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THE SWIRE GROUP CHURCHILL FELLOWSHIP 2002

to study advanced Integrated Pest Management (IPM) techniques, systems, and adoption in Scandinavia, Holland, and the United Kingdom with potential application in Australian horticulture"

Andrew Bishop M.Agr.Sc., CPAg
Leader (Clean Products Team)
Department of Primary Industries, Water, & Environment
Devonport, Tasmania, 7310
Phone: 03 6421 7634
Fax: 03 6424 5142
Email: Andrew.Bishop@dpiwe.tas.gov.au

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Acknowledgements

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Photographs by A. Bishop and H. Russell.
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Churchill Memorial Park sculpture, Copenhagen, Denmark

Sustainability: let's take our future seriously otherwise…

"…the alien anthropologists admitted they were still perplexed but on eliminating every other reason for our sad demise, they logged the only explanation left, this species has amused itself to death"

- Roger Waters, Amused to Death, Sony Music, 1992.

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Executive Summary

Name: Andrew Bishop
Position: Team Leader, Department of Primary Industries Water and Environment (DPIWE), Tasmania
Address: DPIWE, PO Box 303, Devonport, Tasmania, 7310
Contact: Telephone 03 6421 7634, Fax 03 6424 5142,
Email Andrew.Bishop@dpiwe.tas.gov.au

Fellowship Objective

Investigate advanced Integrated Pest Management (IPM) techniques, systems, and adoption in Denmark, Sweden, Finland, Holland, and the United Kingdom with potential application in Australian horticulture

Fellowship Findings

Innovation and adaptation- a progressive agricultural sector in Northern Europe: Northern Europe's agricultural sector, particularly its vegetable and fruit production, are verifiably clean and green[1] due to chemical-alternative practices incorporated into conventional production, and progressive benchmarking systems to measure levels of synthetic pesticide and fertiliser use. I found the farmer attitudes to be very accepting of change in each of the countries visited; there is a definite culture of innovation and adaptation amongst many leading Northern European farmers particularly in Denmark and Sweden. Only a few of the pesticides available to Australian farmers are available to the Northern Europeans with Danish producers having access to the least number of registered products. Innovation is also evident in the government and university agricultural Research, Development, and Extension (R,D,&E) institutions. Equipment and pest forecast techniques are being used commercially by farmers. I identified several tools and techniques with possible application for Australian horticulture.

Government facilitation of organic agriculture: There is very strong government support for developing organic industries in each of the countries visited; organic production is viewed as a pathway to 'Clean and Green'. This support extends to subsidies to assist growers in the conversion process.

Integrated Production as the European way of farming: Marketing challenges exist with producers trying to get consumer recognition for Integrated Production branding at a similar level to organic recognition. This appears to be failing and conventional produce will eventually be produced via integrated production without branding. Such a scenario could also occur in Australia.

Government policies for a clean and green agriculture: Most noticeable were strong government policies, particularly in Denmark. These are driving successful pesticide reduction programs. In Australia a notable lack of such policies needs to be addressed to achieve sustainable horticulture that is capable of being verified 'Clean and Green'.

[1] The meaning of 'Clean and Green' is not easily defined. However substantiated programs that can demonstrate shifts towards low impact high quality, and safe food production can be considered reasonable measures of 'Clean and Green'.

Recommendations

The report identifies 17 recommendations ranked as essential, high priority, or desirable to progress to a productive, efficient, clean and green horticultural sector in Australia. Many of these could be addressed subject to the following actions that are considered of a very high priority:

- Establishment of programs in each of the States to facilitate a 'Clean and Green' Australian horticultural sector. This would incorporate a strategic development program for the organic industry.

- Development of progressive Government policy to stimulate this facilitation and cultural change needed to progress to a 'Clean and Green' status.

- Pesticide Action Plans are needed in each of the Australian States with the adoption of chemical use benchmarking such as the Treatment Frequency Index system used in Denmark.

- The establishment of organic learning centres[2] with international links to similar centres in Europe.

- Expansion of State agricultural agency assessment activities (research and extension) to include the range of reported IPM tools and techniques being used in Northern Europe.

Recommendations will be progressed through my own work program and briefings given to the Tasmanian Premier, Minister for Primary Industries, Water, and Environment and DPIWE Executive. My focus will extend beyond technical implementation to policy development where possible.

Highlights

- Meeting farmers and their families in each of the countries visited. Drinking Danish coffee and eating Danish pastries in Peter Hartvig's traditional Danish farmhouse and discussing his cropping practices. Experiencing the energy and enthusiasm that Hans Axel Anderson had for his farming venture in Sweden.

- Spending a week in Research Centre Flakkebjerg guesthouse and experiencing real Danish countryside and farmland while visiting Flakkebjerg research trials in the shadow of Danish wind turbines.

- Seeing technologies such as brushweeders and flame weeders being used by conventional vegetable growers as part of their normal cropping practice.

- A day organised by Bodil Jonsson visiting the Findus vegetable processing factory at Bjuv, Sweden.

[2] A discussion paper has already been prepared by A. Bishop on the logistics of this.

- Jorgen Persson's frank and open discussions about his production practices successfully growing organic carrots commercially as part of the Marianne's farm business in Sweden.

- A day spent with Christer Torneus as he undertook his crop scouting activities in Kivick apple orchards in Sweden. Complete IPM systems in practice.

- Visit to Ekhaga organic demonstration farm at Uppsala in Sweden. Meeting and farm tour with farm manager, Lennart Karlsonn.

- A quiet afternoon exploring the Ryton Organic Gardens near Coventry England.

- Opportunity to stay in the 15th century Rothamsted Manor at the Rothamsted Research Station and visit Broadbank, the oldest active agricultural experimental site in the world established 1843.

- Luncheon hosted by Swire Group Chairman, Sir Adrian Swire, at the Swire group's head office in London and opportunity to meet Board members.

Study Tour Program 2002

Dates	Institute &Activity	Location
27th May	Arrive Copenhagen **(Denmark).** Travel to Flakkebjerg	
28th May to 1st June	Danish Institute of Agricultural Sciences: -Welcome to research centre -Physical weed control (Bo Melander) -Management of Insect pests in vegetables (Gisela Felkl) -Pesticide regulation in Denmark (Klaas Paaske) -Disease management in vegetables (Lars Bodker) -Chemical weed control strategies (Peter Hartvigs) Farm visits: -Market gardening/farm shop (Peter Hartvigs) -Onion, leek, cabbage cropping (Claus Hunsballe) -Onion and sweetcorn cropping	Flakkeberg Skaelskor
2nd June to 7th June	Royal Veterinary and Agricultural University: -Visit to organic farming unit -Organic vegetable production (Erik Steen Jensen) -Intercropping mixtures (Henning Hogh Jensen) -Integrated production (Peter Esberg) -Beneficial plantings and beetlebanks (Werner Reidel) -Integrated weed management (Jens Streibig) -Aquatic plants as herbicide detectors (Nina Cedergreen -Organic farming education (Jesper Rasmussen)	Taastrup & Copenhagen
8th June to 9th June	Arrive Malmo **(Sweden)**. Travel to Lund/Alnarp.	

10th June to 14th June	Plant Protection Centre, Swedish Board of Agriculture -Introduction to Swedish Board of Agriculture (Magnus Grontoft) -Integrated Production of vegetables (Bodil Jonsson) -Field visits to conventional & organic farmers (Bodil Jonsson) -Findus factory visit (Enar Magnusson) -Findus farmer visits (Bengt Gunnarsson) -Mariannes Farm visit (Jorgen Person, Marianne Harning-Nilsson) -Mariannes farmer visits (Bodil Jonsson) -Apple orchard and Strawberry farm visits (Christer Torneus) -Biological contropl in glasshouses (Barber Nedstam) -Organic weed control (Johan Ascard) -Travel to Uppsala, north of Stockholm	Alnarp, Bjuv, Malmo, Kivik, Angelholm, and Uppsala
14th June	Centre for Sustainable Agriculture (CUL), Swedish University of agricultural Sciences -Introduction to CUL (Karin Ullven) -Organic vegetable management (Fredrick Fogelberg) -Field Visit to Ekhaga Farm (Lennart Karlsson)	Uppsala
15th June to 17th June	Travel to Forssa **(Finland)**	
18th June to 20th June	Agrifood Research Finland (MTT) -Finnish IPM program for vegetable farmers (Kari Tiilikkala) -Organic farming in Finland (Kari Tiilikkala) -Trap cropping (Anna Nissinen) -Visit to Lannen Tehaat, (Pekka Kurrie) -Visit to Rapi Experimental Farm (Pekka Kurrie)	Jokioinen Sakyla Koylio
21st June to 22nd June	Travel to Helsinki (Finland). Flight to Netherlands.	
23rd June	Arrive Arnhem-Papendal Sports Centre **(Netherlands)**	
24th June to 27th June	12th European Weed Research Society Symposium	Arnhem
28th June	Biological Farming Systems Unit, Wageningen University -Mycoherbicides for woody weed control (Meindert deJong & Barend de Voogd)	Wageningen
25th July	Travel to Harpenden **(England)**	
26th July	IACR-Rothamsted Experimental Station -Introduction to Rothamsted research (Stephen James) -Computer based decision support systems (Paul Verrier)	**Harpenden**

	-Encouraging natural enemies (Wilf Powell) -Pest Ecology and management/Insectary tour (Ian Denholm) -Nematodes and IPM (Brian Kerry) -Semiochemicals (Lester Wadhams) -Aphid monitoring, forecasting, and decision support (Richard Harrington)	
27th July	Travel to Coventry (England)	
29th July to 30th July	Organic Horticulture,Henry Doubleday Research Association (HDRA) -Organic horticulture in the UK (Gareth Davies -Economics of converting to organic production (Chris Firth)	Ryton
31st July	Luncheon with Directors, Swire Group Host: Sir Adrian Swire & Board	London

Introduction

Adoption of Integrated Pest Management (IPM) is seen as one essential component to progress Australian horticulture towards sustainability as well as a verifiable 'Clean and Green' status. Integrated Pest Management (IPM) is a dynamic system that coordinates all available methods to effectively control diseases, weeds, and insect pests in crops whilst reducing/eliminating environmental hazards. IPM has been described as socially acceptable, environmentally responsible, and economically practical crop protection i.e. it satisfies the Triple Bottom Line (TBL).

In some regions of the world, such as Scandinavia, government legislation has resulted in the reduction or elimination of the use of pesticides in an effort to develop clean production systems. In these countries research into alternative technologies and systems to manage pests has been intense; development and availability of tools and techniques are well advanced. It was within this context that I undertook the study tour detailed in this report.

This report details findings and recommendations from the 2002 Swire Group Churchill Fellowship investigating advanced IPM techniques, systems and adoption in Scandinavia and Northern Europe with potential application in Australian horticulture. Countries I visited on the tour were Denmark, Sweden, Finland, Netherlands, and England.

My specific goals were to document and investigate advanced key IPM technologies that have been developed in Scandinavia and Northern Europe in recent years. I aimed to assess the technologies for the role they could play in developing sustainable horticultural production in Australia. I also wanted to assess the adoption of IPM in Northern Europe with relevance and application in Australia. This related particularly to farmer attitudes and drivers for change including government policy. Most of my investigations centered on vegetable production.

Fellowship Findings

The geographical region selected for the study tour has an enviable reputation for progressive agricultural policies that has reduced food production reliance on synthetic chemicals. They also have a reputation for advanced IPM technologies enabling TBL approaches to horticulture. I was able to visit Denmark, Sweden, Finland, Netherlands, and England. Over a period of nearly eight weeks I attended ten institutions, inspected several experimental research and demonstration stations, two vegetable processing factories, and numerous farms growing both conventional and organic vegetables, cereals, and fruit. I spoke to scientists, policy makers, farmers and their families, industry personnel, agricultural consultants, and company directors.

Objectives of Fellowship

At the outset of the tour, my specific goals were to document and investigate advanced key IPM technologies that have been developed in Scandinavia and Northern Europe in recent years. I wanted to assess the adoption of IPM in Northern Europe with relevance and application in Australia. This related particularly to farmer attitudes and drivers for change including government policy. In addition to achieving these goals, I was able to gather and assess additional information on Northern European agriculture with a particular emphasis on the organic agricultural industries in the countries visited.

Innovation and adaptation- a progressive agricultural sector in Northern Europe

Northern Europe's agricultural sector, particularly its vegetable and fruit production, are verifiably clean and green[3] due to chemical-alternative practices incorporated into conventional production, and progressive benchmarking systems to measure levels of synthetic pesticide and fertiliser use. I found farmer attitudes to be very accepting of change in each of the countries visited; there is a definite culture of innovation and adaptation amongst many leading Northern European farmers particularly in Denmark and Sweden. Only a few of the pesticides available to Australian farmers are available to the Northern Europeans with Danish producers having access to the least number of registered products. Innovation is also evident in the government and university agricultural Research, Development, and Extension (R,D,&E) institutions. Equipment and pest forecast techniques being used in Europe had been developed by these institutions and are now being used commercially by farmers. I identified several tools and techniques with possible application for Australian vegetable and fruit growers.

Government facilitation of organic agriculture

There is very strong government support for developing organic industries in each of the countries visited; organic production is viewed as a pathway to 'Clean and Green'. This support extends to subsidies to assist growers in the conversion process. Organic certification authorities in Europe appear more liberal and flexible in their certification requirements than Australian authorities. This highlights some certification requirements in Australia that may be limiting the growth of an organic industry in Australia. Despite a supportive environment for organic production, the domestic organic markets have flattened out in Europe and some are starting to decline. Organic industries in

[3] The meaning of 'Clean and Green' is not easily defined. However substantiated programs that can demonstrate shifts towards low impact high quality, and safe food production can be considered reasonable measures of 'Clean and Green'.

each of the countries visited identified increased consumer demand for organics and/or alternative export markets to maintain industry growth.

Integrated Production as the European way of farming

Marketing challenges exist with producers trying to get consumer recognition for Integrated Production branding at a similar level to organic recognition. This appears to be failing and conventional produce may eventually be produced via integrated production without branding. Such a scenario could also occur in Australia. It was generally agreed that the large supermarket chains still consider price to be the major factor in sourcing their product, especially vegetables. However there was a growing secondary consideration for production methods as reflected in the EUREPGAP protocols.

Government policies for a clean and green agriculture

Most noticeable were strong government policies, particularly in Denmark. These are driving a successful pesticide reduction program. Significant improvements to State and Federal government policies in Australia are recommended. I believe Australian States will have difficulties in progressing and claiming a 'Clean and Green' status for their agricultural practices now and into the future if policy issues influencing agricultural practice are not addressed.

Country: Denmark

Denmark is a pioneer in reducing pesticide usage and progressing the development of commercial IPM strategies in both broad-acre and horticultural crops. Denmark is dependent on groundwater for its water needs including drinking water. It was the increasing incidence of groundwater contamination in the early 1980's that resulted in the Danish Parliament legislating for reduced pesticide use. Concurrent to legislative development, a Research and Development (R&D) program was established aimed at developing non-pesticide agricultural systems in Denmark. Denmark's primary agricultural industries are pork and dairy production. Vegetable, cereal, and vegetable/grass seed production are also important. The Danish component of the tour focussed on the island of Zealand where I visited research institutes and commercial vegetable producers.

Hosts: Danish Institute of Agricultural Sciences Research Centre, Flakkebjerg

Research Centre Flakkebjerg is the newest of four centres of the Danish Institute of Agricultural Sciences, a Division of the Ministry of Food, Agriculture, and Fisheries. Opened in 1997, it consists of 6500m^2 of laboratories, auditoriums, meeting rooms, library and canteen. Glasshouses and other working facilities total a further 12300m^2. Located in the centre of Zealand's agricultural production area it consists of 175 hectares of prime farm land used for agricultural field experimentation including organic crop rotation studies.

Physical weed control in vegetable crops
Contact: Bo Melander

Since the Danish Parliament's directive in 1985 to reduce pesticide use in Denmark, activities in the Weed Ecology group have focussed on developing physical weed management options for both conventional and organic vegetable and cereal production. Mechanical weed control in cereal crops is confined mainly to organic producers. Conventional cereal growers find mechanical weed control too labour intensive. Bo commented that such control in cereals was very dependent upon weather conditions. He suggested drier production areas would see increased success for mechanical weed control. Factors contributing to successful physical weed control were different planting architectures and the adoption of a range of technologies such as flame weeders (Fig.1), modified hoeing systems, and torsion weeders (Fig.2). The development of precision agriculture based camera guidance systems was considered essential to improve the economic returns on organic vegetable production.

Figure 1: A commercial flame weeder used at Flakkebjerg Research Centre

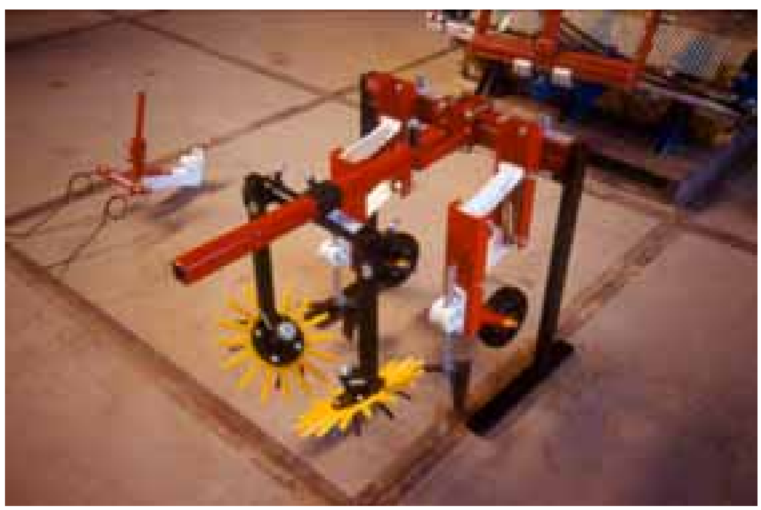

Figure 2: Set of new finger weeders on the right with a pair of torsion weeders on the left.

Plant protection involving insect pests
Contact: Gisela Felkl

Carrot fly management: The primary pest of concern to the vegetable industry in Denmark is the carrot fly (*Psila rosae*). Its pest impact has been increased with progressive de-registration of suitable insecticides as part of Denmark's pesticide reduction program. Pyrethroids are the only insecticide now available but efficacy levels of these products are low. The carrot fly has become the focus of a comprehensive integrated approach to management. A Decision Support System (DSS) has been established for farmers on subscription. The service is based on the use of yellow sticky traps placed in field being regularly monitored by crop scouts. A minimum of five traps are used with economic thresholds established of 0.2 flys/trap/day. In terms of whether to spray or not to spray, the entomologists I spoke with indicated the system lacked such a definite accuracy, However it was sufficiently accurate to indicate insect fly-in times. This has led to the elimination of insecticide application prior to the fly-in period thus reducing insecticide inputs. In addition it has enabled participating growers to harvest early to avoid damage; this was considered critical information for growers of organic carrots.

Regulatory aspects of pesticide registration in Denmark
Contact: Klaus Paaske

Pesticide Action Plan: In 1985, the Danish Parliament responded to public concerns about pesticide use with the development of a 10 year plan (Pesticide Action Plan 1986-97) to reduce pesticide use in Denmark (Table 1). This was undertaken through the setting of a target to reduce both the amount and the application frequency of pesticides on crops by half. An extensive evaluation of all existing registered actives (180) resulted in 133 of them losing registration in Denmark. In addition some actives were completely prohibited for use by law. Despite EU membership, Denmark retains bans on some chemicals that are still used in other EU countries eg. copper based sprays. Indications of pesticide volume reductions are evident with 7500 tonnes/year of pesticides sold pre-1986 being reduced to just under 3000 tonnes of pesticide used last year.

Table 1: Complete listing of approved pesticides for use on outdoor vegetables in Denmark. Crop examples listed in brackets).

Fungicides	**Insecticides**	**Herbicides**
Iprodion (carrots, cabbage, lettuce)	Alphacypermethrin carrots, peas)	Aclinofen (carrot, onions, celery)
Mancozeb (onions, leeks, cauliflower, broccoli, peas)	Cypermethrin (Cabbage, peas)	Clopyralid (cabbage)
Dimethomorph+Mancozeb (onions)	Dimethoat (cabbage, onions, leeks)	Fluazifop-p-butyl (carrots, onions, leeks)
Fenpropimorph (Leeks)	Lambdacyhalothrin (cabbage, peas)	Ioxynil (onions, leeks)
Fosetyl and propamocarb (Lettuce)	Malathion (cabbage, cauliflower, lettuce, peas)	Napropamid (cabbage, peas)
Pyrimethanil (Lettuce)	Pirimicarb (cabbage, peas)	Pendimethalin (onions, leeks, carrots)
	Imidachloprid (lettuce, cauliflower)	Glufosinate-ammonium (Pre-em)
		Glyphosate (Pre-em)

Mechanisms to encourage pesticide reduction were based on the registration removal process for certain pesticides. In addition a special tax was applied to pesticides. Initially this was 3% in 1987 and is currently 54%. The tax is effectively a double-tax as it is calculated on the 25% Value Added Tax-inclusive retail price of the product. The highest level of tax of 54% is on insecticides and has been structured to deliberately discourage farmers using 'insurance' applications of relatively cheap insecticide[4]. The extensive R&D program into pesticide reduction was largely financed by these pesticide taxes; this includes the extensive organic research programs being undertaken in Denmark.

Treatment Frequency Index: In order to be able to determine if targeted reductions in pesticides were being achieved, a Treatment Frequency Index (TFI) was established by the Government as a measure of pesticide use. This calculation takes into account a decrease in total consumption of active ingredients and the number of times pesticides are applied during growth of the crop. A TFI goal is then set eg. the national TFI for 2003 is two. This goal has already been achieved and was considered by some of the scientists and farmers I spoke to as the lowest realistic level that can be achieved. The TFI in the early 1980's ranged from 3 to 3.5 reflecting the measurable success of Denmark's pesticide reduction program. Farmers use the TFI as a promotable measure of their own progress in reducing pesticide use on their farms and there is a strong farmer focus on lowering the TFI on their own farm.

Production Systems in Denmark- Danish IP program: Of the 5788 hectares of vegetables grown in Denmark approximately 38% are grown as certified Integrated Production (IP). Growers can voluntarily participate in the Danish Integrated Production (IP) program called DANKS IP Kvalitet. This is managed by the Horticultural Growers Marketing committee. The program rules and regulations have been developed by growers and the program is controlled by the Danish Government via the Danish Plant Directorate. This is a 'paddock to plate' program and growers who satisfy the production requirements are entitled to use the IP logo on their produce. Discussion with scientists and farmers indicated that although the program was useful in promoting integrated approaches to crop production, the marketing of the logo and IP brand has not been very successful. It is thought consumers are confused by the variety of production system logos being used and that the only really recognisable and understood logo is that of certified organic produce.

Production Systems in Denmark- Organic: Organic vegetable production consists of approximately 10% of the Danish vegetable industry and covers approximately 500 hectares. Carrots and onions are the most widely grown organic crops in Denmark. At present the area of organic production has stabilised primarily as a result of satisfying domestic market demand. Some conventional growers who converted to organic production are reverting to conventional production due to production difficulties. Expansion of the organic sector is likely to rely on developing export markets in the future. Premiums in Danish supermarkets for organic produce are very high. This is reflected in farm gate prices for conventional and organic vegetables; for example, a farmer would receive 3DKK ($A1)/kg of conventionally grown onions compared with 6-7 DKK ($A2)/kg for organically produced onions. Although both solely conventional and solely organic growers are present in Denmark, it is quite common for farmers to have both systems operating on their farms. Two of the commercial vegetable growers I visited owned both certified organic land and conventional land. Organic certification periods ranged from one to two years (compared with three years in Australia). There is only one organic certifier in Denmark and that is government owned. All produce grown organically has to be handled separately at harvest and post-harvest. Although this does not necessarily involve separate equipment or facilities, growers visited were careful to ensure conventional and organic produce were kept apart.

[4] Pesticide reduction is still considered voluntary. Government actions are designed as dis-incentives to pesticide use. In the medium to long term, a failure to achieve decreased application of pesticides is consisdered to translate to market loss.

Vegetable growers around Denmark, particularly carrot producers, have been working in co-operation with dairy farmers renting dairy land off farmers for the planting of organically produced carrots. Benefits of this are the low disease/weed pressures on the carrot crops and shorter periods for certification of site. Some of the dairy farms are already certified organic.

Control of diseases in Danish vegetable crops
Contact: Lars Bodker

Potato Blight: The most significant vegetable crop disease in Denmark is late blight (*Phytophora infestans*) of potatoes. Blight sprays make up the majority of pesticide use in the country; they tend to be applied on a calendar basis or as 'insurance' sprays. Danish researchers have focussed on blight forecast systems in an attempt to reduce the frequency and volume of blight spray applications. This is a decision support system that takes climate into account and aims at both dose reduction and treatment delays. Success in both these areas moves closer to a lower TFI. Lars acknowledged that late blight of potatoes was a complex disease and that use of resistant varieties of potatoes will go a long way towards a solution.

Chemical weed control strategies in vegetables
Contact: Peter Hartvigs

Chemical management of weeds in vegetable crops is more challenging in Denmark compared to other countries due to the limited availability of registered herbicides. Much of the work undertaken by Peter's group is grower funded and is searching for alternatives to past herbicide uses eg. linuron alternatives in carrots. One of the most effective tools developed by Peter and his colleagues in Sweden is a decision support tool for assessing and choosing weed control in carrot crops. It is a hardcopy publication and is based on a decision tree structure.

Hosts: Royal Veterinary and Agricultural University (KVL), Taastrup & Copenhagen

The Royal Veterinary & Agricultural University (KVL) is based in Fredericksberg, part of Copenhagen, Denmark's capital city. The 17 hectare university site is made up of both education and research facilities and includes impressive botanical gardens. I visited Professor Peter Esbjerg and his staff here to discuss Integrated Production guidelines and components of IPM in Denmark. The Taastrup campus is situated approximately 18 kilometres from Frederiksberg and consists of four experimental farms. One of those farms is operated organically and is the location of several organic research projects. I visited Dr Erik Steen Jensen and his staff in the organic farming unit to discuss developments in organic farming in Denmark.

Organic Farming Systems
Contact: Erik Steen Jensen

The Organic Farming Unit led by Erik addressed all aspects of organic farming; its mission was very holistic in its approach and was philosophically based rather than industrially based. Its research and teaching activities were considered by Erik to be the starting point for understanding sustainable agricultural systems.

Organic learning centre and demonstration farm: I was fortunate to visit two field sites located close to Taastrup. One site had been established as a demonstration farm that was comparing a conventional system, an organic livestock system, and an organic system minus livestock. Crop focus was principally cereals and canola. The second site was to be established as a fully functioning organic farm in conjunction with, and incorporating, the nearby village. This project would focus not only on the technical aspects of production but also on wildlife habitat and social impacts on the associated village. It was intended that the farm would become an organic learning and demonstration centre. There was also some discussion of agri-tourism possibilities for the site.

Marketing organic produce: The commercial organic industry marketed its fresh produce through supermarkets where it was well recognised by consumers. The other area that has seen growth in recent years are box scheme delivery programs. Growers or grower agents take orders for various mixes of fresh vegetables, pack them into boxes and deliver them, directly to the consumer. Customers generally have a standard order for a weekly supply of fresh vegetables. Several companies have established internet sites through which orders can be made eg. www.aarstiderne.com. Farmers markets are also establishing, and smaller scale organic growers are supplying these markets. In Germany, organic produce marketing is being organised into producer rings to ensure constant and reliable supply of organic produce to consumers.

Intercropping
Contact: Henning Hogh Jensen

Intercropping involves cropping of more than one type of crop together usually using a cereal crop intercropped with a legume eg. barley intercropped with lupins. The principal is that although the primary cereal crop yield may be reduced, the natural addition of nitrogen by the legume crop for following organic crops is a net benefit. In addition, weed competition is reduced with intercropping.

Hosting of beneficial organisms
Contact: Werner Reidel

In an extension of other European work looking at hosting insects that act as predators of plant pests, Werner has been studying the role of hedgerow and border plantings (Fig. 3) to attract and host predatory hover flies. For example, the planting of vetches near lettuce crops to attract hover flies to predate the aphids. Survey work has indicated that organically grown lettuce has less aphid damage although aphids populations are still detected. A potential explanation is that without insecticide use, predatory hover fly populations can keep the aphids at low levels thus reducing lettuce damage. Discussion on the role of hedges compared with transient planting of beneficial hosts in crops was interesting. Werner agreed that permanent hedgerow planting is a visually more satisfying approach but it was also difficult to incorporate with modern farming practices and machinery movement. However planting of host plants as strips in crops didn’t interfere with farm operations but still hosted the appropriate predators. Because of this work, strips of the plant *Phacelia tanaecitfolia* have been planted at demonstration sites in conjunction with lettuce plantings. Werner has also been involved in bird-monitoring studies in Danish agricultural systems; survey work has indicated a direct correlation between pesticide reduction and increased insectivorous birds indicating a strengthening of natural pest control agents.

Figure 3: Border planting of *Phacelia* alongside a potato crop

IP Guidelines and their application
Contact: Peter Esbjerg

Peter is President of the European body responsible for facilitating the development and publication of the principles and technical guidelines for Integrated Production (IP). Integrated Production is 'a farming system that produces high quality food and other products by using natural resources and regulating mechanisms to replace polluting inputs and to secure sustainable farming'. The principles and guidelines are a sound basis for growing food incorporating IPM. IP would probably be equivalent to Environmental Management Systems (EMS) in Australia. Peter said the IP guidelines when implemented on-farm enabled TFI to be lowered in accordance with Government targets. He acknowledged some consumer confusion over the IP label but indicated the major IP push was coming from supermarket chains and was clearly demonstrated by the EUREPGAP protocols.

Country: Sweden

Sweden is one of Europe's largest countries. Much of the country is mountainous and covered by forests, lakes and marshes. Less than 10% of the country is under cultivation. This totals less than three million hectares. As in Denmark, Government policy has been to reduce pesticide inputs and progress to sustainable less-intensive agricultural systems. Over the last 10 years, these policies have resulted in a halving of the amounts of pesticides used in Sweden. Focus is also on developing systems that reduce ammonia, phosphorous, and nitrogen leaching in agricultural soils.

Sweden's primary agricultural products are cereals. Approximately 40% of agricultural land is used to grow corn, wheat, and oats. Vegetable cropping along with fruit berries and cut flowers accounts for 12 000 hectares of land. Tomatoes and cucumbers are cultivated in glasshouses. Glasshouse production accounts for approximately 300 hectares. Field vegetable production comprises approximately 6000 ha. Carrots, lettuce, and brassica crops are the most widely grown vegetables in Sweden. The Swedish component of my tour concentrated on the southern to central regions of Sweden where most of Sweden's horticulture was based. While in Sweden I visited the Swedish

Board of Agriculture at Alnarp, near Lund, before travelling to the Centre for Sustainable Agriculture at Uppsala, north of Stockholm.

Host: Swedish Board of Agriculture, Plant Protection Centre, Alnarp.
Contact: Bodil Jonssen

The Plant Protection Centre is located in the grounds of the Swedish University of Agricultural Sciences (SLU) on the Alnarp estate. It is a regional office of the Swedish Board of Agriculture and is the base for agricultural research and extension personnel servicing agricultural and horticultural areas in the south of Sweden. Since the mid-1980's, the group's work has focussed largely on pesticide reduction activities in line with Government policy. One of the most significant agricultural/environmental problems encountered in Sweden was extensive leaching of nutrients with subsequent pollution of surface water and local coastlines. Government policy targets an increase in organic production to 20% and this has also influenced the board's work programs. The focus of the 15 staff at Alnarp is reducing the environmental impacts of agriculture in Sweden.

Pest Forecast Services: The Swedish Board of Agriculture employs 10 crop scouts to monitor pest levels in cereals, potatoes, swedes and sugarbeet. These scouts collect data that is relayed to farmers and private consultants for use in their forecasting models and used as the basis for pesticide application advice. All pesticide applications are based on pest counts undertaken by the scouts. Timely data collection is considered essential to the success of the service. For example, carrot fly counts are made on a Monday, the data is collated Monday afternoon and emailed and faxed to farmers/advisors that evening. On the Tuesday morning advisory groups meet, examine the data and make appropriate crop management recommendations that are relayed to the farmers.

Forecasting models have been developed for carrot fly, potato blight and downy mildew (*Botrytis lactucae*). Software is progressively being developed and models adapted for local conditions. Information from the forecast activities is available to farmers/advisors via a paid subscription. Crop scouts are now equipped with digital cameras and often relay high resolution digital images of disease symptoms as they appear to farmers/advisors so that they are more informed visually of symptoms to look out for. The forecast services are tailored to target groups in terms of the content and structure of information provided; the broad groups are scientists, advisors, and farmers.

All forecast models use Adcom technologies with Adcom stations established at key locations across Sweden. Dacom, (www.dacom.nl) a company based in the Netherlands has provided much of the technology components and also acts as an advisory centre for subscribers through its on-line packages, Lantmet and Plant-Plus. The Government owns a series of Adcom stations in key locations across Sweden. Swedish vegetable growers are now purchasing their own Adcon equipment which will provide more monitoring sites increasing the accuracy of forecasting for pest risk.

Field vegetable production in Sweden
Contact: Bodil Jonsson

Discussions with Bodil Jonsson, Vegetables Agronomist, with Plant Protection Service, are summarised below:

- The main insect vegetable pests in Sweden are various types of flies (diptera). The major dipteran pest in Sweden is the carrot fly. The southern part of Sweden is temperate due to the flow of the Gulf Stream; these warmer conditions mean downy mildew is the major fungal disease of vegetable crops especially lettuce.

- Biopesticides are being incorporated into Swedish vegetable production to reduce pesticide residue risks in groundwater. At present the market is small with few registrations. BT (*Bacillus thuriengensis*) sprays are used but approval processes for other biopesticides are more difficult than conventional pesticides due to concerns about pest potential of some bioagents.

- Vegetable growers in Sweden are subject to strict environmental conditions. EU subsidies are available to growers participating in EU IP schemes. EUREPGAP is a significant influence on production standards and agricultural activity in Sweden leading to environmental considerations.

- 54% of vegetables are produced as part of IP certified programs. Organic production composes approximately 8% of production with the Swedish government targeting an increase to 20% of production.

- Pesticide reduction is focussing on the use of conventionally-bred resistant cultivars, crop rotation, careful site selection, and farm hygiene. Hygiene issues in Sweden include proper waste destruction, storage facility disinfection, availability of fresh seed and plants.

- Sweden currently has a moratorium on the commercial planting of GM crops and most field evaluation. Limited field studies are allowed if contained and satisfy regulatory requirements[5]

- Increasingly, larger amounts of limited State funds are being channelled towards organic agriculture research as this is perceived as satisfying government policies that focus on the sustainability of agriculture.

- Club root occurrence in Sweden is variable and appears to be pH dependent. Soils with a pH of 8 or more suppress club root development.

Mixed vegetable enterprise (Hans Axel Anderson): This farm is situated a few kilometres south of Malmo. Hans is principally an onion grower, but also produces small areas of squash and celery.

Squash: Squash plants are grown on fleece covers (Fig. 4). The fleece which costs 0.70 Swedish kroner/m^2 (approximately 14 cents Australian) laid on the prepared soil surface is used to warm the soil and to keep the squash fruit clean. Hans considers it has little value in weed control and relies upon glufosinate-ammonium and plastic mulches for weed control. The squash is irrigated with drip irrigators. As well as water efficiencies achieved, drippers don't interfere with the squash plants pollination process.

[5] In my discussions throughout Scandinavia, scientists and farmers didn't see GM crops as a realistic proposition in the short to medium term due to a lack of public support and restrictive government policies.

Figure 4: Bodil Jonsson (left) and Hans Axel Anderson standing on fibretex fleece on which squash are grown.

Adcom weather station: Hans was one of an expanding group of growers who have bought their own Adcom weather station. He purchased it primarily for disease forecasting purposes although was interested in the role it could play in irrigation scheduling. He has purchased a range of different components for it and found it is particularly useful in assisting with his onion pest management program.

Onions: The largest area of the farm was planted to onions. The primary herbicide being used in both Denmark and Finland on onions was aclonifen. This was being used under permit but growers had been experiencing some initial crop damage. However growers generally considered its benefits at controlling a broad spectrum of weeds made it a worthwhile addition to a very small choice of onion herbicides. Hans had grown organic onions in the past but found them too difficult especially when direct-seeded. He had reasonable results using sets. He found downy mildew to be the worse disease problem in his organic onions. I noticed most growers visited had their own packing and storage facilities. Hans had a large packing shed with an old Nutech sorter which he was planning to upgrade next season. He had refrigerated stores for his onions and marketed his onions directly to the supermarkets.

Dill and leaf parsley: A lucrative niche market that Hans and other Swedish farmers were exploiting was the production of both dill and leaf parsley. These were grown and packed on site and sold wholesale to supermarket chains in Sweden.

Employees: Contracted workers mainly from Poland were employed on this farm subject to work permit conditions. Hans also provided some of his crops as training opportunities for high school students who worked in the crops as part of their curriculum.

Findus Sweden, Vegetable Processing Company, Bjuv: The Findus vegetable processing plant was visited at Bjuv. The Bjuv factory processes principally canning peas, spinach, and carrots. Dill, parsley, and chives were also grown by Findus under contract and were regarded as a premium priced niche product. Findus Bjuv is one of four factories located across Europe. Most notable was the company focus on sustainable agriculture (Low Input Sustainable Agriculture) and a comprehensive funded R&D program. Discussions were held with staff in Findus R&D in relation to crop protection and nutrition. Following Findus field crop visits, further discussions were held with Enar Magnusson who was factory manager.

Crop protection (Mariann Wikstrom, Bengt Gunnarson): With an R&D focus on low input sustainable agriculture, Findus have invested extensively in pea breeding programs breeding for disease resistance in peas. This has been very successful for a range of pea varieties available resistant to several economic diseases particularly downy mildew. Soil root rot diseases are controlled principally through careful site selection. Over 700 soil tests are conducted each year and pea plants grown in the potted soil to determine presence or absence of soil root rot pathogens. The tested soil is indexed (1 to 100). If a soils disease index rates greater than 15, the field will be bypassed for planting by Findus. This preventative approach to disease problems has seen significant yield increases. Work is also being conducted on 'disease-suppressive soils'; these are soils where disease organisms may exist but crop plants are not infected. Findus is attempting to isolate the causes of this. Findus are funding a range of PhD studies one of which is examining effects of organic amendments on infected soil. An example given was trial data showing the addition of pig manure to actinomycetes infected soil resulted in an increase in crop yield of over 100% and appeared to depress disease infection. Biofumigants are also being studied; mustard plants that are grown on a field, and ploughed in result in yield increase in the subsequent pea crop with less disease.

Residue limits: Findus have adopted their own Maximum Residue Level (MRL) standard that is lower than EU accepted standards. In most produce the limit is less than 10 ppb. In their baby food products it is nil. An Environmental Index Quotient (EIQ) is used to assess environmental sustainability; a significant component of improving the quotient is removing pesticides from the crop production systems, or using less toxic pesticides. The EIQ is used as an index to assess overall impact of pesticides. In practice only low EIQ pesticides should be used. The Swedish government also uses the EIG index as a measure of the success of its pesticide reduction program.

The Findus way: Findus negotiates price with its contract growers annually. Before sowing the crop, a minimum guaranteed price is set. Depending on quality and other parameters the return to the grower can be higher than the minimum. However even if the pea crop has to be bypassed, the grower will receive this guaranteed minimum price. Findus staff indicated this protects the growers interest and provides incentive for a higher quality product. Findus sets its own standards to ensure the elapsed time from harvest to freeze is no more than three hours. The company maintains product quality is developed in the field hence the incentives provided to growers.

Apple orchards and strawberry fields
Contact: Christer Torneus

As in Australia, IPM in Sweden is most advanced in the pome fruit industries. Shifts to IPM orchards in Sweden began in the 1970's. Apple growers were already practising IPM when the Swedish Government started setting pesticide reduction targets in the mid-1980s. Christer Torneus is an apple and small fruits extension officer and advises orchardists and growers on IPM. He also provides a scouting service and regularly monitors pheromone traps (Fig. 3) and weather stations throughout south-eastern Sweden.

Figure 3: Christer Torneus provides a scouting service for apple growers in the Kivick region

I spent a day with Christer and during this period we visited both orchards and strawberry farms. We also visited Bombavit, one of Sweden's largest apple packhouses located at Kivick (swedish for apple). Christer told me that government policy had a big influence on the uptake of IPM for apple growing; Swedish policies required nil input of synthetic pesticides in apple orchards within a 10 year period. Although nil inputs haven't been achieved, reductions of 50% have been realised with the introduction of pest forecasting systems (all Swedish orchards contain an array of pheromone traps) and biological controls. One of the most popular forecasting systems is the RIM-pro program developed by a Dutch company (www.biofruitavies.nl). Christer indicated there was a growing interest in organic apple orchards although this was not a commercial reality as yet. In terms of the future of IP in Sweden it was likely that technologies would continue to advance, forecasting systems would be automated, and there would be increased commercialisation of scouting and IPM advisory services. An interesting growing technique for strawberries was noted at one of the strawberry farms visited. They were grown on bales of straw to effectively raise the plants and assist with harvest as well as keeping the fruit clean (Fig.4).

Figure 4: Christer Torneus examines strawberry plants using 'raised beds' primarily to assist with ease of harvest and cleanliness of fruit.

Glasshouse crops-cucumbers and tomatoes under glass
Contact: Barbro Nedstam

A day was spent on field visits to glasshouse producers in the south east of Sweden. My host was Barbro Nedstam, a biological control plant protection specialist who serviced the glasshouse grower industries in southern Sweden. There is approximately 300 hectares of glasshouses in Sweden with the main commercial crops being ornamental flowers, principally orchids. Vegetable crops grown under glass were cucumbers, tomatoes, lettuce, and melons. All glasshouse product was grown to IP standards. Biological control in greenhouses was the principal form of insect pest control. Biocontrol agents were grown by commercial companies outside of Sweden and bought by Swedish glasshouse growers. Barbro's role was to facilitate effective biocontrol programs for growers.
The major pest of ornamentals in glasshouses in Sweden is the Western Flower Thrip (WFT).

Cucumbers: One enterprise visited grew only cucumbers under glass (Fig. 5). The major pest threats in this glasshouse were thrips and spider mites. Visible througout the wired cucumber vines were packets of predatory mites. These are commercially produced (www.koppert.nl) and purchased by the carton from the Netherlands. One packet of predatory mites are attached to every third plant every eight weeks. Barbro regularly scouts this glasshouse sampling 15 leaves through the glasshouse for pest presence and predator establishment. The plants were being grown hydroponically in a reusable substrate. The transplants had been grown in a rockwool medium.

Tomatoes: Tomato glasshouses visited had a strong focus on hygiene. Visitors into the glasshouse were required to wear coverall suits and supplied footwear. The main concern of these growers was the accidental introduction of the Pepno Mosaic Virus (PMV) into their operation. This operation covered 12600m^2 and produced 50 kg/m^2 of Almarta tomatoes.

Figure 5: Barbro Nedstam scouting a glasshouse crop of cucumbers

Organic vegetable production in Sweden
Contact: Johan Ascard

Johan Ascard is an authority on flame weeding. He was able to provide me with extensive and relevant literature on the topic most of which he had authored. He indicated flame weeding to be a central component of organic production but only a single application should be used.

- **Stockholmsgarden AB (Lars Larsen):** Stockholm Farm was a typical Swedish producer/packer. Their principal crops were parsnips, carrots, Jerusalem artichokes, sugarbeet, and onions. The farm was family-owned and had been operated for 50 years. They had been growing vegetables organically for about five years to satisfy supermarket contract requirements. Unlike some of the Danish farmers I met, these farmers used standard row distances. Their weeding regime consisted of one flame application (banded), one mechanical hoeing, and one finger-tyne weeding. They also occasionally used torsion weeders. Lars was an excellent example of an innovative farmer who had highly developed mechanical skills. Much of the equipment he used he had modified or built himself.

Host: Centre for Sustainable Agriculture, Uppsala
Contact: Karin 'Kajsa' Ullven

The Centre for Sustainable Agriculture (CUL) is located at the Swedish University of Agricultural Sciences. CUL's principal role is to co-ordinate project work related to sustainable agriculture and to facilitate cross-discipline programs. The centre acts as a hub for approximately 200 researchers working in areas of soil nutrition, pest management, reduced pesticide work, and organic production. The Centre is also responsible for managing Ekhaga Farm located near the University. This property provides on-farm research and demonstration facilities for organic research. My visit to CUL included discussions with research and extension officers and a field visit to Ekhaga.

Transplant use-facts and figures
Contact: Fredrick Fogelberg

Fredrick Fogelberg is a scientist working with the CUL and is focussed on a range of non-chemical weed control options. He emphasised the importance of transplants when growing organic vegetables such as onions (Fig.6). The onion quality was far superior to both conventional and organic direct-seeded crops and the amount of handweeding was decreased (300 hours/ha to 30 hours/ha). Harrowing and torsion weeding dealt effectively with inter-row weeds in the onion crops. Fredrick indicated it was more expensive to use transplants than using direct seed[6].

Figure 6: Onion transplants are now used in most organic onion crops in Denmark and Sweden as well as some conventional crops.

[6] 18 transplant plugs cost $US1
One Transplant generated seven plants
Row spacing of 500mm was used and transplants were spaced at 200mm intervals within rows.

Ekhaga farm, Uppsala (Lennart Karlsonn): The farm has been established as a KRAV-certified organic learning centre with a focus on research. Importantly, organic production data has been collected at the site since 1988; data includes annual weed surveys and soil analysis every second year. Students are employed as crop scouts and crops are checked on a weekly basis. The farm is 24 hectares in size and is spilt into two organic production systems; one with livestock and one without livestock. Trial work was inspected in both systems. The 'Ekhaga-model' was referred to frequently during my visit; this model aims to develop a holistic farming system incorporating all aspects of the livestock production system into the cropping system with a long term focus on sustainability eg. pigs are used to forage and root through paddocks in rotation and act as biological weeders. They are used to clear up residue materials after harvest. Their manure is used as fertiliser. Eventually they are slaughtered to provide a marketable commodity.

During a discussion on organic crop management, the following points were made by Lennart:

- Site selection is critical in organic cropping; degrees of freedom are very limited and there are few opportunities for a second chance if you make the wrong management decision.

- Timing of operations is critical, especially weeding, much more so than in conventional production.

- Once the organic system is established, many of the crop diseases associated with conventional cropping no longer occur. Lennart has noticed this phenomenon over the last 12 years.

- It was intended that Ekhaga's role would increase in importance in years to come. It would be maintained as a field laboratory and would focus on proactive leading-edge research. It would continue to study and demonstrate low input systems. There were also plans to expand to alternative energy research.

(www.cul.slu.se/english/experfarms/ekhaga.html)

Guidance systems
Contact: Fredrick Fogelberg

Crucial to making mechanical weed control more economical was increasing automation of guidance systems for mechanical weeders and cultivators. Auto-guidance systems using video cameras and sensors were being developed that, although valuable and reasonably effective, were very expensive and would be more suitable to large contractors. Less technological solutions were available such as wheeled guidance furrows (Fig. 7). At crop sowing, a side-mounted tool digs a furrow beside the seed bed. In subsequent operations as long as the guidance bar/wheel is aligned with the guidance furrow, the tractor driver could be sure of accuracy of the operation. This technique required mid-mounted tools. Fredrick estimated that 95% of tractors in Sweden were rear mounted rather than mid-mounted. This was opposite to the situation in Denmark.

Figure 7: Spinach crop with guidance furrows

Country: Finland

Finland is regarded as the most rural of all the EU countries. Rural areas constitute 98% of Finland's total landmass. With a population of five million people, one third of those live in rural areas. An average Finnish farm is approximately 24 hectares. Small farm sizes are a the result of fragmentation occurring when 10% of Finland was ceded to the Soviet Union during World War 2 (WW2), and areas of land were divided for soldier settlements post-WW2. Finland's average farm size is the smallest in the EU and Finnish agricultural enterprises are generally not competitive with larger farms in other EU countries. The total number of farms has declined from 120 000 in 1996 to 100 000 presently. Forecasts indicate that by 2008 there will only be 60 000 farms remaining in Finland.

Finland is the world's northernmost agricultural country. Its range of agricultural enterprises are diverse and influenced strongly by extended coverage of northern latitudes (between 60^{o} and 70^{o}). Vegetable production is restricted to the southern regions of the country. Cereal production extends through to the midlands. Potatoes are generally grown throughout Finland except in the extreme north. Reindeer husbandry constitutes the bulk of the agricultural activity in the Lapland region in the far north. Major agricultural industries are cereal production and dairying although the latter industry is in a rapid decline. Most Finnnish farms grow trees as crops. Over 95% of all active farms have some area of their farm allocated to forestry to supplement their farm incomes.

Most Finnish farms are family operated businesses; corporate farming composes only 1% of Finnish farms. The average age of farmers in Finland is 46 years old.

As in Denmark and Sweden, the mid-1980s saw government policies focussed on minimising environmental impacts of agricultural activity. Their principal concern was the prevention of nutrient leaching into Finland's many lakes and aquatic systems; nitrate leaching and subsequent eutrophication were a particular worry. Whereas in Denmark and Sweden the initial focus was on pesticides, in Finland the primary focus was on fertilisers. The Finnish agri-environmental policies and subsequent management programs are assisted by a range of EU subsidies encouraging Finnish farmers to manage their environment appropriately. Since the mid-1990's much of this financial aid has been directed to subsidising the production of organic foods. Conversion subsidies are provided at the rate of 168 Euros/ha ($A320/ha). After conversion, a subsidy of 118 Euros/ha ($A230/ha) is paid if the arable land is maintained for organic farming. Discussions about EU subsidies and aid identified that compensation was payable to farmers for implementing EU policy that impacted negatively on them in terms of income.

Host: Agricultural Research Centre, Agrifood Research Finland (MTT), Jokioinen.
Contact: Kari Tiilikkala

Agrifood Research Finland is composed of 15 research stations and employs a total of 1000 people across Finland. I visited the Agricultural Research Centre at Jokioinen located about 15 kilometres from Forssa in southern Finland. The region around Jokioinen and Forssa is the principal vegetable production area in Finland. During my visit I had discussions with my principal contact Dr Kari Tiilikkala who is leader of the Plant Protection Section. These discussions focussed on IP and IPM based project work in vegetables in Finland as well as an overview of Finnish agriculture. I met with Anna Nissinen who had established advanced field trials examining trap cropping in brassica crops. I was also given the opportunity to visit Lannen Tehtaat, one of Finland's major food sector companies. The factory at Sakyla was the companies vegetable processing plant; during that visit I also inspected the Rapi Experimental farm at Koylio.

Finnish drivers and funders of agricultural research: Finnish government policies, since the mid-1980's, have resulted in MTT's work programs being focussed on preservation of biodiversity in agricultural systems, biocontrol developments as a part of IP, pest forecasting, and developing the organic agriculture sector. The Finnish government wish to brand their agriculture as 'Clean and Green'. This is based principally on Finnish farming practice being IP based and the geographical location and isolation of Finland.

Finnish IPM program for vegetable farmers: Both Finnish and EU requirements are strong drivers for adopting IPM as part of complete IP on farms. Kari's work is focussed on the development of crop specific guidelines that compliment and facilitate the IOBC IP principles that apply to the whole of the EU. Adoption of IPM into farming systems is assisted by EU subsidies; Kari indicated these subsidies were essential to offset costs to farmers of environmental preservation. The crop specific guidelines consisted of detailed directions about undertaking activities such as crop scouting. The guidelines are accompanied by a two-day training course that is focussed especially on crop scouting and covered topics such as pest identification and economic threshold calculations. In addition the identification of beneficial insect pests was included. As these guides were progressively developed, it was compulsory for farmers to purchase the guides and participate in training. Company crop contracts eg. Lannen Tehaat depended on farmers having satisfied the training and guideline requirements. I was interested in farmer's attitudes to this element of compulsion. Kari indicated many farmers objected to the level of compulsion used; however the end result is that all Finnish farmers are IP trained and most Finnish produce carries the Finnish IP brand.

Mobile phone network and pest warnings: One of the most innovative projects being conducted by the MTT in southern Finland was the use of GPS inclusive mobile phones and SMS messaging to assist in pest forecast warnings. The developing service provides a farmer with a pest forecast warning on their mobile phone delivered via an automated SMS messaging service. The team working on this project originally considered delivery of such information via the internet but farmer surveys indicated that, although farmers were computer literate, the inconvenience of leaving the field, going inside, and logging on to their computers meant they wouldn't use the service. However all farmers carried mobile phones and the warning was now delivered in the most convenient and immediate way possible.

Radar detection of pests: Radar was also being used in Finland to aid in pest warnings. Flights of diamond back moth (*Plutella* spp.) flying in from southern Russia were readily picked up by radar systems. Information was then conveyed to advisors warning of an impending flight.

Trap Cropping the cabbage fly: Expanded field trials testing the concept of trap cropping in brassica crops have been established close to Forssa. The principle of trap cropping is to plant rows of lesser value plants that are more attractive to pests than the commercial crop in a border around the crop (Fig. 8). When cabbage flies fly into the crop they infest the trap crop first instead of the commercial crop. This allows the commercial crop to develop without significant economic damage. The trap crop can then be ploughed in. This scenario manages the pest without using pesticides. As well as the field trials, laboratory analysis is trying to determine the basis of preferential attractiveness of the trap crop to determine if the volatile components (semiochemicals) could be extracted/synthesised and used in artificial traps as lures and decoys. I was able to visit a nearby cauliflower crop that had been border planted with chinese cabbage.

Figure 8: Brassica trap crop near Jokioinen, southern Finland. Trap crop on the left hand side.

'Paddock to Plate'-informing the consumer: MTT were conducting preliminary trials in which fresh and processed foods sold in supermarkets had a barcode incorporated into their label. A computer terminal and scanner located near to the food display in the supermarket could be used by consumers interested in the history of the product they planned to buy. By scanning the product, the full history of that food would appear on the computer screen along with images of the field the food was grown in, photos and information about the farmer, the processing factory and line, and dates right through to the point-of-sale. For those interested, information on operations taken to alleviate environmental impact would also be provided. Alternatively the code could b typed in at an internet site at the customer's home to reveal the same product history

Visit to Lannen Tehtaat Pty Ltd, Sakyla (Pekka Kurrie): The Lannen Tehtaat Group consists of a food group, earthmoving machinery group, materials handling unit, and other units focussed on animal feed production, seedling technology, and contract farming. I visited the food group's agricultural division of which Pekka Kurrier is Manager (Fig. 9). He provided an overview of factory operations, described how the factory sources its vegetables, and the quality systems they have in place. Laanen Tehaat is the most northern vegetable processing factory in the world. It is situated in an intensive vegetable production area and all contracted crops are located within a 70 km radius of the factory to ensure minimal time between harvest and processing of the product. The company produces its crops under contract for one of three quality systems: IP, Organic, and Baby Food (BF). Laanen Taheet provides 70% of Finland's frozen vegetables. The company negotiates its vegetable prices with growers at the beginning of each season and these are independent of any EU pricing structures. The principal vegetable crops contracted by Lannen are peas, carrots, and Potatoes.

Figure 9: Laanen Tehaat Director, Pekka Kurrie, at one of the company transplant machines.

The company requires all growers to be IP certified and to grow their crops in line with IOBC IP requirements. In conjunction with MTT, the company has produced crop specific production guidelines that each grower must follow and sign off on. Farmers own approximately 25% of shares in Laanen and this has been an incentive for producers to grow the very best crops. Recent EU legislation now prevents share ownership in such companies by the contracted farmers.

Rapi experimental farm, Koylio: The Rapi experimental farm has been operated as Lannen's experimental farm since 1954. It is operated by two staff and employs up to ten extra people in the summer period. Part of the farm is sown to commercial crops to assist in offsetting running expenses and trial work is conducted on the remainder of the farm. All commercial crops are cultivated according to IP guidelines with some crops grown pesticide free eg. squash. Lannen finds the farm a useful extension tool and runs a range of grower training programs: these programs centre around the crop specific production guidelines and provide growers with the additional skills they may need to crop according to the guidelines. This training often involves Quality Assurance training, record keeping and similar topics. Rapi itself is an ISO9001 accredited farm and is a focus farm receiving more than 1000 visitors/per year.

Country: The Netherlands

From an agricultural perspective, much of the land currently cropped in the Netherlands has been reclaimed from the sea via a complex series of dykes and weirs. These reclaimed tracts of land are referred to as polders and are governed by polder authorities. As an example, up to 90% of the polders area are used for agricultural purposes. The average farm size in the Netherlands is 40 hectares. Government moves towards reduced-pesticide farming began in 1974 with the establishment of the first government owned pesticide-free farm in Southern Flevoland. The project aimed to gather data on agricultural practice without the use of both synthetic pesticides and synthetic fertilisers. Since that time, various small-scale biodynamic farms have established in the polder. Today there is in excess of 68 bio-dynamic farms established in the region surrounding Lelystad. These operations cover a total of 3631 hectares.

My principal activity in Holland was attending the 12th European Weed Research Society (EWRS) Symposium held at Arnhem near the university city of Wageningen, south east of Amsterdam.

The 12th European Weed Research Society (EWRS) Symposium

The 12th European Weed Research Society (EWRS) Symposium was held in Arnhem, the Netherlands, at the Papendal Sports Stadium from 24th to 27th June 2002. 210 delegates attended the symposium from 38 countries. There was a strong emphasis on sustainable food production, pesticide reduction, and rapidly developing weed management technologies. The symposium also consisted of an 'open space' discussion on the weed research agenda, and a field excursion to the Nagele organic farm and the Lelystad Research Station. On the Nagele organic farm, an ecological infrastructure has been established across the property. It consists of a network of landscape elements including ponds, hedgerows, field margins, and companion planting.

One of the most significant policy drivers for weed research in Europe is pesticide reduction. It was herbicide contaminants of surface and ground drinking water in parts of Europe in the mid 1980's that resulted in Sweden, the Netherlands, and Denmark developing legislative Pesticide Action Plans. These plans set targets of reduction in pesticide use. This has been a key driver for non-chemical weed research activities in Europe since that time. As non-chemical weed management options have become available, European Union (EU) subsidies paid to farmers have been linked to demonstrated reductions in pesticide use. This has provided European farmers additional financial incentive to minimise pesticide inputs. It also has provided additional encouragement to 'go organic'.

Several scientists profiled the impact herbicides have had on crop management practices in the developed world. The advent of herbicides saw weeds become a secondary side issue as they were regarded as 'curable'. In reduced-herbicide and/or organic agriculture far more attention needs to be paid to cropping design including planting architecture. Focus must once again shift to preventative practices where possible. This would require a combination of techniques aptly described as the use of 'many little hammers'.

Data was presented indicating changes in cropping practice translated to shifts in weed population. Changes from conventional to organic cropping practices often resulted in increased weed seed bank build-up. In addition, insufficient available nitrogen and phosphorous was a major problem in Canadian organic systems.

Several papers addressed research into ways of reducing the doses of herbicides used. These systems are computer based and rely on historical data being available. There was a range of papers reporting on the development of novel forms of managing weeds in cropping systems including seed vaccination, alleopathy, and the use of CO_2 lasers in conjunction with precision agriculture to cut weeds down. Band steaming as a solution to intra-row weed control (replace handweeding) in high-value organic cropping systems was considered feasible in the future. Several papers focussed on the role of precision agriculture in weed management using computerised weed distribution maps and automated patch spraying.

Immediately following the conference I had opportunity to visit Drs Meindert de Jong and Barend de Voogd from the Biological Farming Systems unit at Wageningen University principally to discuss mycoherbicide[7] development.

Mycoherbicide application on weedy prunus stumps in a forestry operation
Contact: Meindert de Jong, Barend de Voogd

A forest based trial site (Fig. 10) was visited near Arnhem where different dilutions of a mycoherbicide had been painted on stumps of cut prunus trees. Barend explained the fungal organism takes several months to invade the cut stump and new re-growth. A successful invasion results in the initial silvering of re-growth followed by severe chlorosis and necrosis and the death of new shoots. Rotting of the stump follows. Meindert referred to preliminary studies using the mycoherbicide extracts on gorse plants; he said there had been similar effects.

Figure 10: Barend de Voogd with treated *Prunus* species in forests close to Arnhem, Netherlands

Country: England

The United Kingdom is the most urbanised country in Europe. Over 80% of the population live in centres of at least 100,000 people. Of the land in Britain, 23% is arable and 17% is classed as urban. There are very few areas of remnant vegetation and much of the environment is man-made

[7] Natural herbicides made from fungal extracts.

principally by agricultural activities. Britons are principally urban and view countryside, primarily farmland, as recreational areas. Agricultural practice is very much exposed to the general public, and production demands are made with a strong focus on environmental protection. A shift to full IPM is seen as a way to partially satisfy public demands.

In England, I visited two key institutes/organisations. These were the Institute of Arable Crop Research's (IACR) Rothamsted Research Station at Harpenden, north of London, and the Henry Doubleday Research Association at Ryton, near Coventry. Both organisations are non-government and are noted as high profile achievers in their work areas.

Host: Institute of Arable Crops Research (IACR) - Rothamsted Experimental Station, Harpenden

The IACR was formed in 1986 combining the activities of the Rothamsted Experimental Station, Brooms Barn Experimental Station, and the LongAshton Research Station. The Rothamsted Experimental Research Station is the oldest active agricultural research station in the world dating from 1843. My visit to Rothamsted consisted of meetings with seven senior scientists and managers at the Station discussing aspects of IPM with a focus on natural enemies, insect/nematode pest control, and the role of decision support systems in IPM. A field visit was undertaken to the station's famous long term agricultural study, the Broadbank Experiment, first established in 1843.

Computer-Based Decision Support Systems (DSS) in IPM
Contact: Paul Verrier

Paul Verrier has had extensive experience both assessing, evaluating, and developing computer-based DSS in IPM. He made the following points in our discussions:

- The development of such systems is a multi-disciplinary activity. A typical project could require a team of 28 scientists, technicians, and managers. Major challenges were coordinating a diverse team of people to ensure common outcomes.

- DSS can take several years to develop requiring very large investments of time and money.

- Software packages are difficult to promote to farmers. Adoption of such tools is influenced by cost. Cost- recovery pricing of this type of software will result in farmers failing to adopt the software. Thus for a chance of farmer use, the project would require significant subsidy probably from Government.

Encouragement of natural enemies
Contact: Wilf Powell

The insect behaviour program headed by Wilf Powell is supported by 38 staff. Its aims are two-fold: to alter beneficial insect behaviour and attract them to crops to improve pollination. It also aims at attracting the enemies of crop pests to crops thus boosting biocontrol in IPM systems using natural populations of predators. Discussion focussed on manipulation of aphid parasitoids, the subject of several projects at Rothamsted. This work was prompted by a steady increase in aphicide use in British cereal crops with record quantities used in 1979. This prompted public concern about residues, scientific concern about damage to natural aphid predators, and concern about increases in aphid resistance. Studies following this period identified aphids only exceeded threshold levels every third year identifying opportunities to reduce aphicide use. Further studies identified that parasatoid infestation of aphids occurred but relied on synchronising factors between parasatoid and aphid populations. Artificial methods to promote synchronisation using pheromones were developed. A plant based pheromone was developed that could affect predators. In combination with parasatoid-attractive field margins, work is currently underway to determine how the pheromones can be used to attract the parasatoids to the field margins. This is combined with field margin composition work selecting for mixed plantings to attract hoverflies and other beneficials. Pit fall traps, vacuum machines, and water traps are used to monitor insect populations in field.

Semiochemicals
Contact: Lester Wadhams

Semiochemicals are natural substances emitted by plants that attract specific insects. This feature of plants is being used as a potential pest management strategy with carefully selected companion planting of plant species near crops more attractive to pests. The principal is that pests attack the companion plant rather than the crop. In addition some semiochemicals actually repel insect pests. Repellant companion plants in combination with attractive trap crops work to ensure the primary crop is protected. This mechanism is referred to as a 'push-pull' strategy.

Host: Organic Horticulture, Henry Doubleday Research Association (HDRA), Ryton
Contact: Gareth Davies

HDRA is one of the UK's oldest environmental charities and carries out scientific research, provides advice, and promotes organic food farming and gardening. The organic horticulture section aims to develop and improve techniques used by organic growers and to advance the knowledge of these production systems and their environment/economic impact. My visit to HDRA included meetings and discussions with Gareth Davies (Senior Research Officer) and Chris Firth (Senior Business Analyst), inspection of HDRA research plots (Fig. 11) and facilities, and a visit to Ryton Organic Gardens – a 10 hectare public demonstration site for growing plants organically.

Figure 11: Gareth Davies next to a potato variety testing trial at HDRA research plots at Ryton organic gardens, Coventry.

Box schemes versus broadscale production food distribution: HDRA's work programs are based on developing production systems that produce food locally for local markets. Box schemes (previously described in this report) were a particular focus as organic vegetable production marketing and distribution has been very successful in the UK using box schemes. Although this is the focus of the work, HDRA staff acknowledges there is a significant application of their developing systems to broadscale farming. However they are concerned that the larger the organic production system the more complex and the greater the potential for things to go wrong particularly with respect to pest management.

Conversion to organic field vegetable production: This project is generating data needed to assess the viability or otherwise of converting conventional vegetable production farms to certified organic farms. It is focussed on developing conversion plans and using actual commercial farms as case studies. The economics of conversion have been the base of another project conducted by HDRA, "The economics of organic farming". This project has analysed economic data from 20 farms converting to an organic production system. Preliminary findings indicate that there is a significant cost involved in converting and a time lag before premium prices are achieved for certified produce. Subsidies were acknowledged as important in the conversion process but were considered to distort the economic viability of the organic enterprise. Economically shifts to larger scale organic production were needed but agronomically, management risks increased the larger the operation was which in itself threatened the viability of the organic enterprise. Established and experienced conventional vegetable farms converted their systems with greater success than less experienced smaller vegetable growers, or those entering vegetable production for the first time.

Import replacement: At present, the United Kingdom imports 80% of its organic vegetables, and 45% of its organic meat products. Over the last year there was actually a domestic oversupply of organic milk and organic potatoes. HDRA's project work aims at export replacement as far as possible. This is only likely if the UK production costs of organic produce can be reduced. Supermarket chains can rapidly change source of supply and this is done based primarily on price.

Conversion to organic production in the UK: HDRA project work has established some valuable conversion frameworks. The most significant management issue identified in organic vegetable production is weed management. Non-chemical weed management is a major component of pest management programs. Soil fertility and nutrition is being addressed with careful rotations eg. most demanding crops first, complete rotation with barley (or cereal) crop undersown with clovers. In the United Kingdom it takes three years to convert to a certified system. As in Australia there is no premium paying market for in-conversion produce. However unlike Australia, conversion subsidies are available to growers along with free professional advice on conversion.

Partial conversion: Partial conversion of conventional farms is seen as a possible solution to economic stresses during conversion. Initially only 10% of the farm may be converted with the remaining 90% staying conventional, the income from the conventional produce buffers the initial higher production cost of the 10% in organic conversion.

Ryton Organic Gardens: Promoted as a tourist attraction and as "a great day out in the Heart of England", the ten acres of gardens are a showcase of all aspects of growing plants organically. It consists of 32 individual gardens including:

- Rose Garden

- No-dig garden
- Unusual vegetable garden
- Kitchen garden

The organic gardens act as a wildlife haven and demonstrate wildlife habitat preservation. Other organic growing techniques demonstrated included non-chemical weed control, biological control (orchards and glasshouses), and soil fertility maintenance.

Conclusions

The information provided, if applied as recommended, could result in more profitable and sustainable cropping systems in Australia. The practices described in this report were being implemented as a result of commercial decisions by farmers and are evidence that they are effective. Opportunity exists to reduce input costs and improve profitable returns to farmers and the horticultural industry as a whole in Australia.

Innovation and adaptation have been essential in northern Europe as limitations and restrictions on agricultural practices have steadily increased over the last 15 years in those countries. Only a few of the pesticides available to Australian farmers are available to the Northern Europeans with Danish producers having access to the least number of registered products. If pesticide choices for Australian farmers are limited in the future, this type of innovation and adaptation will be essential to maintain commercial farming operations.

The current status and direction of organic production in Europe should be of interest to all sectors of the agricultural industry in Australia. There is very strong government support for developing organic industries in each of the countries visited; organic production is viewed as a pathway to ‘Clean and Green’. This support extends to subsidies to assist growers in the conversion process. Organic certification authorities in Europe appear more liberal and flexible in their certification requirements than Australian authorities. This highlights some certification requirements in Australia that may be limiting the growth of an organic industry in Australia.

Marketing challenges exist in Europe with producers trying to get consumer recognition for Integrated Production branding at a similar level to organic recognition. This appears to be failing and conventional produce will eventually be produced via integrated production without branding. Such a scenario could also occur in Australia.

Strong government policies, particularly in Denmark are driving a successful pesticide reduction program. Significant improvements to Australian policy are recommended in this report that will be of benefit to the agricultural sector and support an image of a Clean and Green Tasmania, a status that is difficult to substantiate at present.

Recommendations

'Towards a Clean and Green Australian Agricultural Sector'

Group	No	Recommendation	Rating	Source
Policy	**1**	The Treatment Frequency Index should be implemented in Australian States. TFI is a suitable measure to use in to benchmark current pesticide use, and measure the success or otherwise of State pesticide-reduction programs.	Essential	**Denmark**
Policy	**2**	States should consider cross Agency program aimed at progressing all components essential for a verifiable clean and green agricultural sector.	Essential	**Sweden**
Policy	**3**	The Clean and Green branding approach of the Finnish Government is very similar to Tasmania's Clean and Green claim. In order to progress towards a substantiated Clean and Green status in Australian states, shifts in practice similar to those in Finland are needed.	Essential	**Finland**
Policy	**4**	A noticeable difference between Australia and Denmark is the tendency for vegetable growers to grow both conventional and organic produce. Partial conversion of farms to organic production in Australia would assist in development of an organic vegetable production industry. It would allow farmers to enter organic production gradually and possibly offset economic barriers related to full farm conversion. This requires comment from Australian organic certification authorities.	High	**Denmark**
Policy	**5**	Australia is in an ideal situation to facilitate the development of State organic learning centres. These could act as a key platform in facilitating continuing development of a commercial organic industry in Tasmania. Links with KVL's project work should also be investigated.	High	**Denmark**
Policy	**6**	The Environment Impact Quotient (EIQ) index could be another technique to benchmark current pesticide impact/use in Australian States and assess future pesticide-reduction activities.	High	**Sweden**
Policy	**7**	The European Integrated Production guidelines provide a good model on which to develop similar guidelines for Australia. This should be incorporated into the Environmental Management Systems (EMS) development process for Australian agriculture.	Desirable	**Denmark**
Policy	**8**	Organic producers benefit with subsidies through conversion and lesser subsidies after conversion. This provides a significant economic advantage compared with organic producers in Australia. Although the	Desirable	**England**

		subsidies were considered complex to access, it was generally agreed they have played a significant role in developing the organic industry. If Federal and State governments wish to fast-track or facilitate the development of an organics industry there may be a role for incentive payments at least through the three year conversion period.		
Technique	**9**	Onion transplanting is widely used in Denmark. The viability or otherwise of onion transplants in Australia needs to be examined in conjunction with the onion industry. A desktop study of the production economics is recommended. This is especially important if organically grown onions are to be considered.	High	**Denmark**
Technique	**10**	Host plants for beneficial insects are an essential component if true IPM/organic production systems are to be established in Australia.	High	**Denmark**
Technique	**11**	Trap cropping is an ideal technique to demonstrate on in Australia. Sufficient detail on methodology is provided to incorporate it into some pilot studies.	High	**Finland**
Technique	**12**	The Push-Pull technology (semiochemicals) could be a useful IPM tool for use in Australia but would require some local research with respect insect pest/host plant interactions.	High	**England**
Tools, International Collab.	**13**	Automated guidance systems for mechanical weeders. Testing of the Eco-Dan camera unit in Australian vegetable crops could be undertaken in a joint partnership with Danish Institute of Agricultural Science and Eco-Dan.	High	**Denmark**
Tools	**14**	Decision trees for weed management are useful tools. These tools could have great application in Australia assisting farmers and field staff determine the most strategic (and minimal) herbicide solution.	Desirable	**Denmark**
Tools	**15**	Mycoherbicides could be useful in both the forestry and horticultural sectors in Australia. At this stage contact should be maintained with the researchers, and scientific data examined when available.	Desirable	**Netherlands**[8]
Education	**16**	State/Territory botanical gardens provide an ideal resource and focus to demonstrate organic gardening techniques. This is already being done on a small scale at the Royal Botanical Gardens (RBG) in Hobart but could be expanded to provide a high profile facility similar to the Ryton Organic Gardens.	Desirable	**England**
Market	**17**	Final reports and findings in relation to the economic factors of conversion to organics in the UK need to be considered in the context of a organic industry in Australia.	High	**England**

[8] See Conference Report "12th European Weed Science Society Symposium" for additional recommendations arising out of conference attendance.

Progressing Fellowship Findings

Findings, details of techniques used, and recommendations relevant to the Tasmanian horticulture industry have been detailed in a report submitted to the State Minister for Primary Industries and Premier. A Ministerial Brief has been prepared with recommendations. The recommendations in the report will be incorporated into my team's future work programs and some will be the subject of project funding proposals. A Seminar series is being prepared based on my Fellowship findings. This will be delivered jointly to industry/government representatives at Hobart, Devonport, and Launceston. I will be speaking at local service clubs eg. Apex, and plan to present at a meeting of the Royal Society Tasmania. Media coverage is being undertaken based on my Fellowship and I will be giving several radio interviews. I shall be using all these opportunities to profile the Churchill Trust. My report will be available for download from my web page, www.geocities.com/ab62ab

List of Key contacts

Name	**Position**	**Institute**	**Location**	**Email**
Bo Melander	Head, Weed Ecology Group	Danish Institute of Agricultural Sciences	Research Centre Flakkebjerg, Denmark	Bo.Melander@agrsci.dk
Gisela Felkl	Senior Scientist	Danish Institute of Agricultural Sciences	Research Centre Flakkebjerg, Denmark	Gisela.Felkl@agrsci.dk
Klaus Paaske	Scientist	Danish Institute of Agricultural Sciences	Research Centre Flakkebjerg, Denmark	Klaus.Paaske@agrsci.dk
Lars Bodker	Senior Scientist	Danish Institute of Agricultural Sciences	Research Centre Flakkebjerg, Denmark	Lars.bodker@agrsci.dk
Peter Hardvigs	Senior Scientist/ Farmer	Danish Institute of Agricultural Sciences	Flakkebjerg, Denmark	Peter.Hardvig@agrsci.dk
Erik Steen Jensen	Professor	Organic Farming Unit, Royal Veterinary & Agricultural University	Taastrup, Denmark	Esj@kvl.dk
Peter Esberg	Professor of Zoology	Royal Veterinary & Agricultural University	Copenhagen, Denmark	Pe@kvl.dk
Henning Hogh-Jensen	Associate professor	Organic Farming Unit, Royal Veterinary & Agricultural University	Taastrup, Denmark	Hh@kvl.dk
Henrik Hauggaard Nielson	Assistant professor	Organic Farming Unit, Royal Veterinary & Agricultural University	Roskilde, Denmark	Hhn@kvl.dk

Werner Reidel	Researcher	Royal Veterinary & Agricultural University	Copenhagen, Denmark	Wr@kvl.dk
Jens Streibig	Professor	Royal Veterinary & Agricultural University	Copenhagen, Denmark	Jcs@kvl.dk
Jesper Rasmussen	Associate Professor	Royal Veterinary & Agricultural University	Taastrup, Denmark	Jer@kvl.dk
Bodil Jonsson	Vegetable Agronomist	Plant Protection Centre, Swedish Board of Agriculture	Alnarp, Nr. Lund, Sweden	Bodil.jonsson@sjv.se
Magnus Grontoft	Officer-in-Charge	Plant Protection Centre, Swedish Board of Agriculture	Alnarp, Nr. Lund, Sweden	Magnus.Grontoft@sjv.se
Bengt Gunnarsson	Field Officer	Findus Sweden	Bjuv, Sweden	Bengt.gunnarson@se.findus.com
Enar Magnusson	Factory Manager	Findus Sweden	Bjuv, Sweden	Enar.magnusson@se.findus.com
Marianne Wikstrom	Senior Plant Pathologist	Findus Sweden	Bjuv, Sweden	N/A
Carl-Johann Nilsson	Agricultural Economist	LRF Konsult	Angelholm, Sweden	Carl-johan.nilsson@kosult.lrf.se
Jorgen Persson	Manager/ Director	Marianne's Farm AB	Angelholm, Sweden	Info@mariannesfarm.se
Marianne Harning-Nilsson	Manager/ Director	Marianne's Farm AB	Angelholm, Sweden	Info@mariannesfarm.se
Christer Torneus	Plant Protection Specialist-Fruit	Plant Protection Centre, Swedish Board of Agriculture	Alnarp, Sweden	Christer.torneus@sjv.se
Johan Malmstrom	Field Manager	Marianne's Farm AB	Ahus, Sweden	N/A
Johan Ascard	Senior Research Officer	National Board of Agriculture	Alnarp, Sweden	Johan.ascard@vv.slu.se
Karin Ullven	Editor	Centre for Sustainable Agriculture, Swedish University of Agricultural Sciences	Uppsala, Sweden	Karin.ullven@cul.slu.se
Fredrik Fogelberg	Senior Scientist	Department of Crop Science, Swedish University of	Uppsala, Sweden	Fredrik.fogelberg@vv.slu.se

		Agricultural Sciences		
Lennart Carlson	Farm Manager	Ekhaga Farm, Swedish University of Agricultural Sciences	Uppsala, Sweden	Lennart.carlsson@cul.slu.se
Barbro Nedstam	Plant Protection Specialist- Biological Control	Plant Protection Centre, Swedish Board of Agriculture	Alnarp, Sweden	Barbro.nedstam@sjv.se
Benst Jonsson	Farmer	Horta Trading (Bjud Gronsaker)	Vellinge, Sweden	Bengst.jonsson@bjud.se
Ulf Danielsson	Farmer	Horta Trading (Bjud Gronsaker)	Vellinge, Sweden	Bengst.jonsson@bjud.se
Hans Axel Andersson	Farmer	N/A	Malmo, Sweden	N/A
Klaus & Nicholas	Farmers	Torlarps-Gard	Finland	N/A
Kari Tiilikkala	Professor	Agrifood Research Finland	Jokioinen, Finland	Kari.tiilikkala@mtt.fi
Anna Nissinen	Entomologist	Agrifood Research Finland	Jokioinen, Finland	Anna.nissinen@mtt.fi
Jukka Salonen	Research Manager (Weeds)	Agrifood Research Finland	Jokioinen, Finland	Jukka.salonen@mtt.fi
Pekka Kurri	Director	Lannen Tehaat Pty Ltd	Sakyla, Finland	Pekka.kurri@lannen.fi
Meindert de Jong	Scientist	Biological Farming Systems Unit, Wageningen University	Wageningen, Netherlands	Meindert.dejong@biob.dpw.wau.nl
Barend de Voogd	Scientist	Biological Farming Systems Unit, Wageningen University	Wageningen, Netherlands	N/A
Stephen James	Director	IACR-Rothamsted Research Station	Harpenden, England	Stephen.james@bbsrc.ac.uk
Paul Verrier	Senior Scientist	IACR-Rothamsted Research Station	Harpenden, England	Paul.verrier@bbsrc.ac.uk
Wilf Powell	Applied Entomologist /Ecologist	IACR-Rothamsted Research Station	Harpenden, England	Wilf.powell@bbsrc.ac.uk
Ian Denholm	Head of Plant and invertebrate Ecology Division	IACR-Rothamsted Research Station	Harpenden, England	Ian.denholm@bbsrc.ac.uk

Brian Kerry	Nematologist	IACR-Rothamsted Research Station	Harpenden, England	Brian.kerry@bbsrc.ac.uk
Lester Wadhams	Head of Chemical Ecology Group	IACR-Rothamsted Research Station	Harpenden, England	Lester.wadhams@bbsrc.ac .u
Richard Harrington	Entomologist -Rothamsted Insect Survey	IACR-Rothamsted Research Station	Harpenden, England	Richard.harrington@bbsrc .ac.uk
Gareth Davies	Senior Research Officer	Henry Doubleday Research Association (HDRA)-Ryton Organic Gardens	Coventry, England	gdavies@hdra.org.uk
Chris Firth	Senior Business Analyst	Henry Doubleday Research Association (HDRA)-Ryton	Coventry, England	cfirth@hdra.org.uk