Controladores de riego automáticos en cobertura total de aspersión: oportunidades y limitaciones

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Research Group "Irrigation, Agronomy and the Environment"

References and download links

- Zapata, N., Salvador, R., Cavero, J., Lecina, S., López, C., Mantero, I., Anadón, R. and Playán, E. 2013. Field test of an automatic controller for solid-set sprinkler irrigation. Irrig. Sci. 31(5): 1237-1249.

- Playán, E., Salvador, R., López, C., Lecina, S., Dechmi, F. and Zapata. N. 2014. Solid-set sprinkler irrigation controllers driven by simulation models: opportunities and bottlenecks. ASCE Journal of Irrigation and Drainage Engineering, 140(1) January 2014: 04013001.

Syllabus

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1 Introduction

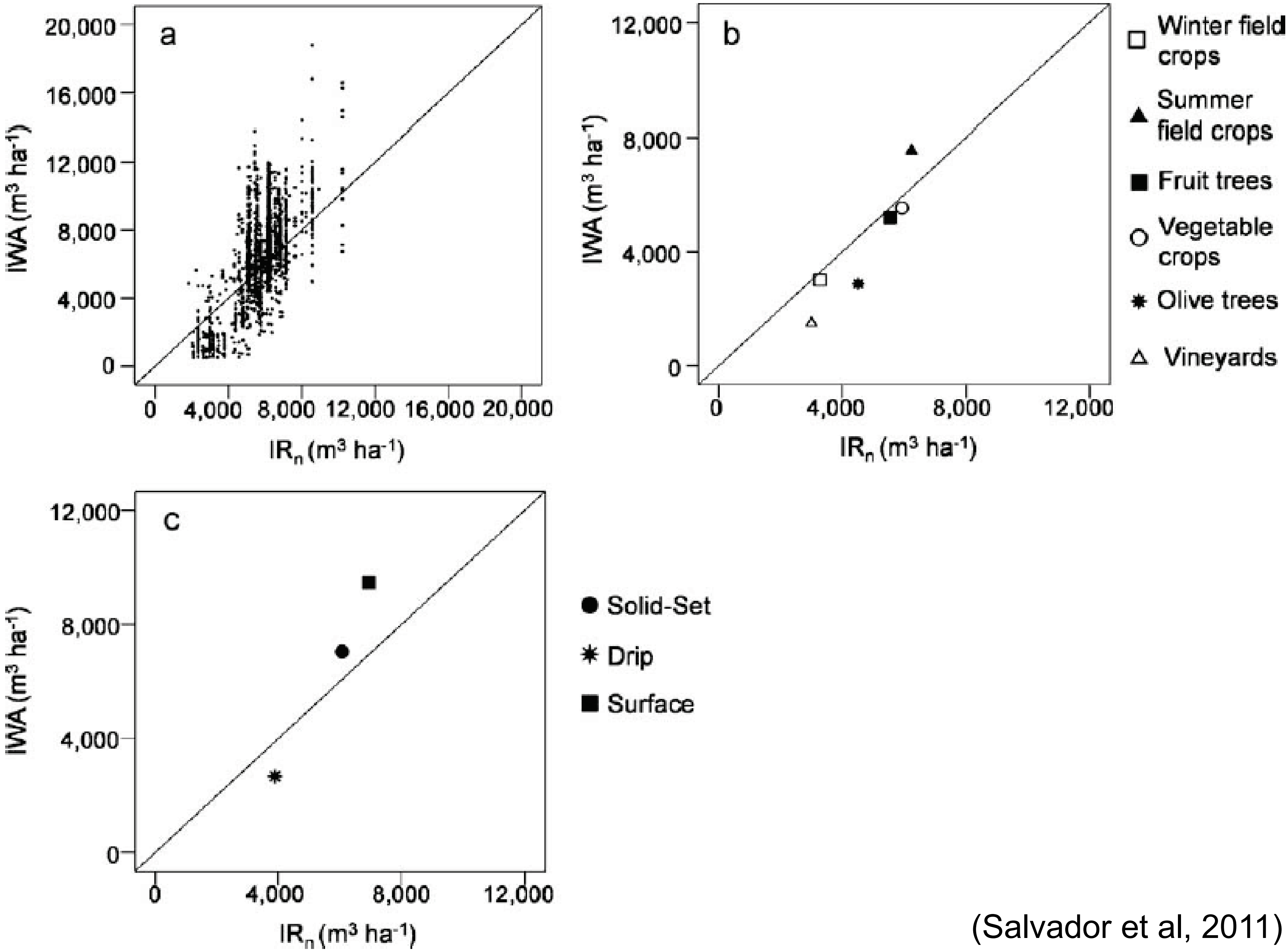
Where we stand today in terms of irrigation automation

Individual sprinkler systems

- Programming irrigation application
- Unattended execution
- Weekly update (about)
- Irrigation execution is generally insensitive to the environment and network status
- Farmers integrate information of different types
- A number of digital information sources are now available

Collective systems: increased complexity

- Water demand and supply must be perfectly matched to avoid operational spills
- Farmers often need to file water orders at their Water Users Associations (WUA)
- Water orders need to be allocated and executed for optimum…
  - Water productivity
  - Energy costs



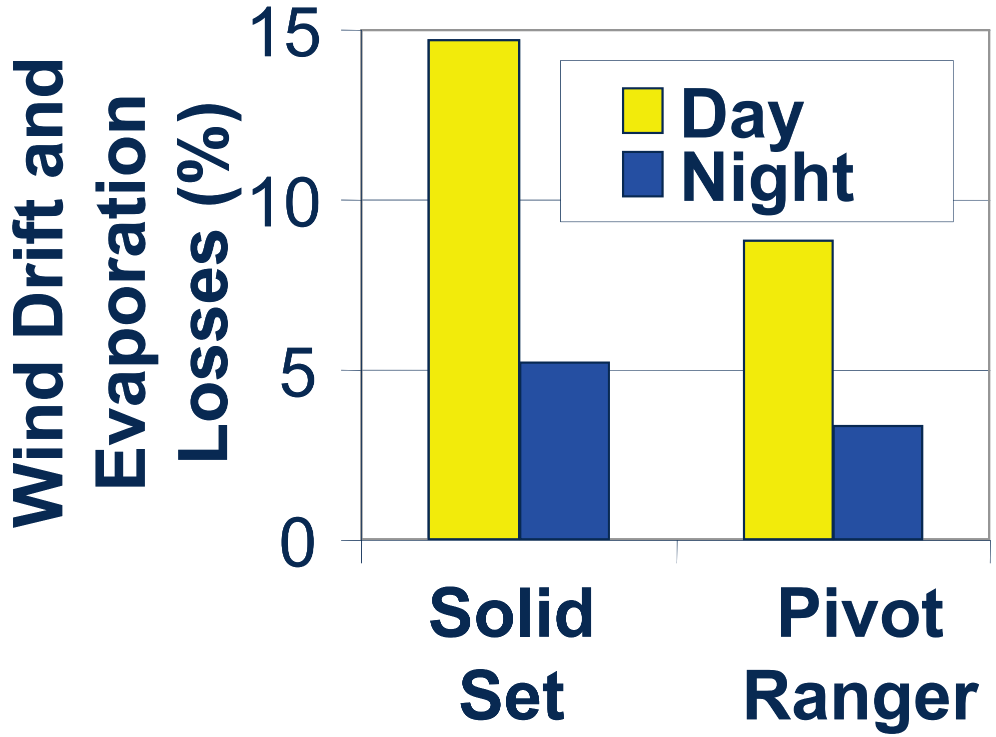
(Salvador et al, 2011)

2 Sprinkler irrigation: a risky business

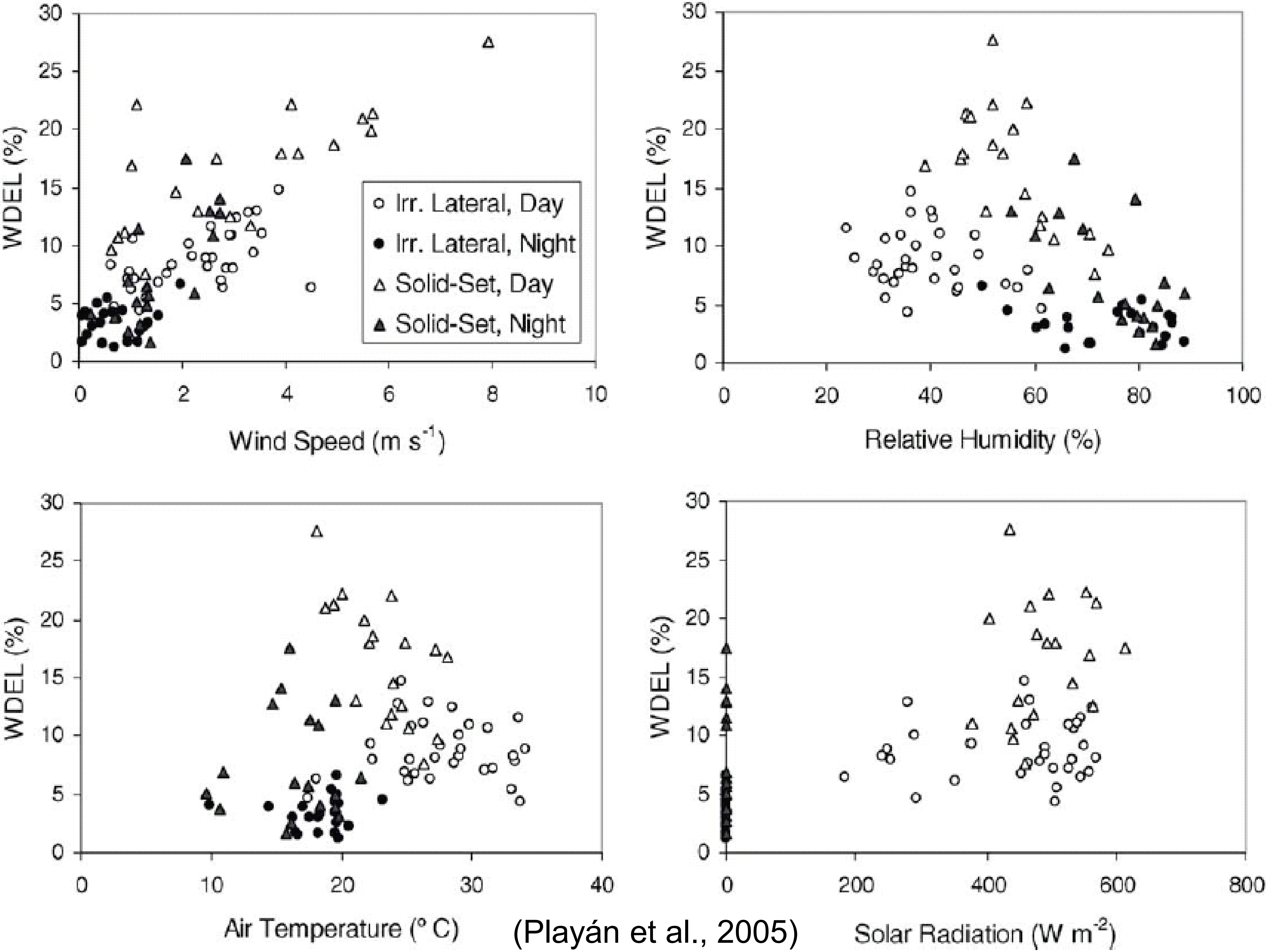
Challenges affecting sprinkler irrigation

Wind drift and evaporation losses

- WDEL for the conditions of Zaragoza, Spain
- A crude generalization…



(Salvador, 2003)



(Playán et al., 2005)

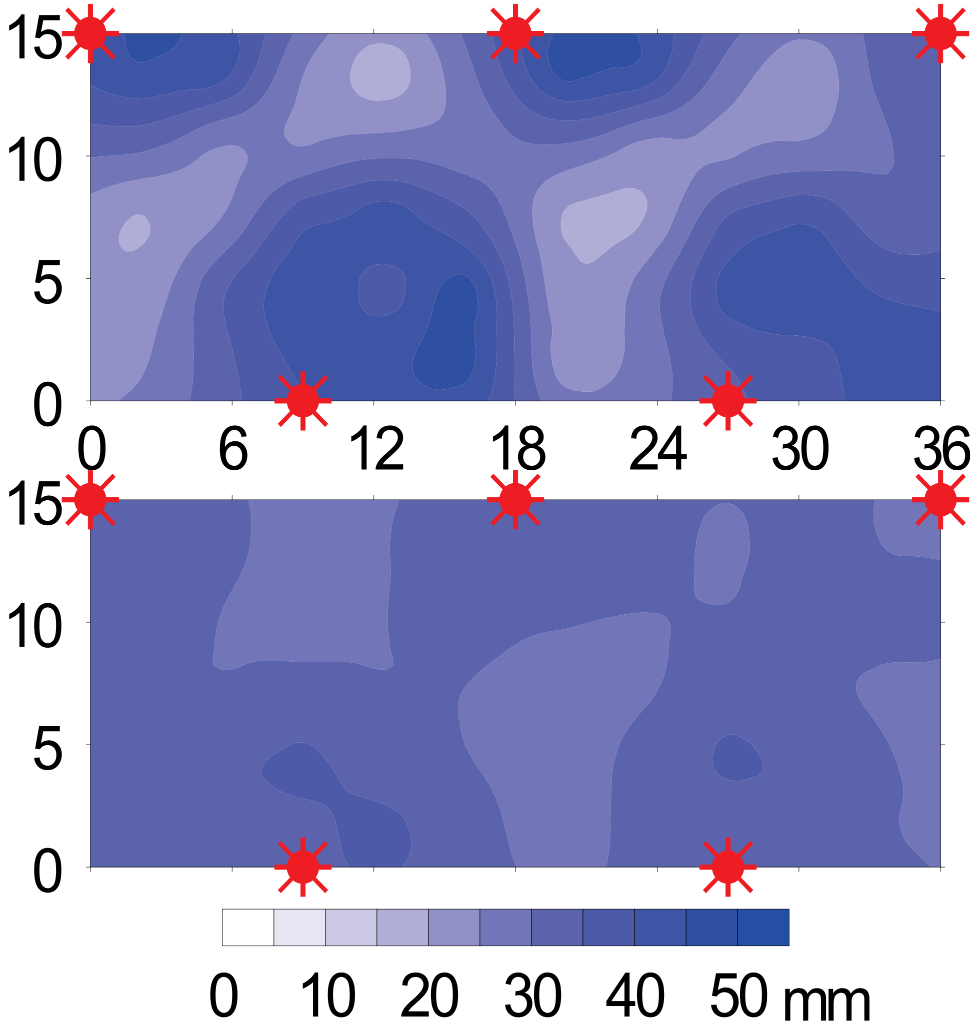
WDEL results in net water losses

- WDEL triggered by:
  - High Wind, temperature, Radiation
  - Low Relative Humidity
  - Sprinkler design: drop size, sprinkler elevation (no luck with experiments so far)
- Martínez-Cob et al. (2008), analyzed a corn field
  - Reported that 75 - 85 % of these observed losses were consumptive
- A variety of predictive equations have been developed for day / night conditions and types of sprinkler systems.
  - A general, non-empirical approach to this process is much needed

Wind and Uniformity

U = 5.3 m/s
CU = 54%

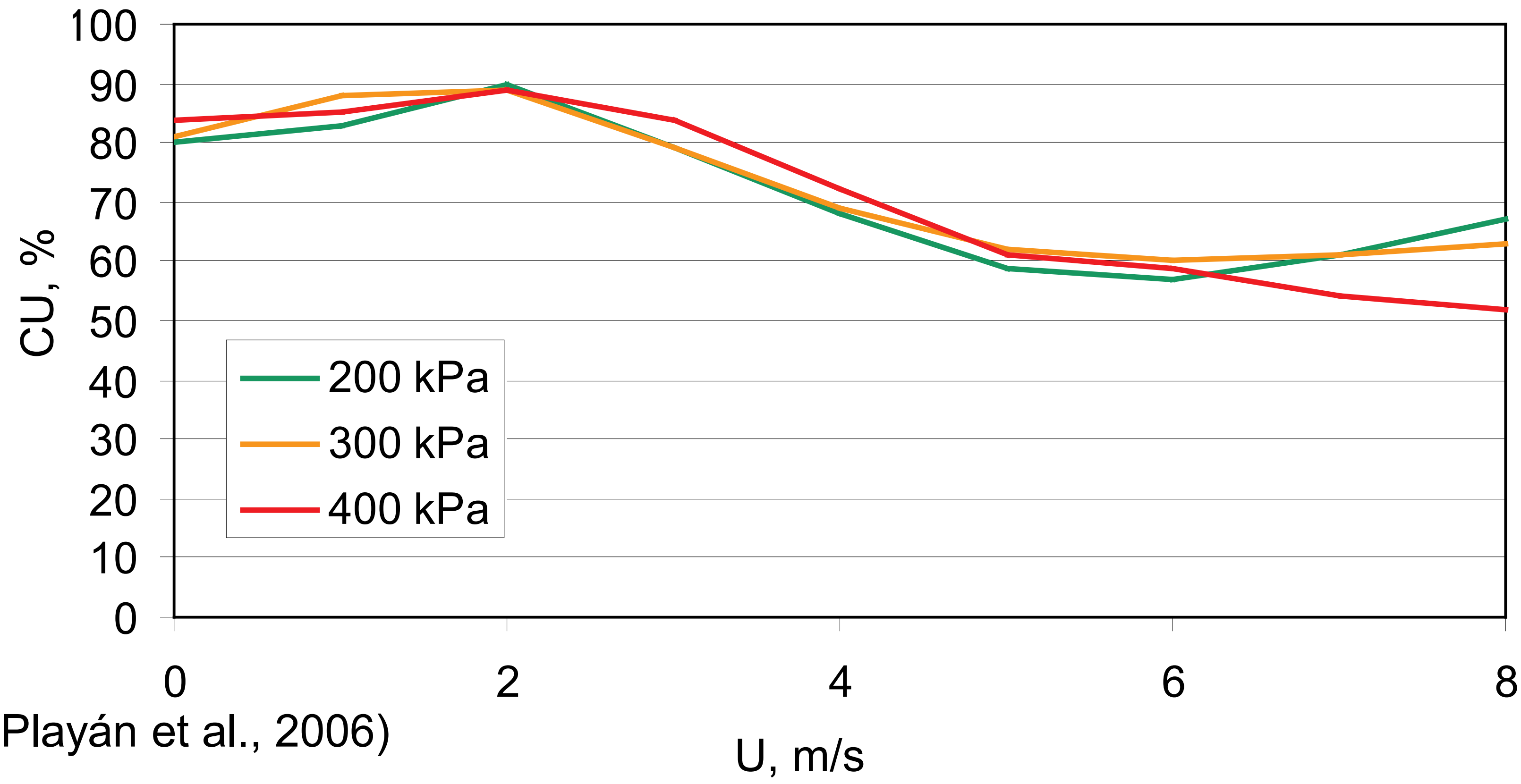
U = 1.2 m/s
CU =91%



(Dechmi et al., 2003)

Wind and Uniformity

- Ballistic simulation models permit to simulate CU under different U, irrigation systems…

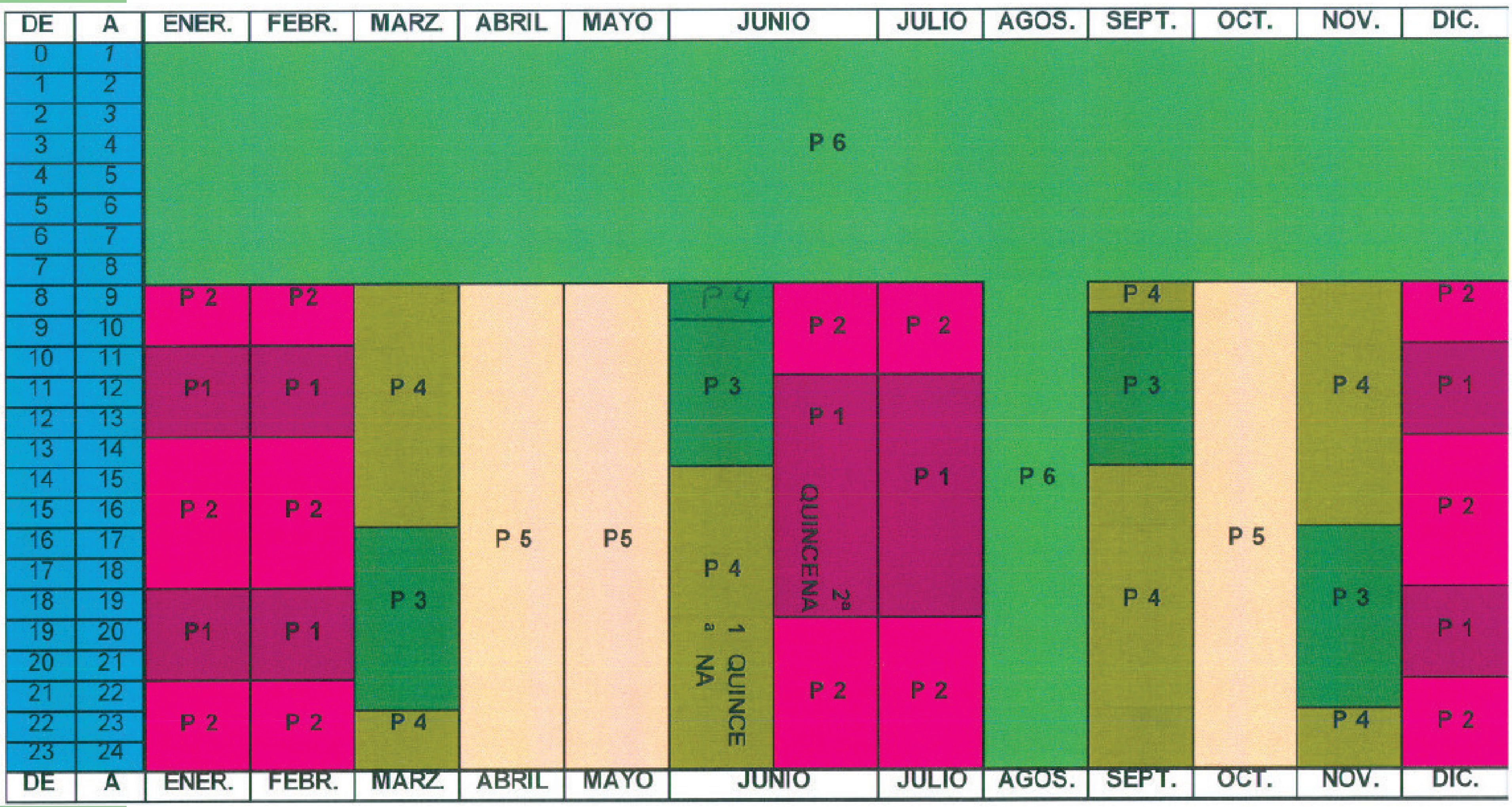


(Playán et al., 2006)

Time-variable Electricity costs

- Electricity (energy) is now a key input to irrigated agriculture…where pumping is required
- Cost is multiplied times 3+ depending of the hour of use and the month of the year
- Need to accommodate water use to periods of low energy cost
- Low WDEL, high CU and low electricity cost tend to happen at the same time…

Time-variable Electricity costs



Low margin, low dedication/ha

- Sprinkler irrigation systems are often associated to field crops
- Low economic margin requires farming large areas, in different plots, with different programmers.
- Professional growers need to supervise and re-program about ten controllers
- It is not rare to:
  - See farms irrigating under strong winds (may be required by a collective system)
  - Notice errors in growers' irrigation programming

3 Opportunities for improved irrigation management

New (and not so new) information sources and tools which may make a difference

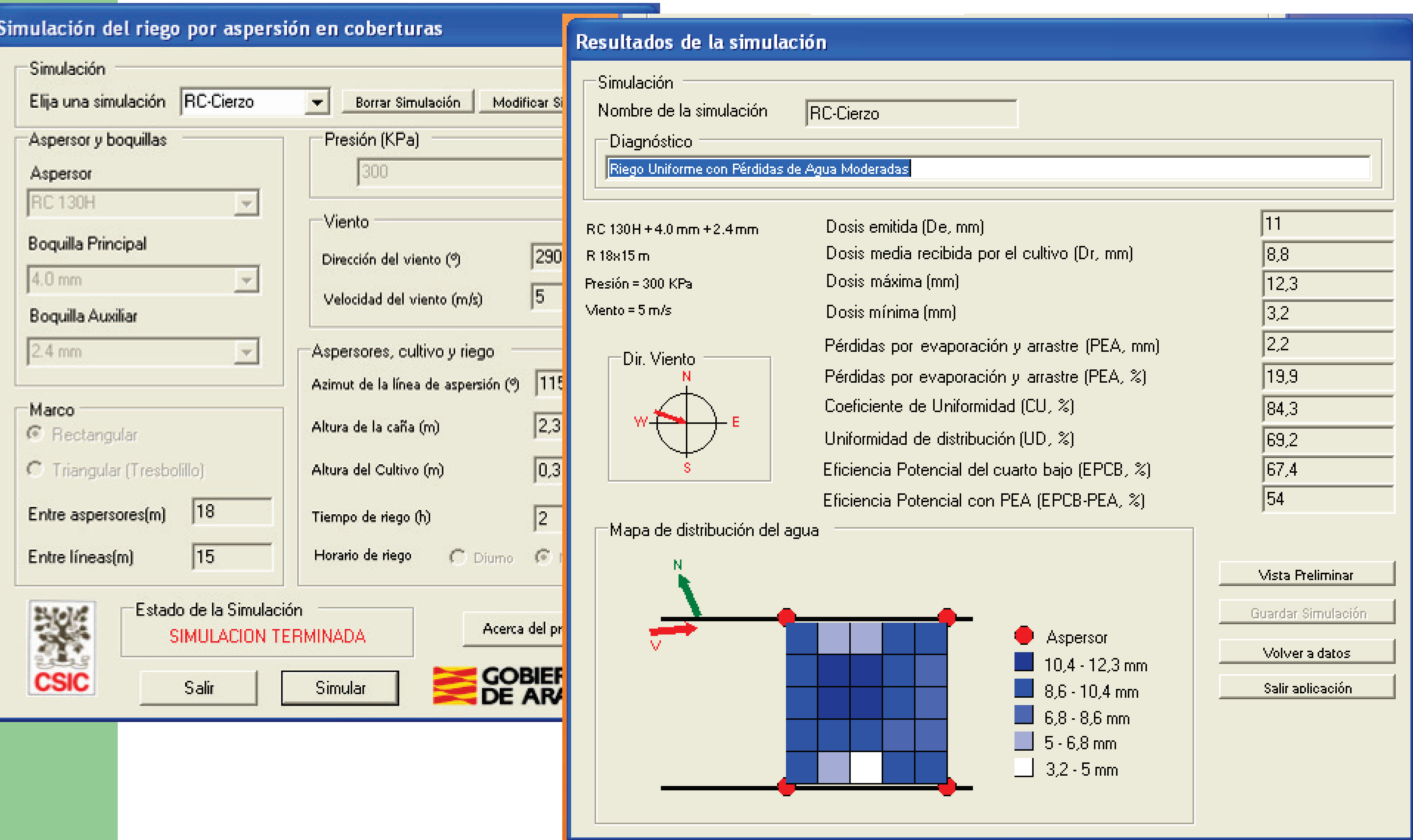
Real-time meteorological databases

- Since CIMIS started operation (Snyder, 1985), the idea has spread to many irrigated areas in the world
- Variables leading to the determination of FAO crop water requirements are commonly available on an hourly basis
  - Over the Internet
  - In many areas of the world
- Information can be automatically accessed in a digital format

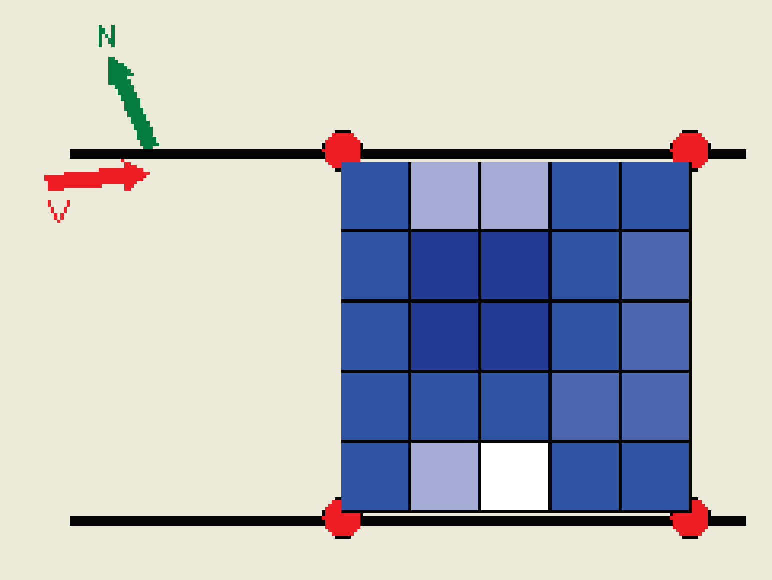
Crop and irrigation simulation models

- A variety of models are available for:
  - Crop / water / yield
    - Simplified models: based on CropWat (Smith, 1992), fast and simple
    - Full crop models (CropSyst, DSSAT, EPIC, STICS…): complex, more predictive capacity, forecasting agricultural pollution
  - On farm Sprinkler irrigation systems:
    - Wind drift and evaporation losses: empirical and analytical approaches (Playán et al., 2005)
    - Solid-sets: Ballistic models using field calibration/validation (Kincaid, 1986)
    - Irrigation machines: Semi-empirical models (Bittinger and Logenbaugh,1962)
  - On-farm and collective pressurized networks
    - EPANet (Rossman et al., 1994)
    - Gestar (Aliod and González, 2008)

Ballistic sprinkler irrigation model



Coupling crop and sprinkler irrigation models



- The space between four sprinklers is divided in 25 square areas.
- A crop simulation is performed in each area, using the irrigation input determined by the sprinkler model.

(Dechmi et al., 2004)

Software for WUA management

- Collective irrigation systems use database applications detailing:
  - Land tenure
  - Water infrastructure
  - Current crops
  - Irrigation systems
  - Soil types
- These data are key to crop water requirements analysis

Remote control / communications

- Remote control / telemetry systems permit to schedule and execute irrigation from the WUA office
- In some cases, the system has access to the hydrant + the sector valves: full remote irrigation automation is possible
- There are examples in Spain of WUAs fully irrigated from the office:
  - Irrigation schedules may be requested by growers
  - Main goals: full automation, energy cost control


… and local sensors

- Meteorology
  - Wind is very local… needs to be measured
  - Temperature, relative humidity… not so variable
- Irrigation system
  - Pressure: to estimate potential efficiency
- Soil water
  - Spatial variability may be very large… how many sensors would be needed?
  - Can we live without?

Time Slack in irrigation system design

- Systems are designed to apply water at a faster rate than irrigation requirements.
- This results in a certain time slack in irrigation scheduling.
- Depending on the fraction of time slack, the irrigation timing can be negotiated with the WUA or selected on pure demand
- Time slack at the on-farm system and at the water inlet is required to optimize irrigation performance.
- Sprinkler irrigation farmers can select the irrigation periods leading to optimum efficiently while timely satisfying crop water requirements.

4 (a possible) Future of automatic irrigation control

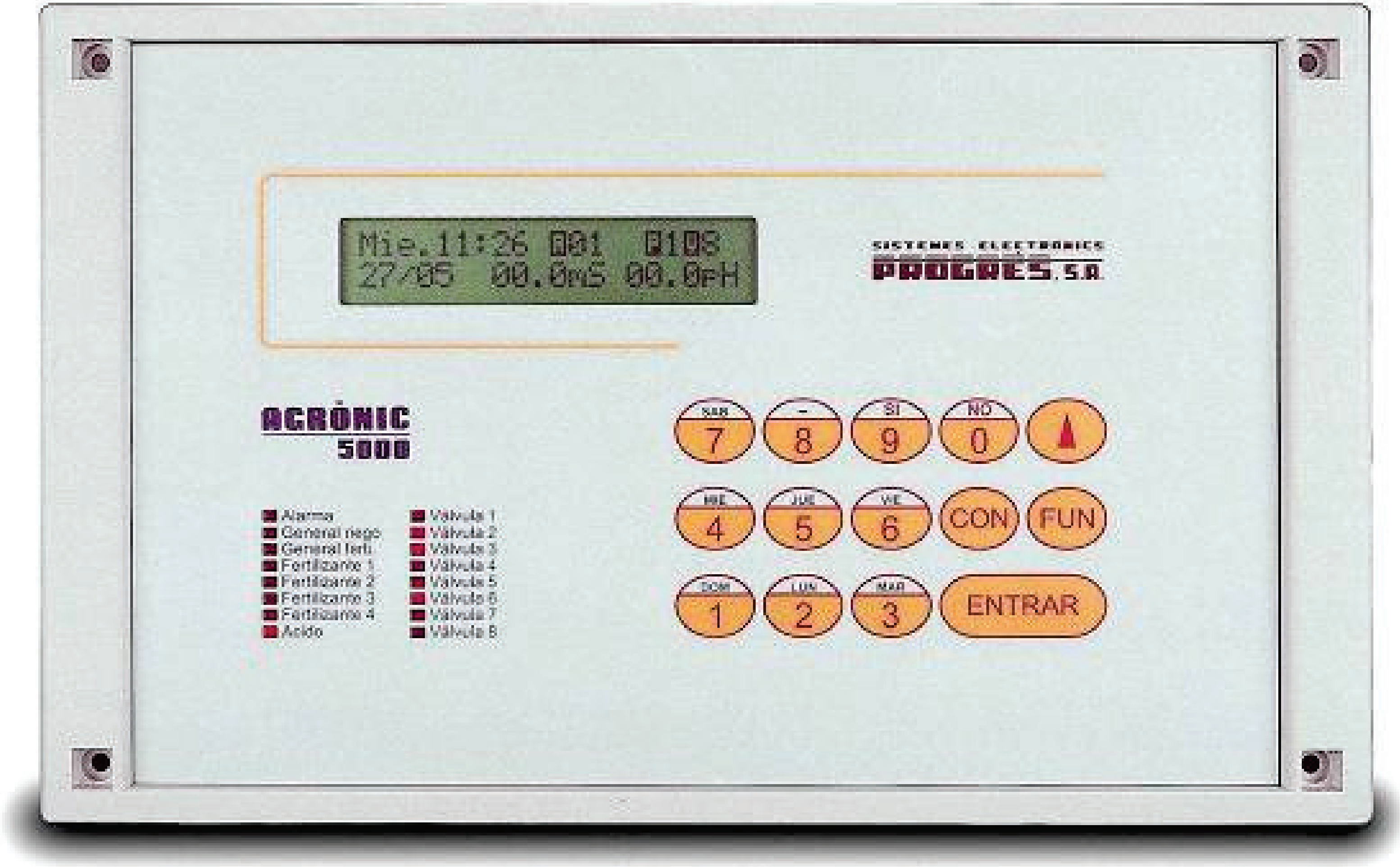
Using and updating plenty of information

Ideas for the future

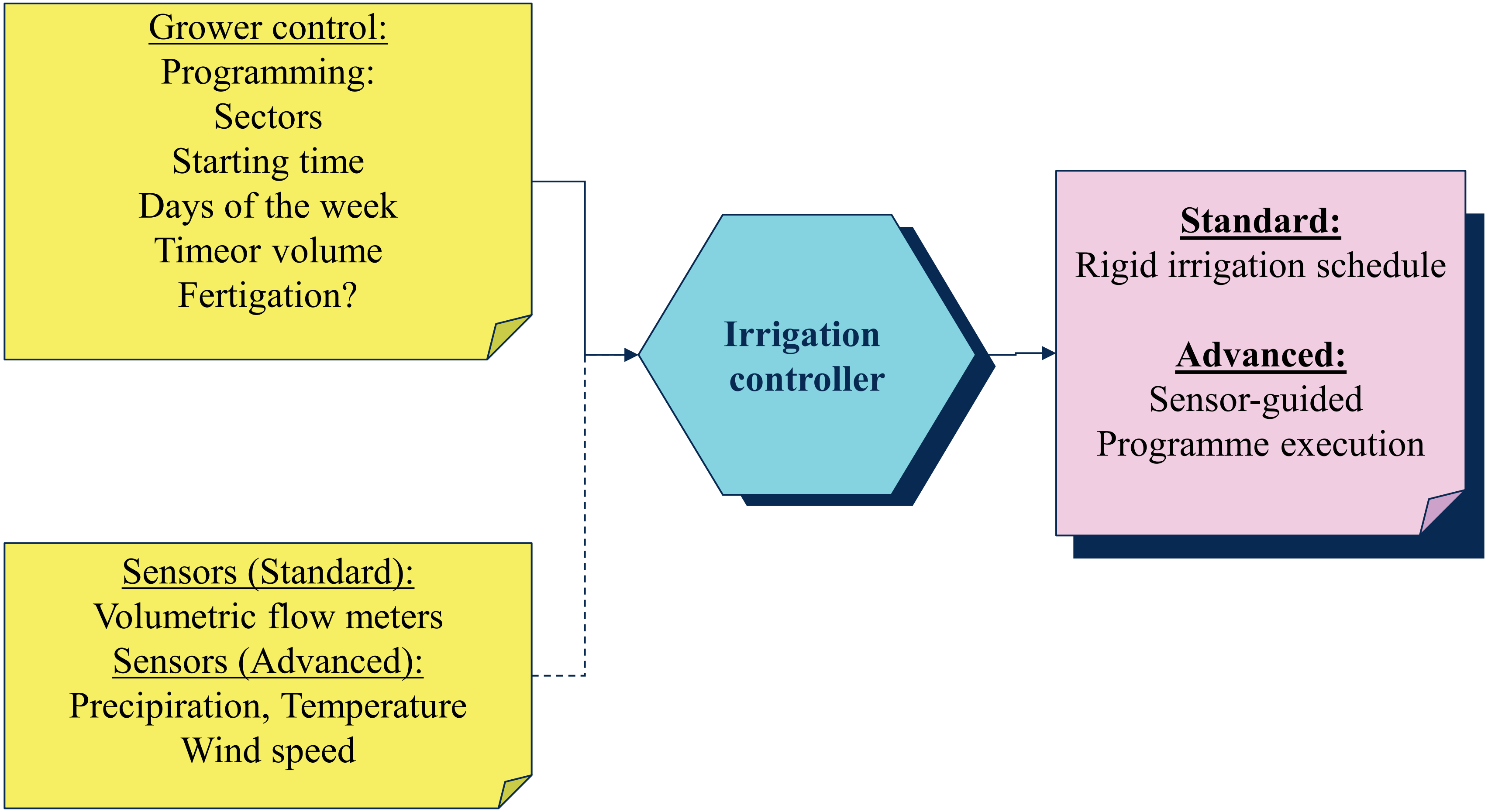
- Recent efforts in irrigation automation
  - Landscape irrigation: often meteo based
    - Broadcasting of ETo information, automatic garden irrigation (McCready and Dukes, 2011)
  - Agricultural irrigation: often sensor based
    - Orchards (Fernández and Cuevas, 2010)
    - Vegetables (Zotarelli et al., 2011)
- Based on forecasting PAEIq, integrating the effects of CU and WDEL
- Configurations
  - A farm: individual user
  - A WUA: multiple users

Irrigation Controllers today

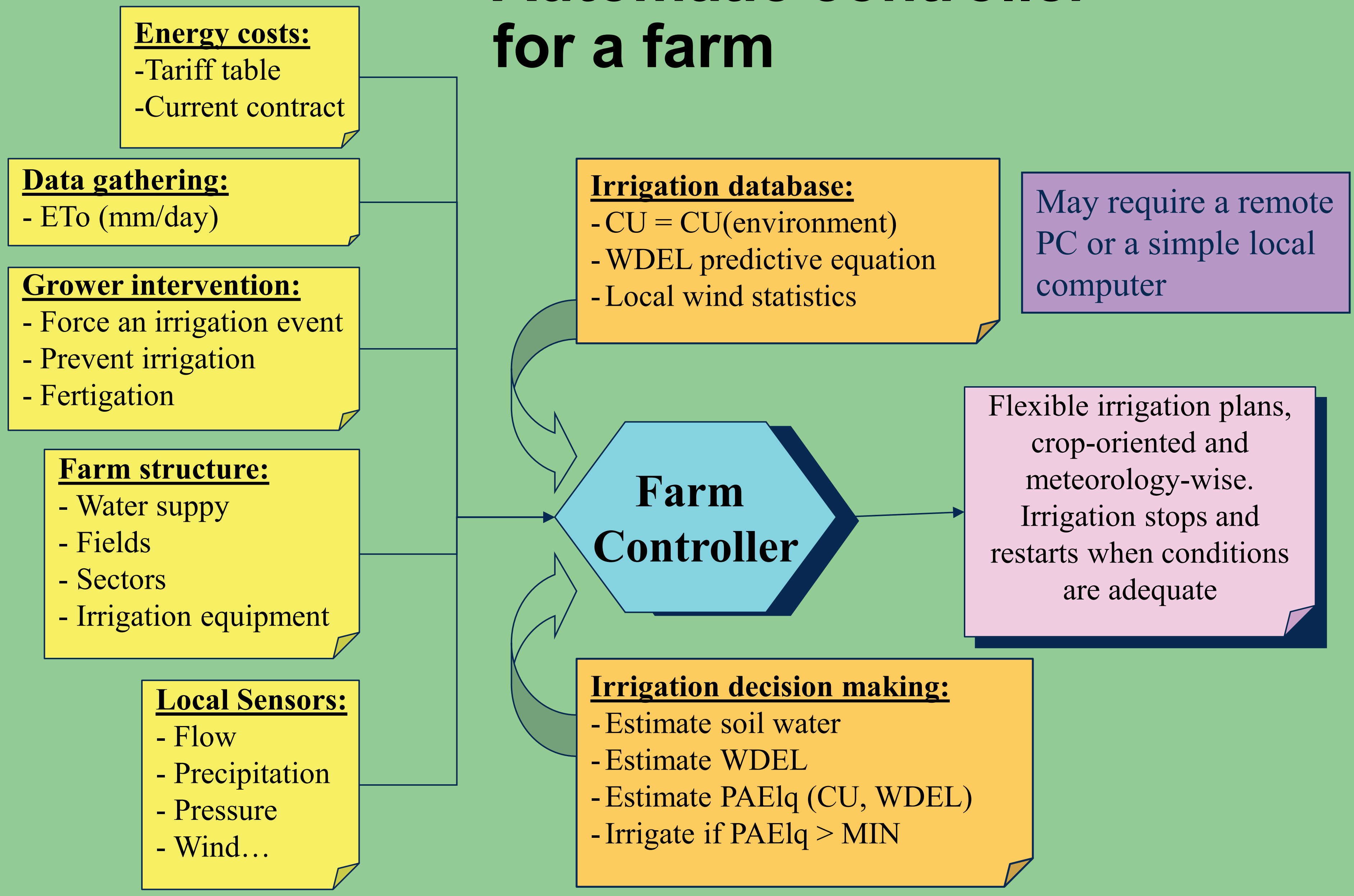
Irrigation Controllers today



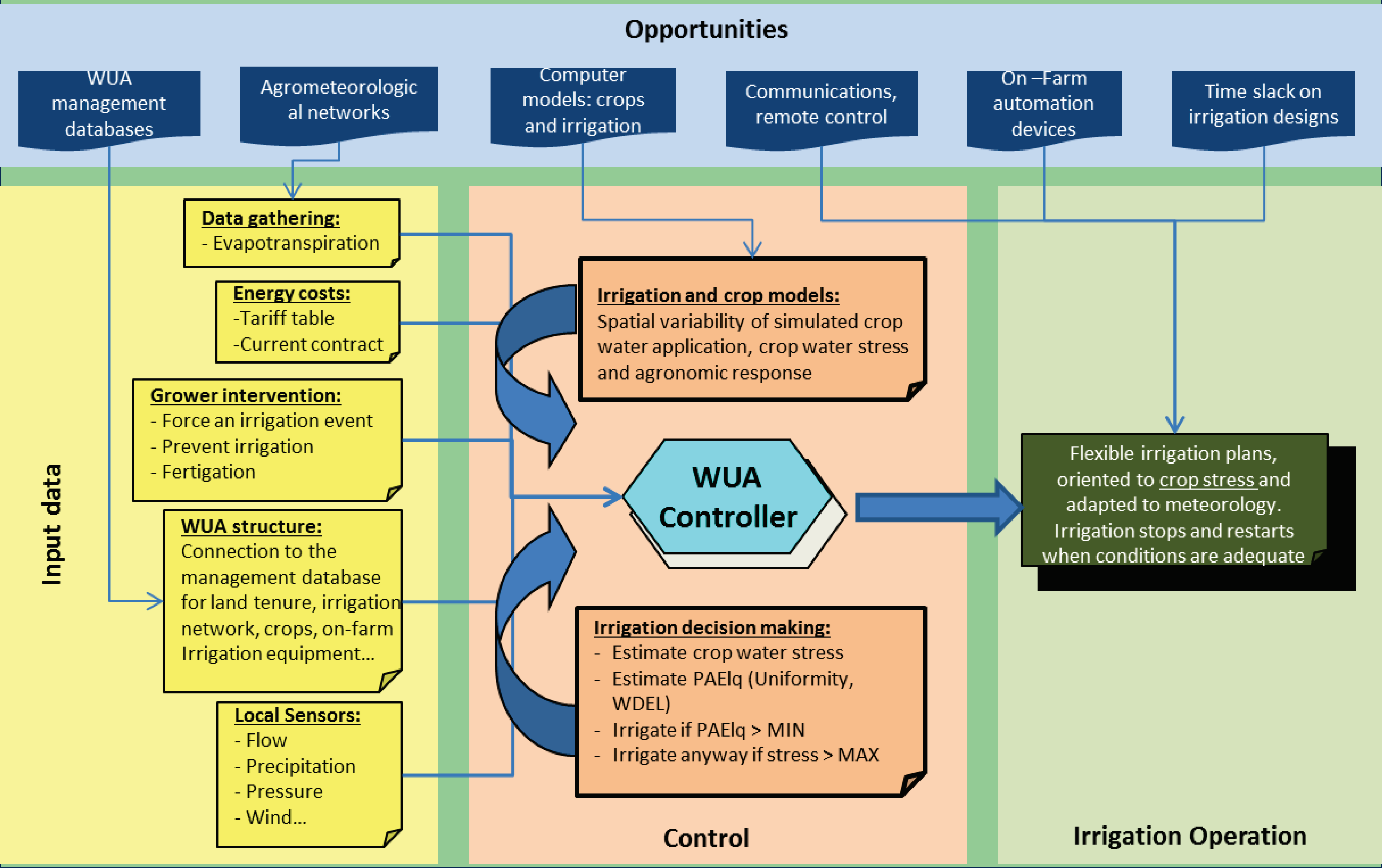
Irrigation controllers today

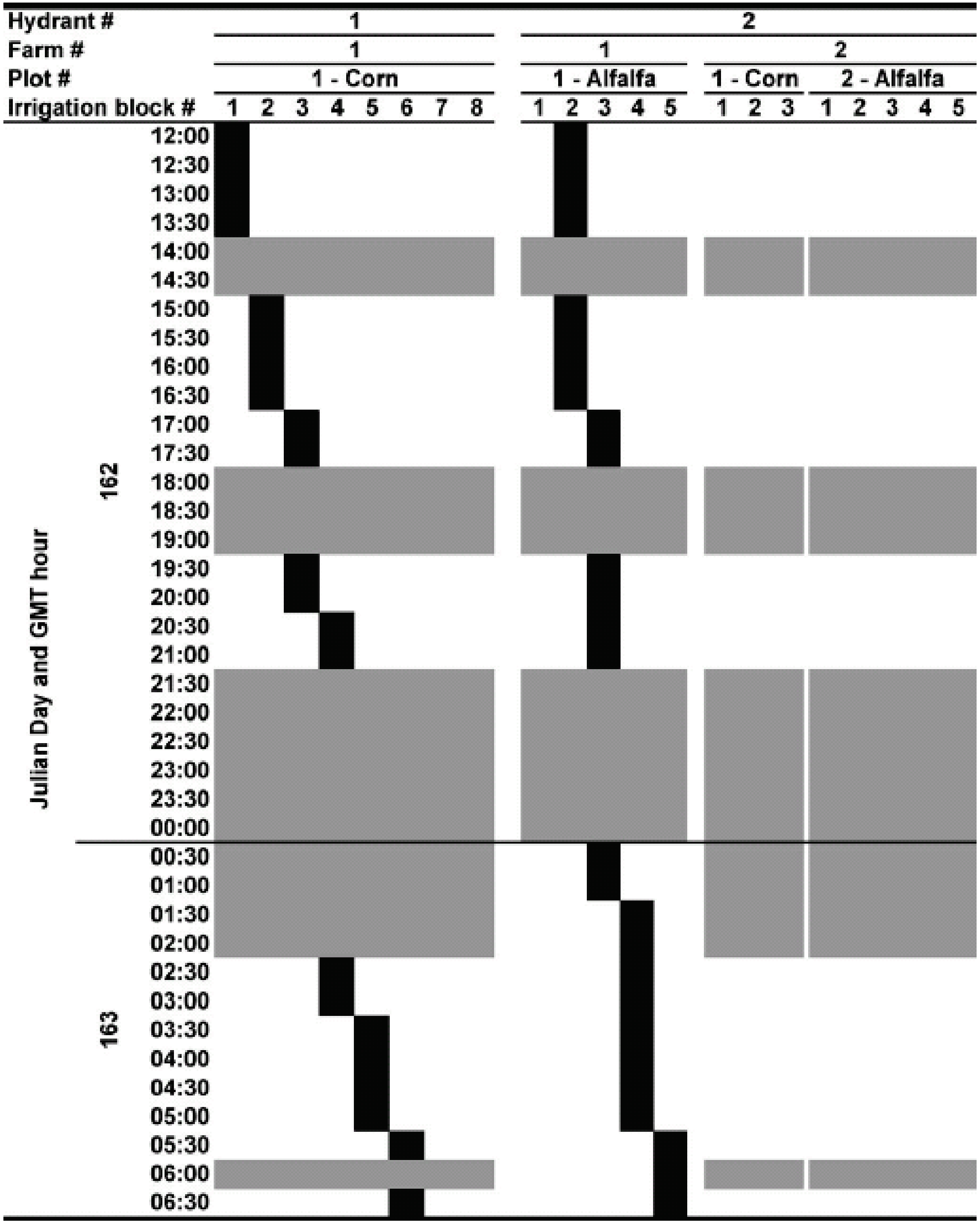


Automatic controller for a farm



Automatic Controller for a WUA



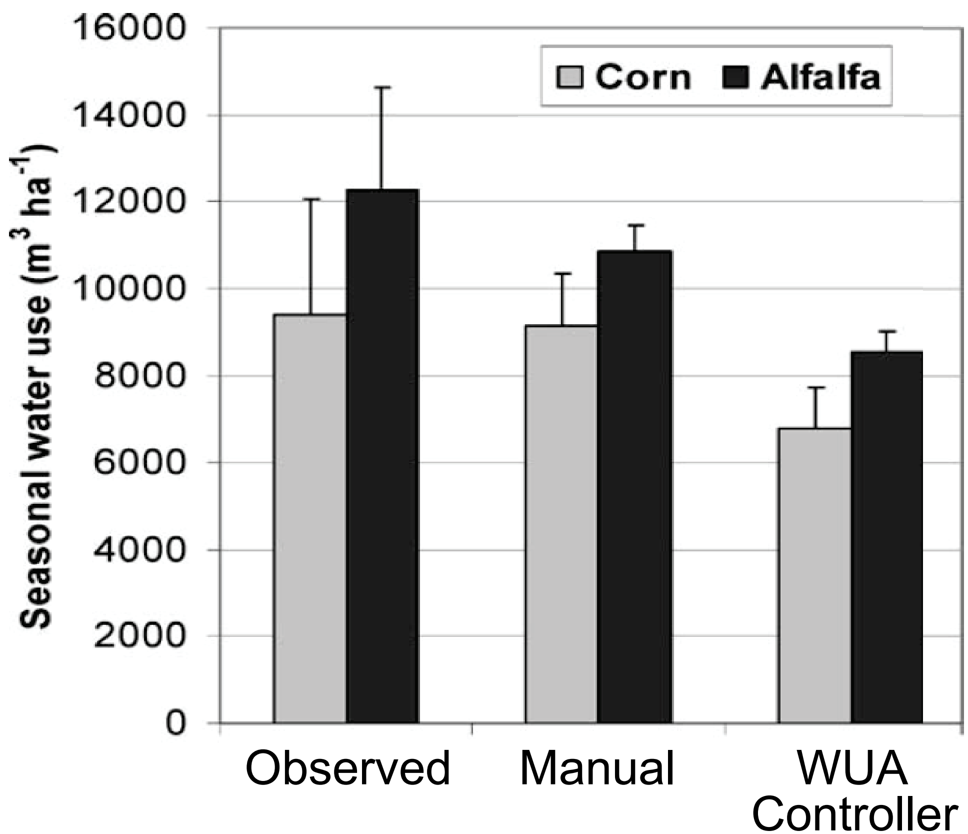


- Automatic WUA controller operating on two hydrants, three farms, four plots and their sectors.
- Irrigation of a sector lasts for two hours
- Irrigation stops for meteorological conditions if stress is moderate.
- Under severe stress any irrigation event will be accepted

(Zapata et al., 2009)

Simulating irrigation districts

- Opportunities for water conservation in irrigation districts when an automatic WUA controller is implemented.
- Particularly in windy areas with sufficiently dimensioned networks.



(Zapata et al., 2009)

5 An experiment: an automatic irrigation controller

A proof of concept to prepare further developments

A remote automatic controller

On-farm equipment

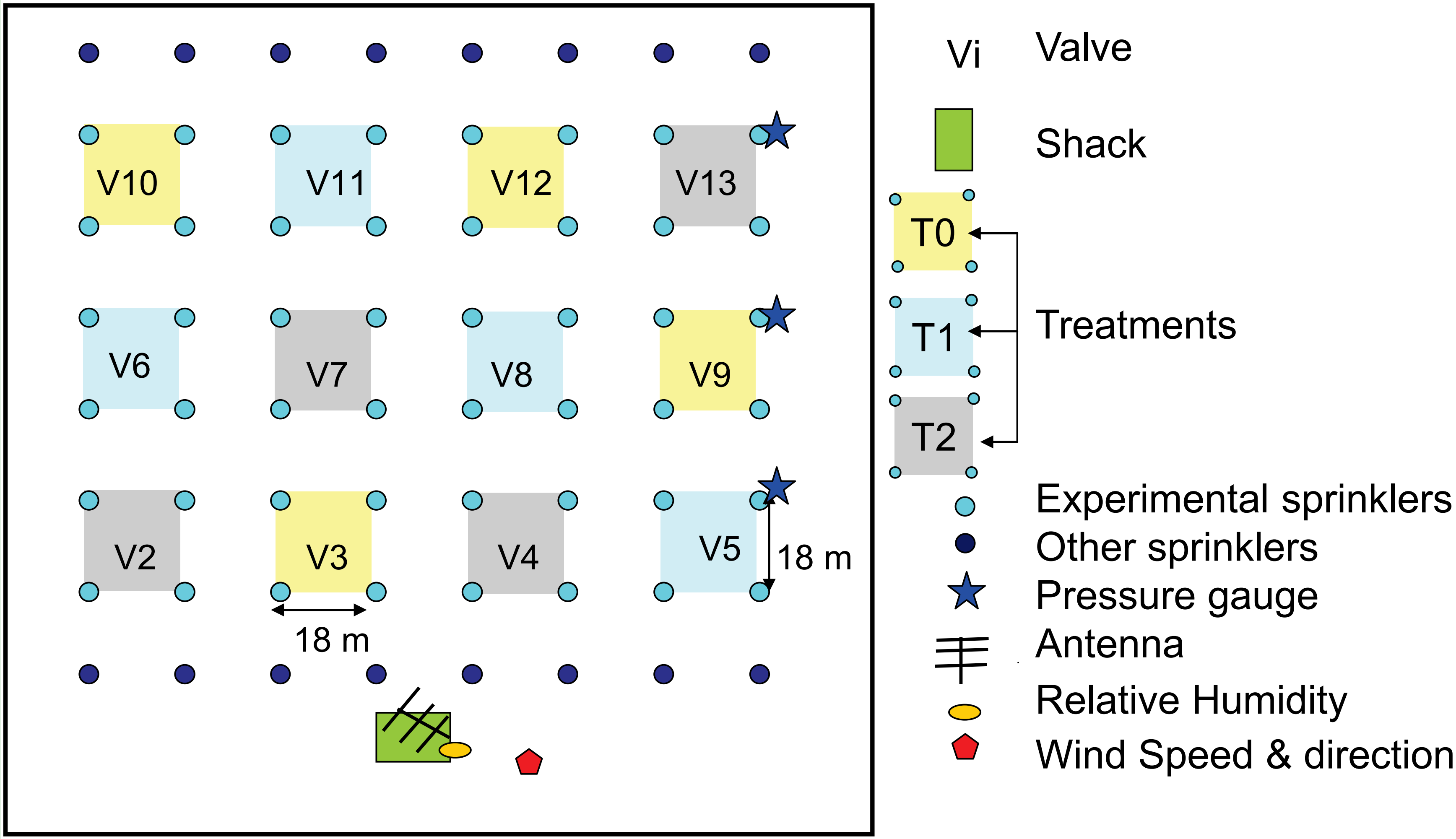
Remote equipment

Three treatments

- T0: a very good grower
  - Weekly updates the program according to the ETo of last week
- T1: Farm Automatic Controller
  - Simplified soil water balance
  - Unattended
- T2: WUA Automatic Controller
  - Soil-Water-Crop model based on CropWat
  - Unattended

- Energy & water limitations were not considered

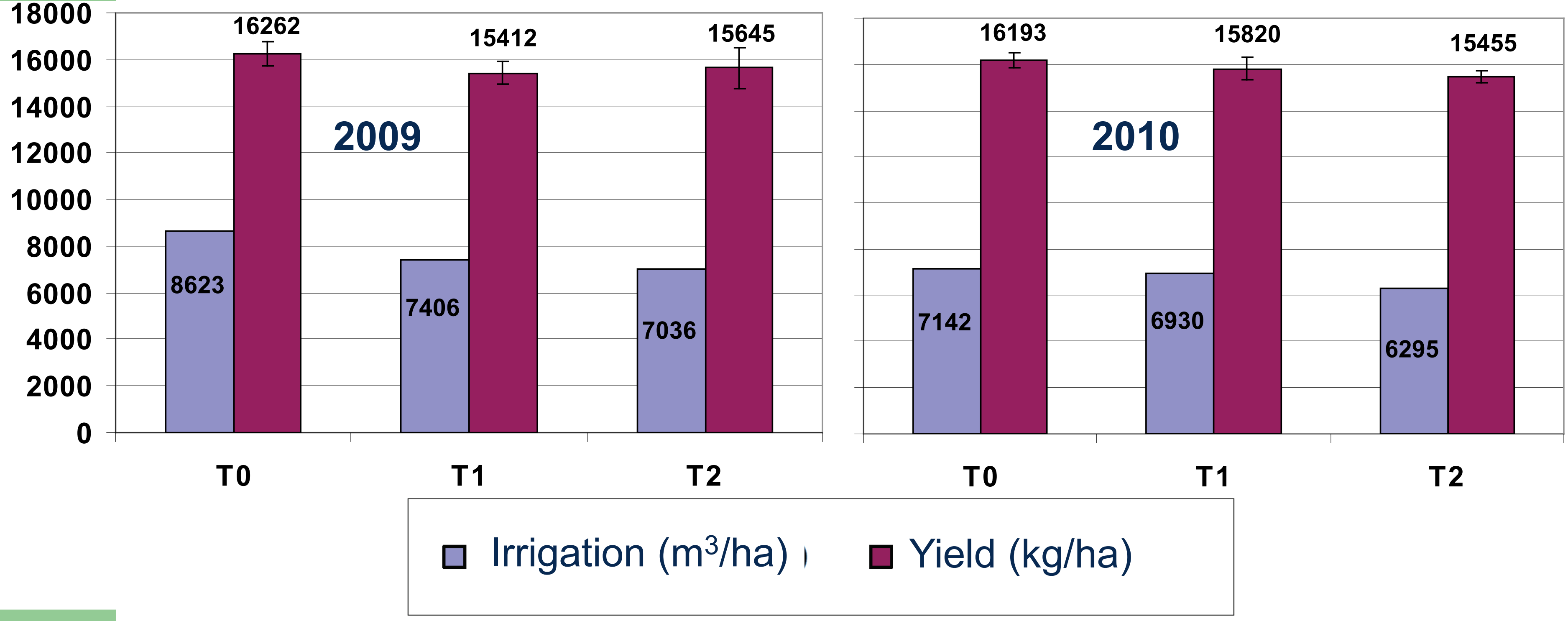
Experiment, treatment, replications



Two years of experimentation: 2009-2010

Harvest, 2009

Results:



- Differences in yield were not significant
- Increased water productivity: Farm Controller by 6 %, WUA controller by 13 %

6 Design Alternatives

Feeding future designs

Design alternatives

- Independent vs. slave on-farm controllers
- Measuring vs. simulating water deficit
- Controlling solid-sets only vs. combinations of pressurized irrigation systems
- Irrigation automation vs. optimization of water productivity and sustainability
- Targeting unskilled vs. advanced farmers

7 Identifying bottlenecks

Limiting factors

Research needs

- More evolved and linkable crop models: environmental effects, fertilization, salinity…
- Calibration needs for irrigation and crop models
- Modeling other pressurized irrigation systems
- Combining with other information sources: sensors (ground level and remote)

Technology needs

- Open hardware platforms for irrigation controllers
- Standardization of irrigation telemetry / remote control systems

Innovation needs

- The new generation of irrigation controllers will require supporting companies to provide a new set of services.
- Some of these services, like irrigation advising, are already offered in some areas of the world, particularly for cash crops.
- A business model can be based on running irrigation scheduling services connected to a number of disseminated on-farm slave controllers.
- Such a company needs to ensure proper functioning of the scheduling system, and needs to keep on-farm controllers functional.

Innovation needs

- Additional services can be based on adjusting the irrigation schedule to observed field conditions, but can add fertigation or general agronomic advice.
- For WUA controllers, farmers can voluntarily subscribe to the WUA advanced scheduling services.
- The concept of solid-sets driven by simulation models is receiving interest on the part of the end-users

8 Conclusions...

Final considerations

Conclusions

- Experimental Automatic Controllers:
  - Unattended operation throughout the season
  - Increased water productivity
  - Avoided unsuitable periods for irrigation (large water losses)
- Bottlenecks have been identified in Research, Development and - particularly – innovation
- We live the days of innovation:
  - Horizon 2020
  - RIS3
  - Rural Development Plans
- How and when will we see automatic irrigation controllers at the farms?