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Chapter

Agronomic Operation and Maintenance of Field Irrigation Systems

Luis A. Gurovich and Luis Fernando Riveros

Abstract

Worldwide experience indicates that projected economic returns on investments in field irrigation systems are seldom obtained by farmers, due to improper strategies on irrigation scheduling, lack of operational control, and limited feedback on the actual performance of irrigation systems, in terms of application efficiency and uniformity. An approach to dynamic integration of soil hydrodynamic characteristics, potential evapotranspiration, and crop leaf area index evolution throughout the irrigation season is detailed, oriented to integrate smart water management strategies and techniques in the operation and maintenance of farm irrigation systems. This dynamic integrative platform has been used in Perú and México by actual farming companies producing table grapes, wine grapes, avocado, and bell peppers exported to international markets; this chapter documents its practical results in terms of water and energy savings, crop yield, and fruit quality.

Keywords: English, agronomy, smart irrigation management, real-time irrigation scheduling, dynamic crop ET coefficient, soil/water monitoring, farmers' attitudes, irrigation infrastructure modernization, irrigation investments and return optimization

1. Introduction

Achieving an efficient use of natural resources and other production factors is a common goal of many of the current policies aimed at the sustainability of human activity; irrigation of agricultural crops uses about 80% of the total freshwater available for all human activities; thus, improving irrigation efficiency is a main endeavor to provide sustainability to this vital resource availability [1, 2].

Worldwide experience indicates that projected economic returns on investments in field irrigation systems are seldom fully obtained by farmers, due to improper strategies on irrigation scheduling, lack of operational control, and limited feedback on the actual performance of irrigation systems, in terms of application efficiency and uniformity. Field irrigation system projects are generally properly designed and installed, considering soil, climate and crop characteristics, with theoretical high water application and distribution efficiencies. However, in most projects, its actual operation and maintenance strategies do not accurately include these characteristics, resulting in excessive water depths applied, generally well over actual crop water needs, unnecessary energy costs, as well as constraints on reaching potential crop yields and marketable fruit quality. Also, irrigation systems' cumulative

deterioration conditions after its installation in the field, due to lack of proper maintenance and timely spare parts replacement, result in a significant reduction of the cost effectiveness of farm investments in irrigation infrastructure [3].

Lack of operational control, limited feedback on the actual performance of irrigation systems, in terms of application efficiency and uniformity, limited use of agrometeorological and crop development data to assess crop water needs, and scant follow-up of soil water content dynamics as an indicator of the fit between actual water applied and actual water evapotranspirated by the crop, as well as limitations on human resources knowledge and training, are the major issues explaining the situation described above.

Irrigation scheduling is related to the farmers' decision process concerning "'when" to irrigate and "how much" water to apply, in order to maximize agriculture production profit. Knowledge on crop water requirements and yield responses to water, as well as specific irrigation equipment constraints, limitations relative to the water supply system, and financial and economic implications of irrigation practice, must be integrated in any rational strategy to optimize pressurized irrigation systems use [4–7].

When appropriate water application techniques (i.e., irrigation system physical characteristics) are correctly coupled with irrigation scheduling (i.e., the volume and timeliness of water applications), as well as the implementation of irrigation system proper maintenance strategies, it is possible to optimize available water for irrigation, achieve potential crop yield/quality, and reduce irrigation costs. Investing resources in an up-to-date technological, sophisticated irrigation system is not by itself enough to attain high levels of performance, if its operation and maintenance are not updated accordingly [8].

Research has made available many tools, including procedures to compute crop water requirements, simulate soil water balance, estimate the impact of water deficits on yield and evaluating the economic returns of irrigation; however, irrigation scheduling and comprehensive irrigation equipment maintenance protocols are not yet utilized by the majority of farmers. Furthermore, only limited irrigation scheduling information is utilized worldwide by irrigation system managers, extensionists, or farmer advisers. It is recognized, however, that the adoption of appropriate irrigation scheduling practices generally leads to increased yield and profit improvements for farmers, significant water and energy savings, reduced environmental impact of irrigation, and long-term sustainability of irrigated agriculture [9–13].

Integration of soil hydrodynamic characteristics, potential evapotranspiration, and crop leaf area index evolution throughout the irrigation season, with actual irrigation operation data, and soil water content periodic measurements, is needed to implement smart water management strategies, aimed to optimize the economic return of investments in irrigation equipment at the farm level, as well as to reduce its operational costs and ensure continuous optimal soil water availability conditions to crops [14].

Pressurized irrigation application equipment (drip, microjet, or microsprinkler) is a high precision machine, which allows the producer to obtain the highest productivity of their agricultural crops, and at the same time, achieve specific quality characteristics, in accordance to market demands. Like any high precision machine, its design, installation, operation, and optimal maintenance are absolutely essential to achieve the objectives of high production and high quality of any viticulture, fruit, or horticultural plantation. If the design, installation, operation and/or maintenance of the systems are not optimal, generally, its negative effects on crop production and quality are more detrimental than the incorrect use of surface irrigation, because root crop soil volume wetted by each emitter (dripper, microjet, or microsprinkler) is restricted, being essential to maintain in this restricted soil volume-specific water and nutrients, salinity, acidity (pH), and oxygen availability conditions, continuously throughout the production season [15].

This chapter reports the main components and actual use of an interactive, dynamic, and relational database management system (RDBMS), an irrigation scheduling platform, using structured query language (SQL) for querying, maintaining, and updating the database [16]. The platform is designed to implement smart water management strategies and techniques in the operation and maintenance of farm irrigation systems in actual plantations, fruit orchards, and vineyards irrigated by drip or microsprinkler systems [6, 11, 17, 18]. The platform allows graphic representation of relevant data and processed results, automatically updating all the information required in any time span and/or in any irrigation sector combination, using interactive, easily understandable dashboards. Specific considerations for field irrigation system maintenance are also discussed in this chapter, with an analysis on the constraints for the platform adoption by farming personnel, farm decision-making stakeholders, and farm advisors.

2. Irrigation scheduling interactive platform

The interactive platform developed integrates soil hydrodynamic characteristics relevant to irrigation scheduling, with crop water requirements, based on atmospheric evaporative demand and the evolution of crop leaf area index throughout the irrigation season, as well as with the irrigation system daily effective operation, in terms of actual water depths (expressed in mm or m^3/hectare, being 1 mm = 10 m^3/hectare) applied to each irrigated sector. Independently, information on the evolution of soil water content is also integrated, allowing next 5 days' irrigation schedules to be automatically modified, aiming to maintain continuous soil water availability conditions to the crop, if the soil profile water content trend is increasing or decreasing with respect to a specific target range [6, 9, 11, 18–20].

2.1 Soil hydrodynamic properties relevant to irrigation scheduling

The platform calculates the soil volume effectively providing water to crop roots, considering soil stratification depths and textures, and the integrated water volume stored at field capacity, calculated using the "Soil Water Characteristics Hydraulic Properties Calculator" [21], assuming that water distribution in the soil below each irrigation emitter forms an ellipsoid, with specific a, b, and c radii measured in soil observation trenches at the onset of the irrigation season [22, 23] (**Figure 1**). We have repeated soil water distribution field observations on a bimonthly basis, and for most soils, a, b, and c values remain fairly constant throughout the irrigation season.

Management of the allowed soil water depletion (MAD) by ETc [8, 9], defined as the percentage of soil water stored at field capacity in the effective soil water volume, is the threshold to initiate the next irrigation event; it considers soil root crop distribution and its water extraction pattern, rootstock relative drought resistance, as well as soil major texture class, crop value, and water costs; this threshold can also be modified according to specific crop phenology stages [19, 20].

The platform is programmed to schedule irrigation based on the "*variable frequency—variable water depth*" approach [4, 6, 7, 9, 13]; however, a maximal irrigation time value for each irrigation cycle is defined for each soil dominant structure, to avoid water percolation in lighter soils and to avoid surface water ponding or partial soil saturation in heavier soils. Thus, during high atmospheric evaporative demand periods, irrigation water depth equivalent to daily ETc in sandy soils determines the need of several watering events or cycles throughout the day, and in clay soils, irrigation is applied in 2–3 days cycle intervals, to replace the total water depth corresponding to Σ (daily ETc since the last irrigation event).

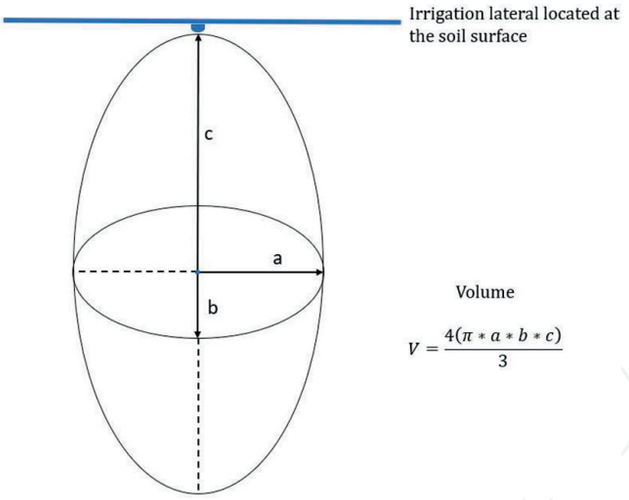


Figure 1.
Ellipsoid representing soil water distribution below a dripper.

2.2 Crop evapotranspiration (ETc) assessment

The platform makes use of the modified FAO Penman-Monteith model [8, 9, 10, 13, 19, 24, 25] to define actual daily crop water use, as the product of site-specific atmospheric evaporative demand maximum value, assuming: (1) unlimited moisture availability and ambient atmospheric conditions, or potential evapotranspiration (ETp) [26] and (2) actual crop leaf area index, expressed as a crop coefficient function (Kc) [27–29].

2.2.1 Potential ET (ETp)

Daily potential ETp data are widely provided by government or private meteorological weather station services in significantly large irrigated areas around the world [8, 14]; additionally, the use of automatic weather stations at the farm is growing rapidly in many countries, because it represents a marginal additional investment in the context of pressurized irrigation systems. Weather stations world nets, like Climwat provided by FAO [30], or regional nets are useful sources of ETp major components' information (air temperature and humidity, solar radiation, and wind direction and intensity). Routine use of ETp data by farmers for irrigation scheduling purposes has not being widely adopted; extensive farm extension work on the subject is urgently needed, especially in areas with restricted water resources.

The representativeness of a single weather station to provide accurate ETp data is highly dependent on topography, crop surrounding areas cultivation pattern, due to albedo effects, as well as on microatmospheric specific conditions. Installation of at least one weather station every 100 hectares is highly recommended; moreover, daily ETp differences in relatively close spots within the irrigated field are highly correlated to one or two climatic parameters (i.e., maximal day temperature, or solar radiation), thus the use of single sensors adequately located, instead of complete weather stations, can be used accordingly [10, 12, 19].

Accurate ETp assessment using weather stations requires keeping adequate maintenance protocols, regarding sensor periodic cleaning and at least a yearly calibration [31]; the extended amount of data provided daily by a specific weather station must be addressed using big data analysis tools and models [16, 20], coupling it with actual data on the irrigation system operation, as well with soil water dynamics in the wetted soil volume, to fully achieve its potential aimed to provide continuous optimal conditions of soil water availability, coupled with water and energy savings.

Incorporating online, real-time weather sensors, with irrigation system sensors data (pressure and discharge, water pH and salinity) and soil water content data, is a useful example of the Internet of Things applied into farming decision-making processes; its rapid adoption by large number of farmers within a specific agriculture area could account for a positive and sound impact in smart water management [5, 11, 19, 20].

2.2.2 Crop ET coefficients [Kc = f (crop phenology)]

Actual water evapotranspirated by a crop (ETc) is not only determined by ETp; an estimation of transpiration canopy is also needed. This estimation corresponds to the concept of leaf area index (IAF; m^2 of transpiring leaves/m^2 of cultivated land) [23, 28, 32]; for irrigation scheduling purposes, this concept is generally expressed as the "crop coefficient" (Kc) [27, 29, 33–35] which in fact is a time function, since IAF varies from bare soils at the end of winter ($Kc_{initial}$ = 0.1–0.15), representing direct soil surface evaporation, up to Kc_{max} = 0.8–1.2), when the maximal IAF is attained. The Kc = (t) function can be represented by a double sigmoid curve (**Figure 2**) for the initial three crop phenology stages (budbreak, flowering, and veraison) [36, 37]; a constant maximal value from veraison to harvest, and a linear decline for the postharvest irrigation stage, reaching a $Kc_{final} = Kc_{initial}$ [37]. The maximal Kc_{max} value has been widely reported for most irrigated crops [27]; at flowering [$Kc_{flower} = (Kc_{max}/Kc_{initial})/2$] [26, 38].

For irrigation scheduling, the Kc daily value is obtained from **Figure 2** or from an equivalent table; the main concern is related to the onset data for each phenology stage, which seldom can be predicted accurately from crop models and needs periodic field observations throughout the irrigation season. Modifying these dates on the platform is a very simple procedure and the Kc = *f* (t) function is easily recalculated. Different crops and/or different cultivation locations for the same crop can have quite different Kc curve (**Figure 2**) shapes, due to the relative onset date and duration of each phenology stage, but essentially, this schematic representation can be adapted to these differences.

2.3 Automatic Kc value adjustments, based on soil water content data

Data on the evolution of soil water content at specific depths and distances from the irrigation lateral enable the platform to automatically adjust Kc values for the next 5 days, with the aim to increment or reduce recommendations for next irrigation dates and water depths to be applied, in order to keep a constant soil water

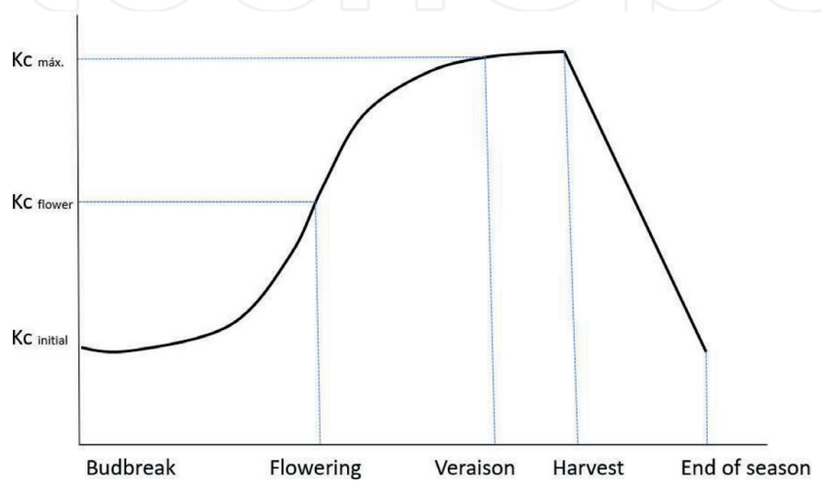


Figure 2.
The Kc = f (phenology stage) function.

availability condition; these data are obtained by using soil water content probes, providing either real-time or periodic measurements with portable soil probes. This platform feature is an independent checking for the balance between calculated ETc and actual depth water applied, enabling to automatically correct eventual errors in the calculated ETc. If the calculated ETc value is lower than the actual ETc, platform recommendations will determine underirrigation and a gradual reduction in the soil water content, while if calculated ETc > actual ETc, overirrigation will determine a gradual increment in the soil water content. Soil water content increments or reductions over 5% between consecutive measurements trigger automatic modifications on Kc values for the next 5 days and thus, the process is self-adjusted. All Kc adjustments are kept in an historical file, to be used as platform input data for the following irrigation seasons (see Section 2.2.2) [35].

Adjustment of Kc daily values related to soil water dynamics, as affected by the balance between calculated ETc and actual irrigation water depth applied, represents an automatic fine-tune procedure on irrigation scheduling, aimed to keep a constant crop water availability condition, simultaneously considering atmospheric evaporative demand, crop IAF evolution, and actual irrigation timing and water depth applied; this adjustment is seldom found in most irrigation scheduling models available in the market. We have assumed that ETp data retrieved from weather stations and actual irrigation water application are trustworthy, since modern irrigation equipment provides automatic digital operation registering options (date, time, water volume applied on each field irrigated section), including data transmission by radio frequency or through the Internet, thus reducing human intervention on data handling.

3. Irrigation system maintenance, improvements, and spare parts replacement

Routine irrigation equipment maintenance protocols are needed for sustainable achievement of the potential economic return of investments, by ensuring the timely, complete, uniform, and efficient water supply to the crop. In most field systems, regardless its size or irrigated crop value, maintenance protocols are seldom implemented in full, and generally are only addressed when major system failures are detected, affecting crop yield and fruit quality, due to water supply interruptions during the repairing time span [39]. Maintenance is an important, though often overlooked, operation to extend not only the trouble-free life of the system itself but to maximize returns on investment. Preventative rather than corrective maintenance is more economical and less traumatic. The implementation of a maintenance program for drip irrigation systems will keep the system operating at peak performance and increase the system's work life expectancy. The best way to determine if the maintenance program implemented is effective is to constantly monitor and record the flow rate and pressures in the system [3].

3.1 Winter maintenance protocol

It is one of the most important maintenance activities, to be performed during the postharvest winter period; if the total winter rainfall is below the average value of the area, it is necessary to operate the irrigation system at the beginning of spring, before crop budbreak (permanent orchards) or emergence (annual crops), when the spring root activity is initiated, in order to start the irrigation season with a soil water depth equivalent to its field capacity.

Pumps, filters, and valves are dismantled in the control room, as well as the entire electrical installation, including power boards, irrigation programming

boards, filter back-washing boards, and all the fertilizer preparation and injection systems. In the field, mains, submains, manifolds, and irrigation laterals are washed to evacuate any sediment that may have precipitated and the emitters are revised to change those that are in poor condition. In persistent fruit orchards species, it may be necessary to continue watering in the winter, so this maintenance operation is performed after a significant rain.

The goal of the winter maintenance is to ensure that at the start of the new irrigation season, all equipment components are in optimal operative condition. The cost of this winter maintenance operation, including the cost of some spare parts that need to be replaced, plus the replacement cost of filtering media (quartz sand, meshes, and filter disks), generally represents 2–3% of the original irrigation equipment investment. Once the irrigation equipment has been reassembled after this winter maintenance, it is necessary to calibrate its operation, in terms of the emitters' discharge uniformity, operating pressures across the whole hydraulic network, and elimination of water leaks [40].

3.2 Irrigation equipment routine operation maintenance

Throughout the irrigation season, implementing a daily maintenance protocol for the irrigation equipment components is required, basically consisting of the analysis of the registered operation information provided by volume totalizers, flow measurements, and operation times for each irrigated sector, for early detection of eventual anomalies in its operation.

The goal is to always keep within a range of variation that does not exceed 5% of the pressure and discharge values established in the original design of the equipment. If any of these two parameters deviate above or below this range, at any point of the irrigation network, it is necessary to find the failure point or section and repair it immediately, to maintain the correct supply of water to the crop.

The most frequent problems to find during the irrigation season are partial emitter clogging, irrigation hydraulic valve elasticity reductions, leading to incomplete opening or closing, breakages and leaks in the water distribution pipes, filters' inadequate cleaning, malfunctioning of electrically operated pilot valves, pump efficiency reductions, and mechanical damage of laterals due to field operations (labor, animal, or machinery) or rodent damage.

3.3 Periodic maintenance

At least once every 2 weeks, the following maintenance procedure is mandatory:

1. Flush all the laterals by opening end plug 1–5 in a series; then close them 1–5 in the same sequence allowing flushing for 3 min until clean water starts flowing.

2. Flush each submain at the end of every section (shift) till dirt-free clear water starts flowing.

3. Check inlet and outlet filter pressures. Remove slurry from sand filtration media with back flush at every 5 h; flush screen/disc filter.

4. Take out the element of screen/disc filter and clean it thoroughly. Open the lid of sand (media) filter, allow the water to come out through it, for thoroughly separating accumulated foreign material with media (sand) for recharging its filtering capacity.

In most situations, irrigation equipment malfunctions develop dynamically, leading to increasing expenditures for its solutions; thus, early detection of operational issues not only prevents negative impacts on crop yield and quality, but also in repairing costs. Comparing data on emitter discharge, end of lateral pressure, pressure at main valves, and water flow after filters, registered at least weekly, has proven to be an excellent method for early detection of irrigation equipment deficiencies.

Many irrigation systems are provided with operational registering options; however, the systematic analysis of this information is seldom included in the routine activities of field decision-making personnel. Available technologies enable the use of automatic cellphone alarms, triggered when the system operation deviates from specific preset discharge or pressure parameters. Data on actual irrigation system performance are seldom considered as a valuable crop production input; thus, a major educational effort is due to fully make use of these system capabilities, at a very low cost and in just a few training hours.

4. Experiences

We have selected data from just one field using our irrigation scheduling platform as an example, to fully present its many applications. The authors have implemented irrigation scheduling professional consulting since 1982 in more than 150 horticultural plantations in Chile, Mexico, Peru, and Argentina, on a cultivated area estimated at 5500 hectares. Concepts, parameters, coefficients, and computer programs, developed and published extensively in scientific and professional journals and presented at countless congresses, courses, and workshops, today serve as the basis for the correct use of irrigation systems in horticultural plantations, carried out also by many other professionals and technicians in different countries; selected irrigation scheduling publications by the senior author are available on Internet [41].

PLOT

Cultivar	C. sauvignon	Merlot	Syrah	Sauvignon blanc	Chardonay	C. sauvignon
Weather station	1	2	3	4	5	6
Area (has)	9.35	6.68	11.24	10.26	14.23	9.45
Soil type	1	2	3	3	1	2
% Sand	60.20	26.8	18.5	18.5	60.2	26.8
% Loam	34.40	49.2	41.3	41.3	34.40	49.2
% Clay	5.40	24.1	40.2	40.2	5.40	24.1
Field Capacity (Vol. %)	19.84	29.77	38.21	38.21	19.84	29.77
Irrigation sistem number	1	1	1	2	2	2
Dripper flow (L/Hr)	1.2	2.0	2.0	2.0	1.2	2.0
Laterals/Line	2	1	1	1	2	1
Drippers/Ha	14815	4000	4000	4000	14815	4000
Discharge (m3/Hr)	17.78	8.00	8.00	8.00	17.78	8.00
Phenology:						
Budbreak	18-09-2018	14-09-2018	31-08-2018	15-08-2018	18-08-2018	18-09-2018
Flowering	14-10-2018	08-10-2018	04-10-2018	30-09-2018	27-09-2018	18-10-2018
Midseason	04-11-2018	31-10-2018	29-10-2018	14-10-2018	08-10-2018	06-11-2018
Veraison	08-01-2019	29-12-2018	26-12-2018	26-12-2018	18-12-2018	08-01-2019
Maturity	03-03-2019	06-03-2019	10-03-2019	31-01-2019	18-02-2019	10-03-2019
Last Irrigation	19-04-2019	14-04-2019	14-04-2019	14-04-2019	20-04-2019	21-04-2019
Kc:						
Kc min	0.15	0.16	0.17	0.18	0.19	0.20
Kc max	0.71	0.69	0.65	0.75	0.70	0.71
Kc end of harvest	0.60	0.58	0.60	0.70	0.68	0.60
Kc end of season	0.10	0.10	0.11	0.12	0.13	0.14
MAD* (%)	5.0	10.0	15.0	15.0	5.0	10.0

Table 1.
Vineyard data relevant for irrigation scheduling.

Data for a 61.31-hectare vineyard, with two independent drip irrigation systems, three sectors each, planted in three different soils, with five different cultivars and two climate evaporative demand conditions are presented (**Table 1**).

Figures 3 and **4** present data on irrigation for Cabernet sauvignon for plots 1 and 6 (different evaporative demand conditions, due to site topographic positions within the vineyard, as well as different soil hydrodynamic characteristics), for a time frame from November 15 to December 31, 2018; the platform enables the user to select data for any plot or plot combination, for any time span, from 1 day to the whole irrigation season. Daily comparisons between calculated ETp (red columns) and actual water depth applied (blue columns) are provided in graphic format, indicating a correct operation of the irrigation system throughout both dates, with the exception of December 25th, when no irrigation was performed, followed by two intensive irrigation days, to recover the difference. Water depths applied during the specified time span are also provided, comparing calculated ETp and water depth applied. This information is a helpful tool to decision-making for water recovery or withhold, aimed to keep a constant soil water content in the root zone.



Figure 3.
Irrigation scheduling for two Cabernet sauvignon plots, November 15–December 31, 2018.



Figure 4.
Irrigation scheduling for Chardonnay and Merlot plots, November 15–December 31, 2018.

A 15.1% difference on ETp between plots 1 and 6 accounts for climatic evaporative water differences between both plots. Three years before the implementation of the irrigation scheduling platform at this vineyard, both plots were irrigated with identical water depths and timings; as a result, significant differences in grape yield, average berry size, and wine organoleptic characteristics were obtained. These differences are almost nil for the last two vintages. Also, annual water and energy savings, due to the adoption of irrigation scheduling, account for 34.7%.

Similar data for plots 2 and 5 (cultivars Merlot and Chardonnay, respectively) are presented in **Figure 4**. Irrigation scheduling procedures follow a consistent concordance for daily calculated ET and actual water depth applied.

Between these dates, differences in water depth applied, as compared to calculated ETp, are 3.79% for Merlot and 0.21% for Chardonnay; however, the difference between both cultivars accounts for 340 m^3/hectare. Considering the whole season (data not shown), the calculated ETp difference between both cultivars is 1.216 m^3/hectare, equivalent to 19.7%, due to differences in the onset

of each phenology dates, which significantly modify its respective Kc = f(t) functions. An irrigation scheduling strategy adequate for Merlot, applied into Chardonnay, will result in overirrigation, excessive canopy vigor, and poor wine organoleptic characteristics, as well as unnecessary water end energy costs in this last plot.

At the same vineyard, a different situation regarding irrigation scheduling was detected; **Figure 5** presents data for plots 3 and 4 (cultivars Syrah and Sauvignon blanc, respectively). Irrigation scheduling between December 1, 2018 and January 18, 2019 consisted on a daily 8 h unique irrigation event, regardless of actual ETp, with no irrigation taking place in December 25.

For the Syrah plot, on the average between these dates, no differences between calculated ETp and actually applied water depth are detected, but if each day is considered separately, overirrigation took place during 20 days, and during 19 days, the plot was underirrigated. This time span includes the berry veraison



Figure 5.
Irrigation scheduling for Syrah and Sauvignon blanc plots, December 1, 2018–January 18, 2019.

to maturity stage; this irrigation strategy produced 14.6% larger than targeted average berry size (data not shown) and possibly, with expected negative effects on wine organoleptic indicators. In the Sauvignon blanc plot, overirrigation took place throughout these dates, except for December 25 and 26; for this cultivar, the phenology stage corresponds to berry final maturity, which was delayed by 10 days (harvesting date was January 31'); also, 18–20% of the berries cracked due to excessive irrigation and *Botrytis cinerea* affected a significant number of grape clusters.

5. Constraints in the adoption of smart water management tools and strategies into farming operations

There is a generalized feeling among farmers and field extensionists in relation to irrigation, who almost unanimously and systematically consider today that this agronomic practice is the major limiting factor in crop productivity in most farms. Efforts done to effectively improve water productivity are affected by two main constraints in the adoption of smart water management applications in field-pressurized irrigation systems:

1. The relatively low cost of water/energy, in relation to other production inputs, which determine a negative stimulus to actively implement irrigation scheduling and equipment maintenance, and

2. Inadequate knowledge on the actual relation between crop yield/quality and the correct water supply strategy, in terms of the effective water depth applied on each irrigation event, the importance of correct water application timing and the impact of uneven water distribution over the irrigated field, due to improper equipment maintenance.

The first constraint is being painfully addressed as a result of decreasing irrigation water availability, due to climatic global change, but the second constraint requires an urgent upgrade in irrigation decision-makers' knowledge and professional abilities, at the farm level. Highly motivated extensionists, with specific quantitative goals to address these constraints are needed in most agricultural areas, in the scope of well-financed collective policy schemes, to obtain the highest economic return for each water drip available. Efforts to provide short-term, accredited, and practical courses on irrigation system performance and maintenance at the farm level to operators and agronomists are urgently needed in most agricultural irrigated areas.

6. Conclusions

Integration of irrigation scheduling and irrigation system maintenance concepts and techniques is a most needed technology to be adopted by agricultural stakeholders, providing data and orientations to optimize the benefits of irrigation investments, influencing both crop yield and quality, as well as by significant reductions in water, energy, and repairing costs. Professional specialized advice on the operation of the irrigation equipment, including daily irrigation scheduling, irrigation equipment maintenance and training, and control of irrigation system and field personnel operational performance throughout the season is highly recommended.

Implementation costs of continuous irrigation scheduling services and system maintenance protocol analysis, including field personnel training, are almost irrelevant (in the range of U$ 20–U$ 90/hectare-year), in the scope of crop annual production costs. Moreover, incorporation of new Internet of Things applications for sensor collection of field data and its real-time analysis with increasingly powerful graphic software, using big data analysis tools, indicates that further cost reductions and increasing applications of irrigation scheduling to farming can be expected.

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