CHARTS AND CALENDARS FOR IRRIGATION SCHEDULING OF SUGARCANE IN THE ZIMBABWE LOWVELD

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Abstract

Many emergent farmers growing irrigated sugarcane do not have easy access to computers. To provide such farmers with appropriate agronomic and water management decision aids, charts showing when irrigation water should be applied were produced and are described in this paper. The charts can be used with most types of irrigation systems and on all soil forms found in the sugar industry. A simple but robust methodology to determine and account for effective rainfall was also developed. The information in the irrigation scheduling charts, together with other appropriate agronomic recommendations, could help growers to derive more inclusive 'sugarcane growing' management calendars, which include fertiliser and herbicide recommendations. Although not as accurate for water management as the use of credible computer simulation models and near-real time weather data, these schedules and the methodology for accounting for rainfall, could be better suited to many growers.

Keywords: sugarcane, emergent farmers, irrigation scheduling, effective rainfall, management

Introduction

Many farmers growing irrigated sugarcane are either averse to the use of computer-based decision support tools, or do not have easy access to computers. This is particularly evident with emergent farmers. Charts showing when irrigation water should be applied have been produced to provide such farmers with appropriate water management decision aids. This paper outlines the development of these charts and gives examples of their application. The charts show the average number of days between irrigation applications for cane cut at different times during the harvest season, using different types of irrigation systems and on different soil forms. A robust methodology to determine and account for effective rainfall was also developed.

Methodology

ZIMsched 2.0, an irrigation systems simulation model (Lecler, 2000; Lecler, 2003), was used to determine the ideal intervals between irrigation water applications for various target soil water depletion levels, at different times during the growing season. Irrigation water applications were simulated to take place immediately after planting/harvesting and subsequently throughout a 12-month growing period whenever the simulated soil water depletion level reached the selected target value. The target soil water depletion levels were selected dependent on the type of irrigation system and/or soil water holding characteristics.

The results shown in this communication are for target soil water depletion levels of -50, -36 and -25 mm, corresponding, in absolute terms, to the magnitude of typical furrow, overhead sprinkler and centre pivot irrigation water applications, respectively. Long term average daily values of maximum and minimum temperatures and A-pan evaporation, recorded at the Zimbabwe Sugar Association Experiment Station (ZSAES) were used as the inputs to *ZIMsched 2*.0. The number of days between successive irrigation applications for a range of representative harvest dates were then tallied and tabulated for the growing season (cf Figure 1).

Accounting for rainfall when using the scheduling charts
Values for rainfall ranging from 3 mm to 60 mm were input to *ZIMsched 2.0* in order to simulate the resultant period of extension to the next required irrigation, at different times during the year. This period was dependent on soil and drainage characteristics, the time of year and the amount of rain. However, it was found that a rule of thumb to determine this period, was to divide the recorded rainfall by the mean daily A-pan evaporation value for the respective month during which the rainfall occurred. This rule of thumb proved fairly robust, provided the result was limited to a maximum value of six. The resulting number of days is then added to the day count between irrigation water applications, as illustrated in the following two examples.

Example 1: 20 mm of rain falls in May
Referring to Table 1, the mean daily A-pan evaporation for May is 4 mm. Dividing the 20 mm of rain by an A-pan evaporation of 4 mm yields 5. This result is not greater than 6, the maximum number of days to be added, therefore 5 days are added to the day count between successive irrigation water applications.

If the day count between irrigation applications was 10, it would change to a total of (10 + 5) = 15. If 7 days had already been counted when the rain occurred, a further 8 days (15 − 7 = 8) would still need to be counted before the next irrigation water application is applied. The rain has resulted in the day count between irrigations changing from 10 to 15.

Example 2: 60 mm of rain falls in March
Mean daily A-pan evaporation for March is 6 mm. Dividing 60 mm of rain by the March mean A-pan evaporation of 6 mm yields 10. This result is greater than 6, the maximum number of days to be added, therefore only 6 days are added to the day count between irrigation applications, and not 10 days.

Table 1. Mean monthly A-pan values. Values were calculated from more than 24 years of data recorded at the Zimbabwe Sugar Association Experiment Station.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7	6	6	5	4	3	3	5	6	7	7	7

Results

The day counts between successive irrigation water applications for typical furrow, overhead sprinkler and centre pivot irrigation systems are shown in Figure 1. To illustrate the use of the charts in Figure 1, consider the following example. For a furrow irrigated field cut in late April, which takes approximately 50 mm of water per irrigation application, the grower would select the 'Furrow Irrigation Schedule' in Figure 1. After cutting, 50 mm of water would be applied within one week.

Thereafter, following the chart column headed 'May', irrigation applications would proceed as follows:

- count 78 days, apply 50 mm on day 79
- count 24 days, apply 50 mm on day 25
- count 13 days, apply 50 mm on day 14
- count 10 days, apply 50 mm on day 11, and so on.

The day count between successive irrigation water applications will eventually reduce to 7, and stay at 7, until February and March when it increases to 9. Drying off would start around 12 March.

Note: The count is re-set to one on the day following an irrigation water application, and the irrigation water is applied on the day after the day count reaches the value shown in the table. The information in the table was derived on the assumption that the crop would be cut on the first day of the month. Therefore, if a crop is cut, say, in late April, it is best to select the 'May' column. Alternatively, if a crop is cut in early April, it would be best to select the 'April' column.

The time between the initial irrigation (within one week of cutting) and the following irrigation may seem excessively long. Research at the ZSAES has, nevertheless, shown that at least 200 mm of A-pan evaporation can be accumulated between such irrigation applications with no yield losses (Nyati, -). These trial-based research results are in general agreement with what *ZIMsched 2.0* predicts, although *ZIMsched 2.0* also shows variations due to different cutting dates, canopy development rates and irrigation systems. Evaporation losses during the early phase of growth are very low, and occur mainly from the bare soil surface, especially in the winter months when crop canopy development is relatively slow. The traditional crop factors of 0.4-0.5 that have regularly been used to schedule irrigation applications during this period are often inappropriate, especially for furrow irrigation. Under furrow irrigation evapotranspiration in the early part of the growing season is relatively low, because large water applications are applied relatively infrequently and only a portion of the soil surface is wetted.

Discussion and recommendations

An accurate way to schedule irrigation water applications is to use a suitably representative and credible computer simulation model with appropriate input information / data. However, many growers are averse to the use of computers or do not have easy access to computer technology. These same growers are nevertheless under increasing pressure to improve production efficiencies in order to sustain profitability. In southern Africa they also often operate in environments where water is scarce and where there is increasing competition for existing water supplies. In order to help such farmers, many of whom over-irrigate and/or apply irrigation water in an *ad-hoc* manner, simple scheduling charts have been produced for different irrigation systems. Correct use of these charts should facilitate improved production efficiencies by the provision of better information on when to irrigate and how much water to apply. Although not as accurate as a computer simulation tool such as *ZIMsched*, the charts and 'rule-of-thumb' methodology for accounting for rainfall are, nevertheless, likely to be a significant improvement on many irrigation scheduling approaches. Whilst hopefully simple to interpret and use, they are based on sophisticated and proven water budgeting and crop growth algorithms (cf. Lecler 2003). The information in the charts can also be integrated with other appropriate agronomic recommendations to derive more inclusive management calendars for irrigated cane, which include, for example, fertiliser and herbicide recommendations. These management calendars may prove popular and valuable decision aids for many farmers, especially emergent farmers.

The development and evaluation of similar charts and management calendars for other irrigated areas in southern Africa where growers may be averse to the use of computers, is recommended.

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FURROW IRRIGATION SCHEDULE (TAM > 90 mm)

Average Time (Days) Between 50 mm Irrigation Applications for Different Cutting / Harvest Dates

Note: An initial irrigation application of approximately 50 mm must be applied within 1 week of cutting if the cane has been well dried off

Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
41	52	**78**	78	66	51	40	35	34	34
18	29	**24**	22	20	18	17	16	15	15
14	21	**13**	11	9	9	8	9	8	8
13	18	**10**	9	8	7	8	7	8	8
16	10	**9**	7	7	7	7	7	7	"
17	10	**8**	7	7	"	7	"	"	"
17	10	**8**	"	"	"	"	"	"	"
14	8	**7**	"	"	"	"	"	"	"
10	8	**7**	"	Feb - 8	"	"	Feb/Mar - 8	"	"
10	8	"	Feb - 8	Mar - 9	Feb/Mar - 8	"	Apr - 10	Feb/Mar - 8	Apr - 10
8	7	"	Mar - 9	Apr - 10	Apr - 11	Feb/Mar - 8	May - 13	Apr - 10	May - 13
8	7	"			May - 11	Apr - 10	Jun - 17	May - 13	Jun - 17
8	"	"	D/Off 2 Apr	D/Off 20 Apr		May - 14	Jul - 18	Jun - 17	Jul - 18
8	"	**Feb/Mar - 9**			D/Off 11 May	Jun - 17	Aug - 12	Jul - 18	Aug - 11
7	"							Aug - 11	Sep - 9
7	"	D/Off 12 Mar				D/Off 25 Jun	D/Off 15 Aug	Sep - 10	Oct - 8
"	"								
"	Feb - 8							D/Off 23 Sep	D/Off 26 Oct
"									
"	D/Off 15 Feb								
"									
D/Off 18 Jan									

OVERHEAD IRRIGATION SCHEDULE (TAM > 70 mm)

Average Time (Days) Between 36 mm Irrigation Applications for Different Cutting / Harvest Dates

Note: An initial irrigation application of approximately 50 mm must be applied within 1 week of cutting if the cane has been well dried off

Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
38	48	69	70	57	42	36	30	29	29
11	14	20	17	16	16	12	12	12	12
10	16	10	9	9	7	7	7	6	6
10	15	9	8	7	6	6	6	6	6
9	14	9	7	6	6	6	5	6	5
10	11	6	7	5	5	6	5	5	6
12	8	6	5	5	5	5	"	5	6
13	7	6	5	"	"	5	"	"	"
13	7	6	"	"	"	"	Feb/Mar - 6	"	"
13	7	5	"	Feb/Mar - 6	Feb/Mar - 6	"	Apr - 7	Feb/Mar - 6	Apr - 7
10	6	5	Feb/Mar - 6	Apr - 7	Apr - 7 / 8	Feb/Mar - 6	May - 10	Apr - 7	May - 10
7	6	"			May - 9	Apr - 8	Jun - 12	May - 10	Jun - 12
7	6	"	D/Off 2 Apr	D/Off 20 Apr		May - 10	Jul - 12	Jun - 12	Jul - 13
7	5	Feb/Mar - 6			D/Off 11 May	Jun - 12	Aug - 12	Jul - 13	Aug - 8
6	5							Aug - 8	Sep - 6
6	"	D/Off 12 Mar				D/Off 25 Jun	D/Off 15 Aug	Sep - 6	Oct - 6
6	"								
6	Feb - 6							D/Off 23 Sep	D/Off 26 Oct
5									
"	D/Off 15 Feb								
"									
D/Off 18 Jan									

OVERHEAD (PIVOT) IRRIGATION SCHEDULE (TAM > 60 mm)

Average Time (Days) Between 25 mm Irrigation Applications for Different Cutting / Harvest Dates

Note: An initial irrigation application of approximately 50 mm must be applied within 1 week of cutting if the cane has been well dried off

Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
30	38	53	64	52	39	33	28	28	27
7	10	13	7	8	7	5	5	5	5
6	9	11	7	6	5	4	5	4	4
"	"	11	7	5	5	"	4	"	"
"	"	6	5	5	4	Nov - 3	"	Jan - 3	Mid Jan - 3
Jun - 9	Aug - 5	5	5	5	"	"	Dec - 3	"	"
Jul - 9	Sep - 4	Sep - 4	4	Early Oct - 4	Mid Oct - 3	Feb/Mar - 4	Feb/Mar - 4	Feb/Mar - 4	Feb/Mar - 4
Aug - 5	Oct - 3	Oct - 3	"	Mid Oct - 3	"	Apr - 5	Apr - 5	Apr - 5	Apr - 5
Sep - 4	"	"	Mid Oct - 3	"	"	May - 6	May - 6	May - 6	May - 6
Oct - 3	"	Feb/Mar - 4	"	Feb/Mar - 4	Feb/Mar - 4	Jun - 10	Jun - 9	Jun - 9	Jun - 9
"	D/Off 15 Feb		Feb/Mar - 4	Apr - 6	Apr - 5		Jul - 10	Jul - 10	Jul - 10
"		D/Off 12 Mar			May - 7	D/Off 25 Jun	Aug - 7	Aug - 6	Aug - 5
D/Off 18 Jan			D/Off 2 Apr	D/Off 20 Apr				Sep - 5	Sep - 4
					D/Off 11 May		D/Off 15 Aug		Oct - 4
								D/Off 23 Sep	
									D/Off 26 Oct

Note: The **drying-off dates** shown in the scheduling Tables correspond to an accumulation of an average 270 mm of A-pan evaporation prior to harvest. This corresponds to the general ZSAES recommendation of drying off to approximately 3 x TAM. Research findings in Australia and South Africa recommend drying off for up to only 1.5 x TAM. Discrepancies may be due to the way in which TAM has been estimated in the different trials and some trials may have been influenced by the presence of a water table. Therefore, the start of drying off may need adjustment, especially if soils are shallow with TAM's <130 mm, or if one is unsure of the TAM. If a water table is present, every effort should be made to drain the field and/or reduce irrigations until the water Table has been lowered to > 1.2 m. In such cases, the dry-off period may need to be extended.

Figure 1. Irrigation scheduling charts for different types of irrigation systems. The charts were derived using *ZIMsched* and long term average weather data.