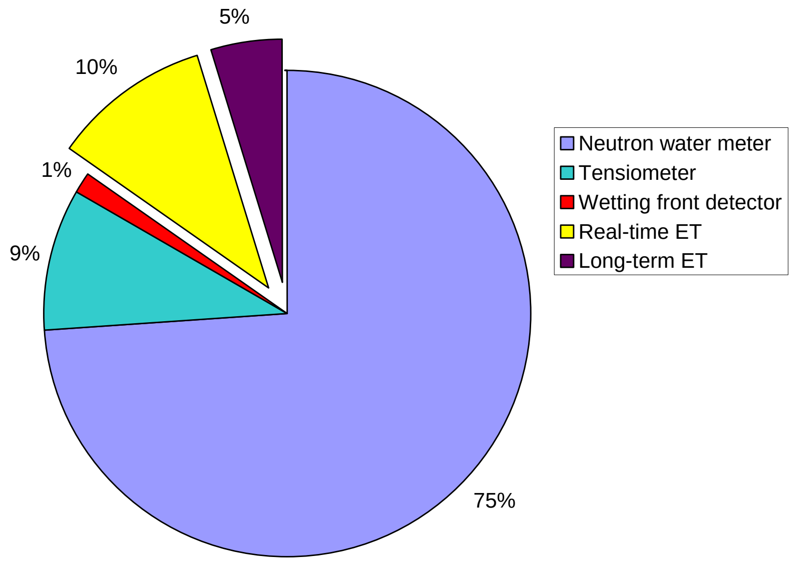

Figure 1. Percentage of growers with flexible irrigation schedules that make use of direct monitoring of soil water content (neutron water meter, tensiometer or wetting front detector) or by soil water budgeting (real-time or long term evapotranspiration (ET)).

Budgeting calculations are mostly performed on in-house developed spreadsheets. Generally, growers are not willing to spend more than one hour per day on irrigation scheduling. Water budget calculations are seen as too much trouble. Only one grower interviewed is using a crop model for irrigation scheduling. Crop models are perceived to be too complex and difficult to use.

Effects of age of individual growers, farm size, average yield, irrigation cost and irrigation demand on irrigation scheduling strategy were also investigated. No clear trends could be observed.

Although most growers realise the importance of accurate irrigation scheduling, they are often unable to successfully apply the scheduling information in the field. This is mainly due to the inflexibility of the dragline irrigation systems, problems with labour, theft, farm security and complexity of the farming enterprise (more than one kind of crop). In many instances, dragline systems are not capable of applying the required irrigation amounts and growers are consequently forced to give up on their efforts to schedule irrigation accurately.

Conclusions

Key findings from this work were:

- The dragline irrigation system is used by most growers (67%), followed by drip (18%) and centre pivot (12%) systems.
- Scheduling practices are highly dependent on the irrigation system. Semi-fixed scheduling is predominant in dragline systems, while flexible methods are used the most in centre-pivot and drip systems.
- It is estimated that over 12 000 ha of dragline irrigated sugarcane could potentially be converted from fixed to semi-fixed scheduling, while 6000 ha of centre pivot and drip irrigated sugarcane could be converted from semi-flexible scheduling to flexible scheduling. This will bring about considerable improvement in irrigation WUE.

- Direct soil water content monitoring is favoured (85%) above water budget calculations based on crop water use data (15%). The neutron water meter is the most popular method of soil water content monitoring, followed by tensiometers.

Recommendations

Attempts should be made to promote a change from fixed to semi-fixed scheduling for dragline systems. Tables with appropriate cycle and stand times could be generated by applying crop models to historic climate data.

More centre pivot and drip irrigation systems should be converted to flexible schedules. Irrigation scheduling based on water budgeting could be promoted by providing simple, easy to use spreadsheets or crop models and appropriate crop coefficient data. Effective soil water monitoring should also be encouraged.

The survey has also identified the need for information and advice on available irrigation scheduling tools and methods. A concerted effort is required to promote and implement scheduling technology to improve irrigation water use efficiency in sugarcane production. Agricultural extension and demonstration trials are possible options.

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