FIELD TESTS OF OSIRI — A DECISION-MAKING TOOL FOR IRRIGATION OF SUGARCANE FARMS IN REUNION

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ABSTRACT

A decision-making software tool for monitoring irrigation of small farms in heterogeneous environments (OSIRI) was developed at the request of small-scale sugarcane farmers on the island of Réunion (France) hampered by variable climate and soil conditions. This program, which is based on a simple water balance simulation model coupled with a comprehensive set of decision rules, was designed to provide farmers with customized advice on discrete irrigation units and to simulate irrigation system scenarios so as to optimize their performance. The basic equations and main decision rules of OSIRI, as well as the software features, were given in Chopart et al. (2007). A detailed experimental study was carried out on a 5000 m^2 irrigated sugarcane field to compare the performance of this tool with the currently used method based on maximum crop water requirements (control). The results showed that OSIRI reasonably well simulates actual evapotranspiration and drainage below the sugarcane root zone. Moreover, it allowed savings of about 26% in irrigation delivery throughout the crop cycle as compared with the control method, without a significant decrease in yield, and irrigation water productivity increased by 25%. The results of a survey of 25 farmers using OSIRI showed that it is a well accepted valuable decision-making tool.

INTRODUCTION

More water is applied than necessary in many irrigated systems, particularly when water fees are low. In Réunion, with a growing population and urbanization, industrial and domestic water use is rising, thus boosting competition with the agricultural sector for this resource. Public and regulatory agencies are now concerned about the possible contamination of water bodies due to the increasing use of agrochemicals and the development of newly irrigated areas on the island (eg Bernard et al., 2005). Consequently, agricultural water resource management should be optimized to maintain a sustainable usage level, particularly by developing irrigation-monitoring tools adapted to local environmental and socioeconomic conditions, such as high climate and soil variability at small scales, tiny fields and poorly trained farmers. Although several such tools are available, most were specifically designed for surface irrigation (eg Rowshon et al., 2003a and 2003b, Georges et al., 2004). Tools for sprinkler irrigation (eg Cabelguenne et al., 1996, Dechmi et al., 2003a and 2003b, Stirzaker and Hutchinson, 2005) and drip irrigation (eg Wieldenfeld, 2004) require equipment and

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input data that are not readily available to Réunion farmers. Recommendation tools for small-scale irrigation include: (i) water state indicators for plants like leaf temperature (Jackson et al., 1981) or soil (Ozier-Laffontaine and Cabidoche, 1995), (ii) soil water balance models (eg Smith, 1992; Imman-Bamber et al., 2002), and (iii) data sheets based on average climatic forcing and crop water requirements. The water state indicator-based approaches are not applicable to Réunion because the soil types are highly variable and *in-situ* measurements would be too cumbersome.

The Agricultural Extension Service (AES) of Réunion currently provides recommendations for irrigation based on crop water requirement estimates calculated according to regional mean potential evapotranspiration (ET_0) and crop coefficient values (Doorenbos and Pruitt, 1977). Hereafter, this method will be referred to as MET-rec. However, this approach was not satisfactory in many places. The new OSIRI tool was thus developed in collaboration with farmers and the AES so as to provide them with better operational advice (Chopart et al., 2007). After summarizing the main features of OSIRI, this paper presents the results of a 1-year evaluation of the tool against field data. They are also compared with results obtained by using the MET-rec method. Finally, the results of a survey conducted among a sample of 25 farmers who used OSIRI to assess its acceptability, usefulness and ease of use are given.

MATERIALS AND METHODS

The study was conducted in southern and western Réunion (21°S, 55°E, Figure 1a). Because of its compact orography (highest elevation: 3100 m), climatic variability is spatiotemporally high. Annual rainfall ranges from 0.5 to 10 m depending on the location along the coast and the elevation, with steep gradients on a kilometric scale. The main crop is sugarcane (26500 ha, year 2006), with at least half of the fields irrigated. Most irrigated farms are less than 5 ha. Each farmer gets water from an outlet at a constant flow rate. An irrigation unit may consist of subdivided field units. In sprinkler irrigation, farmers irrigate each unit sequentially. The time between two irrigations ranges from 2 to 10 days. Drip irrigation usually takes place once a day. The time interval between two irrigations is proportional to the time required to irrigate all units of a farm from the same water outlet. Irrigation systems are often monitored by a computerized irrigation autotimer. Farmers can seek advice from an AES officer but there are not enough officers to meet the needs.

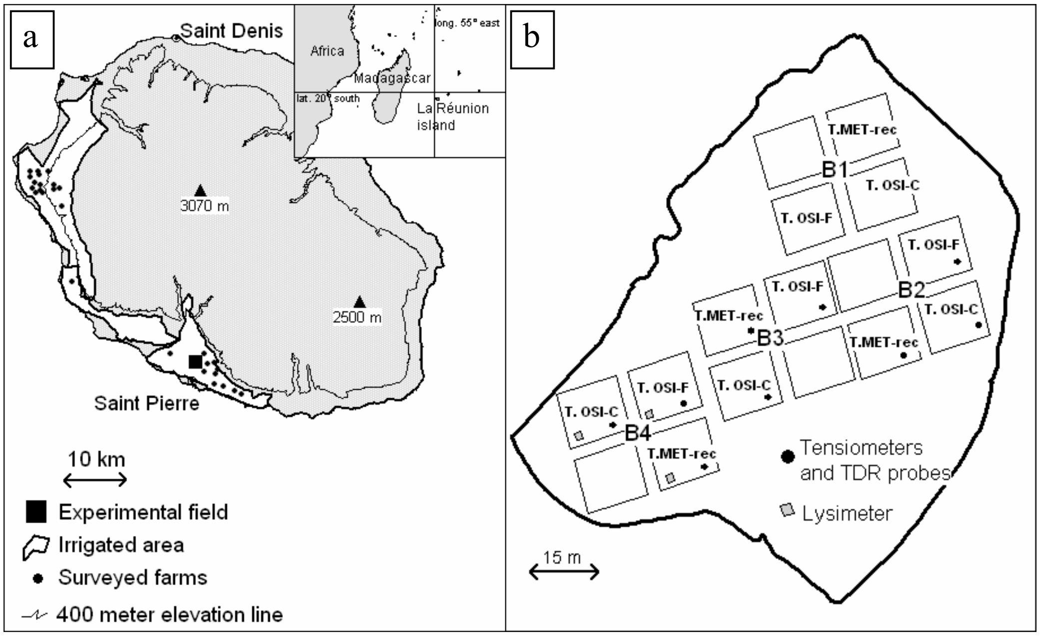

Figure 1. Map of the island of Réunion showing the locations of the surveyed farms (1a) and a schematic representation of the experimental setup (1b). The fourth plot of each block was cultivated with an irrigation deficit (data not reported)

OSIRI software description

The French acronym OSIRI stands for “Outil Simplifié pour une Irrigation Raisonnée et Individualisée” (i.e. simple decision–making tool for sustainable individual irrigation monitoring). This easy-to-use product is designed to optimize irrigation water and rainfall use, while taking irrigation parameter and environmental factor variations into account. The software can be operated on any Office 2000®-run PC through Windows (Microsoft®) on Excel 2000® spreadsheets (or more recent versions). Data are saved in Excel® files compatible with standard spreadsheets. English, French or Portuguese versions are available free of charge on request.

OSIRI was designed to provide irrigation recommendations for single sprinkler units or dripper lines or for large jointly irrigated areas. Whenever irrigation is possible, depending on the irrigation frequency, the amount of water to be delivered is calculated by algorithms with several factors taken into account: predicted rain, daily actual soil water storage rates estimated through the PROBE model (Chopart and Vauclin, 1990), crop water requirements, water delivery flow rates at the outlet, irrigation duration and frequency, as well as available soil water storage constraints (see below). Predicted rainfall is estimated on the basis of frequency analyses of rainfall recorded at the nearest meteorological stations. A daily simulation of the PROBE water balance is then carried out for the next water roster, with programmed irrigation and predicted daily rainfall.

This provides a forecast of the actual water storage level in order to determine the irrigation dose for the next water roster. These calculations are ongoing until harvest. This provides the farmer with an estimation of irrigation application needs for the whole cropping season, thus facilitating irrigation scheduling. For each irrigation-monitored unit, the recommended applications are presented in two ways: (i) per irrigation unit for the duration of the crop cycle, and (ii) per month for all units. It is advisable to periodically update the water balance calculation by considering actual rainfall and irrigation applications in order to adjust the soil water level and maximize the efficiency of the recommendations. This task is fulfilled by an extension officer, but the farmer may adjust the irrigation applications according to actual rainfall between two visits by the officer. One OSIRI module proposes a simple method for this operation. Five functions are listed on the OSIRI home page: (i) creation or cancellation of irrigation units, (ii) recording of rainfall or irrigation application data, (iii) calculation and editing of water balance and recommendations, (iv) printing and export of data and recommendations, and (v) exiting OSIRI. Only basic computer notions are required to use the software. More detailed information is available in Chopart et al. (2007) and in the user guide (Chopart et al., 2005).

The farmer, alone or with the assistance of an AES officer, starts by creating a new file containing all irrigation units sharing the same climate inputs. Once a first soil water balance simulation has been achieved, OSIRI suggests an irrigation schedule applied to each water roster until harvest. A recommendation preview allows the user to check whether the whole process and first choices lead to irrigation applications in line with the farmer's initial requirements. If not, the strategy can be changed by modifying elements. Recommendation sheets are edited when the proposed irrigation calendar meets such requirements.
These guidelines enable farmers to program irrigations at the beginning of the recommendation period. They subsequently have to record water volumes used and rainfall levels during this given period. Then they have the alternative to make a new soil water balance calculation with actual irrigation applications and rainfall for another recommendation or to adjust the data by a simplified method.

Field test

Experimental setup and irrigation methods tested. The experimental setup consisted of four blocks within a 5000 m^2 field on a sugarcane farm in southern Réunion (Figure 1b). The soil is clayey, derived from recent volcanic rock (Cambisol). It is more than 2 m deep and has a dry bulk density close to 1 g/cm^3. The field had been cropped with sugarcane for several years before the experiment took place during the 2005-2006 crop season. It was irrigated with a fixed sprinkler system to obtain a uniform water supply. Three 160 m^2 plots were randomly located within each block. They were managed according to the following three irrigation advice tools: (i) T.MET-rec: irrigation was conducted as recommended by the monitoring sheet. If total rainfall during the 5 previous days exceeded 30 mm, then no irrigation was applied for 5 days (one water roster), (ii) T.OSI-F (F = farmer): irrigation was applied as recommended by OSIRI, and as routinely carried out by farmers, with soil water storage calculations updated once a month to adapt to the harsh local constraints experienced by farmers, and (iii) T.OSI-C (C = control): irrigation was conducted according to the OSIRI water roster advice (5 days). This was considered as the control treatment**.** Three blocks were equipped with TDR probes and tensiometers implemented between 0.2- and 2 m depths in order to estimate components of the soil water balance.

In addition, three single-block plots were equipped with free-drained lysimeters of 2.25 m^2 surface area and 180 cm depth. They were carefully filled with soil taken from the surrounding field and packed in such a manner that their properties were similar. The bottom was equipped with an automatic water outflow measuring device. Rainfall was automatically recorded as well. A sugarcane row was planted in each lysimeter in such a way that the plant density was the same as that of the surrounding field. The lysimeters were set up 2 years before the field study so as to obtain uniform soil and crop conditions.

Treatments were applied after 1 year of homogeneous sugarcane cultivation. In terms of irrigation monitoring, the following input parameters common to all three tools were: (i) climatic data (rainfall and potential evapotranspiration), (ii) water roster period (5 days), (iii) crop regrowth date (October 31, 2005) and harvest date (October 30, 2006), and (iv) crop coefficient time-course (Chopart et al. 2007). In addition, T.OSI-Ag and T.OSI-C require the following complementary input parameters: (i) irrigation efficiency (IE = 80%), (ii) maximum available soil water storage (0.072 cm of water per cm of soil), (iii) drainage depth (DZ = 180 cm), and (iv) root depth (RD = 120 cm). Note that RD was considered temporally constant since the field study addressed the sugarcane regrowth stage. Maximum filling of the root zone reservoir and the irrigation triggering threshold (see Chopart et al., 2007) were set at 80% and 60% of the maximum available water storage of the root zone (68 mm), respectively.

<u>Comparison between measured and OSIRI-calculated values</u>. T.MET-rec, T.OSI-F and T.OSI-C were compared with respect to three water balance components: (i) total irrigation delivery, (ii) drainage loss below the root zone (DT), and (iii) actual evapotranspiration (AET). They were also compared according to yields and irrigation water productivity, defined as the ratio between the millable yield and irrigation volume and calculated for the 12-month growing season.

The OSIRI software soil water balance component was run for both treatments (T.OSI-F and T.OSI-C) with its required soil and crop data. It was forced by actual rainfall and irrigation quantities. For the lysimeters, experimental AET values were obtained on the basis of the difference between water input (rainfall + irrigation) and drainage losses measured at baseline since the experimental conditions led to a quasi-steady-state water flow regime after the first stage of growing season (0-60 DAR). OSIRI recommendation tools were compared with field soil water storage variations (ΔS) measured by TDR probes. They just gave estimates of the sum of cumulative AET and drainage values between two dates. This calculation is useful when drainage is either nil or very low. Fortunately, the lysimeter measurements indicated low drainage, as confirmed by the tensiometer readings (data not reported) during four periods ranging from 20 to 36 days long. This enabled calculation of cumulated AET+ DT, which here resulted in water losses, from ΔS. Differences between measured and OSIRI-calculated values of AET and DT were analyzed according to the following classical statistical entities: Nash efficiency coefficient (NE), root mean square error (RMSE), and mean bias (MB). They should be as close as possible to 1, 0, and 0, respectively.

<u>Farm survey</u>

To evaluate the end user's degree of satisfaction of OSIRI, a survey of 66 farmers who had been using the tool for more than 1 year, or who were beginning to use it during the current sugarcane cycle, was carried out. They were distributed in two regions more than 30 km apart (Figure 1). A sub-sample of 25 randomly selected farmers was considered for the analysis. The survey was conducted by a student who had not been involved in designing OSIRI, thus reducing the survey response bias. Farmers were asked about their irrigation practices before and after using the OSIRI advice tool. The main questions were: (i) What is your overall impression? (ii) Do you consider that water doses suggested by OSIRI are: too small, adequate, or too high? (iii) Has irrigation water consumption increased or decreased? and (iv) Is irrigation control easier or more difficult as compared to your previous situation? A score ranging from 1 to 5 was assigned to each answer (see below).

Additional information was collected to try to explain variations in different farmers' responses, such as: age, type of training, duration of experience in using OSIRI (first year or second year), type of irrigation advice used before OSIRI, irrigation programming mode (control programmed in terms of time or volume). Two types of training were identified: practical irrigation training without agricultural studies (I), and basic agricultural studies complemented by practical irrigation training (AI).

RESULTS

Experimental test

Comparison of irrigation applied according to OSIRI and MET recommendations. As Table 1 shows, no significant difference was noted between the two versions of OSIRI (T.OSI-F and T.OSI-C). Irrigation amounts programmed by the currently used T.MET tool were, however, higher than those recommended by OSIRI. For the whole 360 day period, OSIRI allowed irrigation savings of about 26%, while the sugarcane crop showed no signs of water stress based on leaf observations and tensiometer readings at 20-cm depth (data not reported here).

Table 1. Mean irrigation quantities recommended by the three tools for the soil rewetting phase (0-60 DAR) and the rest of the sugarcane cycle (60-360 DAR). DAR represents day after regrowth, CV is the coefficient of variation with three repetitions. Values followed by the same letter (a, b) are not significantly different (P> 0.05)

		T. MET-rec	T. OSI-C	T. OSI-F.	CV%
Rainfall (mm)	0-60 DAR	47	47	47	
	60-360 DAR	871	871	871	
Irrigation (mm)	0-60 DAR	209 [a]	149 [b]	169 [b]	12.7
	60-360 DAR	416 [a]	347 [b]	324 [b]	7.7

This resulted (Figure 2) in slightly higher drainage loss measured at the base of lysimeters on the T.MET plots (only one measurement per treatment). There were four periods during which rainfall was quite low throughout the sugarcane cycle (Table 2 and Figure 2). After a few days without rain, drainage (measured in lysimeters and assessed from the TDR probe and tensiometer readings) became nil or very low, making it possible to calculate AET. The results (Table 2) revealed no significant difference between the three compared irrigation methods.

Table 2. Mean actual evapotranspiration (mm/d) for the three treatments during four periods in which drainage at DZ= 180 cm was nil or very low. Values followed by the same letter are not significantly different (P> 0.05). MET is the maximum evapotranspiration (mm/d). CV is the coefficient of variation with three repetitions

	Rainfall	MET	T.MET-rec	T.OSIRI-C	T. OSIRI- F	CV%
Period 1 (28 d)	19.2	4.5	3.51 [a]	3.57 [a]	3.24[a]	15.1
Period 2 (21 d)	17.2	4.3	3.93 [a]	4.13 [a]	3.68 [a]	15.1
Period 3 (21 d)	5.4	3.3	2.82 [a]	3.15 [a]	2.99 [a]	16.6
Period 4 (36 d)	28	3.6	3.34 [a]	3.04 [a]	3.16 [a]	9.9
Total (106 d)	69.8	3.9	3.40 [a]	3.42 [a]	3.25 [a]	8.3

For the MET and OSIRI treatments, AET values were very close to each other and to the MET values, indicating that both irrigation advice tools were able to meet sugarcane water requirements. While yields were similar for both treatments (Table 3), irrigation water productivity was improved (by about 25%) in the OSIRI-managed plots as compared to the MET-managed plots.

Table 3. Effects of irrigation methods on sugarcane yield components and water productivity. Values followed by the same letter (a, b) are not significantly different (P> 0.05). CV is the coefficient of variation with four repetitions

	T.MET-rec	T.OSI-C	T.OSI-F	CV%
Number of stalks per m²	6.1[a]	6.2[a]	6.1[a]	15.6%
Stalk diameter (cm)	2.8[b]	2.9[a]	2.9[a]	0.9%
Stalk height (m)	2.66[a]	2.69[a]	2.64[a]	4.1%
Sugar concentration (%)	15.0[a]	15.0[a]	15.1[a]	2.0%
Fresh millable stalk (t/ha)	86[a]	88[a]	86[a]	11.0%
Sugar (t/ha)	13.9[a]	14.3[a]	14.1[a]	12.8%
Irrigation water productivity (t/mm)	0.137[a]	0.177[a]	0.174[a]	17.5%

Tables 1, 2 and 3 show that use of the two tested OSIRI irrigation methods, i.e. OSI-C (control, with calculations updated every 5 days) and OSI-F (calculations updated every month), led to very similar results. Monthly updating of OSIRI, as presently done by AES, can be considered suitable for optimising irrigation using this tool.

Comparison between experimental and OSIRI-calculated values. Calculated and measured drainage at DZ = 180 cm over a time course (between 60 DAR and harvest) are plotted in Figure 2 for the three treatments. The observed and calculated values were very similar, regardless of the treatment. Monthly values were also compared in order to obtain 10 periods between 60 and 360 DAR (Figure 2). NE, RMSE and MB values given in Table 4 show that the OSIRI model reasonably well simulated the real situation in the field. Note that these values are of the same magnitude as those reported for many field evaluation studies of water transfer models (Duwig et al., 2003). The linear correlation given in Figure 3 confirms the close agreement between the calculated (DT_c) and measured (DT_O) drainage values for the three treatments, and the regression line is not statistically different from the first bisector.

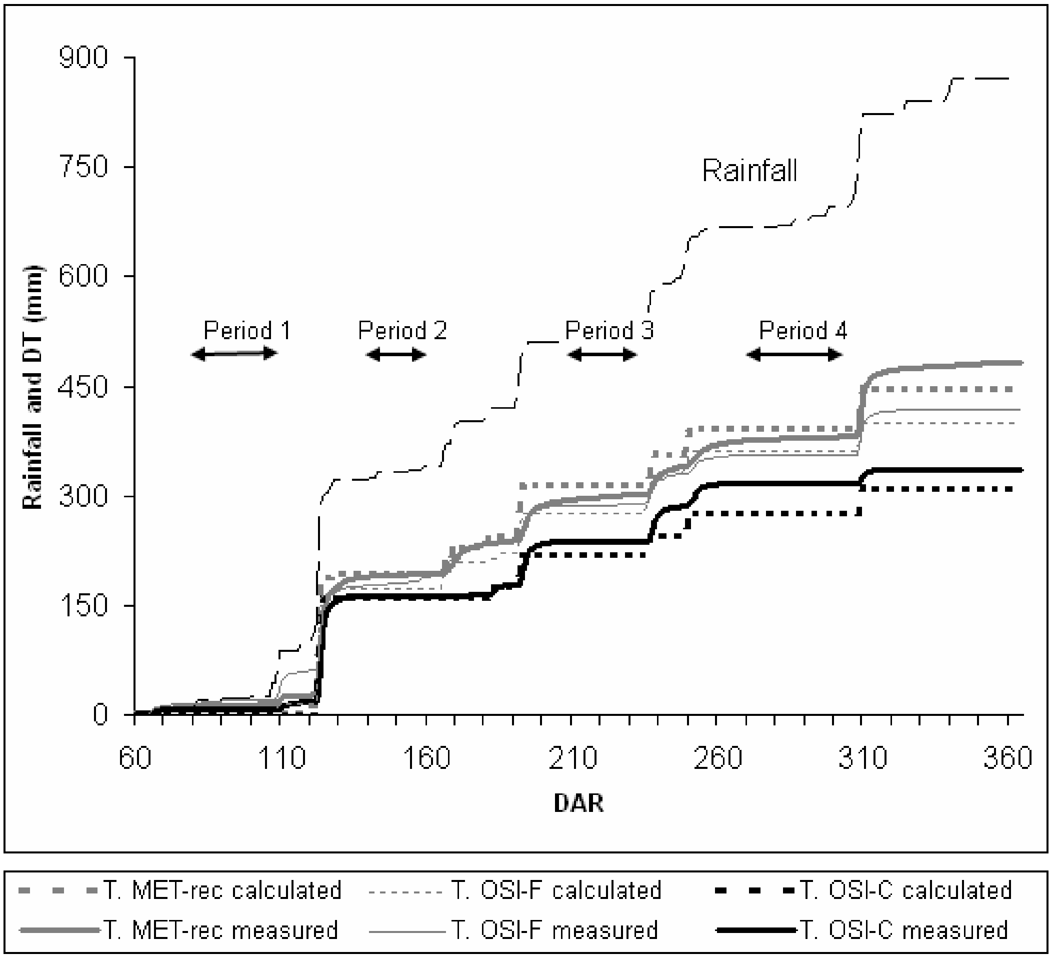

Figure 2. Comparison of cumulative drainage values (DT, mm) measured at the base of lysimeters (DZ = 180 cm) and those calculated by OSIRI for the three treatments. Cumulative rainfall is also plotted as function of DAR (days after regrowth)

Table 4. Statistical results comparing drainage measured and calculated by the OSIRI model at the base of lysimeters for the three treatments. Observations are averaged over 10 1-month periods of sugarcane growth (60-360 DAR)

	Drainage
Number of observations	30
Observed mean (mm/day)	1.37
Mean bias, MB (mm/day)	-0.02
Nash efficiency, NE (-)	0.85
Root mean square error, RMSE (%)	39

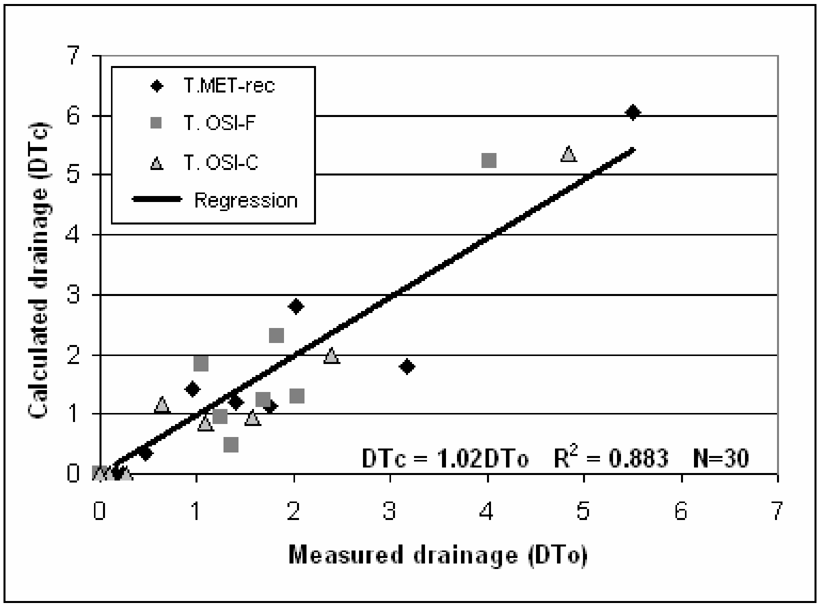

Figure 3. Comparison of calculated (DT_c) and observed (DT_o) drainage at the base of lysimeters (DZ=180 cm) for the three treatments. Mean monthly values (mm/d) between (60 DAR) and harvest (360 DAR). R^2 is the coefficient of determination and N is the number of observations

During the four periods without substantial rain, it was possible to estimate AET from simple field observations of soil water storage variations and according to rainfall and irrigation contributions. This revealed no statistical differences between treatments (Table 2). It also enabled a comparison between measured AET values and those calculated ones by the OSIRI software. Corresponding NE, RMSE and MB values calculated for 36 observations (four periods, three treatments, three repetitions) are given in Table 5. They indicate that OSIRI was also able to accurately simulate actual evapotranspiration.

Table 5. Statistical results comparing observed and OSIRI-calculated AET values in nine plots during four dry periods (see Fig. 3)

	AET
Number of observations	36
Observed mean (mm/day)	3.38
Mean bias, MB (mm/day)	- 0.16
Nash efficiency, NE (-)	0.97
Root mean square error, RMSE (%)	16

Farm survey

Temporal variations in the number of advised farmers and information on irrigation practices. In the survey area, irrigation advice is provided by the equivalent of three AES officers. Although this figure has remained unchanged since 2002, the number of advised farmers nearly doubled between 2002 and 2006 (Figure 4). OSIRI advice was first given at the beginning of the 2004 sugarcane crop season (August-September 2004). The number of farmers using OSIRI drastically increased between 2004 and 2006. Advisers present the different available irrigation advice tools but leave farmers free to choose between them. Figure 4 clearly shows that OSIRI is gradually replacing IRRICANNE (Combres and

Kamiéniarz, 1992), a former local irrigation monitoring tool, and that it has been adopted by a majority of newly advised farmers. However, some farmers still prefer MET recommendations as they are simpler than those provided by OSIRI. Introduction of the OSIRI tool in the Réunion farming community thus clearly enabled a constant number of advisers to provide recommendations to a growing number of farmers. Only six out of 25 of the surveyed farms were equipped with a rain gauge. Very few of them generally record actually applied irrigation doses, which makes it difficult to use OSIRI for optimizing irrigation.

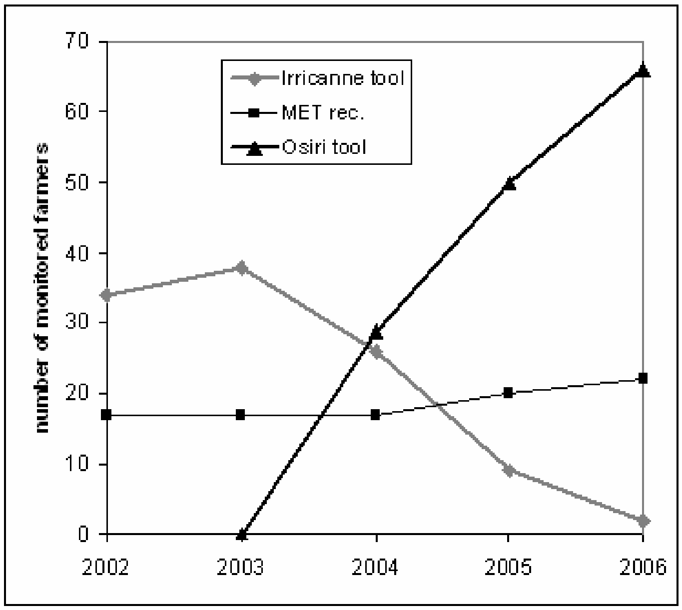

Figure 4. Temporal patterns in the number of sugarcane farmers receiving different types of irrigation advice from three Agricultural Extension Service officers

Acceptability of the OSIRI tool by farmers. A preliminary data analysis showed that there was no noticeable difference in farmers' answers when comparing those surveyed in the southern and western parts of Réunion (Figure 1a). Therefore all the 25 farmers' responses were pooled into one group. Table 6 shows that most farmers considered that: (i) doses recommended by OSIRI met their needs, (ii) OSIRI advice led to a slight reduction in irrigation water application compared with their former practices, and (iii) irrigation was slightly easier to control than before.

Table 6. Opinion of 25 surveyed users on the OSIRI tool. Overall impression (1 = very bad, 2 = bad, 3 = medium, 4 = good, 5 = very good); Recommended doses (range from 1 for too small to 5 for too high); Irrigation dose variations since the beginning of OSIRI use (1 = much more to 5 = much less); Easiness to control irrigation compared with former practices (1 = more difficult to 3 = easier)

	Overall impression about OSIRI	Accuracy of recommended doses	Consumption variation with OSIRI	Easiness to control irrigation
Average (SD)	3.9 (0.64)	2.9 (0.40)	4.1 (0.70)	2.25 (0.44)
Min and max	2 - 5	1-3	3 - 5	2-3
Medium	4	3	4	2
Average opinion	Good	Adequate doses	Drop	A bit easier

These results are very encouraging, especially since they show that the farmers were aware that water application could be decreased by using OSIRI compared with their previous practices, thus meeting one of the main objectives of the new tool—reducing precautionary irrigation without reducing crop yield.

However, the standard deviations (Table 6) obviously show a certain degree of variability in the answers. At least part of this variability (Table 7) could be ascribed to factors such as: age and training type of farmer, programming mode, and type of irrigation advice before using OSIRI. Groups of younger and more trained farmers (AI type) appeared to be slightly more convinced by the advantages of using OSIRI. However, the variability in opinions likely mainly resulted from causes other than those assessed, e.g. human factors associated with the farmer during the survey, or the interviewer. Table 7 also indicates that OSIRI was well accepted and useful for all types of farmers surveyed, irrespective of age, training type and irrigation system.

Table 7. Variability in farmer answers. Overall impression of OSIRI (1 = very bad to 5 = very good); Recommended doses (1 = too small to 5 = too large); Level of irrigation water recommended by OSIRI (1 = much more to 5 = much less); Easiness to control irrigation compared with former practices (1 = more difficult to 3 = easier). Numbers in parentheses indicate standard deviations. “I” indicates farmers with practical irrigation training without agricultural studies and “AI” indicates farmers with basic agricultural studies complemented by practical irrigation training

Explanatory variables		Number of farmers	Overall impression	Recommendation accuracy	Consumption variation	Easiness to control irrigation
Age group (years)	<40	14	4.1 (0.47)	3.0 (0.00)	4.0 (0.68)	2.21 (0.43)
	>40	11	3.7 (0.79)	2.8 (0.60)	4.2 (0.75)	2.27 (0.47)
Training type	I	12	3.8 (0.83)	2.8 (0.58)	4.1 (0.67)	2.25 (0.45)
	AI	13	4.1 (0.47)	3.0 (0.00)	4.0 (0.68)	2.21 (0.43)
Former advice	Nothing	12	3.9 (0.83)	2.8 (0.60)	4.1 (0.83)	2.27 (0.47)
	Irricanne	11	4.0 (0.43)	3.0 (0.00)	4.0 (0.60)	2.17 (0.39)
Programming	In time	10	3.9 (0.32)	3.0 (0.00)	3.8 (0.63)	1.80 (0.42)
	In volume	14	3.9 (0.83)	2.9 (0.53)	4.3 (0.73)	1.79 (0.43)

Impact of the OSIRI management tool on sugarcane yields. Millable sugarcane yields of five farms selected among the 25 surveyed farms were measured each year for 6 successive years. They are located in the same southern area of Réunion with a maximum distance of 1 km between them to offset climatic variability. During the first 2 years (2001-2002), irrigation was applied without any advice and the equipment was old (removable sprinklers). In 2003, farmers bought new equipment (fixed sprinklers and programming irrigation autotimers), but they did not follow any irrigation advice in 2003 and 2004. Since 2005, these five farmers have been using the OSIRI decision-making tool. Consequently, the whole period (2001-2006) can be separated into three classes of irrigation practices (equipment and advice).

Table 8. Millable yield measured on five farms between 2001 and 2006 for different equipment, climate conditions and irrigation advice. Solar radiation and temperature are daily mean values during the sugarcane growing season. Maximum evapotranspiration (MET) and rainfall are cumulative values. Numbers followed by the same letter (a, b) are not significantly different (P>0.05)

	2001-2002	2003-2004	2005-2006
Equipment, sprinklers	Removable	Fixed	Fixed
Advice	without	without	OSIRI
Solar radiation (J/cm²/d)	1776	1757	1791
Mean temperature (°C)	21.8	21.9	22.0
MET (mm)	1131	1087	1110
Rainfall (mm)	1169	892	864
Millable yield (T/ha)	97.8[a]	112.9[ab]	124.4[b]

Table 8 shows an interesting trend in millable yields from the first to the third period, which cannot be explained by temperature, solar radiation and MET values as they were quite stable. Annual rainfall obviously varied between periods, but irrigation is supposed to supply enough water each year to maintain the sugarcane at optimal evapotranspiration. There was a positive effect (+15%) of the new irrigation equipment acquired in 2003. Although not spectacular or highly significant, a positive effect (+10%) of using OSIRI as a decision-making tool for monitoring irrigation should also be noted. However, the main purpose of OSIRI is not to increase yield but mainly to reduce irrigation delivery, without any yield reduction. It is worth mentioning that these on-farm survey results confirmed those obtained in the detailed field experiment. For the five studied farms, the combined use of new equipment and the OSIRI advice tool led to a significant 27% increase in millable yield.

CONCLUSION

This study was carried out to evaluate the performance of OSIRI, a new decision-making tool for monitoring irrigation. Detailed field measurements in different sprinkler irrigation treatments highlighted that OSIRI recommended lower irrigation applications than the currently used tool, thus reducing drainage loss below the sugarcane root zone without affecting yield. Satisfactory agreement between the measured and OSIRI-calculated actual evapotranspiration and drainage values was obtained. Good concordance was confirmed both for relatively dry conditions (the main reason for developing and using this irrigation tool) and wet conditions leading to high drainage. OSIRI is thus suitable for predicting drainage loss and studying environmental impacts of irrigation, for example. In the studied conditions, updating OSIRI monthly seems enough to optimise irrigation doses, while updating every water roster (5 days) did not improve this parameter or yield. Tests are nevertheless under way to estimate the effects of lowering updating frequencies (3 or 6 months).

Since OSIRI is beginning to be used by farmers, an on-farm survey was conducted with 25 of them in order to test its acceptability and usefulness. Analysis of the results revealed that OSIRI is well accepted by farmers who consider it to be a valuable decision-making tool. Farmers realize that OSIRI can lower irrigation water volumes without reducing sugarcane production. Most of them felt that OSIRI allowed irrigation water savings as compared to the currently used method, without any yield decrease, as clearly shown by the results of the experimental test conducted under controlled conditions.

While there is a sharply increasing demand for the use of this tool in Réunion, its dissemination will clearly be dependent on the capacity of the Agricultural Extension Service to train farmers and on their ability to use the tool thereafter. For proper use of OSIRI (as for most of irrigation advice tools), it is essential to measure local rainfall. In Réunion, only a few farmers are currently equipped with rain gauges. More, rain gauges (even low tech guages) are thus required and farmers should be trained on their use.

OSIRI was developed for sugarcane farmers in Réunion, but it is likely also applicable in other social and physical environments. Studies in different setting are thus essential and would certainly contribute to improving this software tool.

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