A SIMPLE METHOD OF SCHEDULING IRRIGATION

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Abstract

The main factors limiting cane growth on farms participating in the Pongola irrigation scheme are inefficient irrigation practices, which commonly result in overapplication of water with the associated problems. Because few growers use the United States Department of Agriculture's (USDA) Class A evaporation pan, a system of irrigation scheduling was developed using long term mean (LTM) evaporation data for the area and various other relevant criteria. These criteria, such as soil form and series, effective rooting depth, soil moisture capacity, total and freely available moisture, and daily evaporation for each month of the year at various stages of the crop canopy were first discussed with the participating growers. An irrigation scheduling board was then constructed and its use implemented on a number of farms in the Pongola area. The benefits accruing from this form of scheduling are described in terms of improved yields and greater water use efficiency, measured on three farms where the system has been implemented.

Introduction

The scheduling of irrigation, using the soil moisture profit and loss account system, has been recommended in the Pongola area for many years but it has seldom been practised. Irrigation water is commonly applied in the area for a fixed time interval irrespective of crop growth stage or the season. This has commonly resulted in over-irrigation in winter which has led to many drainage problems and yields which fall short of the potential growth for this area.

A course on the identification and management of soils was presented to growers in the Pongola area by staff of the South African Sugar Association Experiment Station in 1985. This created an awareness that irrigation management in the area should be improved.

Method

In 1985 three small groups of growers, called 'productivity groups', were formed to provide the participating growers with the technology necessary for them to irrigate their lands to the best advantage, and to develop a suitable irrigation scheduling system. The productivity groups met regularly with the Extension Officer for the area.

The 3 phases of the project were:

Education — during this phase basic concepts were thoroughly discussed, eg available moisture capacity (AMC) of the soil; total available moisture (TAM) content in the soil profile; freely available moisture (FAM) content; effective rooting (ER) depth; infiltration rate (IR); evaporation (E_o) from a Class A pan; evapotranspiration (E_t), and crop factor (CF).

It was realised that if the basic concepts were not fully understood a grower would not be able to adapt his irrigation scheme to take account of all the relevant factors. During the educational phase the layout of the pegboard to be used for irrigation scheduling was presented to the group.

Information gathering — this phase comprised inspections made by the grower and the Extension Officer of the soil profile in pits dug at strategic points in each field on the farm. Effective rooting depths, soil forms, and the likely AMC, FAM, TAM, and IR were assessed from the SASA Experiment Station's Bulletin No 19 (Anon[1]). To confirm the various soil moisture characteristics, soil samples were submitted to the Fertilizer Advisory Service (FAS) of the Experiment Station for AMC determinations and, where necessary, adjustments to the field assessments were made. To assess the soil TAM for each field the lowest estimate within a field was used provided it was representative of at least 15% of the entire field.

This inspection of soils on the farm was essential in order to acquire the data used for the irrigation scheduling board, but it was also most important in reinforcing the grower's understanding of the characteristics of his soils. The cause of many of the problems which had developed in the past became clear when the soil pits were examined.

Irrigation scheduling system — the third phase comprised familiarising the growers with a scheduling system, which is planned on a pegboard and is based on the following assumptions:

- that in the case of flood irrigation the soil moisture is replenished to field capacity with each irrigation application, and in the case of sprinkler irrigation, the amount of water applied is determined by the stand-time (ST)
- that any cumulative errors due to the use of long term mean (LTM) data will be eliminated whenever rainfall exceeds the soil moisture deficit
- in very dry periods, if the LTM evaporation is exceeded, the LTM data can be substituted by current evaporation data (using an average from the preceding weeks' Class A pan readings, from the SASA Experiment Station farm at Pongola).

The scheduling pegboard is set out in the following way:

FIELD no	Area (ha)	Canopy 0 ¼ ½ ¾ F	Days 1 to 31	TAM (mm)	FAM (mm)	Clay (%)	ST (h)	per ST (mm)	TI (mm)
1	4,0	●●*●●	●●●●	116	70	25	12	40	

The information on the board relates to the following factors:

Canopy	= the degree of canopy ground-cover during the interval between irrigations
Days	= calendar date. At month-end calendar peg returns to beginning of month
TAM	= total available moisture (mm), eg if rooting depth is 0,8 m and AMC m^{-1} of soil = 145 mm, then TAM = 145 × 0,8 = 116 mm
FAM	= freely available moisture (no yield reduction due to moisture stress) = TAM × 60% = 70 mm
ST	= stand-time of irrigation sprinklers, eg 12 h
Net mm per ST	= net mm applied in the stand-time
TI	= total accumulated irrigation (mm) on crop

The operation of the board entails the use of coloured pegs:

- red peg (A) = calendar date indicator. This is moved daily
- green peg (B) = day irrigation started
- blue peg (C) = day irrigation completed
- orange peg (D) = day irrigation needed again.

Example

The date is 8 March 1988 (Peg A).
Crop canopy = ½.
LTM E_t in March × ½ canopy = 3,9 mm d-2.
Net application in Field 1 (sprinkler) = 40 mm
Cycle time = net application 40 mm ÷ daily E_t 3,9 mm = 10 days
Net application in field 2 (flood) = 70 mm
Cycle time = net application 70 mm ÷ daily E_t 3,9 mm = 18 days.
Previous irrigation started 1 March (Peg B) and ended on 5 March (Peg C) in both fields.
Irrigation needed again after 10 days in Field 1, ie on 11 March (Peg D).
Irrigation needed again after 18 days in Field 2, ie on 19 March (Peg D).

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Field                         Days
 no   1   5   8   10  11 12 13 14 15 16 17 18 19 20 21 22 23
 1   (B). (C). (A) .  (D)
 2   (B). (C). (A) . . . . . . . . . . . .  (D)

15 mm ER falls on 8 March (15 ÷ 3,9 = ±4 days Et)
Add 4 days to Field 1, Peg D moves to 15
Add 4 days to Field 2, Peg D moves to 23

      1   5   8                 15                          23
 1   (B). (C). (A) . . . . . . . (D)
 2   (B). (C). (A) . . . . . . . . . . . . . . . . . . . .  (D)
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Results and discussion

The results shown in Tables 1 to 3 were extracted from the SASA Field Record System (FRS) data for three farms on which irrigation scheduling was introduced.

On Farms 1 and 2 mean yields of cane and sucrose ha-1 and sucrose ha-1 per 100 mm of water were markedly improved by scheduling compared with those obtained prior to the introduction of scheduling; and in the case of Farm

Table 1

Results from Farm 1 using flood irrigation

Year	Mean average age at harvest (mths)	Mean yields						Rainfall on crop (mm)	Irrigation applied (mm)
		tc ha-1	tc ha-1 mth-1	tc ha-1 100 mm-1 water	ts ha-1	ts ha-1 mth-1	ts ha-1 100 mm-1 water		
1984	14,0	96,1	6,8	3,9	11,9	0,85	0,48	1 061	1 418
*1985	12,3	101,7	8,1	5,3	14,3	1,15	0,74	489	1 443
1986	11,4	106,7	9,3	6,8	14,4	1,26	0,92	535	1 030
1987	12,5	113,8	9,1	6,0	15,6	1,25	0,83	559	1 327

*Scheduling started in October 1985

Table 2

Results from Farm 2 sprinkler irrigation

Year	Mean average age at harvest (mths)	Mean yields						Rainfall on crop (mm)	Irrigation applied (mm)
		tc ha-1	tc ha-1 mth-1	tc ha-1 100 mm-1 water	ts ha-1	ts ha-1 mth-1	ts ha-1 100 mm-1 water		
1985	14,8	106,8	7,1	5,3	14,1	0,95	0,69	561	1 481
*1986	12,6	115,6	9,1	7,3	15,0	1,18	0,94	553	1 042
1987	14,2	123,2	8,7	8,0	15,7	1,10	1,02	527	1 015

* Scheduling started in October 1986

Table 3

Results from Farm 1 using flood irrigation

Year	Mean average age at harvest (mths)	Mean yields						Rainfall on crop (mm)	Irrigation applied (mm)
		tc ha-1	tc ha-1 mth-1	tc ha-1 100 mm-1 water	ts ha-1	ts ha-1 mth-1	ts ha-1 100 mm-1 water		
1985	10,5	105,4	10,0	5,3	14,0	1,33	0,71	654	1 317
*1986	9,8	103,0	10,5	5,6	13,0	1,32	0,68	600	1 311
1987	12,8	128,2	10,0	5,9	16,6	1,27	0,76	664	1 504

* Scheduling started in October 1986

2 there was a substantial saving in the amount of irrigation water applied. There is, however, no apparent improvement in yield from irrigation scheduling on Farm 3; but the yield levels prior to the introduction of the new scheduling system were already relatively high, eg 1,33 ts ha^{-1} mth^{-1}, and the farm has deep Hutton form soils on which, because of the favourable characteristics of the soil a smaller response to irrigation scheduling would be expected. Although the production on Farm 3 in terms of ts ha^{-1} mth^{-1} is comparatively good, the water use efficiency ts ha^{-1} 100 mm^{-1} compares unfavourably with Farms 2 and 3. It is considered that over-irrigation is being practised because of the growers' tendency to over-estimate the degree of crop canopy for fear of incurring moisture stress. It is probable that this tendency to over-irrigate will be remedied in future.

Approximately 3 or 4 min d^{-1} is required by the grower to manage this system of irrigation scheduling. A minimal amount of record on paper is required, which is one of the major benefits of the system. It is thought that the systems recommended in the past have not been adopted by growers because of the time and paperwork required. The apparent yield responses and the use of less water justify the time spent in operating a scheduling board.

Another important benefit is that there is no over-irrigation on shallow soils, and these soils no longer have drainage problems and support increasingly good cane growth.

There are currently 18 growers using this method in the Pongola area to schedule irrigation and they are satisfied that productivity has improved.

It is clear that the introduction of irrigation scheduling leads to improvements, not only an irrigation management but also in greater attention to detail in terms of all husbandry practices.

Acknowledgements

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REFERENCE

1. Anon. Identification of the soils of the sugar industry. Bulletin No 19 (Revised) 1984. SASA Experiment Station.