Study tour to visit European apple tree physiology experts and attend the International Horticultural Congress in Lisbon

John Wilkie
Department of Employment, Economic Development & Innovation

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Agri-Science Queensland,
a service of the Department of Employment, Economic Development and Innovation (DEEDI)

AP10007

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The purpose of this project was for the project leader, John Wilkie, to gain a greater understanding of the options available for apple and pear planting systems and improve his ability to create innovative solutions for, and to improve the profitability and productivity of Australia's apple and pear industries in his role as a research horticulturist for Agri-Science QLD.

Funding sources: This project was funded by the levies of Australian apple and pear growers through Apple and Pear Australia Limited and the Australian federal government through Horticulture Australia Limited.

December 2010

Media Summary

Dr John Wilkie, Research Horticulturist with Agri-Science Queensland, undertook a study tour to Europe in August/September 2010 to attend the International Horticultural Congress in Lisbon and spend time with pome fruit scientists, growers and consultants in Italy, Spain, France, Belgium and the Netherlands.

The purpose of this tour was for Dr Wilkie to gain a greater understanding of the options available for apple and pear planting systems and improve his ability to create innovative solutions for, and to improve the profitability and productivity of Australia's apple and pear industries in his role as a research horticulturist.

Research efforts in the European countries tend to focus on improving productivity in their respective environments, with little focus on the comparative performance of systems in different environments. The Australian pome fruit industry, by contrast, has limited resources to undertake research across several production regions with diverse environments. Doing this may help the Australian industry better understand environmental influences on productivity, assist in the development of orchard systems and tree management appropriate to our unique conditions, and use limited R & D resources most effectively.

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Expected outcomes and how they were achieved

Introduction

Industry average commercial yields of apples and pears in Australia are well below the yields achievable using modern high density planting systems. The apple and pear industries have identified increasing productivity and fruit quality as a major focus for research, development and extension in the coming years. The industry has also identified that the professional development of personnel will play a key role in meeting this objective.

The purpose of the project was for the project leader, John Wilkie, to be exposed to the most recent advances and trends in horticultural tree physiology and

culture by attending the International Horticultural Congress in Lisbon and visiting pome fruit researchers, consultants, and commercial orchards in Europe. This will give the project leader a greater ability to develop ideas for current and future innovative research projects to benefit Australia's apple and pear industries.

Study tour

The primary project activity was a 4 week study tour to Europe (see Itinerary) which included attending the International Horticultural Congress in Lisbon (IHC 2010) and visiting apple and pear researchers and consultants in Italy, Spain, France, Belgium and the Netherlands.

Outcomes

The study tour and subsequent reflection was intended to:

1. Improve the project leader's understanding of current and experimental apple planting systems, culture and underlying physiology. This was achieved through attendance at the IHC 2010 and by visiting key pome fruit experts throughout Europe. The article I have written for the 'Australian Fruit Grower' (Appendix 3) demonstrates an in depth knowledge gained of the concepts associated with modern apple planting systems.
2. Improve the project leader's ability to develop innovative research projects for the benefit of the Australian pome fruit industries. For example, the tour highlighted the importance of environmental influences on apple growth and development (described in Appendices 1 and 3), and I am now in the process of developing a research proposal with other Australian pome fruit researchers to exploit the environmental variation between Australian apple growing regions to improve our understanding of rootstock effects on productivity and water relations.
3. Improve the project leader's international scientific network. Both the IHC 2010 and the study tour were very useful for improving my networks. One idea I had was to use my existing contacts and those I made while away to start a 'young tree crop researcher's network'. This is because broadly there are two cohorts of tree crop researchers; those that are in their mid to late careers (and they already have their networks established) and those who are in their early careers like myself who are still developing their networks.

4. Provide a foundation for future international collaborations. A number of the scientists (from research centres in Italy and France) have similar or complementary skill sets to our Agri-Science Qld apple physiology and variety evaluation research team and may be useful in future collaborations. One method of international collaboration with these research centres is to utilise the exchange of PhD students. This should be investigated as a part of future project development.

Results of discussions

I have integrated the major themes of the study tour in the 'Australian Fruit Grower' article (Appendix 3). I think this is generally a more valuable exercise for industry than summarising individual discussions. The highlights of the IHC 2010 are included in Appendix 2, and further implications for my research interests are included in Appendix 1.

Implications for Australian horticulture

The implications of the project in terms of future productivity research for the pome fruit industries are discussed in Appendices 1 and 3.

How the information gathered will be disseminated

On 27 October I presented some of the main findings of the trip to an audience of Queensland apple growers at Applethorpe Research Station. Daniel Nicoletti, a local grower, also presented findings from his study tour to the Washington state apple industry during August 2010. The talks were attended by approximately 20 growers, 1 apple industry consultant, 1 Apple and Pear Australia Limited (APAL) director and the APAL Technical Manager.

I have submitted an article (Appendix 3) in December 2010 on some of the findings from my study tour to be published in the 'Australian Fruit Grower', the major Australian apple industry journals.

The major use of the information I gathered on the study tour will be its integration into future research projects for the Australian pome fruit industries.

Itinerary

14/08/10	Depart Brisbane
15/08/10	Arrive Rome, Travel by train to Bologna
16/08/10	University of Bologna, Italy: Professor Luca Corelli Grappadelli; Dr Luigi Manfridi
17/08/10	Travel Bologna to Trento
18/08/10	IASMA San Michele, Italy: Nicola Dallabetta (apple planting systems expert) and Paolo Lezzer (PhD student- apple tree physiology).
19/08/10	Laimburg Research Station South Tirol, Italy: Dr Walter Guerra (apple breeder), Philip Brunner (apple physiologist), Paolo Lezzer.
20/08/10	South Tirol, Italy: Bernhard Botzner (apple production consultant)
21/08/10	Travel Bolzano, Italy to Lisbon, Portugal (air)
22/08/10	Lisbon: International Horticultural Congress (IHC) registration, meeting of ambassadors of IHC 2014 Brisbane, and IHC 2010 opening
23-26/08/10	Lisbon: presentations, meetings and workshops of the IHC. Exposure to the most recent international horticultural research; opportunities to meet and develop ideas with international horticultural experts.
27/08/10	Depart Lisbon – arrive Zaragoza, Erbo Valley, Spain for deciduous fruit tree production official Post-Conference tour.
28-30/08/10	Erbo Valley, Spain: This official post-conference tour led by Dr Joan Bonany included visits to Aula Dei Research Station, pome fruit experimental sites, and pome and stone fruit orchards and packing houses.
30/08/10	Depart Lleida, Spain and travel by train to Montpellier, France.
31/08/10	French National Institute for Agricultural Research (INRA), Montpellier: Prof Jean-Luc Regnard (apple physiologist and water relations expert) At this research facility I spent time with Dr Pierre-Eric Lauri, Dr Evelyne Costes and colleagues to learn about apple tree structure, apple tree training systems and physiological modeling of apple trees.

01/09/10	Southern French apple production areas with Dr Pierre-Eric Lauri (tree architecture and apple planting systems expert)
02/09/10	INRA Montpellier, France: Dr Evelyne Costes (apple tree physiologist and modeling expert)
03/09/10	INRA Montpellier, France: Dr Jean-Michel Legave (crop modeling – currently modeling the effects of climate change on apple phenology)
4/09/10	Depart Montpellier, France and arrive Brussels, Belgium (stopover on way to Netherlands)
5/09/10	Belgium to Wageningen, Netherlands (train)
06/09/10	Applied Plant Research, Wageningen University, Netherlands: Dr Frank Maas (apple and pear planting systems expert)
07/09/10	Wageningen and other apple and pear growing areas in the Netherlands: Jan Peeters (apple and pear production consultant). Then train to Sint Truiden, Belgium.
08/09/10	Royal Research Station for Fruit Growing, Sint Truiden, Belgium: Dr Tom Deckers (apple and pear planting systems expert)
09/09/10	Travel from Sint Truiden, Belgium to Amsterdam, Netherlands.
10-11/09/10	Travel from Amsterdam to Brisbane

Recommendations

The recommendations from the project in terms of future productivity research for the Australian pome fruit industries are discussed in Appendices 1 and 3. Briefly, environmental influences on pome fruit culture should not be underestimated. The need to undertake research across multiple environments with limited resources is a challenge for Australian apple and pear industries with limited R & D resources available nationally, but will result in a greater understanding of our growing environments and the required variation to cultural practices to optimise performance between environments.

I would recommend a study tour for interested Australian pear growers to Sint Truiden in Belgium to visit Dr Tom Deckers and Wageningen in the Netherlands to

visit Fruit Consult and Dr Frank Maas, and also to the University of Bologna where highly productive pear planting systems are used both commercially and experimentally.

Acknowledgements

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Appendices

Appendix 1: Critical analysis of current and future research directions of the Agri-Science Queensland apple physiology and variety evaluation research team

Our goals

As part of Agri-Science Queensland, an arm of DEEDI, an economic development agency, our goal is to further the development of Queensland agricultural industries through innovation.

Agri-Science Queensland participates in Australian pome fruit research under the National Framework. As part of this process the research we undertake is broadly aimed at improving the productivity and profitability of the Australian pome fruit industries.

The two goals are not mutually exclusive.

Current agronomy/physiology research

Our team focus is apple variety evaluation, developing tree management strategies, and to a lesser extent furthering the understanding of the underlying apple physiology.

Agri-Science Queensland has had an active apple breeding program since the mid 1980's with the aim of developing apple scab resistant varieties for the Australian industry. This program is in its final stages, focussing on the evaluation of the elite progeny. We are collaborating with scientists from the Queensland Alliance for Agriculture and Food Innovation (QAAFI) to determine the consumer acceptability of the elite scab resistant selections.

A separate project is focussing on developing tree management packages for a small number of the elite progeny which have the greatest chance of commercialisation. The management package includes suitability of rootstocks, appropriate crop loads, appropriate thinning times, seasonal fruit development, etc.

This multi-faceted approach to variety development acknowledges that success of a new variety depends on both market acceptability and high productivity and quality in high density planting systems. One research team undertaking these two research areas, and using external expertise where necessary, is an efficient system for developing the new varieties.

We are also involved in the Productivity Irrigation Pests and Soils (PIPS) research program as part of the Tree Structure components research team. Collaborating organisations include Plant and Food Research New Zealand (PFR) and the Tasmanian Institute for Agricultural Research (TIAR). The Tree Structure component is looking at how manipulations to apple tree architecture affect fruit quality and productivity as a basis for developing a precision apple tree management system.

We are also part of a research team undertaking a desktop study on the potential effects of climate change, in particular the effects of changing temperature and rainfall patterns, on apple growth and development, and the implications for horticultural management. Collaborating organisations include Growcom, South Australian Research and Development Institute (SARDI), and Victorian DPI

So, we undertake a range of research trials, including planting systems on the Applethorpe Research Station and on commercial orchards around Stanthorpe. This work is of course of direct relevance and benefit to the Queensland and Australian industry. We also collaborate extensively with other Australian and international research providers, including being part of work being undertaken in other Australian states, which satisfies our role as part of the National Framework due to the national relevance of the research.

The study tour

The study tour allowed me to see current apple and pear research efforts and commercial practices across a number of sites in Europe. Each of these growing regions had their own research centres, which were in general focussed on issues of relevance to their particular environments. For example, in Spain one of the main research efforts of the 'Institute for Research and Technology in Agriculture', based near Lleida in Catalonia, is the development of apple and pear varieties acclimated to produce high quality fruit in their hot and dry environment.

Cultural practices, including the preferred planting systems in the commercial orchards, varied between countries, and even growing environments within countries. For example, in southern France the most common apple planting system is the 'Centrifugal' training system, which is characterised by permanent branches and dormant pruning that removes only those fruiting shoots on the permanent branches that are excess to the required crop load or that will produce poor quality fruit. By contrast, the preferred planting system in the Netherlands uses a branch renewal strategy, in which branches are removed whenever they become too large or they are leading to crowding and shading.

The above examples of specific research priorities and cultural practices for different apple growing regions highlight the need to alter cultural practices with environmental conditions to optimise productivity.

The focus for future agronomy/physiology work

The examples above also highlight the challenges for the Australian pome fruit industry. The Australian industry is spread across a range of growing regions encompassing diverse environments, which undoubtedly influence the physiology of the trees. We need to be undertaking our research trials in a range of Australian growing environments to better understand the factors affecting the growth and fruiting of our apple trees in these areas. This understanding will help us to modify our cultural practices and genetics appropriately. The PIPS research program is currently undertaking research in multiple environments, and I think we need to continue to this trend.

Our research team has a considerable number of international scientific contacts, which should be further utilised in future project development. One avenue for international collaborations is through the exchange of PhD students, who may undertake more fundamental research as part of a larger industry focussed project.

Appendix 2: IHC 2010

The IHC in Lisbon allowed me to keep up-to-date with the most recent advances in the understanding of the physiology, breeding, management and potential implications of climate change of horticultural crops.

The major advantage of attending the IHC is that the event is sufficiently large that you will be able to view content that is directly relevant to your own field of research, but also view content from different fields with different paradigms that may lead to the transfer of ideas.

Another benefit of the IHC 2010 was of course the development of international networks with other scientists at the meeting. As an ambassador for the IHC 2014 to be held in Brisbane I was also able to further develop contacts with scientists from Australia and New Zealand through a team meeting on Sunday 22 August and by staffing the IHC 2014 promotional booth.

A few technical highlights of the IHC 2010 included:

1. Evidence for a genetic component to the regulation of biennial bearing in apple trees (Guitton B *et al*.). As this work develops further it will give horticulturists a greater understanding of how the genetic and environmental components of the biennial bearing of fruit trees are related; and potentially lead to novel management strategies.
2. The development of permanently inserted stem micro-tensiometers for the continuous monitoring of water potentials in trees and vines (Lakso *et al*.). This technical development may lead to significant advances in the experimental systems available for understanding water use in tree and vine crops.
3. The physiology, biochemistry and genetics of fruit growth seminar convened by John Palmer and Stuart Tustin from Plant and Food Research New Zealand. This 1-day session included overviews of the current knowledge of pome and stone fruit growth and development and integrated this knowledge with advances in orchard planting systems and canopy architecture. This was an important session

for developing future ideas in apple planting systems due to the commercial importance of fruit quality.

4. A workshop held on Functional-Structural Modelling of horticultural crops chaired by Evelyne Costes (INRA, France) and Jim Hanan (The University of Queensland). This session allowed me to develop a greater understanding of the power of using Functional-Structural models to understand the underlying physiology of horticultural tree crops.
5. A 1 day thematic session on fruit production systems chaired by Anthony Webster from the United Kingdom. This session included important advances in orchard plantation technologies.

Appendix 3: Article to be submitted to the 'Australian fruit grower' industry journal

European trends in apple planting systems

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Trends in planting systems

I was recently fortunate enough to visit apple and pear growing regions in Italy, Spain, France, Belgium and the Netherlands as part of a study tour, which also included attending the International Horticultural Congress in Lisbon, Portugal. The tour was funded by the levies of apple and pear growers and Horticulture Australia Limited.

The main purpose of the study tour was to have a look at commercial and experimental apple planting systems and culture across these European growing regions, and look at the potential applications for Australian environments.

There were a few important similarities in the apple culture between these growing regions. The all encompassing similarity is the use of high density planting systems. Prof Luca Corelli Grappadelli from the University of Bologna described the evolution of planting systems as a continuum from old style inefficient low density orchards to modern high density highly productive orchards. I suppose one of the major reasons these growers are further along this continuum than the Australian industry, in general, is that their land costs can be extraordinarily high. For example, Figure 1 is a view of a valley in the South Tirol province in northern Italy. I was quoted values for horticultural land in these areas of northern Italy at anywhere from 600 000 to 1 million Euros per hectare (approx. $900 000 to $1.5 million), and

consequently there is barely a single square metre of land down in that valley that is not being utilised for either high value horticulture or urban land use.

A second similarity between these growing regions is the planting of highly feathered 2-year-old trees. This advanced planting material is essential for the high early yields these growers require. I suppose their focus on high early yields is another consequence of their high land prices.

A third similarity is the choice of rootstock, with 'M.9' being the rootstock of choice in all growing regions. This is because 'M.9' tends to give trees in these areas the right balance of precocity, vigour and fruitfulness. I think rootstock performance in Australian environments is a question that requires more attention, I think we would benefit significantly from a greater understanding of how a range of rootstocks perform under the very varied growing environments throughout Australia.

Of course there were also differences in the planting systems used by growers in the different regions. I think the biggest conceptual difference I encountered was that of systems that use permanent branches compared with systems that renew branches.

The majority of the apple training systems that I encountered, across most of the growing regions, used renewal pruning on at least a portion of their canopy. For example the predominant training systems promoted in the Netherlands is a central leader with a base level tier of 3 to 4 branches that are supported by 1 trellis wire on either side of the row about 1.2 m above the ground and about 0.4m from either side of the trunk. The supports for these basal tier branches allows further extension of these branches into the row than would be possible under the weight of fruit which they carry. These branches only remain while they are considered to have a good balance between vegetative and reproductive growth, and are removed for renewal once their diameter increases above one third to one half of the diameter of the central leader. The remaining lateral branches along the central leader are non vigorous branches that are renewed frequently. Replacement shoots in their first year of growth are retained only if they have a terminal flower bud that will produce fruit in the following season. Following their second season of growth, the one-year-old wood at the apex of these later shoots will often be tip-pruned.

One system that relies on permanent branches is the centrifugal training system which was developed in southern France by Dr Pierre-Eric Lauri. Well spaced limbs along the central leader of the tree are retained and bent down to below the

horizontal to manage the balance between flower production and vegetative growth. Structural dormant pruning of these trees aims to leave the permanent branches complex. Shoots are removed from the permanent branches for one of three reasons. First, shoots are removed if they originate from the bottom of the branches and are growing toward the ground, because the fruit produced on these shoots is likely to be shaded. Second, all shoots and spurs close to the trunk are removed, because fruit originating from these shoots is also likely to be shaded. Third, spurs and short-to-medium length one-year-old shoots that appear to contain flower buds are counted and any of these spurs and one-year-old shoots that are excess to the target crop load, based on the fruit per cm^2 of branch cross-sectional area, are removed. The result is a tree structure characterised by long, pendant, complex limbs, and more regular bearing even in inherently biennial cultivars such as 'Fuji'.

The two systems described above are conceptually very far apart, but they achieve exceptional results in their respective environments, which are also very different. I think the main lesson for us here is that whatever system we use, we need to make sure that its components (rootstock, planting density, etc) combine to deliver a system suitable to the environment.

The Tree Structure component of the current PIPS (Productivity, Irrigation, Pests and Soils) research program is developing a management strategy for Australian growing environments which has similarities to the French centrifugal training system described above. One benefit I see of the approach being trialled by the PIPS research team is that it will potentially provide a method for precision management to be applied to existing central leader systems that are planted at a range of densities and on a range of rootstocks.

New ideas

One of the things in the back of the minds of several of the scientists I visited is potential planting systems for a future of mechanisation and robotics. So how can we manipulate apple tree canopies to present the fruit for automated thinning, harvesting, and other operations?

There were two planting systems in particular which appeared to have characteristics suitable for mechanisation. The first is the so called 'Fruit Wall', which I saw trialled at the San Michele all'Adige Institute for Agriculture (IASMA), but which I believe has been developed in France by CtiFl. The version of the 'Fruit

Wall' that I saw was a high density central leader setup for which minimal dormant pruning is undertaken. During the growing season, when the new shoots are still actively growing, the trees are mechanically pruned with a vertical cutter bar. The result is a very even canopy surface with well exposed fruit (Fig 2).

The second system is the 'Bi-baum' (double leader), which I also saw at IASMA in northern Italy (Fig 3). These double leader trees are planted at densities similar to a high density spindle tree, with maybe 10% less trees within the row. The idea behind these double leader trees is that the vigour is split between the two leaders, so that vegetative growth is easier to manage. Lateral shoots on the double leader trees tend to be less vigorous than on single leader trees, which will probably lead to a narrower canopy than a single leader tree and greater exposure of the fruit to canopy surface. I think it will be exciting to watch the evolution of these double leader systems over the next few years.

Where to for the Australian industry

I think any of these new planting systems are worth evaluating for adaptation to the Australian industry, but if we're going to get the most out of our limited research funds we probably need to think a little more strategically than empirically testing a range of new apple planting systems on a research station somewhere. This is because the Australian industry is spread across such diverse environments, and we can't underestimate these influences. We need to be undertaking our research trials in a range of our Australian growing environments to better understand the factors affecting the growth and fruiting of our apple trees in these areas. This understanding will help us to modify planting systems appropriately. The PIPS research program is currently undertaking research in multiple environments, and I think we need to continue this trend. The obvious place to start would be to look at the performance of our conventional and emerging rootstocks in a number of Australian growing regions (this has never been done in Australia), from both a productivity and underlying physiological perspective.

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Legave, Dr Frank Maas, Jan Peeters, Dirk van Hees and Dr Tom Deckers, for spending time with me. I also thank Apple and Pear Australia and Horticulture Australia Limited for the funding.

Fig 1. The intensive use of high value horticultural land in northern Italy.

Fig 2. A version of the ‘Fruit Wall’ grown at the IASMA research centre in northern Italy.

Fig 3. An example of the ‘Bi-baum’ apple training system at the Laimburg Experimental Station in South Tirol, Italy.