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PROTECTED CROPPING

Leigh Taig
ISS Institute/TAFE Fellowship

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Executive Summary

Australia is one of the driest continents on Earth, yet many of our irrigation practices and techniques are inefficient and wasteful of such a precious resource. The hydroponic and greenhouse industries (protected cropping) are models of efficiency when we look at production levels for the relatively small environmental footprint they occupy. Despite these efficiencies, protected cropping is still in its infancy in Australia, with Europe and North America leading the way in greenhouse technology.

At present Australia has significant skills deficiencies in the Protected Cropping Industry. Skills to manage the overall environment within the greenhouse are:

- Access to suitable skills and knowledge to collect and record data for crop registration of a variety of crops (benchmarking)
- Physiology and manipulation of the growing plant and its relationship to number, size and quality of fruit (such as tomato or strawberry) and other products (edible foliage, roots)
- Knowledge of latest techniques and technologies and the ability to evaluate/adapt to Australian growing environments
- Understanding of the role of nutrients and their affect on number, size and quality of fruit and other products

The threat of global warming and climate change makes it imperative that Australia is prepared for possible water shortages and extreme weather conditions. Taig believes that protective cropping offers a viable, productive growing system that meets the financial, environmental and social requirements of the future.

Australian growers have very little access to current skills and knowledge of hydroponics and greenhouse growing. Hydroponics is an extremely cost effective way of producing a range of fresh produce, however comparisons of yields between European and Australian growers in many greenhouse crops indicate that we still have a long way to go.

The Fellowship was partly undertaken in conjunction with 15 growers from the Australian Hydroponic and Greenhouse Association 2007 Greenhouse Study tour. Together this group participated in five days training at the Practical Training Centre Plus (PTC+) in Ede, Netherlands, visited a number of growers, research facilities, and allied enterprises, as well as attending the Horti Fair over two days. In addition, prior to and immediately after the tour, meetings were held with representatives from PTC+ and nearby Wageningen University.

It is important for the industry to not only catch up with current technology but to stay abreast of new and emerging technologies. Initially the skills and knowledge in hydroponic and greenhouse management acquired will be passed on directly to growers, their staff, horticulture students and other TAFE teachers, improving yields and the overall wellbeing of the industry. However, the greater long term benefit will be the relationships initiated with organisations like PTC+, Wageningen University, representatives of AHGA, and the opportunity to establish specialist centres in Australia.

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Abbreviations and Acronyms

AHGA	Australian Hydroponic and Greenhouse Association
AQF	Australian Qualification Framework
CEH	Controlled Environment Horticulture
CO_2	Carbon Dioxide
DPI	Department of Primary Industries
GIC	Greenhouse Improvement Centre
GOTAFE	Goulburn Ovens Institute of TAFE
IPM	Integrated Pest Management
ISS Institute	International Specialised Skills Institute
m^2	Square metres
OTTE	Office of Training and Tertiary Education
PTC+	Practical Training Centre Plus
RSVP	Research Station for Vegetable Production
TAFE	Technical and Further Education
VET	Vocational Education and Training

Acknowledgments

Leigh Taig would like to thank the following individuals and organisations who gave generously of their time and their expertise to assist, advise and guide him throughout the Fellowship program.

Awarding Body – International Specialised Skills Institute (ISS Institute)

We know that Australia's economic future is reliant upon high level skills and knowledge, underpinned by design and innovation.

The International Specialised Skills Institute Inc (ISS Institute) is an independent, national organisation, which has a record of nearly twenty years of working with Australian industry and commerce to gain best-in-the-world skills and experience in traditional and leading-edge technology, design, innovation and management. The Institute has worked extensively with Government and non-Government organisations, firms, industry bodies, professional associations and education and training institutions.

The Patron in Chief is Sir James Gobbo AC, CVO. The ISS Institute Board of Management is Chaired by Noel Waite AO. The Board comprises Franco Fiorentini, John Iacovangelo, Lady Primrose Potter AC and David Wittner.

Through its CEO, Carolynne Bourne AM, the ISS Institute identifies and researches skill deficiencies and then meets the deficiency needs through its *Overseas Skill Acquisition Plan (Fellowship Program),* its education and training activities, professional development events and consultancy services.

Under the Overseas Skill Acquisition Plan (Fellowship Program) Australians travel overseas or international experts travel to Australia. Participants then pass on what they have learnt through reports, education and training activities such as workshops, conferences, lectures, forums, seminars and events, therein ensuring that for each Fellowship undertaken many benefit.

As an outcome of its work, ISS Institute has gained a deep understanding of the nature and scope of a number of issues. Four clearly defined economic forces have emerged out of our nearly twenty years of research. The drivers have arisen out of research that has been induced rather than deduced and innovative, practical solutions created - it is about thinking and working differently.

A Global Perspective. 'Skills Deficiencies' + 'Skills Shortages'

Skill deficiencies address future needs. Skill shortages replicate the past and are focused on immediate needs.

Skill deficiency is where a demand for labour has not been recognised and where accredited courses are not available through Australian higher education institutions. This demand is met where skills and knowledge are acquired on-the-job, gleaned from published material, or from working and/or study overseas. This is the focus of the work of ISS Institute.

There may be individuals or firms that have these capabilities. However, individuals in the main do not share their capabilities, but rather keep the IP to themselves; and over time they retire and pass way. Firms likewise come and go. If Australia is to create, build and sustain Industries, knowledge/skills/understandings must be accessible trans-generationally through nationally accredited courses and not be reliant on individuals.

Our international competitors have these capabilities as well as the education and training infrastructure to underpin them.

Addressing skill shortages, however, is merely delivering more of what we already know and can do to meet current market demands. Australia needs to address the ***dual*** challenge – skill deficiencies and skill shortages.

Acknowledgments

Identifying and closing skills deficiencies is vital to long-term economic prospects in order to sustain sectors that are at risk of disappearing, not being developed or leaving our shores to be taken up by our competitors. The only prudent option is to achieve a high skill, high value-added economy in order to build a significant future in the local and international marketplace.

The Trades

The ISS Institute views the trades as the backbone of our economy. Yet, they are often unseen and, in the main, have no direct voice as to issues which are in their domain of expertise. The trades are equal, but different to professions.

The ISS Institute has the way forward through its 'Master Artisan Framework for Excellence. A New Model for Skilling the Trades', December 2004. The Federal Government, DEEWR commissioned ISS Institute to write an Australian Master Artisan School, Feasibility Plan.

In 2006, ISS Institute Inc. set up a new ISS advisory body, the **Trades Advisory Council.** Members are Ivan Deveson AO; Martin Ferguson AM, MP, Federal Labor Member for Batman; Geoff Masters, CEO, Australian Council of Educational Research; Simon McKeon, Executive Chairman, Macquarie Bank, Melbourne Office; Richard Pratt, Chairman, Visy Industries and Julius Roe, National President Australian Manufacturing Workers' Union.

Think and Work in an Holistic Approach along the Supply Chain - Collaboration and Communication

Our experience has shown that most perceive that lack of skills is the principal factor related to quality and productivity. We believe that attitudes are often the constraint to turning ideas into product and a successful business; the ability to think laterally, to work and communicate across disciplines and industry sectors, to be able to take risks and think outside the familiar, to share – to turn competitors into partners.

Australia needs to change to thinking and working holistically along the entire Supply Chain; to collaborate and communicate across industries and occupations - designers with master artisans, trades men and women, Government agencies, manufacturers, engineers, farmers, retailers, suppliers to name a few in the Chain.

'Design' has to be seen as more than 'Art' discipline – it is a fundamental economic and business tool for the 21st Century

Design is crucial to the economic future of our nation. Australia needs to understand and learn the value of design, the benefits of good design and for it to become part of everyday language, decision making and choice.

Design is as important to the child exploring the possibilities of the world, as it is to the architect developing new concepts, and as it is to the electrician placing power points or the furniture designer working with a cabinet-maker and manufacturer. As such, design is vested in every member of our community and touches every aspect of our lives.

Our holistic approach takes us to working across occupations and industry sectors and building bridges along the way. The result has been highly effective in the creation of new business, the development of existing business and the return of lost skills and knowledge to our workforce, thus creating jobs - whereby individuals gain; industry and business gain; the Australian community gains economically, educationally and culturally.

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In Australia

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- Graeme Smith, National President, Australian Hydroponic and Greenhouse Association
- Steve Caruthers, Editor, Casper Publications

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- Ben van den Brink, Horticulture Programme Manager, PTC+, Ede
- Ben van Onne, Trainer/Course Developer, PTC+, Ede
- Engelie Benneen Account Manager, PTC+, Ede
- Rene van Geneijan, Specialist Teacher in Irrigation, PTC+, Ede
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- Dr Uulke van Meeteren, Associate Professor, Horticultural Production Chains Group Department, Wageningen University, Netherlands

Australian Organisations and Peak Bodies Impacted by the Fellowship Program

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- Skills Victoria
- Primary Skills Victoria
- Agrifoods Industry Skills Council

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Industry and Professional Associations

- Australian Hydroponic and Greenhouse Association
- Hydroponic Farmers Federation (Victoria)
- Horticulture Australia Limited
- AusVeg
- Victorian Vegetable Growers Association
- Tasmanian Association of Greenhouse Growers

Education and Training

- Goulburn Ovens Institute of TAFE
- Victorian Horticulture Teachers Network

Community

- Violet Town Nursing Home
- Shire of Strathbogie
- City of Greater Shepparton
- Rural City of Wangaratta
- Alpine Valleys Leadership Program

About The Fellow

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Qualifications

- Graduate Certificate in Leadership in Education and Training, Victoria University, 2006
- Graduate Diploma in Vocational Education and Training, Latrobe University, 2004
- Diploma in Applied Science (Horticulture), University of Melbourne, 2002
- Certificate IV in Workplace Assessment and Training, GOTAFE, 2002

Memberships

- Member of the International Plant Propagation Society
- Associate Member of the Australian Hydroponic and Greenhouse Association

Over a career of almost 30 years Leigh Taig has gained a breadth of experience in the horticulture industry. His career in horticulture began as an apprentice with the City of Bendigo. Upon qualification he worked as a head gardener, ran his own garden maintenance business and in addition, established a retail and wholesale production nursery. In the early nineties he began a diploma course at the University of Melbourne Burnley campus and started teaching horticulture sessionally at GOTAFE.

Taig's knowledge of horticulture and his ability to communicate with his students saw his teaching career develop. He gained a number of qualifications in education and assumed substantial responsibility when he was appointed as acting manager on three separate occasions at GOTAFE.

In 2005 his organisation enrolled him in a leadership course with Victoria University, run in conjunction with the Chair Academy (USA). Taig is currently Manager of Horticulture at GOTAFE where he combines his practical knowledge of the industry and his leadership skills.

Away from work Taig's interests include gardening, drawing, home renovations and relaxing with his family and friends.

The Fellowship Program

Aims of the Fellowship Program

Protected cropping (hydroponics in particular) is a rapidly developing sector of the Production Horticulture Industry. There is no current national accredited Training Package or dedicated training facility that is devoted to this important sector.

Europe and Canada are particularly well-advanced in terms of technology and skills within greenhouse growing and are also well-advanced in greenhouse training. Recognising this need, industry consultant Graeme Smith, in conjunction with the Australian Hydroponic and Greenhouse Association (AHGA), hosted an annual greenhouse study tour for Australian growers. It was an opportunity to participate in training and gain access to a variety of horticultural enterprises and facilities recognised for utilising new technology and demonstrating current practices.

The Fellowship program included a five day course in greenhouse management delivered by the Practical Training Centre Plus (PTC+) in Ede, Netherlands, attendance at Horti Fair, meeting with management and staff at PTC+ and Wageningen University, as well as five days of industry visits, to look at state-of-the-art technology and practices.

The primary aim of this Fellowship was to gain first hand experience of the practical skills required for high level management and control of various greenhouse systems – matching the greenhouse environment to the exact requirements of the crop. In addition to this, the Fellowship looked at PTC+ as a model for delivery of training in the area of protected cropping. In addition the Fellowship provided an opportunity to:

- Understand the methods of collection and recording of data for crop registration of a variety of crops (benchmarking)
- Understand the physiology and manipulation of the physical environment of the growing plant and its relationship to optimum production.
- Observe the latest techniques and technologies in greenhouse production – especially in relation to water and energy conservation.
- Differentiate techniques and technologies for use in the broad context of the Australian Greenhouse Industry.
- Understand the role of nutrients and their affect on greenhouse production.
- Understand current education pathways and models in the Netherlands for training in greenhouse production, with particular emphasis on operational management with the intention of determining how this training might be used in an Australian context.
- Develop ongoing education programs through ISS Institute, Goulburn Ovens Institute of TAFE and other educational institutions.

The Australian Context

An Overview of the Industry

"Over the last 10 to 15 years there has been a rapid growth in the controlled production industry around the world and continued growth is anticipated. Types of crops that are presently grown include tomatoes, capsicums, cucumbers, lettuce, herbs, nursery plants, Asian vegetables, strawberries and cut flowers." (Smith, 2006, p.4)

There are also opportunities for a larger, diversified range of new, niche annual or perennial crops – together with applications in other areas such as utilising nutrient rich waste water from aquaculture (aquaponics).

According to Smith (2006, p.4): *"…there are a number of reasons behind the growth in controlled environment agriculture.*

These include:

- *Consistent quality*
- *Higher yields*
- *Reduced chemical usage*
- *Reduced post harvest and in-store wastage*
- *Cosmetically appealing*
- *Tend to taste better than field produce*
- *Higher prices*
- *Less chance for food-safety contamination*

The Dutch are recognised as world leaders in controlled environment production. The Netherlands has a total controlled environment production area of some 10,000 hectares comprising over 13,000, mostly family based farms that employ an estimated 40,000 people. Most other countries have tended to follow Dutch methods.

The Dutch industry is moving towards almost complete automation of glasshouse production to reduce labour costs. Controlled environment research is primarily focused on productivity improvement and greater energy efficiency." (Smith, 2006, p.4)

"Australian horticulture is the fastest growing primary production sector in Australia. Australia has one to two percent of world output of horticultural products. The industry is a vibrant and growing producer of goods valued at more than $6.5 billion; a direct employer of almost 100,000 Australians; and includes the nation's most innovative food producers, processors and exporters." (Horticulture Australia Council, 2005, p.3)

Protected cropping currently shares a growing proportion of this output. According to Smith (2006): *"The Australian Protected Cropping Industry is the fastest growing food producing sector in Australia. Farmgate value per annum is an estimated $600 million; this is equivalent to 20% of the total value of vegetable and flower production nationwide. Combining all sectors (retail, service providers, research, etc), the industry contributes around $1 billion to the national economy, and is estimated to employ over 10,000 people throughout Australia."*

The Australian Context

Market and Structure of the Protected Cropping Industry

Historically, horticultural industries consisted of numerous small holdings, often strategically close to major urban markets. Those patterns still persist but there are other trends at work as well. While the number of production enterprises continues to grow (from 15,000 to over 17,250 in four years) there is also consolidation occurring.

According to Smith (2006) *"Current investment in greenhouse infrastructure is valued at $975 million, with expected investment in new infrastructure valued at $45 million over the next 12 months."* Most of this investment will be larger developments of 0.5 hectares or more.

At a recent Industry conference however, informal discussions with various industry professionals suggests that projected figures for future infrastructure may well be extremely conservative. One project, which is in the advanced stages of planning, will invest a total of $100 million dollars at 10 separate sites. Several other projects discussed were at various stages of development and painted a picture of large scale expansion by a number of experienced hydroponic operators.

While horticultural industries are spread throughout Australia, *"In many industries the few biggest producers account for the majority of all produce (eg in the mushroom industry, five businesses produce 60% of the national crop and for processed tomatoes, 60% of the volume comes from 15% of growers). There has been a move from 'market gardening' (small scale enterprises) to 'vegetable farming' (much larger enterprises). A similar consolidation has also occurred in sales. Many lines of produce are now sold predominantly through supermarkets; where the major companies dominate sales. It is estimated that 55% of fruit and vegetables are sold via the major two supermarket chains; Coles and Woolworths. For vegetables alone, around 70% is sold fresh; with over 80% of that produce moving through supermarket chains."* (Australian Horticulture Report, 2007).

This almost certainly seems to be the future of a significant proportion of the Protected Cropping Industry. There are a number of large enterprises such as Moraitis Group and Costas that are involved in all stages of the food chain, supplying the supermarket sector. These large enterprises have invested significantly to develop their own strategic production, packing and despatch areas, but also have a number of independent regional suppliers who are able to ensure a continued supply of product due to varietal and climatic differences.

The major domestic retailers (Coles, Woolworths, etc) are sending strong market signals to increase consumption from 17% to 50% for (hydroponic) tomatoes in the next five to eight years. The industry is currently expanding at around 4-6% per annum. (Smith, 2006)

Supermarket demands for a continued, consistent supply throughout the year have placed the Protected Cropping Industry at an advantage. Field grown crops are problematic in that quality can be extremely variable; they rely on suitable soil type, large quantities of water, large areas for production, suitable climate and favourable seasons.

As identified in the Australian Horticulture Report (2007): *"Some of the seventy product lines are grown (for supermarkets) in a wide variety of locations, while the production of others is geographically concentrated in areas of optimal climate, soils or water availability. As 'value chains' are shortened, there can be significant regional value adding occurring through packing and processing; adding to the considerable economic value horticulture generates to the regions in which it is predominant."*

Protected cropping reduces the reliance on soil by the use of inert media, uses approximately 20% the amount of water to produce the equivalent amount of field-grown fruit (less if the system is fully recycling), can produce more than 9 times the amount of fruit per annum, and has less reliance on climate and seasonality.

Sustainabilty

The geographic and climatic diversity of production is matched by the diversity industries face in terms of the administration of environmental matters. Any commodity may have to deal with legislation in a number of states covering factors from water allocations, to chemical use, to noise, generation, to native vegetation management. (Horticulture Australia, 2007, p. 1-2)

The response to the pressures placed on dwindling water supplies brought on through climate change is a major environmental challenge for today and the future. The Australian Protected Cropping Industry is well poised to deal with this challenge and other environmental issues.

In a recent report, Horticulture Australia (2007) stated: *"The regional arrangements and approaches to resource management and planning are even more diverse, and there is a wide spread in the capacity of local bodies. This range of policy and administrative environments is a challenge the industries must accommodate."*

Protected cropping offers a consistent approach to production, despite climate and geographic location in a far more efficient and effective way, compared with conventional field production. This consistent approach should provide a framework for local, state and federal authorities to implement a uniform approach to policy and administration.

Protected cropping offers many advantages over field production. In a recent letter to John Fitzsimmons, Editor of 'Good Fruit and Vegetables', Graeme Smith outlined a number of 'compelling reasons' why growers should look at the Protected Cropping Industry:

1. Closed systems can deliver near zero waste water all year round
2. Smaller footprints therefore less impact on the natural environment
3. Marginal land is not an issue
4. The ability to grow foreign plants in local climates
5. A controlled environment allows better use of integrated pest management (IPM) and beneficial insects and much reduced sprays
6. Higher Brix (sugar) levels delivers sweeter flavoursome fruit and longer shelf life
7. Year round supply of consistent quality and quantity to meet consumers' needs
8. Environmentally sound and responsible growing system
9. No weeds, no weeding, no herbicides!
10. Higher production per hectare (1ha glasshouse produces the same as 9.4ha field)
11. Higher returns for farmers' efforts

The Australian Context

Smith went on to say *"…all Australian growers should aim to grow important consumer products in the most productive, efficient and environmentally responsible way and protected cropping systems clearly shine out as the best option for a range of common consumer crops. Forward thinking countries around the globe recognise and indeed utilise these technologies to great effect. Australian growers and politicians need to think beyond the square of traditional broad-acre farming and embrace this modern and efficient face of horticulture…"*

Export Potential

Horticulture, in 2001-2002, produced a total export value of $1.34 billion, of which fresh or lightly processed fruit, nuts, and vegetables accounted for nearly $1.1 billion.

Internationally, based on data from the last 10 years, vegetable and fruit exports are expected to increase over the long term by 5-15 per cent a year, depending on market opportunities and crop type. The main factors that drive export opportunities in Asia are competitive pricing, product quality and consistency, food safety, ease of preparation and high nutritional value. (Rural Training Council of Australia, 2002, p.1)

Protected cropping is able to deliver on all these parameters. It provides export opportunities for fruit and vegetables as well as floriculture, through its ability to produce product of a high and consistent quality. New markets are continually being tested. Research and development currently undertaken by a grower in Tasmania is looking at producing high quality/high value wasabi stems for export to niche markets in Japan. (Soilless Australia, 2008)

Quality Assurance

The Victorian Horticultural Industry has widely adopted quality assurance measures to maintain quality and food safety in the processing and marketing chain. There are currently 294 Victorian businesses accredited with the 'safe, quality food' program, SQF 2000. The Department of Primary Industries (DPI) is also investigating the potential marketing edge that may be gained from employing modern biotechnology techniques to improve horticultural production (www.dpi.vic.gov.au).

Protected cropping provides a cleaner, safer environment for the production of fruit and vegetables with less likelihood of chemical residue.

Future Developments

Various traditional field crops are currently moving into protected cropping such as eggplant, culinary and medicinal herbs, lettuce and strawberries.

Niche crops such as wasabi are being trialled in Tasmania for export and domestic consumption (Soilless Australia, Vol 4, 2007).

Aquaponics (combining the technology of hydroponics with aquaculture) systems are currently under development in Victoria. Aquaponics is not a new development, however previous emphasis has been in using the waste water from aquaculture enterprises to grow mainly leafy crops. The new development looks at hydroponic crops as the main output and then matches fish production to the hydroponics.

Floriculture too is moving to hydroponics as an alternative system that may be employed when the soil sterilant methyl bromide is finally phased out.

Summer fruits, such as blackberries, blueberries and currants are the subject of extensive research in the Netherlands, Belgium, Canada and New Zealand – where varieties are being developed for perpetual fruiting under protected cropping.

Allied industries such as the nursery production industry are sharing in the knowledge and technology developed for the Protected Cropping Industry (Proceedings of 2007 Hydroponic and Greenhouse Association Biannual Conference).

Current Education and Training in Australia

Currently Taig is involved in a project titled 'Pathways to Production'. It is a collaboration between Goulburn Ovens TAFE, the Australian Hydroponic and Greenhouse Association, NSW DPI and funded by AusVeg. One of the main aims of the project is to develop a Training Package that meets the needs of the Protected Cropping Industry. The initial stage of this project involved conducting a series of grower meetings and surveying them using a variety of techniques. One of the overwhelming results of talking with growers is their lack of opportunity to develop skills and knowledge in crop and greenhouse management. Most felt they had rudimentary knowledge to successfully manage their enterprises, but clearly articulated their frustration in not being able to gain higher level training in Australia.

Currently most training in protected cropping in Australia has been aligned with units from the Rural Production Training Package or the allied Horticulture Training Package. Qualifications, where possible, have usually been matched to the various certificate levels in Production Horticulture or general Horticulture. This has proved adequate for most tasks undertaken by employees at Australian Quality Framework (AQF) levels 2 and 3. However, higher level technical skills at AQF levels 4, 5 or 6 are poorly catered for (http://www.ntis.gov.au/).

A preliminary investigation undertaken as part of the Pathways to Production project has identified current units that are suitable for inclusion in a specific protected cropping qualification at various levels; units that may be suitable with some modification, as well as identifying areas of skills and knowledge that require new units to be written (see Attachment – *Pathways to Production*, report to AusVeg, by Graeme Smith).

Currently, Goulburn Ovens Institute of TAFE offers a number of short courses in hydroponics aligned to units from AQF levels 2 and 3 in Production Horticulture. They also provide training and assessment for hydroponic trainees, mainly at Certificate III in Production Horticulture.

Northern Melbourne Institute of TAFE (NMIT) also runs similar programs and align the qualification to general Horticulture.

Virginia Horticulture Centre in South Australia offers two certificate courses that specialise in hydroponics: the Certificate IV in Production Horticulture, using mostly existing level 4 units and one level 5 unit, as well as the Diploma in Production Horticulture.

NSW DPI through their TAFE section provide some training to growers where possible, aligning to units mainly from AQF levels 3 and 4.

One private training provider also offers limited training in hydroponics suited more to small-scale production and hobbyists. This qualification is not aligned to nationally recognised training.

Most of the shortcomings in existing training become more evident at higher levels. One of the purposes of this Fellowship was to identify these areas and assist in the development of suitable units at management level.

SWOT Analysis

A brief SWOT analysis (strengths, weaknesses, opportunities, threats), provides a snapshot of the current state of play regarding the Australian industry.

Strengths	Weaknesses
• Protected cropping is a rapidly expanding industry • Vegetables and other crops of high quality and consistency can be produced in a greenhouse environment on a much smaller environmental footprint all year round • Significant water efficiencies through recycling of nutrients and water • Less use of pesticides and herbicides • Not reliant on suitable soil type • Not as reliant on climatic conditions • Greenhouses can be established close to urban centres, reducing transport/ freight costs • Ability to utilise marginal/degraded land, freeing up more productive land for other horticultural agricultural enterprises	• Urban planners have a poor understanding of the industry, classing greenhouses as factories • 'Hydroponics' has negative connotations in relation to illicit drug use • Individual enterprises are spread across Australia, promotion of the industry is difficult • Infrastructure costs high • No national training program • Little local expertise at higher levels • Capital intensive industry
Opportunities	**Threats**
• Niche markets such as alternate crops; or, producing conventional crops on a small footprint close to populated areas • Growing systems for food production after natural disasters • Green walls and rooftop gardens • Aquaponics	• Lower tech greenhouses producing lower grade products with higher energy and pesticide usage

Identifying the Skills Deficiencies

The following outlines the skills deficiencies that were addressed during the Fellowship.

Understand the methods of collection and recording of data for crop registration of a variety of crops (benchmarking)

- Tomatoes in their various forms (such as cherry, or truss) are the most commonly grown greenhouse vegetable in Australia. Consequently there is a lot of benchmarking data available to Australian growers. For the industry to expand and develop, benchmarking data should be available for a range of crops.
- The data needs to be more than just yield per square metre of greenhouse – it should also include growth rates, number of leaves per plant, and internode distance (stem length between clusters of leaves).

Understand the physiology and manipulation of the physical environment of the growing plant and its relationship to optimum production.

- At different stages of a plant's life cycle, growth can be generative or vegetative. Different varieties of the same crop can also display greater tendency to be either generative or vegetative. Altering the physical environment can affect these tendencies, allowing the grower to 'steer' the crop in the desired direction.

Observe the latest techniques and technologies in greenhouse production – especially in relation to water and energy conservation.

- Compared to field production, greenhouse production offers significant advantages in its economic use of water. For instance, greenhouse tomato production utilises approximately 20% the volume of water than field tomatoes producing a similar yield. Significant water savings may still be possible – over 90% of the water taken up by plants through root systems transpires at leaf level.
- As the cost of fossil fuels rise, so too will energy costs. The affects of climate change may also place a greater responsibility on industry to reduce its carbon footprint. Energy conservation or alternate sources of energy will ensure the industry remains viable.

Differentiate techniques and technologies for use in the broad context of the Australian Greenhouse Industry.

- The Netherlands has a well developed and well established research and development culture aligned with industry. Australia relies on the Netherlands for much of its greenhouse technology. However, geographically, the equivalent latitude of the Netherlands, south of the equator, would place it just south of Tasmania. Similarly, Victoria's climate is more closely aligned to southern European countries such as Spain or Greece. Not all techniques and technologies will be suited to the Australian industry.

Understand the role of nutrients and their affect on greenhouse production.

- All nutrients that a plant would typically acquire from the soil, is supplied dissolved in the irrigation water (fertigation). These nutrients are required in exact amounts as there is little else to buffer variations in concentration. Any media utilised in hydroponics is likely to be inert.

Identifying the Skills Deficiencies

Understand current education pathways and models in the Netherlands for training in greenhouse production with particular emphasis on operational management, with the intention of determining how this training might be used in an Australian context.

- There is a clearly identified need for industry training in Australia for the greenhouse industry.
- What are the similarities and differences for training pathways in the Netherlands?
- How is theory and practical application developed within the curriculum?

Develop ongoing education programs through ISS Institute, Goulburn Ovens Institute of TAFE and other educational institutions.

- PTC+ has a long history of agricultural/horticultural training. What relationships could be developed to utilise this experience in an Australian VET context?

The International Experience

The Destination and Objective

The Netherlands has a population of 16.3 million people and is one of the world's most densely populated countries (483 people/sq km). It is the second largest exporter of agricultural produce (the USA is the first) such as dairy products, pig and poultry products, floriculture, flowering bulbs, glasshouse products, as well as management, marketing and logistics.

Nearly a quarter of the Dutch landmass lies below sea-level, so historically the Netherlands has centuries of land and water management experience. The Dutch horticulture industry employs around 270,000 people and was responsible for €6,500 million worth of exports in 2003 (approx AUD$13 billion). They are the third largest exporter of mushrooms in the world; responsible for one third of European exports in vegetables (especially tomatoes, lettuce, capsicum, cucumber and cabbage). They export 540 million kilograms of tomatoes and make up 70% of European exports in ornamental flowers and plants, as well as 93% of European exports in flowering bulbs.

Greenhouse horticulture is the most important horticulture sector in the Netherlands: 75-80% of Dutch greenhouse products are exported. The industry employs around 62,000 people within the greenhouse production sector. Greenhouses cover an area of more than 60 square kilometres and are mostly concentrated in two regions: Westlands (bordered by the cities of Rotterdam, Delft and The Hague) and Aalsmeer (south of Amsterdam).

Education

The strength of the Netherlands Greenhouse Industry is due in part, to the educational links with industry and ongoing research. The Dutch education structure is such that at secondary level there are three distinct pathways. One is equivalent to the current technical school model – linking formal secondary education with vocational training. The other two are more closely aligned to Australian high schools, preparing students for higher education. The significant difference however is that one pathway focuses on preparing students for higher educational pathways in research – while the other pathway prepares students for higher educational pathways within professions and industry.

Practical Training Centre Plus (PTC+)

During the Second World War, the Netherlands was decimated by German occupation and many were left starving. After the war the task of rebuilding the nation was immense. Millions of dollars worth of aid from an alliance of countries that would later form the United Nations flowed into Europe. As part of the rebuilding the Dutch Government developed policies and support for agriculture and horticulture, promoting and subsidising training of its people in institutions like PTC+. Since 1950 all secondary students involved in agriculture and horticulture training spend a week each year at one of the five PTC+ campuses as part of their education.

Currently its five campuses turn over €25 million (AUD$50 million) per annum, with approximately 30,000 participants. The five centres employ 275 employees (150 trainers) and specialise in five key areas: Horticulture and Arable Farming, Agricultural Engineering/ Process Technology, Retail and Communication, Companion Animals and Horses, and Production Animals and Rural Development.

The PTC+ centre located in the town of Ede, is the horticulture campus. Ede has a population of almost 70,000 and is located on a major transport route to Germany and Eastern Europe, approximately 80km south east of Amsterdam.

The International Experience

Horticulture Programme Manager at PTC+ in Ede, was Ben van den Brink. In an early meeting, van den Brink outlined the principal areas of training, which were crop production – including fruit, vegetables, cut flowers, nursery production under protected cropping, as well as management skills training. The centre also has workshop facilities for practical training in agricultural technology (including tractors, agricultural vehicles and cooling systems), simulated retail areas for retail sales and communication training (in garden centres, hardware, wholesale trade), practical areas for telephone and cash register training, and areas for retail display and decoration courses. Equipment and facilities were originally financed through a bank loan, with ongoing support from industry in relation to materials and equipment.

Facilities at PTC+ are extensive. The site at Ede has student accommodation, a canteen and purpose-built greenhouses and classrooms to enable training and practical experience in all aspects of greenhouse management. There are ten greenhouse environments that are working demonstrations of a range of technologies and crops – in ground crops such as cucumbers, hydroponic capsicums, hydroponic cut flowers, and ornamentals in pots. Specialist classrooms are adjacent to the greenhouses, connected by glassed-in walkways which are spacious enough to conduct a variety of practical activities. All greenhouses are monitored and controlled via computers from within the classroom. Computers control and record parameters such as air temperature, humidity, supplementary lighting, opening and closing shade screens, vent opening and closing temperatures, as well as irrigation scheduling and nutrient dosing.

A natural gas-fired boiler provides additional heating for all greenhouses and classrooms, and carbon dioxide is extracted from the flue gases to be pumped back in to growing areas to enhance plant growth and production. Excess heated water is stored in buffer tanks (500,000 litre, insulated, above ground tanks) and pumped back into greenhouses to maintain night temperatures at desired levels.

The facility also houses functioning packing and post harvest equipment for fruit, vegetable and cut flower production.

Gerbera in training greenhouse at PTC+

The International Experience

The Dutch Ministry of Agriculture, Nature Management and Fisheries, has been the major funding agency and covered a substantial part of the operating costs. It is the Fellow's understanding that there is a gradual shift away from this policy to where programs and courses at PTC+ are mostly delivered on a fee for service basis, with little government subsidy. Occasionally priorities are identified by government and industry, prompting additional government financial support for some areas of training.

The programs are tailored to suit the needs of the client stakeholder and are typically short courses. The longest course offered is a 12 week greenhouse management course. PTC+ also has courses to engage secondary school students as well as structured programs to provide practical experience for students engaged in other tertiary programs, such as Laurenstein Hogeschool (School of Higher Professional Education) and nearby Wageningen University. Written resources have all been developed by PTC+.

Similar to the Australian apprenticeship system, the Dutch have two, three or four year apprenticeships. However, PTC+ is not accredited to deliver this training and will sometimes deliver under auspice arrangements with accredited institutions.

Most of the current teaching staff come from industry originally or are still working part time within the industry. This is encouraged by management at PTC+ to ensure that resources, equipment and staff knowledge continues to reflect current industry practices. Industry relationships are further enhanced through assigning staff to industry clients. The staff member becomes the point of contact for the client and is responsible for program development and coordination.

To further develop the capacity of individuals, staff take responsibility for their own personal development, which is planned and discussed every six months with their manager. This might be as simple as gaining experience in operating a new piece of equipment, or completion of a qualification.

Few staff have formal teaching qualifications. New staff have a professional development plan developed and are assigned a teaching mentor from the existing teaching team. The new staff member undertakes a range of competencies related to delivery and assessment relevant to their current skills and experience.

Internationally PTC+ has various training and development arrangements in countries such as India, Korea, Indonesia and Uganda. Each one is different. PTC+ consults with local stakeholders in an effort to create projects that are ongoing in terms of future development and sustainability. Resources and knowledge that already exist within the country of origin are employed and extended to meet the required outcomes of a project. A case in point was the use of bamboo poles to construct greenhouse structures in Indonesia, rather than using conventional materials such as zinc coated steel alloy poles. Sometimes the projects only fill an immediate need, such as a response to natural disaster – however this is not the preferred model. Every effort is made to create ongoing, self-sustaining, viable enterprises which ultimately operate independently of PTC+.

Training at PTC+ is tailored to suit the needs and knowledge level of the client group. A class, tailored for a group of international students, who had completed or part completed tertiary courses (predominantly teaching) in their own country was observed. The session was conducted by Rene van Geneijan, specialist teacher in irrigation for PTC+. Later conversations with the students revealed they either required this training to complete their qualification, or were simply adding to their existing qualification to improve their career prospects.

The students came from as far afield as Uganda, Russia, Croatia and Czech Republic. As part of the course, they received training in basic principles of plant growth and greenhouse control. The topic of the day was greenhouse irrigation and fertilisation management.

As part of the greenhouse study tour, participation in training was undertaken with a group of 15 Australian growers of varying experience. They received high level training in greenhouse management as well as computerised monitoring and control of environmental parameters such as temperature, humidity, CO_2 concentration and light radiation.

One factor in common was the delivery strategy of the training. In both cases the client group was introduced to the theory and technology of the principles being taught, and then were able to move in to a range of practical activities that not only reinforced the theory, but prompted discussions and activities around 'what if' scenarios. Sometimes the 'what ifs' came from the trainer, often they came from the participants, especially with the more experienced growers – the strategy clearly exercising problem solving skills of the group. Ordered access to facilities and equipment enabled the trainer to easily and practically illustrate the principle or scenario in question.

Other strengths of PTC+ were the strong links with industry and their access to up-to-date research. This was partly facilitated by the relationships that exist with and close proximity to research facilities such as those of Wageningen University.

Wageningen University

Wageningen University is less than 20km from Ede. The plant sciences faculty has an international reputation of being at the forefront of plant production research and development. Separate meetings were held with Dr Uulke van Meeteren, Associate Professor, horticultural production chains group department, and Dr Ep Heuvelink, Associate Professor, greenhouse crop physiology and modeling, plant sciences, Wageningen University.

Wageningen University offers 18 Bachelor of Science degrees (three years) and 32 Masters of Sciences programs (two years), in the areas of life sciences and natural resources. For undergraduate courses, the first year is delivered in Dutch. During the second year, much of the delivery is still in Dutch, but most of the reference material is in English. The final year of the program is delivered entirely in English. The post graduate programs are all delivered in English, with a large proportion of students being international. Apart from academic qualifications, students must also have language qualifications. Students coming from other Dutch and international institutions needed to satisfy the requirements of an entrance committee.

The plant science faculty has access to a one hectare research greenhouse. The greenhouse has approximately 120 compartments (some compartments are small growth chambers). The main areas of research are tomatoes, capsicums, chrysanthemums and roses. The facilities are shared with the entomology department and partly funded (approximately □1 million) by government contribution.

Current Research

At the time of the Fellowship visit, Dr Heuvelink was researching ways of inducing parthenocarpy (natural or artificially induced production of seedless fruit) in capsicums to promote more uniform production. Typically, capsicum fruit production rates are cyclical – with periods of extremely high production, followed by periods of very low production.

This phenomenon was problematic for capsicum growers – impacting on cash flow and creating varied demand for labour and equipment.

Dr van Meeteren was involved with research that looked at the mechanisms of a cut flower stem, to better understand what happens when a flower is harvested for floriculture. Further research Taig observed included the work of a Masters student, which involved roses for cut flower production. The research aim was to create a three dimensional computer model of a 'typical' rose bush by measuring its response to various crop maintenance activities, such as severity of pruning, over a number of growing seasons. Growers would then be able to predict via the computer model, how a plant would respond to a variety of growing practices and forecast the affect on production.

Most research funding comes from the Dutch Government through levy money. The money is collected from growers based on the size of their greenhouse. Growers have input into research through identification of priority areas. Appointed growers then monitor progress of research and are also available to provide expertise or guidance for researchers. Some research is funded by large companies.

In terms of formal arrangements, Wageningen University has only a minor relationship with PTC+. Undergraduates spend approximately one week gaining practical skills in greenhouse systems and equipment. At Laurenstein Hogeschool, graduates of their programs are able to articulate into Wageningen University's Masters programs. The transition from one institution to the other was eased by establishing a better relationship, introducing some Wageningen University subjects into the final year of a Laurenstein qualification, as well as staff exchange between institutes. When asked how difficult it was to establish links between the two programs, Dr Heuvelink suggested that it wasn't difficult, but the initiative really needs to come from teaching sections, who have the drive to make it successful. Management can then formalise the arrangements.

According to Dr Heuvelink, graduates of Wageningen University are typically employed as researchers, at anywhere where high level horticultural advice is required (such as seed companies, greenhouse companies, or chemical companies).

Further Research: The Greenhouse Improvement Centre (GIC)

The Greenhouse Improvement Centre (GIC) is an industry funded research facility of around 11,000m^2 under glass. It is divided into eleven compartments where a variety of trials are conducted at any one time. Participants, who use the services of the centre, are primarily technical producers of horticultural products, suppliers and other parties – such as research institutions. With the high infrastructure costs of establishing a greenhouse and rising energy costs, much of the research has focused on the maximum utilisation of available space within the greenhouse.

Each trial is proposed by stakeholders and may include research on a number of parameters such as a horticultural lighting and new vegetable varieties.

Past trials included:

- A tomato production trial to achieve 100kg/m^2 yield in twelve months. This trial employed supplementary lighting for optimal light quality and duration, and a 'closed greenhouse' system, which helps to maintain constant CO_2 levels for optimal plant development. A supplementary trial looked at the effect of Trichoderma (soil-borne fungi) in the substrate on growth and production.

- An aquaponics trial was conducted which utilised the filtered waste water from edible fish (tilapia species) production as a partial nutrient source for greenhouse hydroponic tomato production. By adjusting the mineral balance, the systems remained closed. The fish were housed in plastic tanks (similar to rectangular stock troughs) under rows of the hydroponically grown crop.
- Cultivation of red peppers (capsicums) under artificial light to maintain production through the European winter – typically a time when production is usually very low and prices for peppers are at a premium. With the growing system employed it was expected production would increase annually by around 10%.
- Cultivation of pepper under a number of variables such as the use of diffuse rather than clear glass, grafting on to two different rootstocks to promote more uniform fruit set, and the effect of media block height (and therefore substrate volume) on production.
- Conditioned cultivation of cucumbers under artificial light, using a hoistable wire system to support the crop, using two different slab volumes.

Variety Trials

The most common source of variety information was initiated by the seed companies themselves. At Steenbergen the Fellow visited the Rijk Zwaan Demonstration Greenhouse where for the last four years some of the latest tomato varieties bred by Rijk Zwaan Seeds are assessed and trialled. The demonstration 7,000m^2 greenhouse is remotely located (by Dutch standards) from the more intensively developed Westland area and is owned and operated by Harry Augustijn. The trial featured beefsteak-type tomatoes (large single fruit), truss tomatoes (medium sized fruit in clusters of five or seven), and grape tomatoes (smaller varieties in long trusses or singles).

Tomato varieties on display at Rijk Zwaan Demonstration Greenhouse, Steenbergen, Netherlands.

Each variety had extensive crop registration details recorded, which will become a basis for crop management for the new varieties when grown commercially. A quantity of each variety was harvested prior to arrival and labelled. Augustijn then highlighted particular outstanding attributes of the varieties and samples were available to taste test, reinforcing such characteristics as high Brix (sugar content) and firm texture.

In Meerle, Belgium, north east of Antwerp, is the Research Station for Vegetable Production (RSVP), formerly the Belgium National Research Centre for Strawberries. The RSVP has long been established as a facility for research into field grown and greenhouse strawberries, and also conducts variety trials in tomatoes, capsicum and strawberries. In contrast to the GIC and Rijk Zwaan Seeds, these trials are often sponsored or proposed by grower organisations to allow comparisons between varieties from different companies. RSVP also researchs and trials in the areas of cultivation techniques, new growing systems, disease and pest management, as well as waste management.

Growing Systems

In the town of Barendrecht (Western Netherlands) a 'mobile gully system' for hydroponic lettuce is employed. Developed by Hortiplan, the system enables the seedling crop – planted in seven metre long gutters (aligned parallel) – to move through the greenhouse via a chain drive system from one end of the greenhouse to the other. The system is capable of spacing the gutters as the crop developed. Eventually the mature crop reaches the opposite side of the greenhouse to coincide with harvesting – a period of around four weeks. The gutters are cleaned and returned to the growing system as the crop is moved to the adjoining packing area.

Moving gully system showing drip feed lines and drive system under gullies, Barendrecht, Netherlands

The International Experience

In Honselersdijk, Penning Freesias breed and export Freesia and Hippeastrum (Amaryllis) bulbs worldwide – principally for the cut flower market. The company had two distinct business arms: one responsible for flower and bulb production; the other responsible for breeding and research. Due to the low root zone temperatures required for growth and maximum bulb production, the crop is grown in soil within the greenhouse. Soil temperature is controlled by water pumped through pipes located close to the root zone. The water pipes are connected to a unique 'ground-loop' system, which stores excess heat from the gas fired boiler or cooled water in subterranean wells to be used on demand. Due to the insulating properties of the surrounding ground water and its slow movement, as little as 10% of the energy stored in water within the wells is lost annually. The stored energy within the water can then be converted via a refrigeration/condenser unit to either heat or cool root zone temperatures as required.

The boiler unit also assists with the disinfestation of the soil between crops. After the bulbs are harvested, the soil is loosely cultivated, covered by plastic sheeting, anchored, and steam is then injected into the soil.

Themato, a family-owned enterprise in the Westlands is a good demonstration of how technology and sound growing principles can be readily adapted to a totally new crop. Market forces lead the family owned business away from tomatoes to strawberries.

Hanging gutters of strawberries over central walkway, Westlands, Netherlands. Gullies are lowered for picking or as required.

The Themato greenhouse and hanging gutter system was originally designed and built by Innogrow, in conjunction with Priva, for hydroponic Roma tomato production. The greenhouse is a 1.4 hectare structure converted to a 'closed' system, utilising stored energy from subterranean wells, similar to Penning Freesias. The closed greenhouse system relies on effective and intricate control of the growing environment using sophisticated monitoring and system controls.

Effectively the greenhouse remains closed to the outside environment by reducing the need for venting. In conventional greenhouses venting is used to control excess temperatures and high humidity. When the vents are opened energy escapes, CO_2 is lost, humidity levels can be altered and the grower becomes more reliant on the outside environment. Transpired air is also captured and condensed to be reused for irrigation.

The greenhouse environment and growing system rewards the grower with significant reductions in energy costs through this unique heating and cooling system, condensing the air, and concentrating CO_2 by only venting when absolutely necessary. There is also the added bonus of reduced entry points for pest and disease incursion.

Because the system is so efficient in relation to energy loss and heating, a further four hectare neighbouring 'open' greenhouse are heated with the excess energy.

Metazet's Demonstration Nursery

Located in Wateringen, near Delft, this facility is a 5,000m^2 demonstration greenhouse area where growers can view and experience a vast range of products and greenhouse systems. The greenhouse features internal plant transport systems such as the 'walking plant system' – a series of conveyors that moves pot plants from one location to the next within the greenhouse. The system incorporates a number of sensors which allows sorting of plants by different height, colour, weight or density.

Various trolley systems for movement of harvested product were demonstrated. These relied on monorail, tracks, chains or cables to direct harvest equipment through predetermined pathways within the greenhouse. An experimental hanging gutter system for hydroponic tomato production also featured. The system allows a greater crop density by eliminating the need to have walkways between the rows of the crop. When daily crop maintenance or harvesting is required, the gutters are cycled along an overhead track, until the row reaches the maintenance area. The space between the rows is expanded to a position where normal maintenance can occur. Other items featured include artificial lighting, automated doors for human (as well as vehicle) traffic in and out of the greenhouse, and mechanical pallet wrapping equipment.

This facility is not only of value to growers and people in the industry, but is also a valuable teaching resource, with the company frequently catering for clubs and school group visits.

Horti Fair: Amsterdam

Horti Fair ran over four days in the RAI Exhibition and Conference Centre, Amsterdam. It was one of the largest horticultural trade exhibitions in the world, with around 87,000m^2 of exhibition space. Over 980 exhibitors took part and attendance was close to 47,000 people. Horti Fair is the premier horticultural expo of Europe and features products, plants, services and technologies for all areas of horticulture from ornamental plant production, floriculture as well as crop production in greenhouse and in the field.

The International Experience

Because of the physical size of the site and extent of the displays, it took at least two days to do justice to the event. On advice of the tour leader, Graeme Smith, the first day was spent simply getting around to see all the displays and to gain a sense of the scope of the exhibition. The second day then became an opportunity to talk to industry people from around the world, visit some of the specialist lectures that were offered and generally look over the vast array of exhibitors. The exhibition featured everything from the latest flower and foliage releases in floriculture, to biodegradable tomato clips, to massive boilers and co-generation units (boilers and power generators combined).

Combined heat and power generation unit at Horti Fair, Amsterdam

The extent of automated equipment on display enabled a futuristic view of the industry. For example, a robotic arm (similar to what might be seen on a vehicle assembly line) was capable of taking 1,000 to 1,500 cuttings per hour (about the same a good human propagator might take in a day), that were uniform length and shape. The arm then accurately placed the cuttings into propagation containers (in this case 175mm squat pots) in a predetermined pattern, ready to be transported via conveyor to the propagation facility. The machine required one person to feed the cutting material into the hopper. Three digital cameras almost instantly constructed a three dimensional 'image' of the stem, and the robot accurately cut it to size, trimming leaves and stems as required.

Outcomes

Understand the methods of collection and recording of data for crop registration of a variety of crops (benchmarking).

- At the Rijk Zwaan Demonstration Greenhouse the importance of crop registration was evident as it was explained how new and existing varieties were grown to provide 'marketing' and crop advisory data for growers. Information was simply recorded on hard copy proformas that were then collated at the end of the season, to provide an accurate summary of how a particular variety performs in terms of growth rates and annual yield. The information also extended to Brix content, whether the plant had generative or vegetative tendencies and timing of the first onset of fruit.
- Many other growers stored the hard copy data on to software programs – some had taken the next step, utilising hand held electronic mini computers to first record data in the greenhouse which could then be downloaded, stored and later analysed via a central computer.

Understand the physiology and manipulation of the physical environment of the growing plant and its relationship to optimum production.

- Greenhouse horticulture is a precise science. Variations in the physical environment can have significant effects on production. In tomato production, an increase of one degree Celsius above an optimum overnight temperature can result in crop maturity slowing by 6%. Increasing concentrations of CO_2 in the greenhouse can increase photosynthesis and potentially increase yield. Similarly, increasing available light by 1% can cause a similar increase in production.
- In all the greenhouses visited, to maintain a consistent environment, correcting equipment such as heating, ventilation, screening and CO_2 enrichment is used. Measuring equipment for temperature, humidity, light radiation, CO_2, wind speed, wind direction and rain, were linked to computer controls which activated the correcting equipment.
- Linking all equipment by a computer controller has now created a powerful tool for precise crop monitoring and steering. The controller compares measured values with predetermined set values and then calculates new target values. It then gives commands to the corrective equipment.
- Many greenhouses incorporated a Netherlands-made Priva Integro climate control system. This system automatically controls all the greenhouse parameters to suit a particular crop. The system is fully integrated in that it will consider all current environmental set points (temperature, relative humidity, CO_2, light), prior to making any adjustments to equipment.

  The system is PC based to allow the set points to be supplied in a diagrammatic form for easy identification. The logged data is stored and graphed on demand to display the environmental conditions achieved over a particular period, and to assess the averages actually attained. This information is then available for surveys, graphs and historic storage. This data is crucial to ensure that set points are optimised for each crop and can be used as a 'technology tuner' tool. All the systems had complete weather stations both inside and outside the greenhouse for efficient control.
- Powerful software programs such as SimTom also enabled modelling of tomato crops in the greenhouse, with the ability to alter greenhouse settings and preview the effect on annual yield.

Observe the latest techniques and technologies in greenhouse production – especially in relation to water and energy conservation.

- An estimated 90% of Australian greenhouse growers operate a free drainage system, which is to say that all drainage water and nutrients are allowed to run to waste. In the Netherlands, legislation requires growers to recycle their water which has produced significant savings in water and fertiliser use. This has driven technological development in this area such as water disinfestation through the use of UV light, and the specialist management of the technology.

UV water sterilisation unit, Horti Fair, Amsterdam

- At the Greenhouse Improvement Centre water recycling was taken to a new level, with research into a commercial aquaponics system. This combines aquaculture and hydroponics within the one production system. Fish and plants are grown in an integrated system, where water from the fish tank is circulated through the hydroponic growing beds. Nitrifying bacteria convert the fish waste into a nutrient supply that can be used by the plants, thereby reducing the need for the addition of chemical fertilisers. Meanwhile, the fish also benefit from the natural filtration functions of the plants, providing fresh, clean water for the fish to live in.

- At both the Research Station for Vegetable Production (Meerle, Belgium) and Themato (Westlands) completely closed greenhouse systems also employed closed ventilation systems. Transpired air is recaptured and not lost to the outside environment. The moisture laden air is condensed and the water reused as part of the fertigation system, reducing total water use. The addition of carbon dioxide was used to enrich greenhouse atmosphere, and by closing off the system completely, high levels of carbon dioxide were also retained.

  The fully closed system had recorded yields of up to 105kg per square metre, compared to an average yield of 60-70kg per square metre in open ventilation systems.

Differentiate techniques and technologies for use in the broad context of the Australian Greenhouse Industry.

- Priva Assist is a software and hardware system for total greenhouse data management. It utilises portable terminals at the end of each growing row in the greenhouse for workers to input their daily tasks. The system consists of several modules. The 'local-assist' module is used to record labour and production data at any work location within the greenhouse and production facility. All data is processed instantly and can be requested immediately, which allows a quick and informed response to the production process. 'notes-assist' offers the possibility of recording independent observations like disease in crops and defects to the greenhouse. In addition, a Priva Assist weighing installation and a grading machine can be connected to the network.

- The Netherlands was well developed in the co-generation of heat and electrical power. Typically greenhouse growers use natural gas burnt in large boilers to provide heat through steel pipes and rails in the greenhouse. A useful by product is the CO_2 harvested from the flue gases, and often the heat is in excess and stored in insulated tanks. Combined heat and power units (CHP) are boilers that not only provide heat and CO_2 gas for production, but are also capable of electrical power generation.

  Typically a CHP unit converts 40-45% of the energy of the gas to electrical power with the remaining 55-60% converted to heat. The unit produces around 300kW of electricity which in turn can be sold to the electrical grid. Anecdotally, in previous years some growers had made more from power generation than production.

Understand the role of nutrients and their effect on greenhouse production.

- The practical skills and knowledge required to successfully manage crop production in a greenhouse environment is precise and demanding. A grower requires a firm understanding of the physiology of the plants he/she is growing and the affects varying parameters may have on product quality and quantity.

  Again in most greenhouses, Priva Integro climate control systems were employed which also integrated the fertigation and irrigation demands of the greenhouse system with the environmental parameters for optimum control of the plant microclimate. Fertigation systems match the crops irrigation needs during the entire growing season. It reliably delivers pre-mixed fertiliser based on predetermined menus to suit the crops blueprint for growth, with no fluctuations in EC, pH, flow, and pressure or irrigation volume. The systems utilise large tanks (typically around 1,500 litres) to ensure complete mixing prior to delivery to the plants.

Understand current education pathways and models in the Netherlands for training in greenhouse production with particular emphasis on operational management. Determine how this training might be used in an Australian context.

- The PTC+ model has served the Dutch horticultural industry for many decades and continues to meet the needs of this well developed sector. The Australian industry is still in its infancy. However, in terms of teaching facilities and principles, PTC+ provides a valuable model for an Australian context.

  The facilities, which provide access to various technologies and crops, gives the user the opportunity to practice learned theories and techniques in simulated environments. The delivery strategy of the training involves the introduction of the theory and technology of

the relevant principles, followed by reinforcement of the theory through a range of practical activities. The activities prompt discussion and further experimentation around 'what if' scenarios. Sometimes the 'what ifs' come from the trainer, sometimes from the participants. The strategy clearly exercises problem solving skills of groups and individuals.

For Australian greenhouse training such a facility and model is still sound. It would assist the industry to expand and develop – enabling training in modern greenhouse principles and practices, as well as showcasing new technologies.

- Vocational training in the Netherlands is well developed with clear industry pathways within the equivalent primary and secondary sectors. After decades of neglect, there is now a strong move within the Australian education sector to focus on vocational or technical training as a legitimate alternative to academic pathways. Again, a PTC+ style specialist training centre would provide opportunities for industry engagement at secondary and even primary levels, to provide a training pathway into the industry.
- Research and development will also play a key role alongside education to develop an industry. The close proximity to Wageningen University as a location for world class horticultural research provides access to modern theories and research – stimulating discussion, further research and practical application of new technologies.

Develop ongoing education programs through ISS Institute, Goulburn Ovens Institute of TAFE and other educational institutions.

- For the Australian Greenhouse Industry to develop and prosper it is important that the industry commit to and support education and training, as well as recognising the important role that research plays (especially in an Australian context) in improving what we do.
- The Australian industry is hungry for information on how they can best utilise current technology, or what the new technologies are that will improve the efficiency or quality of greenhouse production. PTC+ has participated and is still active in many overseas partnerships that raise the capacity of the local industry.

Knowledge Transfer: Applying the Outcomes

Education and lifelong learning are essential for individuals, communities, business and industry to grow. Being open to new ideas that challenge traditional educational practices and practical processes and being able to incorporate developments into existing structures can be the difference between industry success and failure. Similarly, the opportunity to undertake this Fellowship provided a unique experience that must provide the basis for future knowledge transfer activities.

Protected cropping is the modern face of horticultural production. The industry is still in the early stages of development within Australia. Australian growers require a greater understanding of greenhouse environmental management. Many growers understand the fundamentals of crop production, but few have an understanding of the potential for greater yields and improved efficiencies through better crop management.

In order to facilitate effective knowledge transfer activities, it is essential that a distinct Training Package be developed for protected cropping covering Australian Qualification Framework levels 2 to 6, as well as articulation pathways to higher education programs. Australia needs a dedicated training facility that allows participants to learn from experiencing first-hand the various growing systems utilised within the industry, as well as gaining a greater understanding of the requirements of a greenhouse crop. To develop a comprehensive package, peak industry bodies would need to work in close partnership with training providers, such as TAFE, to develop suitable curriculum and suitable physical facilities to optimise learning experiences.

Two further factors for consideration:

- With the current water crisis, Federal and State Governments are desperately looking at ways we can conserve water and increase the efficiency of our current water use, especially in relation to industry and primary production. Protected cropping offers many of the solutions for the future in terms of efficient water usage, high production yields on a relatively small footprint, as well as cleaner production with the use of beneficial organisms and low impact sprays to control pests and diseases.
- Many large protected cropping enterprises are now well established, expanding or in early stages of development. Much of the technology that is used comes from overseas sources. Many of the specialised staff required to operate these facilities, such as grower managers, also come from overseas. The Australian industry needs to build its capacity through training.

For many in the industry it's a case of "I don't know what I don't know". It is important that information is disseminated to the Protected Cropping Industry, as well as those that may be associated with the industry, such as peak industry bodies, legislators, government departments – people who can assist in the development, either directly or indirectly.

As a result of this Fellowship, Taig will deliver presentations to providers of horticultural training – such as the Victorian Horticulture Teachers Network. He will extol the virtues of the ISS Institute Fellowship program to GOTAFE staff, as well as write articles for peak industry journals such as Practical Hydroponics.

Additionally, with the relationships that have been developed with PTC+, Taig will seek to formalise an agreement between them, the AHGA and GOTAFE. Taig will facilitate training for growers in Australia delivered by PTC+ in mid 2009, facilitate a series of national workshops in 2009-10, as well as seek to establish a specialist greenhouse training facility in Victoria.

Recommendations

Government – Federal and State

1) Australia needs a specialised greenhouse training facility similar in structure to PTC+ in The Netherlands. Such a facility could introduce accredited full-time and part-time courses in the areas of hydroponic crop production, greenhouse environmental management, and nursery production. Additionally, the facility could provide specialist training in advanced greenhouse control and crop production, be a conduit for the introduction of new technology and research, as well as establishing a training pathway for secondary students through school-based VET programs and school-based apprenticeships. Such a facility would require a strong relationship with, and need to be driven by, the Protected Cropping Industry in Australia. Opportunities would be provided for further resource development and ensure the Institute's position within the industry.

   The Protected Cropping Industry is a rapidly expanding sector of production horticulture. As the water crisis deepens and consumers look for cleaner and more sustainable produce, protected cropping will continue to grow. It is capable of developing in any area where clean water and access to an economical fuel source, such as natural gas is available.

   In terms of locating such a facility, the Goulburn Valley area is well suited to protected cropping. The already extensive allied industries such as packaging and freight are well established and are currently utilised by a strong local greenhouse industry.

2) The strength of the European Greenhouse Industry is due in part, to the educational links with industry and ongoing research. As already mentioned, the Dutch education structure is such that at secondary level there are three distinct pathways. One is equivalent to the current technical school model – linking formal secondary education with vocational training. The other two are more closely aligned to Australian high schools, preparing students for higher education. The significant difference however is that one pathway focuses on preparing students for higher educational pathways in research – while the other pathway prepares students for higher educational pathways within professions and industry.

   There are significant advantages for the government and industry to emulate the close relationship that exists between education, industry and research. Australian State and Federal Governments need to support training towards research in parallel with industry.

Industry and Professional Associations

Professional associations, such as the Australian Hydroponic and Greenhouse Association, need to establish strong relationships with registered training organisations such as TAFEs, working in partnership to drive training, establish career pathways and to foster innovation.

Education and Training

Schools

Hydroponics is the modern face of horticulture. The industry and TAFEs need to engage the secondary school sector and promote career pathways within the industry through pre-employment programs, VET in schools programs, Australian school-based apprenticeships, in-school hydroponic kits that complement school curriculum, and online certificate programs.

Recommendations

University and TAFE

TAFE, in conjunction with the AHGA, currently jointly sponsor visits from specialist trainers from the Dutch training institution, PTC+, providing tailored workshops for growers and trainees. Specialist trainers could also provide training for Australian teachers and trainers to increase local capacity. This could be further enhanced through teacher exchange and mentoring with overseas colleagues.

National Curriculum

A nationally recognised Training Package that meets the specific needs of the Greenhouse Industry is essential for continued growth and to enhance the capacity of the industry. The current Training Package related to production horticulture is more suited to field and orchard production and neglects the Greenhouse Industry and especially hydroponics, in many key areas.

The impending amalgamation of the Amenity Horticulture, Agriculture and Conservation and Land Management Training Packages is an ideal opportunity to complete this task.

Community

As overseas research continues and the need for cleaner, more cost effective production systems increases, so too will the need for international updates on the latest in greenhouse technologies.

Protected cropping is about controlling the physical growing environment of the crop, within specific parameters. Many of the techniques and technologies employed to do this could be transferred into modern buildings and housing for efficient climate control and energy transfer.

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Attachments

FINAL REPORT

PROJECT NUMBER – VG05095

PATHWAYS TO PRODUCTION

(A Skilling Initiative of the Australian Protected Cropping Industry)

31st October 2008

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VG05095 – *Pathways to Production, a skilling initiative of the Australian protected cropping industry)*

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Purpose: The projects aim is to address a significant market failure in the Australian protected cropping industry by developing a comprehensive training program for delivery to all growers. Even though we operate in a global economy and therefore compete against imported horticultural produce, we do not enjoy equal access to training opportunities that has the capacity to significantly lift our productivity and quality. 'Pathways to Production' has been developed to meet the commercial growers need to up-skill and improve their farms viability.

Funding Source: Horticulture Australia Limited & AusVeg

Collaborating Institutions:
Australian Hydroponic & Greenhouse Association (AHGA), Graeme Smith Consulting, Goulburn Ovens Institute of TAFE, NSW DPI, Virginia Horticulture Centre

Date of Report: **31st October 2008**

Attachments

Contents

Appendices (all attached as PDF Files)

Summary

A common theme running though the protected cropping industry was a lack of training and skilling options for all levels of participants. A 2005 review of the industry performed by the Australian Hydroponic & Greenhouse Association explored market failures and constraints to industry development with the main industry representatives in all Australian states. This review resulted in identification of around 19 issues that urgently require attention, with the number 1 common issue identified as a lack of skills training opportunities.

There is currently no schools to industry pathways (to encourage horticultural students to pursue careers in our industry), industry career pathways or specific hydroponic production modules (units & competencies) within the national curriculum framework, but rather some limited sub-modules within other horticultural production modules and it was identified that this failure would only be rectified with industry support.

It should be noted that our industry has received some support in the past for important industry issues (such as IPM, Minor Use Registration, etc), however there has never been any support for grower skilling that has the capacity to lift the entire industry.

This project consulted industry participants via a series of national workshops to perform a needs and gap analysis and then develop the programme, research and produce the training units & competencies. (The actual delivery of training will be the subject of a future VC application to AusVeg & HAL.)

A compelling argument for adoption of this project is that without basic skills training in specialised horticultural subjects (eg plant physiology, environmental management, etc), then no amount of new or existing technology, chemical or fertilizer regimes, integrated pest management strategies or new varieties or cultivars, etc will change or enhance the growers productivity or viability.
Skills training at all levels was seen as necessary to underpin industry development & growth.

Currently growers are required to travel to overseas training institutions (most notably in the Netherlands) to receive tuition in this specialised area, and at significant cost and additionally our growers operate in a global economy with fierce competition from exporting nations that have access to full training programs at all levels.

The project has successfully delivered a total of 63 base units and competencies covering certificate's II – VI (see appendix a., 5 x PDF).
These units are being aligned with the Australian Qualifying Framework (AQF) to facilitate national recognition that would create a new discipline within 'Production Horticulture' to be known as 'Controlled Environment Horticulture' (CEH).

Additionally, a further 12 supplementary units identified during the project by industry are to be developed. These units are not necessarily required within the base qualifications and could be delivered as a short-course to meet specific enterprise needs (see appendix b., 1 x PDF).

An outcome of the P2P project for the Australian Protected Cropping Industry was a demonstrated need for a pre-employment program to introduce intending new industry participants to a comprehensive overview and heightened awareness of Controlled Environment Horticulture (CEH). (see appendix c., 1 x PDF)

An additional output from this project was the strong potential for development of a 'National Training Centre for Controlled Environment Horticulture', based on a Dutch model that

delivers both theoretical and practical training in a purpose-built glasshouse facility. The AHGA has been approached by two colleges to enter into an MOU to deliver this to industry.

(see appendix d., 1 x PDF)

Introduction

The project aimed to address a significant market failure in the Australian protected cropping industry by developing a comprehensive training program for delivery to all greenhouse or hydroponic growers.
Even though we operate in a global economy and therefore compete against imported horticultural produce, we do not enjoy equal access to training opportunities that has the capacity to significantly lift our productivity and quality. Skills' training at all levels was considered necessary to underpin industry development & growth.
It is a national imperative that access is provided in all states to ensure that training and accreditation is developed to meet the growing needs of the protected cropping participants and the needs of their staff.

'Pathways to Production' has been developed to meet the commercial growers need to up-skill and improve their farms viability.
The current lack of formal training was addressed at all levels from Certificate 2 - 6 in horticultural production, as well as development of a pre-employment program targeted at new industry entrants.

One initiative is development of a 'Greenhouse Passport' to record grower accreditation levels that could be transferable across different workplaces or employers.

It was discovered that production and quality increases were necessary to meet the increasing demands of QA systems for both domestic and export markets. Industry skilling has the capacity to meet these needs and match the standards of the competitive imports/exports.
Improved productivity also enhances the industry to the wider horticultural community resulting in overall growth through increasingly attracting new entrants.

Some expected benefit/consequences of this work are a significant lift in grower productivity and viability with a concomitant decrease in cost of production through improved production techniques. Improved techniques should translate into enhanced production and quality that satisfies the QA requirements of both domestic & export markets leading to enhanced market opportunities.

Target audience was all growers in the Australian protected cropping industry with no or little formal horticultural training in their field (industry estimates over 90% of current growers).
Adoption strategies included trained industry facilitators surveying the growers and comparing their production levels with common practice around the world as well as assessing % of 1st v 2nd class product.
Resultant data could be used to encourage growers to lift standards necessary to meet market & QA expectations through improved education.

Project evaluation is ultimately proved by increased lift in production per m^2 (standard measure used worldwide to compare production systems and individual growers), as well as increased uptake of product by consumers.
Qualitative & quantitative data can also be assessed through the main grower distribution markets in all major capital cities. Grower feedback can be sought to assess pre & post production levels per m^2 with an industry database developed to track grower accreditation levels and production improvements.

It is proposed that regular consultation with the National Greenhouse Vegetable Working Group and AusVeg IDO's re outcomes and on-going adoption of project be conducted.

Factors considered necessary for project adoption included ensuring that the grower's needs were comprehensively surveyed, prioritised and effectively delivered. Significant production advantages were clearly articulated to all growers to overcome some reticence to sharing production data. Failure to reach the majority of industry growers would have impacted on the programmes success, therefore it was imperative to run a minimum of two workshops in each state to ensure reasonable data capture.

Methods & Activities

The principle investigator and collaborators met at the Virginia Horticulture Centre in June 2006 to develop suitable tools for use by facilitators in each state.
The facilitators conducted a skills audit of all industry participants in each state to assess their needs in terms of greenhouse skills and education and this would take form the basis of a needs & gap analysis.
In addition, the opportunity was to be taken to conduct a simple survey to allow a dimensioning of the industry by investigating grower numbers, locations, crops, technology types, etc. (see appendix e., 1 x PDF)

Tools were developed (included a PowerPoint presentation) (see appendix f., 1 x PDF) to facilitate the proposed workshops by driving group discussion and feedback.
This presentation also ensured that facilitator's were consistent in both their message and data collection.

This presentation introduced the industry project by exploring the background, advised of expected outcomes, announced the timeline, industry benefits and facilitated the workshop. The input from participants was prioritised and options for future delivery of training were considered, and finally, explored the best ways to maintain communication with each workshop group.
A detailed list of possible areas for training was then shown to participants to prompt further discussion when all ideas from the local group have dried up. This list was kept in reserve to ensure that participant most pressing needs are first met and then introduced to ensure important areas are not overlooked. (see also appendix f., 1 x PDF)

Also developed was a facilitator's toolkit as a prompt to ensure all tools were available for each workshop. (see appendix g., 1 x PDF)

The facilitators for each state were nominated as follows:

Western Australia	- Graeme Smith (Graeme Smith Consulting)
Victoria	- Graeme Smith (Graeme Smith Consulting)
	- Leigh Taig (GOTafe Shepparton)
Tasmania	- Graeme Smith (Graeme Smith Consulting)
	- Leigh Taig (GOTafe Shepparton)
New South Wales	- Jeremy Badgery-Parker (NSW DPI)
Queensland	- Jeremy Badgery-Parker (NSW DPI)
South Australia	- Peter de Lacy (Virginia Horticulture Centre)
Northern Territory	- Peter de Lacy (Virginia Horticulture Centre)

Industry Consultation
This involved detailed consultation with industry participants in all Australian states. Nominated facilitators surveyed each state to determine their specific requirements taking into account their geographic location and market characteristics. The Units & Competencies titles were presented, discussed and prioritised. State dimensioning was used to produce

data for individual skills audits that highlighted skills gaps and a needs analysis. Facilitators located, communicated and delivered workshops to key identified industry areas.

A total of fifteen workshops were completed:

Western Australia –	2 (Perth & Geraldton)
NSW –	4 (Windsor, Leppington, Coffs Harbour & Dareton/Mildura)
Tasmania –	2 (Hobart & Launceston)
Victoria –	3 (Shepparton, Geelong & Cranbourne)
SA -	2 (Adelaide Plains & Murray Bridge)
QLD -	2 (Brisbane & Bundaberg)

Some attendees of a grower's workshop.

Workshop Results:
From analysis of the priority lists and group discussions with participants to clarify key points, it was determined that there were five over-arching aspects of controlled environment horticulture for which growers are seeking comprehensive training and information from basic through to advanced instruction. Technology and how it is used to provide the optimal (and most economical) growing environment is the primary consideration of the industry. One of the most interesting outcomes is that the industry is looking for production systems (as well as information and skills) that enable effective management of different crops so that growers can diversify or readily change crops to reflect market conditions.

A. Greenhouse climate control
- selecting and operating appropriate technology to effectively manage and operate the controlled environment system with respect to crop management and crop performance

B. Implementation of IPM
- practical (and feasible) implementation and integration of pest and disease management decisions and tools (includes selecting and effectively operating appropriate technology)

C. Marketing

- strategies for selling product, new crop selection and development, implementing flexible controlled environment systems that enable niche marketing and changeable crops

D. Growing systems

- appropriate nutrient, substrate and irrigation management techniques and decision making with respect to crop management and crop performance

E. Performance benchmarks

- financial management including costs of production, making capital purchase decisions (relates to selecting appropriate technology) and operating decisions (relating to optimising economic performance and management of crops.

The general consensus on what workers require is training and information in –

- Safe and effective use of chemicals
- Identification and management of pests and diseases
- Post-harvest practices – primarily improved grading and packing methods
- Farm and greenhouse hygiene – how and why
- Hydroponics – understanding and managing effectively

Specific information and training priorities:

The specific key priorities identified by owners were

1. nutrient management
2. training and development
3. using climate control properly to manage the greenhouse environment
4. disease identification and management
5. using heating properly to manage the greenhouse environment
6. practical application of biological control agents
7. measurement and control of EC and pH
8. crop cultural management
9. using venting properly to manage the greenhouse environment
10. hydroponic systems
11. greenhouse structures
12. chemicals and their use
13. environmental management
14. seedling production
15. finance and business funding
16. farm safety
17. using solar and thermal screens properly to manage the greenhouse environment
18. general pest and disease management
19. pest identification and management
20. marketing

The specific key priorities identified by owners for employees were:

1. crop cultural management
2. training and development
3. using climate control properly to manage the greenhouse environment
4. personal protective equipment
5. pest identification and management
6. equipment operation and maintenance
7. chemicals and their use
8. spray application and techniques

9. hygiene in the greenhouse
10. using thermal screens properly to manage the greenhouse environment
11. trolleys and internal transport systems
12. disease identification and management
13. measurement and control of EC and pH
14. farm safety
15. hydroponic systems
16. grading and packing systems
17. monitoring
18. post-harvest management
19. team management
20. plant nutrition

Survey results: (see appendix e., 1 x PDF)
A basic questionnaire was also conducted with participants. The information is low quality and incomplete and therefore should not be used to make extrapolations on a wider basis, however, it can provide some insights to the industry.

There are some conclusions that could be drawn.

- Growers do not know very much about their own industry, in terms of production area or participants
- Conventional crops – cucumbers and tomatoes – dominate production
- Most hydroponic growers use free-drainage substrate culture systems
- Effective climate control of greenhouses is generally poor, with relatively few structures heated and many not vented
- The industry wants a National Training Institute and almost all want it close to their own production area.

Full Program Development
Three of the program developers (Graeme Smith – AHGA, Jeremy Badgery-Parker – NSW DPI & Leigh Taig – GOTafe Shepparton), met in May 2007 at the Gosford Horticulture Institute, to consider and develop the next steps in the program:

1. collate all the collected workshop data (key findings)
2. analysis of training gaps (industry training priorities)
3. outline development for proposed training package (required training course topics)
4. list topics, learning outcomes & competencies
5. explore existing training courses, materials and competencies
6. ensure program is linked to national recognition & accreditation
7. develop proposal for Greenhouse Passport
8. & review budgets and milestones

As noted above, it was resolved that the units and competencies would align with the "Australian Qualifying Framework" (AQF) to facilitate national recognition, and that a new discipline (within 'Production Horticulture') be created to identify this industry training initiative to be known as "Controlled Environment Horticulture" (CEH).

The term 'Controlled Environment Horticulture' (CEH) was considered the best fit to cover the protected cropping industry, as these growers focus on controlling both the aerial environment and the root-zone environment which covers all typical growing systems. This definition would then include both indoor and outdoor hydroponic growers (i.e. lettuce/herb growers in hydroponic channel systems outdoors)

Industry Work Roles
These roles were identified for certificate levels II – VI as follows:

CEH Level	Explanatory Description	Supervision Level
• Level II	Entry Level, (Horticultural Assistant)	High
• Level III	Worker, (Horticultural Worker)	Limited
• Level IV	Supervisor	Low
• Level V	Grower/Manager (diploma)	Autonomous
• Level VI	General Manager (advanced diploma)	Autonomous

General Work Roles & competencies were also identified for levels II – VI as follows:

CEH Level	General Work Roles & Competencies
• Level II	hygiene protocols, CEA overview, OH&S, introduction to workplace environment, **Perform**: basic crop maintenance, picking & packing
• Level III	hygiene protocols, chemical users certificate, OH&S **Perform** crop & system monitoring, recording plant registration and benchmarking, P&D ID & monitoring, basic plant physiology, basic climate management, basic irrigation management, basic nutrition management, basic growing systems, internal transport systems, general equipment (crop trolleys, meters, sensors, boilers, screens, etc), basic IT (software, PC's, etc)
• Level IV	**Schedule Develop & Implement:** hygiene protocols, chemical users certificate, OH&S, crop & system monitoring, recording & reporting plant registration and benchmarking, P&D ID & monitoring, advanced plant physiology, advanced climate management, advanced irrigation management, advanced nutrition management, advanced growing systems, internal transport systems training, general equipment (crop trolleys, meters, sensors, boilers, screens, etc), advanced IT (software, PC's, etc) and staff supervision.
• Level V	**Plan & Manage:** hygiene protocols, chemical users certificate, OH&S, QA, crop & system monitoring, recording & reporting plant registration and benchmarking, P&D ID & monitoring, advanced plant physiology, advanced climate management, advanced irrigation management, advanced nutrition management, advanced growing systems, internal transport systems training, general equipment (crop trolleys, meters, sensors, boilers, screens, etc), advanced IT (software, PC's, etc) and staff management, budgets, business marketing, strategic plans, production plan, all farm planning
.	
• Level VI	**Manage, Develop & Review**: production systems, human resources, strategic plan, business capital, capital works, enterprise quality systems, analyse business performance, export markets, domestic markets

Units & Competencies for CEH
The final result ended in development of 63 new units & competencies for CEH over the five certificate levels.
Certificate II – CEH - 17 units (attached as * Final draft PDF)
Certificate III – CEH - 16 units (attached as * Final draft PDF)
Certificate IV – CEH - 12 units (attached as * Final draft PDF)

Certificate V – CEH - 10 units (attached as * Final draft PDF)
Certificate VI – CEH - 8 units (attached as * Final draft PDF)

The above PDF files are composed of a total of 353 pages.

Specialty Skill Sets (see appendix b., 1 x PDF)
In addition to the above units, the project identified an initial 12 'specialist skill sets' that are unique to CEH and will require further development in the future. (attached as *.PDF). These specialty skill sets are supplementary units identified by industry, which are not necessarily required within the base qualifications.

These additional 12 units could be delivered as a short-course to meet specific enterprise needs.

(n.b. these units would result in a total of 75 developed for CEH by this project)

CEH Pre-Employment Program

An outcome of the P2P project for the Australian Protected Cropping Industry was a demonstrated need for a pre-employment program to introduce intending new industry participants to a comprehensive overview and heightened awareness of Controlled Environment Horticulture (CEH).

It is anticipated that the current 10,000 employees directly employed in the industry will climb to around 30,000 by 2015. (source: national greenhouse advisory group, 2006)

The P2P program facilitators identified a CEH Pre-Employment Program as a suitable pilot program as required under the funding requirements by HAL & AusVeg

'Flavorite' (Warragul, west Gippsland, Victoria), was identified as a suitable work location as it was a relatively large greenhouse employer with a good mix of industry technologies and employment opportunities that included, plant management, picking, packing, grading and transport.

The CEH Pre-Employment program (Pilot) consists of the following agreed elements:

1. It would be on a competency basis (i.e. competency needs to be demonstrated to attain accreditation)
2. The program would include practical elements (i.e. not just theory for accreditation)
3. It would be delivered as a Certificate Level II in Production Horticulture (CEH). (i.e. a new unit of competency to be created)
4. Whilst this pilot unit would be developed to meet the needs of Flavorite, it also will be generic to meet the needs of all national greenhouse growers

As Flavorite was recruiting in October 2008 and new crop staff expected to commence duties around November, it was resolved to run the pilot program 12th – 14th November.
(see appendix c., attached 'CEH Pre-Employment Program. PDF')

Greenhouse Passport
Another output from the project was the development of a portable 'Greenhouse Passport' that will record participant's accreditation levels. This passport can then be used to provide individual industry recognition that is transferable between employments and workplaces.

Initial discussions with AusVeg were held with a view to utilise their planned national grower database to both record individual accreditation levels and output a document suitable for use for growers to utilise as a 'greenhouse passport'.
Future liaison with the database developers will need to be performed when AusVeg are in a position to carry this national project forward.

The Greenhouse Passport will be the catalyst to facilitate industry career pathways by articulating individual achievement and show competency for each CEH level for consideration by all greenhouse enterprises.
To this end, industry is encouraged to begin using the above CEH Level terms in regular 'day to day' communication to develop familiarity and career pathways.

National Accreditation
It was resolved that the units and competencies would align with the "Australian Qualifying Framework" (AQF) to facilitate national recognition and this process is currently being facilitated by Leigh Taig of GOTafe.
This national accreditation would then allow any Registered Training Organisation (RTO) to delivery any or all of the CEH units to the appropriate standard.
This approach is considered necessary to ensure equal opportunity for all industry participants (inc workers and enterprises) to have a consistent approach to training and career options, therefore building industry capacity and cohesion.

Industry Presentations
The outcomes of the Pathways to Production project are planned to be communicated to industry at a wide-range of forums, with a particular focus on the original workshop locations around the nation. This is consistent with advice given to participants during the original workshops to ensure we report back directly to industry.

The initial targets included the state-based protected cropping grower representative bodies as well as the AHGA & AusVeg, plus a range of industry publications & periodicals.

Presentations Completed
As at time of this report, the following reports to industry have been completed:
1. VIC - Hydroponic Farmers Federation October grower meeting in Lara
2. WA – West Australian Greenhouse Growers Association September grower meeting in Perth
3. TAS – Tasmanian Association of Greenhouse Growers September grower meeting in Campbell Town
4. AHGA Web site
5. AHGA national 'Soilless Australia' magazine to all association membership

Presentations to come
1. SA – at Virginia Horticulture Centre
2. NSW – at Coffs Harbour
3. NSW - AHGA national biennial industry conference in Sydney in July 2009
4. QLD – at Bundaberg Fruit & Vegetable Growers Association
5. Practical Hydroponics & Greenhouses (national and international trade magazine)
6. AusVeg national magazine – 'Australian Vegetables'

National Training Centre for Controlled Environment Horticulture

A protected cropping industry review in 2005 found a number of market failures that were to be addressed.
The market failures detected included a lack of:

- Demonstration facilities
- Specific Hydroponic education streams
- Centralised training facilities
- EO/IDO to develop & coordinate industry
- Marketing & Promotion of Greenhouse produce
- Urban design principles to facilitate development in key areas
- Natural Gas delivery to key areas
- Bio-control Facilities
- Minor-Use Registration Program
- Model business plans
- Global radiation figures
- Dedicated R&D facilities
- Market access studies
- Appreciation for major water & energy resource efficiencies
- Field grower incentives
- Bumblebees
- Financial Institution Support
- Industry Strategic Plan

Some of the above have now been addressed by the AHGA, however a significant number could be addressed through the development of a national greenhouse training institute based on the Practical Training Centre Plus (PTC+) in Ede, The Netherlands.

- This centre in Ede (Holland) specialises in horticultural training (being close to Wageningen, the centre of horticultural research in the Netherlands).
- PTC+ has purpose built greenhouses to demonstrate technology & put into action their slogan "Learn by Doing".
- They annually train 40,000 graduates in 5 campuses, have 450 employees and annual turnover of US$28million

Each year, The AHGA facilitates a greenhouse study tour of Europe that includes a 5-day intensive training course at PTC+ on computerised environmental control, substrates, water & fertiliser management, post harvest & crop protection.
On the completion of the course, each participant is presented with a completion certificate entitled "Advanced Horticultural Course on Greenhouse Management"

PTC+ has well developed training facilities that include classrooms connected to a glasshouse (divided into 10 different compartments for 10 different crops and their unique growing technologies), that allows us to immediately put into practice the theory learnt.
The course entry level is aimed at greenhouse managers & consultants, however ample time is allocated to ensure all participants' needs are met.
The course modules covered are subject to feedback from participants and can be tailored to best meet any group's needs.
Our main instructor was Ben van Onna who comes with great credentials and was well received during his all-states visits & workshops for the 2003 & 2007 AHGA national conferences.

PTC+ is not just a training institute but also offers a number of other roles that have been identified by the Australian protected cropping industry in 2005 as constraints to industry development. These roles include:

- Centralised Training Facilities
  a location that delivers industry specific training in both theory and practical
- Demonstration Facilities
  to showcase both existing, new and emerging technology and how to integrate into growers systems
- Dedicated R&D Facilities
  to ensure our technology driven industry adapts to Australian conditions and crops
- Field Grower Incentives
  demonstrate alternative production techniques to traditional Australian farmers
- Model Business Plans
  developed using centre's growing technology for each crop
- Minor-Use Program
  a location to assist with efficacy trials on new greenhouse products
- Bio-control Facilities
  potential area to develop or trial new greenhouse bio-controls and beneficial insects
- Energy & Water Efficiencies
  centre for industry research into resource utilisation and efficiencies

A National Greenhouse Training Centre

- has capacity to lift entire industry through targeted education and research
- Can assist in overcoming grower reluctance to invest in unfamiliar (yet proven) technology
- sets industry standards and targets (both quality & production)
- demonstrates best-practice growing techniques for Australian greenhouse crops
- be a centre for Asia/Pacific education and training in greenhouse crops and technologies (targeting Malaysian, Indonesian, Chinese, New Zealand and other regional growers.)
- AHGA will enter into a partnership with PTC+ to develop & deliver specialist industry training.
- The centre to be based on PTC+ model (theory & practical)
- It would include classrooms, growing systems, structures, common technology, café, catering, admin, student accommodation, etc
- Crops targeted – tomatoes, capsicum, strawberry, cucumber, lettuce & herbs, rose, gerbera, aquaponics, etc
- It would need to be located for best industry return (TBA?)
- Potential funding sources would include: TAFE funds, industry and commercial partnerships, government, course fees from participants, produce sales, breeders trials, etc
- The expected base capital infrastructure costs are yet to be determined.

Another issue of concern to the industry is the reluctance of existing growers to adopt innovation and invest in new technologies that are crucial to keeping pace with global production and quality standards.
This proposal to establish a Centre for CEH would ultimately encourage existing growers to adopt and invest by showing them how to integrate new and emerging technologies into their own systems.

A National Greenhouse Training Centre can meet a significant number of identified industry failures and industry is urged to investigate proposals from two Victorian training institutions.

1. Goulburn Ovens TAFE (William Orr Campus, Shepparton)
2. Chisholm Institute (Cranbourne Campus)

Both colleges have approached the AHGA to enter into an MOU with a view to creating a combined management team with the AHGA to deliver this training facility. (n.b. it should be noted that we do not intend to support two centres, but partner best option to suit industry needs.)

PTC+ MOU

Graeme Smith (President AHGA) traveled to Holland this October to meet with directors of PTC+ to develop a Memorandum Of Understanding to assist us with high-level technical support and ongoing industry training. PTC+ have entered into similar partnerships to deliver training centres to both China and India.

Graeme also presented the proposed centre model to PTC+ for assessment of technical merit (see appendix d., 1 x PDF) as well as took the opportunity to attend Hortifair in Amsterdam to cost the proposed model with a number of large Dutch greenhouse design & development companies that have installed multiple systems in Australia.

We emulate Dutch growers in terms of technology and varieties, however if we aim to match their quality, efficiency & productivity, then industry up-skilling is mandatory. An institute can offer this and more.

This proposed National Training Centre for Controlled Environment Horticulture is a direct outcome of the Pathways to Production project and has received 100% support from all attendees of our national workshops

Participants of 2007 European Greenhouse Study Tour (at PTC+)

Participants of 2005 European Greenhouse Study Tour (at PTC+)

(Theory) **(Practical)**

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