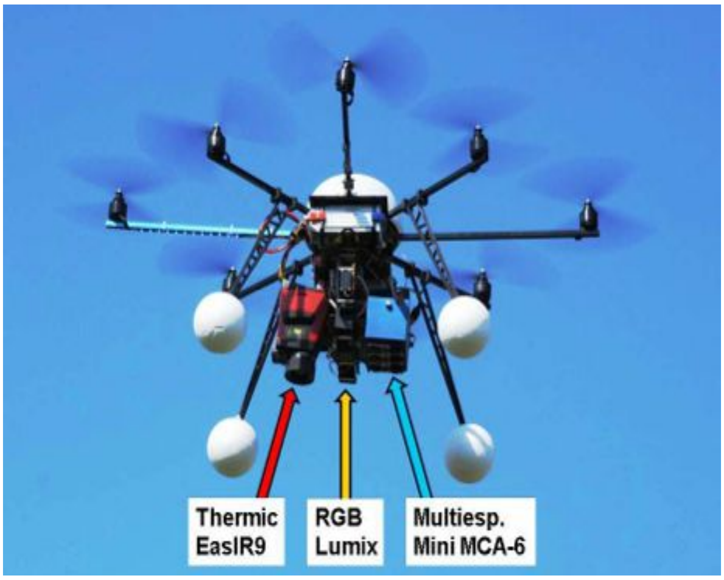
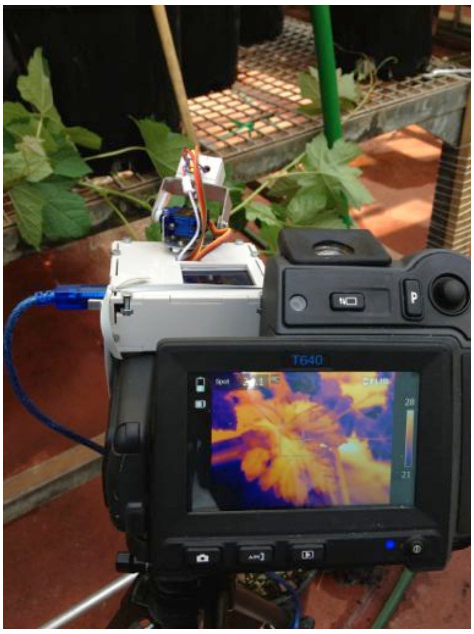
Attendance and Presentation at the 29th International Horticultural Congress 2014





FINAL REPORT to

AUSTRALIAN GRAPE AND WINE AUTHORITY

Project Number: **GWT1409**

Principal Investigator: **Dr Sigfredo Fuentes**

Research Organisation: **The University of Melbourne**

Date: **15th September 2014**

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Abstract

Latest work lead by Dr Fuentes with collaborations with colleagues in Australia and Chile was presented at the 29th International Horticultural Congress 2014. Specifically, four oral presentations and one poster were delivered in the following symposia:

- Two oral presentations at the Sustaining Lives, sub-section: Water Scarcity, Salinisation & Plant Water Relations for Optimal Production and Quaity;
- One oral presentation to the Production and Supply Chain symposia: sub-section: Education, Research Training & Consultancy;
- One oral presentation to the Sustaining Livelihoods, sub-section 4th International Symposium on Tropical Wines & International Symposium on Grape and Wine Production in Diverse Regions.
- One poster in the posters section with five minutes oral presentation.

Executive Summary

To main topics were covered in the presentation given at the Congress in Brisbane:

i) Development and application of new tools to asses plant water status in grapevines using short range remote sensing and
ii) Novel tools to improve the education in horticultural sciences, with emphasis in Viticulture, using Do It Yourself (DIY) kits to assess physiology and wine quality.

The titles of the presentations were:

- **1. LOWERING RESOLUTION OF INFRARED THERMAL IMAGERY RENDERS ACCURATE RESULTS FOR WATER STATUS MONITORING OF HORICULTURAL CROPS AT A FRACTION OF PRICE.** ***Fuentes, S***, *Lima, B, Poblete-Echeverria, Lobos G*
- **2. LOW COST EXPERIMENTAL DYI ROBOTIC KITS FOR HORTICULTURAL SCIENCE EDUCATION** ***Fuentes, S***, *Howell, K, Needs, S, Lima, B, Caron, M, Tesselaar, B, Hollingworth J, Fraser D, Collmann R.*
- **3. THE USE OF A PORTABLE ROBOTIC SPARKLING WINE POURER AND IMAGE ANALYSIS TO ASSESS WINE QUALITY IN A FAST AND ACCURATE MANNER** *Lima, B,* ***Fuentes, S,*** *Needs, S, Caron, M, Howell, K*

- **4. PLANT WATER STRESS DETECTION BASED ON INFRARED THERMOGRAPHY: A STUDY CASE FROM VINEYARD AND OLIVE ORCHARD.** *Poblete-Echeverria C**., Fuentes S.***
- Poster Presentations (confirmed):
- **5. SEASONAL VARIATION OF NIGHT-TIME SAP FLOW OF A YOUNG OLIVE ORCHARD: THE UNSEEN PROCESS FOR EVAPOTRANSPIRATION ESTIMATIONS.** *Lopez-Olivari R,* ***Fuentes S.,*** *Ortega-Farias S.*
- **6. ASSESSMENT OF OLIVE ORCHARD WATER STATUS VARIABILITY USING AN UNMANNED AERIAL VEHICLE SYSTEM (UAV).** *Poblete-Echeverria C., Ortega-Farias S.,* ***Fuentes S.***

Background

Water is a scarce resource in Australia and has become a decreasing resource due to climate change and the quantitative and qualitative deterioration of water sources. Significant night-time water losses have been recently reported by different plant species which, in the case of crops, reduces water use efficiency (WUE) and have not been considered by Evapotranspiration (ET) models developed by FAO (Allen et al. 1998).

There is an imperative need on improving WUE of crops through defining critical plant water status parameters for precise and efficient water management in a changing environment (Anderson et al. 2008).

For such purposes, it is not only important the use of more sophisticated soil-plant-atmosphere sensor technology but also to unravel the links between hormonal and hydraulic signals on night-time physiological processes, such as night-time water uptake, refill and transpiration, which have been considered as non-existent previously. Filling this knowledge gap is of extreme importance since: i) night-time water losses decrease WUE (not linked to photosynthesis); ii) Night-time temperatures are predicted to rise in a higher rate compared to diurnal temperatures, which can exacerbate night-time processes; iii) Night-time water losses are not considered in evapotranspiration models, which assume zero values for all C3 and C4 crops. The latter having significant implications in the estimation of plant water consumption and irrigation scheduling.

New sensor technology, specially those carried by Unmanned Aerial and Terrestrial Vehicles (UAVs and UTVs respectively) could facilitate assessing the relationship between night-time water uptake / loss more efficiently.

Advances in open hardware and software have allowed creation of sensors and mini-robots at really affordable prices. Some of these techniques have been compared to more robust and expensive technologies rendering similarly accurate results. We have presented in the Congress the development of inexpensive experimental kits that students can assemble by themselves to gather scientific data in their own homes. In addition to the disciplinary knowledge gained by experimentation, this project will allow students to learn basic mathematics, physics and computational analysis involved in the easy construction of kits.

This initiative will help to deliver an outstanding student learning experience at the graduate and postgraduate levels and supporting the students in maximising their graduate outcomes. Therefore, the implementation of the system proposed address also the following critical areas:

- Use of technology to facilitate more effective in-class interactive learning experiences in large and medium-sized group teaching settings;
- Increased interaction between staff and students, and among student peers through innovative use of learning technologies.
- Use of technology to improve student feedback and assessment mechanisms;
- Creation of more flexible access to learning materials via mobile devices on and off campus.

Project Aims and Performance Targets

The aims of the presentations were mainly to gather feedback from the international scientific community in relation to the applicability of the different techniques and tools presented. The performance targets will be measured in relation to the number of scientific publications (six publications proposed) that will arise from these innovations. The main objective journals are:

- Australian Journal of Grape and Wine Research (IF = 2.778)
- Sensors Journal (IF = 2.457)
- Computers and Electronics in Agriculture (IF = 2.066)
- Remote Sensing Journal (IF = 2.729)
- Irrigation Science (IF = 2.843)

Expected publications submission: June 2015.

Furthermore, performance targets have been set in relation to applications from international collaborators to The University of Melbourne in relation to the presentations to the Congress. Specifically, a PhD student stay (Ms Esther Hernandez) in Australia for 6 months (internal application at The University of Balearic Islands, Mallorca. Spain) and an application to the Mackenzie Fellowship (Dr Angela Melado, Madrid. Spain) for Post Doctoral funding at the University of Melbourne. Both applications submitted the second week of September 2014.

Results / Discussions

Two papers have been submitted to the Acta Horticulturae as part of the Congress presentations related to oral presentations number 3 and 4.

Following is a summary of the presentations delivered:

1)

LOWERING RESOLUTION OF INFRARED THERMAL IMAGERY RENDERS ACCURATE RESULTS FOR WATER STATUS MONITORING OF HORICULTURAL CROPS AT A FRACTION OF PRICE

***Fuentes, S*[1]**, Lima, B[1], Poblete-Echeverria[2], Lobos G[3]

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[2] *Centro de Investigación y Transferencia en Riego y Agroclimatología (CITRA) Universidad de Talca, Chile.*

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ABSTRACT

It has been shown in the last two decades that infrared thermography is an accurate tool to assess plant water status of different crops. However, infrared cameras are still of high costs, making difficult to use this technology by growers and irrigation practitioners. Furthermore, this technique requires specialised know-how to use the cameras, process the images and interpret results. Most of the commercial companies that produce infrared cameras also have proprietary rights over images to readily access information, such as temperature and emissivity, among others. The latter makes difficult the automated analysis of thermal images to obtain reproducible data in a quick manner. Open hardware and software technology currently available has allowed the creation of sensors and mini-robots at considerably reduced costs with specialise analysis software enabling users to automate data gathering and analysis processes. In this paper we describe the creation and testing of infrared scanners (single and multisensors) controlled by inexpensive electronics against infrared thermal cameras for plant water status assessment. Results have shown that a reduction of 90% of resolution from infrared thermal images renders accurate and similar results compared to high resolution infrared thermal cameras for the estimation of plant water status. Testings of this inexpensive technology were conducted in grapevines, olive trees, apple trees and canola among other horticultural crops. The testing scales varied from single leaves to whole canopies.

2)

LOW COST EXPERIMENTAL DYI ROBOTIC KITS FOR HORTICULTURAL SCIENCE EDUCATION

Fuentes, S[1], Howell, K[1], Needs, S[1], Lima, B[1], Caron, M, Tesselaar, B,

Hollingworth J[3], Fraser D[3], Collmann R[3].

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ABSTRACT

Advances in open hardware and software have allowed creation of sensors and mini-robots at really affordable prices. Some of these techniques have been compared to more robust and expensive technologies rendering similarly accurate results. This paper describes the development of inexpensive experimental kits that students can assemble by themselves to gather scientific data in their own homes. In addition to the disciplinary knowledge gained by experimentation, this project will allow students to learn basic mathematics, physics and computational analysis involved in the easy construction of kits. This project will help to deliver an outstanding student learning experience at the graduate and postgraduate levels in Horticultural Sciences and supporting the students in maximising their graduate outcomes. Therefore, the implementation of the system proposed address also the following critical areas:

- Use of technology to facilitate more effective in-class interactive learning experiences in large and medium-sized group teaching settings;
- Increased interaction between staff and students, and among student peers through innovative use of learning technologies.
- Use of technology to improve student feedback and assessment mechanisms;
- Creation of more flexible access to learning materials via mobile devices on and off campus.

The kits developed up to date are: i) Automated wine pourer and multivariate analysis of sparkling wine quality; ii) Yeast diversity in wine fermentations and species identification; iii) Sensory evaluation and training using coffee; iv) Multicopter to assess plant physiology in agricultural systems; v) Automated pheromone trap and image analysis tool for insect identification.

3)

THE USE OF A PORTABLE ROBOTIC SPARKLING WINE POURER AND IMAGE ANALYSIS TO ASSESS WINE QUALITY IN A FAST AND ACCURATE MANNER

Lima, B[1], Fuentes, S[1], Needs, S[1], Caron, M[1], Howell, K[1]

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ABSTRACT

The Australian wine industry contributes strongly to the country's economy. Australia is the sixth largest wine producer and the fourth largest wine exporter. Sparkling wine accounts for approximately 9% of the domestic wine sales and 13% of total wine imports in Australia. Wines with dissolved carbon dioxide are also economically important for several countries, France, Spain, Italy, USA, and Chile. Increase in temperature and carbon dioxide levels in the atmosphere have shown to affect flavour and aroma of wines, decrease protein concentration in and increase alcohol in wines. Consequently, climate change is expected to influence the final quality of sparkling wine, since several compounds, including protein concentration and alcohol are related to foam stability and the ability of the wine to produce. The quality of sparkling wine is visually assessed by its colour, bubble behaviour, appearance (bead) and foam persistence (mousse). However, as discussed by a number of authors, these parameters are extremely variable and are affected by pouring, reception vessel shape and type as well as temperature. Robotics and chemometrics allows us to control and monitor these parameters, and thus repeatedly measure sparkling wine for quality assessment and to correlate it with traditional measures of quality. A robotic bottle pourer has been developed to standardise time and wine volume of pouring into a standardised vessel. Images are collected automatically with a digital camera attached to the pourer and transferred to a computer. These images are then evaluated by image analysis algorithms, which convey the information into bubble size and speed, foamability (ability of the wine to produce foam), foam persistence and stability, and collar stability.

4)

SEASONAL VARIATION OF NIGHT-TIME SAP FLOW OF A YOUNG OLIVE ORCHARD: THE UNSEEN PROCESS FOR EVAPOTRANSPIRATION ESTIMATIONS

Lopez-Olivari, R[1]., Ortega-Farias., S[1]., Fuentes, S[2].,
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[2] *The University of Melbourne, Melbourne School of Land and Environment. Victoria3010, Australia.*

ABSTRACT

It has been shown that night-time transpiration is an important unseen factor that contributes significantly to total evapotranspiration (ET) of horticultural and fruit tree crops. Since night-time transpiration is not associated to photosynthesis, it contributes to decrease water use efficiency. Since there is a direct and strong correlation between night-time transpiration and vapour pressure decifit for non-stress situations, this nocturnal process will be likely increased in a climate change scenario, where it has been forecasted increases in night-time temperatures at higher rates compared to diurnal temperatures. Recent research has also shown that night-time water consumption accounts for 15-30% compared to diurnal transpiration, which is not considered in ET models. Therefore, it is of great importance to characterise night-time water consumption for different horticultural crops and its dynamics according to changes within and among seasons. In this study, the compensated heat-pulse (HP-c) sap flow technique was used to monitor five-year-old drip-irrigated olive trees (Olea europaea L. cv Arbequina) located at the Pencahue Valley, Maule Region, Chile (35° 23′ S; 71° 44′ W; 96 m above sea level) in the 2009-10 and 20010-11 growing seasons. The nocturnal component of water use measured by the HP-c technique was calculated from sunset to sunrise (S_n in L). An Eddy covariance system was installed in the orchard for both seasons to measure real ET. Results showed that night-time sap flow changed significantly within the same season and within seasons depending on different phenological stages and atmospheric demand. A parabolic relationship was found between plant water status estimated by canopy conductance (g_c) measured and S_n, which has been reported for other horticultural and fruit tree crops.

5)

Assessment of olive orchard water status variability using an unmanned aerial system (UAV).

Poblete-Echeverría, C[1]., Fuentes, S[2]., Ortega-Farias., S[1].
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ABSTRACT
Several studies have demonstrated that a certain degree of water stress improves olive oil quality. However, most of the currently available methods used for monitoring plant water status, are based on manual measurement points, which have low spatial resolution and are time-consuming. In this context, canopy temperature (Tc) has been recognized as a good indicator of plant water status. Nowadays, thermal images can be obtained from airborne sensors and satellites. However, airborne sensors are of high cost and operational complexity. On the other hand, satellite-based products have limited application in crop management due to low spatial and temporal resolutions. An alternative is the use of the unmanned aerial vehicles (UAVs), which allow solving the problem of lack frequency, spatial and spectral resolution presented by satellite platforms. Therefore, the main goal of this study is to assess plant water status and its spatial variability in a trial within a commercial olive orchard (Olea europaea L. cv. Arbequina) using infrared thermal images obtained from an UAV (Octocopter). Results show that thermal indices of water status derived from the infrared thermal data have strong correlated with ground measures of stomatal conductance (g_s) and midday stem water potential (Ψ_x).

Relevant images from presentations:

www.vineyardofthefuture.wordpress.com

Figure 1: Image and link to the Vineyard of the Future webpage, where news and papers are posted regularly in relation to latest advances on sensor tools and programs available to Viticulture and Winemaking.

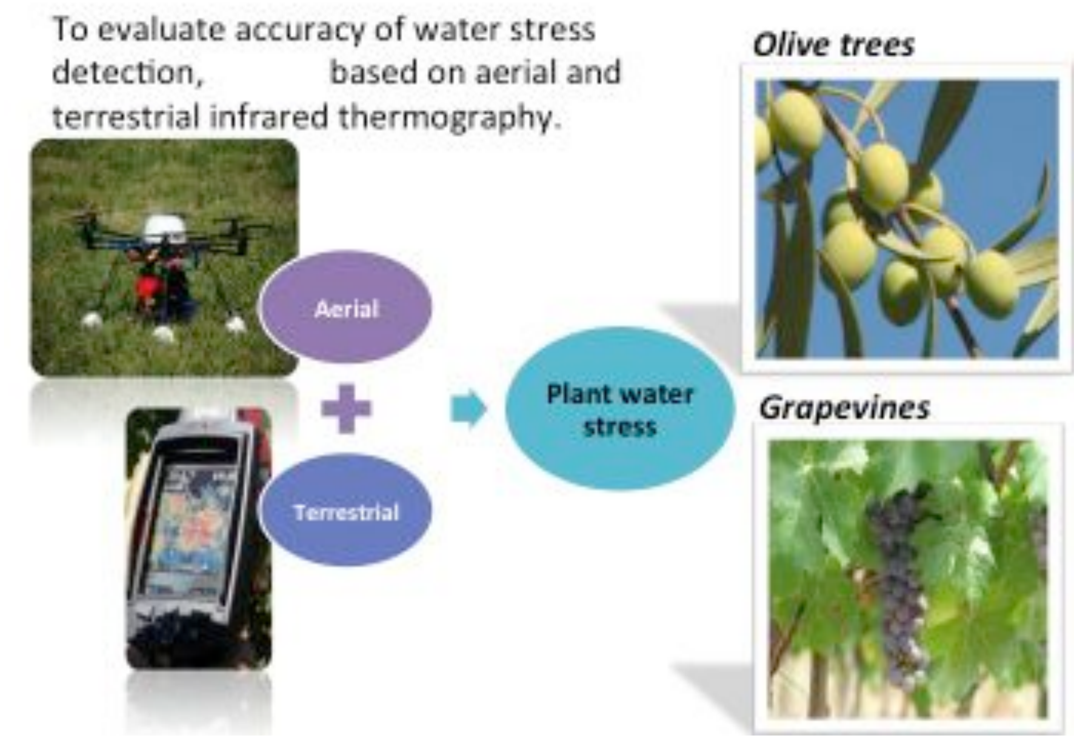

Figure 2: Proximal and short range remote sensing using infrared thermography for grapevines and olive orchards plant water status assessment.

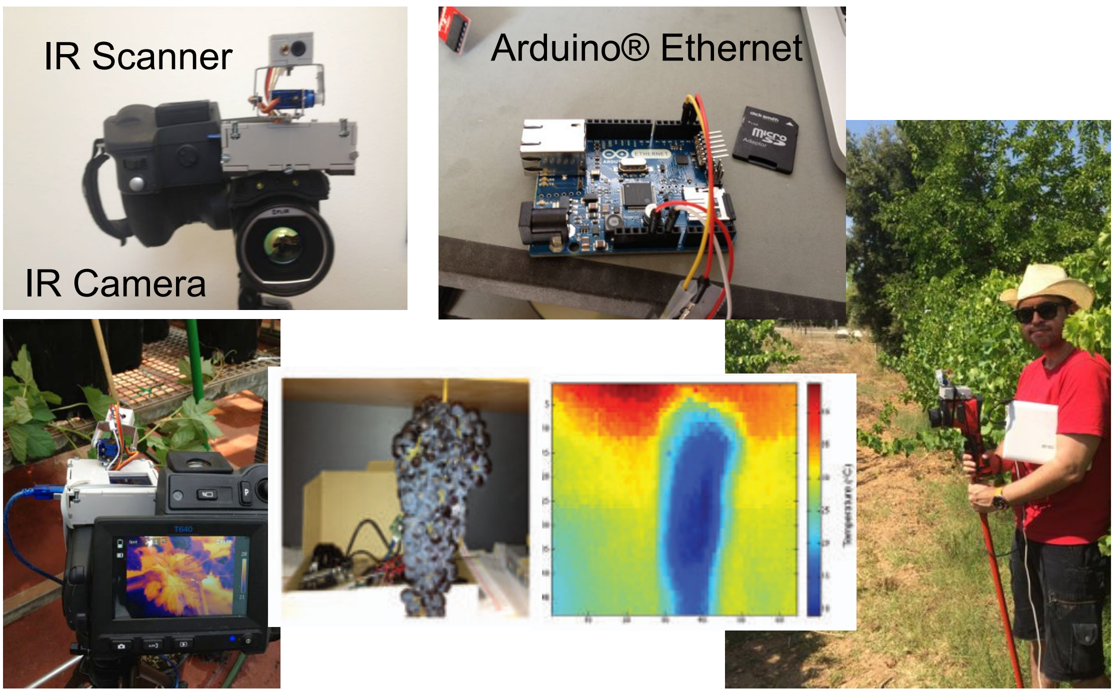

Figure 3: Low cost Infrared scanner kit compared to a high resolution infrared camera.

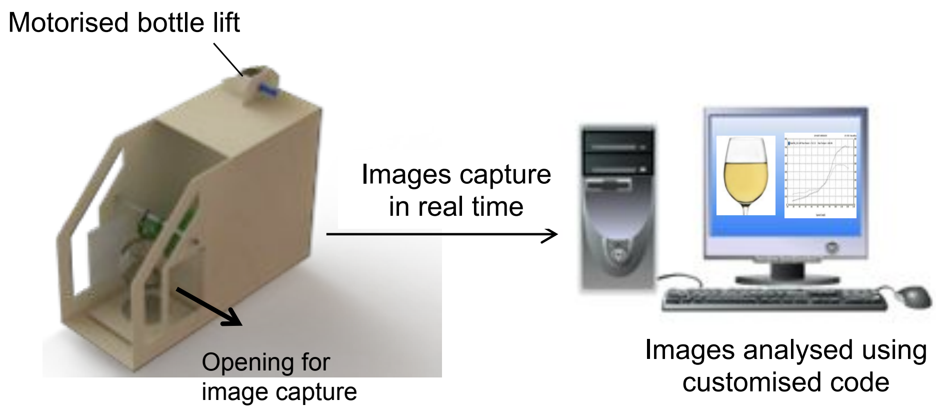

Figure 4: Robotic pourer kit and associated image analysis layout to assess quality of sparkling wine.

Relevant Literature Published in the Last Three Years

Following is a list of relevant publications to the presentations given at the Congress:

1. Poblete-Echeverría C., **Fuentes S.,** Ortega-Farias S., González-Talice S., Yuri J.A. 2014. Leaf area index (LAI) estimation by digital cover photography using a variable light extinction coefficient for apple orchards. ***Sensors***. (Accepted – In press).
2. **Fuentes S.**, Poblete-Echeverria C., Ortega-Farias S., Tyerman S., De Bei R. 2014. Automated Estimation of Leaf Area Index Using Cover Photography, video and Computational Analysis Methods. ***Australian Journal of Grape and Wine Research***. DOI: 10.1111/ajgwr.12098.
3. **Fuentes S**., De Bei R., Collins M., Escalona J.M., Medrano H., Tyerman S. 2014. Night-time responses to water supply in grapevines (Vitis vinifera L.) under deficit irrigation and partial root-zone drying. ***Irrigation Science*** (Accepted – In Press).
4. Trung-Ta Nguyen, **Sigfredo Fuentes**, Petra Marschner. 2013. Effect of incorporated or mulched compost on leaf nutrient concentrations and performance on Vitis vinifera L. cv. Merlot. ***Journal of Soil Science and Plant Nutrition***. 13(2): 485-497.
5. Marcos Bonada, Víctor Sadras, Martin Moran and **Sigfredo Fuentes**. 2013. Elevated temperature and water stress advance shrivelling, mesocarp cell death and sensory traits in Shiraz berries. ***Australian Journal of Grape and Wine Research.*** 31(6): 1317-1331.
6. Trung-Ta Nguyen, **Sigfredo Fuentes**, Petra Marschner. 2013. Growth and Water Use Efficiency of Capsicum annuum in a Silt Loam Soil Treated Three Years Previously With a Single Compost Application and Repeatedly Dried. ***International Journal of Vegetable Science.*** DOI: 10.1080/19315260.2013.764508
7. **Fuentes S**., Mahadevan M., Bonada M., Skewes M.A., Cox J.W. 2013. Night-time sap flow is parabolically linked to midday stem water potential for field grown almond trees. ***Irrigation Science***. DOI: 10.1007/s00271-013-0403-3.
8. Bondada M, Sadras V., **Fuentes S.** 2013. Effect of elevated temperature on the onset and rate of mesocarp cell death in berries of Shiraz and Chardonnay and its relationship with berry shrivel. ***Australian Journal of Grape and Wine Research***. 19: 87-94.

9. Escalona J., **Fuentes S.**, Tomas M., Martorell S., Flexas J., Medrano H. 2013. Responses of leaf night respiration and transpiration to water stress in Vitis vinifera L. ***Agricultural Water Management***. 118: 50-58.

Trung-Ta Nguyen, **Sigfredo Fuentes**, Petra Marschner. 2012. Effects of compost on water availability and gas exchange in tomato during drought and recovery. ***Plant, Soil and Environment.*** 11: 495-502.

10. **Fuentes, S.**, De Bei, R. Pech, J., Tyerman, S. **2012**. Computational water stress indices obtained from thermal image analysis of grapevine canopies**.** ***Irrigation Science***. 30(6): 523-536.

11. Poblete-Echeverria, C., Ortega-Farias, S., Zuniga M., **Fuentes, S. 2012**. Evaluation of compensated heat-pulse velocity method to determine vine transpiration using combined measurements of eddy covariance system and microlysimeters. ***Agricultural Water Management***. (109): 11-19.