Fusion Farming in Brassicas: Sustainable Agriculture for the Future?

A report for

By Scott Samwell

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Executive Summary

- Sustainable agriculture seeks to balance the long-term goals of economic profitability, environmental stewardship, and quality of life for farmers and their communities. Sustainability will mean different things for different producers depending on their culture, education and moral bearing.

- Fusion farming is one attractive production system which is a possible alternative to current agricultural practices. Fusion farming is a blend of the positives from many production styles, thereby creating a functional hybrid.

- Organic production systems offer practices such as green manure crops and composting as a source of nitrogen.

- Biological production systems offer an understanding of cover crops using mixed species for greater diversity in the field and working with the soil to enhance soil and plant health.

- Larger scale operations demonstrate how efficient conventionally grown food can be where the demand for high quality produce is stringent and ruthless.

- Brussels sprout growing is a challenging business, especially so when the consumer demands a high quality product all year round. More and more the consumer has a desire to know where their food is coming from and how healthy their food is.

- Brussels sprouts in Australia are a small crop so advice given is often based upon other brassica crops such as cabbage, cauliflower or broccoli.

- There is undoubtedly a balance between all these production methods, however one was not found in Brussels sprout production. The intention is continued experimentation on the home farm to see what practices can be implemented to enhance soil health and crop production.

- The intention of this study was to examine other brassica growing businesses, specialising in Brussels sprouts, throughout the world and to investigate their production methods.

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Foreword

Sustainability is a word which is used frequently in all areas of life on planet Earth. It is a key idea for political parties, governments and lobbyist groups. There has been much comment of late about the world's human population heading towards nine billion people, and the need for food to feed them. David Attenborough in the British Broadcast Corporation production 'How many people can live on the planet' observed in his lifetime the tripling of the earth's population to seven billion people. Currently population is growing at a rate of about eighty million per year (Attenborough, 2009). The United Nations has projected by 2050 population will reach 9. 6 billion, (UN News, 2013). These people will need food. Where will it come from? Will there be land and resources to meet this increased demand? Agriculture will need to become more efficient and use sustainable practices in an environment of dwindling resources and increasing cost of production if this demand is to be met.

Fusion farming is one proposed system of farming which may prove to be a viable alternative to existing farming systems and one which could prove to be sustainable. Fusion farming looks at encompassing all the positive aspects of farming systems such as conventional, biological, organic and biodynamic. Graeme Sait says, *'…. fusion farming is where we take ideas from many different philosophies and combine them to produce a more functional hybrid'* (Sait, 2000).

One of my passions is growing healthy food in healthy soils. As food producers we need healthy soils to produce a food full of nutrients for our customers. About eight years ago I started doing trial work with biological farming practices in which there is a large emphasis on soil health. The focus is on finding an ideal balance of minerals, nutrients and the organisms found in the soil. Using this approach it is hoped that a healthy plant will grow which will be resistant to attack from pests and disease using its own defense mechanisms.

Throughout the trial work I had successes and failures. I was very enthusiastic with the initial success of the trial field which resulted in trying the biological farming principles across the whole farm. This did not work out as well as hoped and resulted in a loss of confidence in the practical expansion of the growing principles. In 2006 I endeavoured to further my knowledge in alternative farming practices by attending a seminar given by Arden Anderson and a one-week course in Queensland on Sustainable Agriculture.

My family has been growing fruit and vegetables for 60 years in the Adelaide Hills, South Australia. Currently our main crops are Brussels sprouts, fresh and processing cabbage with oaten and pasture based hay and beef production as side enterprises. My brother Luke, our cousin James, and myself make up the third generation of our business. Along with our fathers, Kent and Leigh, we grow and produce about 45 hectares of Brussels sprouts, 10 ha of cabbage, 45 ha of rye and clover pasture, and 160 ha of oaten cover crops.

Our markets are domestic and international. Refrigerated trucks leave our packing facilities daily carrying produce to Adelaide, Melbourne, Sydney, Brisbane and Perth. During the months of May through to July we can supply the United Kingdom and the Netherlands. The ability to supply these markets is dependent on global supply and the Australian dollar.

Brussels sprouts in Australia are not a widely grown crop; however, in Europe they are grown extensively throughout Belgium, the Netherlands and Germany. Another big player is the United Kingdom, where they are grown in England and Scotland. Surprisingly, there is also a strong market in the United States situated on the west coast in Monterey Bay, California. I was keen to see if commercial enterprises were using different production systems and techniques to grow their sprouts and cabbage. Would I find a model farm which grew commercial volumes of produce using minimal inputs? Is it a viable operation, with minimal environmental impact, and does its practices increase soil health?

My Nuffield Scholarship enabled me to travel to the Philippines, China, the United States, Continental Europe, and the United Kingdom. In all of these places I was able to see how culture and traditions influenced farming and growing practices. It was interesting to see what sort of pressures growers were facing in their own countries and to see how their circumstances compared to ours.

I believe that future research and development in agriculture needs to be in soil health research. We need a greater understanding of what is happening under the surface. This information needs to be factual and quantifiable. To help me understand, learn and experience, I set off to visit brassica growers around the world to observe the farming practices employed in other countries.

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- The many individuals, contacts, businesses and researchers who kindly gave up their valuable time to share their knowledge with me and those that helped with accommodation during the course of my study. Special thanks to Laura Paine, Denise Doetzer, Matthew Rawson and Benoit Presles.

- My father Kent, Uncle Leigh, brother Luke and cousin James for holding the fort whilst, as they say, I gallivanted around the world.

- And most importantly my beloved wife Rochelle for carrying on running the family home with my 3 princesses: Paris, Poppy and Priya.

Abbreviations

@ - at

AUS – Australian dollar

Bt - Bacillus thuringiensis

CSA – community supported agriculture

GPS – global positioning system

kg/ha – kilograms per hectare

kph – kilometers per hour

l/ha – litre per hectare

m – meter

m^2- meters squared

mm - millimeters

NPK – nitrogen, phosphorus and potassium

N – nitrogen

OM – organic matter

USDA – Unite States Department of Agriculture

Objectives

- To visit and observe farms growing brassica crops, in particular Brussels sprouts and cabbage, which utilise conventional, biological, organic and biodynamic principles.
- To investigate how growers are managing their soils in relation to soil health and sustainability.
- To examine the viability of these farms and to consider if any alternative practices are commercially viable.

Chapter 1: Introduction

The gross value of production of the Australian horticulture sector is in excess of AUS$9 billion per annum (HAL, 2013). Two crops under this umbrella are Brussels sprouts and cabbage, which are members of the brassica family. Brussels sprouts, compared to other brassica crops, are only grown in small amounts. In Australia there may be up to 200 ha grown which is more than enough to cover the domestic market. Compare this to Europe where the total area grown is around 8,000 ha! As a result there is little technical advice and expertise in sprout growing in Australia. This creates a need for on farm experimentation or sourcing information from other sprout growing areas.

Growing produce in a sustainable way is critical for the future of horticulture in this country. Australia is in a great position to capitalise on its isolated location and provide an image of agriculture which is clean and green. It is the aim of this project to see if it is possible to grow sprouts using fewer inputs such as synthetic chemicals and fertilisers whilst still maintaining viable yields and a nutritious product. The best way to ascertain this was to go where the majority of sprouts and cabbage are grown and to examine the growing practices they are using.

Chapter 2: United States of America

Wisconsin

Michael Borzynski – Racine WI

Michael belongs to a third generation family owned business that farms a total area of 2800 ha in SE Wisconsin, Georgia, Illinois and Texas. The land is made up of freehold and leased portions. For the US fresh market they grow collards, kale and cabbage. Their cabbage production is on around 920 ha. They have their own in-house nursery facility which enables them to grow their required 43,000,000 cabbage plants. This gives them control from seed to market. This makes them one of, if not the largest, producers of fresh market cabbage in the US. This requires them to utilise as many growing days as possible to provide year round product for their markets. Round-up Ready® corn is also grown for livestock and biofuels.

As a conventional grower Michael uses synthetic fertilisers for all of his nutrient needs. Pesticides, fungicides and herbicides are used in the production system. His brassica program starts with around 550 kg/ha of a NPK blend with some boron added as a trace. This will be applied pre-plant, and during the life of the crop nitrogen will be added via the centre pivot through fertigation using a liquid fertiliser which has 28% N.

His belief is that he needs to stay with conventional methods to be able to continue to produce food that is at an affordable price for the average consumer. He felt that organic production was cost prohibitive on a large scale due to the greater need for manual labour. This would then increase the cost of production leading to a higher price for the end consumer. Their production system has been designed to keep the costs down to provide the American people with a cheap food price. Does this mean that nutritional value of the end product has been compromised?

Some points of interest from Michael's conventional production system concern the chemical resistance of some pests. He has noticed there is a growing resistance to the insecticide called Success2®. Success2 has the active ingredient *spinosad* which controls diamond back moth (DBM) in brassicas. Another area of concern for him is the development of resistance to herbicides in his corn crops. In some fields it has reached the stage that the only way to control is mechanical weeding whilst the corn is growing and then to resort to hand pulling

once the corn has reached maturity. This is possible due the low labour wages and available labour in the United States. For long term sustainability these practices may need to change.

Another avenue for the family's produce is through their Farm and Floral Market. This is located on a portion of their land and caters for a broad clientele: from the locals requiring weekly fruit and vegetables right through to the tourist wanting Wisconsin gourmet food and home wares. Due to the population density this outlet provides another strong outlet for the Borzynski's family business.

Figure 1: Borzynski's farm shop logo. Source M. Borzynski

Mid-Western BioAg – Field day

Nearly 75 years ago, USDA soil scientist Charles E. Kellogg wrote: "*Essentially, all life depends upon the soil"* (Kellogg, 1938). Expressing a similar sentiment, President Franklin D. Roosevelt said: *"The nation that destroys its soil destroys itself*" (Roosevelt, 1937).

Each year in the third week of August Mid-Western BioAg hold a field day at Gary Zimmer's family farm in Wisconsin, USA. Gary is the founder of the company called Mid-Western BioAg. Gary is passionate about biological farming. Biological farming *'…utilises resources of both science and nature in a superior farming system' (Zimmer, 2000)*. He is an advocate for working with the soil and realising the full potential of the land that any farmer has to use to grow food. He firmly believes in building from the ground up.

There are a number of important steps that a biological farmer will learn to be successful. First the soil will be nurtured, fed a balanced diet and worked using equipment which will enhance soil life. Green manure crops and cover crops are critical in rotations which help in feeding the soil biology and increasing soil health. Secondly, constant evaluation is needed to

establish crop health, root and plant deficiencies, as well as insect, disease and weed indications. Together these attributes will provide a firm, healthy foundation for a successful crop.

At the Mid-Western BioAg Field Day Gary aims to show the principles that he teaches which gives attendees a firsthand look at a working biological farm. The aim is to promote biological farming with both information and on farm walks. The farm walks allow visitors to view and discuss cover crops, the soil pit, tillage equipment, compost windrows and equipment, crops and technical displays and advice.

The major points I gleaned from this field day are as follows:

- Biological farming offers an entire system that can be adopted. Management, balance and efficiency can make biological farming profitable.
- There is no one way to farm biologically. Some universal practices are required; however, each farm is different so this will mean different base fertilisers, cover crops, rotations, soil amendments and so forth.
- A farmer needs to be mindful of what types of fertilisers are to be used. How will the applied fertiliser impact on the soil biology and plant life?
- Micronutrients are essential for plants and microbes. Microbes are linked with transforming fertiliser into plant available form.
- Balance soil minerals.
- Maximise photosynthesis.
- Manage air and water in the soil.

The three legged stool is an excellent illustration for soil health and balance showing 3 legs which support soil.

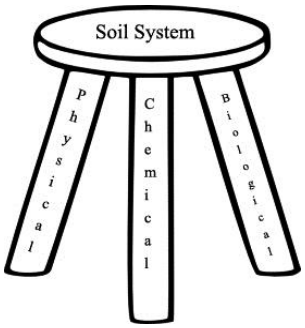

Figure 2: Chuck (2013) Soil Scientist USDA/NRCS, - Soilhealth. net

Another illustration using the stool imagery could be the following where the stool is more like a pedestal with a focus on the centre being biological management. The other two components, the physical and chemical management help maintain the balance of the whole but are minor when compared to the centre pillar.

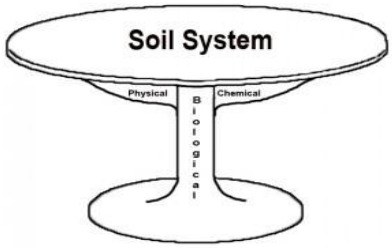

Figure 3: Chuck (2013) Soil Scientist USDA/NRCS, - Soilhealth.net

Allen Philo, the specialist crop agronomist at BioAg, explained how in his view using compost was a great way to inoculate the soil rather than using compost as a soil organic matter (OM) improver. He felt that growing cover crops such as a Sudan grass (50%)/clover (50%) (white/red/yellow) mix was an excellent way to build soil OM. The benefits are found underground, a complete natural ecosystem. Sorghum/Sudan grass is very good for building organic matter. It builds biomass quickly, suppresses weeds and can withstand drought. It has large deep roots and at the same time produces substantial root mass underground. A suggested sowing rate is 37. 5 kg/ha. Allen suggested that mixed cover crops were more productive as they mimic natural systems. Another viable cover crop for use in a brassica crop rotation is buckwheat. It grows quickly, takes up a lot of phosphorus, thrives in poor soils and suppresses weeds. Suggested sowing rate is 56. 5 – 68 kg/ha.

Sudan grass **Buckwheat**

Figure 4: Sudan grass & Buckwheat, Otter Creek Organic Farm, Avoca, Wisconsin (Samwell, 2012)

Gary explains that cover crops can provide the following benefits (Zimmer & Zimmer-Durand, 2011);

- Improving water infiltration into the soil.
- Reducing water loss from soil by evaporation.
- Holding soil in place and reducing erosion from wind and rain.
- Reducing fertiliser inputs by providing calcium, phosphorus, potassium, nitrogen and micronutrients to the following crop.
- Breaking up soil compaction.
- Producing compounds that deter weeds and crop pests.
- Increasing soil organic matter levels
- Feeding soil biology

Harmony Valley – Richard de Wilde

Harmony Valley is a family owned, diversified farm with over 40 years of experience producing high quality, organic vegetables and berries. They are located in an isolated valley in south-western Wisconsin. Their silt loam fields are high in organic matter, humus and biological life. They receive green cover crops, generous amounts of compost and rock powders. Their vegetables are grown and harvested with care and immediately cooled and kept refrigerated. All of the products are certified by the Midwest Organic Services Association. They believe this an assurance of high quality, nutritious, flavoursome food produced in a system which does not compromise the farmers or the environment. Harmony Valley is run by Richard and his family, with a crew that varies with the seasons from 15 - 50 team members. The home farm consists of 80 ha of woods, pastures and crop land lying along Spring Creek. Additional land is leased to give a total of 48 ha of fresh market produce. Their crops encompass a wide variety of standard and specialty vegetables and berries. Amongst their customers they are best known for their season long, high quality salad mix, sauté greens and spinach. In the autumn and winter months root crops are a specialty. Produce is sold through a 400 member Community Supported Agriculture (CSA) group, a weekly stall at the Dane County Farmers Market, retail grocers and wholesale distributors.

At Harmony Valley Farm, Richard says they go beyond basic certified organic farming methods. They have researched and implemented many innovative and cutting edge techniques. To promote soil health and fertility, Richard has developed a system of cover cropping with green manures, applying natural rock powders and incorporating compost. To

control pests, a perennial habitat and nesting sites are provided for natural control agents such as raptors, song birds, bats, wasps and beneficial insects. Richard has the advantage of being in a location where he is naturally isolated from other farming areas. He farms in the valley floors and is surrounded by heavily wooded hills which provide a natural barrier to pest and disease and create micro environments conducive for organic production "(Figure 5)".

Some of their latest research involves studying disease suppressive properties of soil amended with compost. "*We are dedicated to organic farming and believe strongly that it produces the highest quality, best tasting food while protecting the quality of our water and wildlife,*" says Richard (De Wilde, 2012).

Figure 5: Collards surrounded by woodland, Harmony Valley Farm, Viroqua Wisconsin (Samwell, 2012)

Featherstone farms

Featherstone Farm is a 100 ha certified organic farm located in the bluff country in and around Rushford, Minnesota. It is run by co-owner Jack Hedin who is extremely passionate about sustainable agriculture. The farm produces around 70 varieties of fresh market fruits and vegetables for distribution to natural food stores, wholesalers CSA members (>1000 members) throughout the region. Summer Share CSA and Winter Share CSA is on offer for subscribers to participate across Minnesota, Wisconsin, and Iowa, and they also sell their produce wholesale to local markets throughout the region.

Featherstone has enjoyed steady growth — from marketing $18,000 worth of produce in its first year (1996) to $1. 4 million–plus in 2012, showing that this business model is a viable one. Jack characterizes their soil as "A + soil" which is essential for organic growing. As an organic farm their nutrients come from cover crops, green manure crops, crop residue, compost, rock phosphate, peat moss and other non-chemical sources. Jack's dream is to farm sustainably with one of the key goals being *"to build the soil rather than to mine it"*.

Michael Fields Agricultural Institute – Smaranda Andrews

Michael Fields Agricultural Institute (MFAI) is a public, non-profit organisation focused on education, policy and research. The organisation has a mission to nurture the ecological, social and economic resilience of food and farming systems through education, research, policy, and market development.

MFAI envision an ever-creative cultural process in which farmers and consumers create agricultural landscapes with healthy regional systems of land use, food production and distribution. This is done by adhering to four cultural pillars, which are research, education, public policy and transitions. Research is done off-site as well as at their teaching location in East Troy, Wisconsin. Whist some of their research is aimed at larger operations, a large portion of their work is helping budding farmers start through education and assistance in startup programs with help from various government organisations and local groups. The main facility in East Troy is education based, where students and interns can carry out the practical applications of their theoretical lessons.

Figure 6: Michael Fields Agricultural Institute, compost windrow, East Troy, Wisconsin (Samwell, 2012)

Standard Process – Annie Gentil

Standard Process is a large organic farm of around 168 ha which grows a range of crops used in their diet supplementary products, sold mainly through chiropractors. The produce grown is for processing only. The whole foods are processed on site through their cutting and dicing machine and then onto a drying machine which will make it ready to be made into supplement form. Some of the whole foods they grow are alfalfa, barley grass, beets, Brussels sprouts, buckwheat, kale, kidney beans, oats, pea vine and Spanish black radish.

Cover crops are used for weed prevention and as a source of nitrogen and organic matter. As in most organic production systems weed control is essential for a viable crop. Weed control is managed using cultivating, mowing, hand weeding and a crop flamer. The by-products from the farm's processing facility and other areas have been composted since 2011 and are returned to the farm's land for a monitored land spreading nutrient management program. Pest control is helped through the use of natural predators which are able to survive due to the successive plantings of cover crops and vegetable crops. Christine Mason, the farm manager, likes to have a constant source of food available for the predators and also the honey bees which provide pollination. Permanent buffers are in place around fields to provide shelter, food and hive sites for the bees.

Vermont Valley Community farm – David Perkins

Vermont Valley Community Farm (VVCF) operates under the CSA. CSA is a social model that connects the consumer to their food, the land, and with those that tend the soil. CSA is an economic model that allows people to place their food dollar directly in the hands of a family farm, a farm they know, a farm that adopts organic practices to respect the health and nutritional value of food, or a farm that reduces the impact of agriculture on the environment.

The CSA philosophy creates a food system that adopts practices emphasising taste, nutrition, local economies and respect for the land. The benefits of a CSA based food system are many. Besides providing fresh organically grown produce, a CSA farm provides the non-farmer with an understanding of the challenges and rewards of farming. Members participate in the risks and uncertainties of farming as well as sharing in the rewards of a bountiful harvest. Having direct contact with the land can be a spiritually and physically rewarding experience. Family farmers can survive because of a guaranteed market that includes a dedicated community, a set income, and the freedom to experiment with new varieties and techniques.

VVCF has between 2,200-2,300 paying customers who pay up to $600 each for 20 deliveries through the main growing season. This income is up front which is great for the farmer's cash flow. 50 different vegetables with 100 different varieties are grown for the customer. David, the founder of the business, farms on about 44 ha with 26 ha of this being arable land. Of this, 14ha is used for vegetable production. The rest of the arable land is cover cropped or has a green manure crop with field peas, oats, lucerne, wheat, tillage radish, rye, small seeds and Austrian winter pea. Chicken compost is used for nutrition as well as the legumes.

Alsum Farms & Produce – Larry Alsum

Alsum Farms began, over 40 years ago, with Wisconsin potatoes and onions — and they still comprise the majority of their business, gracing the plates of American homes across the nation. Committed to preserving the earth, as a Healthy Grown® grower, each step of their potato planting, growing, harvesting and shipping processes meet the exacting sustainability standards of Protected Harvest (see below). As part of this commitment, they also restore biodiversity and conserve ecosystems on their non-farmed lands — after all, they feel that what they do today on their farms affects the future of the land and communities around them. Whilst their production, packing and storage facility is based in Wisconsin, its soils can't provide all their produce requirements. By partnering with family farms across the nation, Alsum Farms & Produce provides a wide variety of fresh fruits and vegetables to grocers in the Great Lakes region every day of the year.

It is important to mention here a little about Protected Harvest, the sustainable certification that Alsum Farms uses. Protected Harvest is a standards setting and third-party certifier of sustainably-grown food products. Buyers of Protected Harvest-certified products can be assured that claims of environmental and social sustainability performance are specific, measurable, and verifiable. Protected Harvest growers are assessed and audited on water, air, and soil quality, wildlife protection and social impacts on workers and the community. For growers such as Alsum Farms they must follow a detailed check sheet which uses a point system. The point system rewards growers for implementing ecologically based practices in nine different management categories: field scouting, information sources, pest management decisions, field management decisions, weed management, insect management, disease management, soil and water quality, and storage management. A minimum number of points must be achieved in each category to qualify for certification. Part of the standard also consists of a toxicity score, in which the grower must stay below an established level of

pesticide use in a given hectare. Highly toxic pesticides are prohibited whist other pesticides may be used with restriction. The established level is low so growers must use their chemical choices wisely in order to pass the certification. This is a good example of a system trying to enforce sustainability in an agricultural environment.

There are a growing number of these types of 'sustainable certifications' emerging globally. It is a response to a growing demand from consumers concerned about where their food is coming from, how it is being grown and the safety of it, especially where chemicals are concerned.

Pennsylvania

Cover crop solutions – Steve Groff

Steve Groff and his family farm 86 ha of vegetables, crops and cover crop seeds on rolling fields in Lancaster County, Pennsylvania. He has pioneered the 'Permanent Cover Crop System' that includes no-tillage, strategic planting of cover crops and effective crop rotations as a way to increase profits, save soil and reduce pesticides. Some fields on his Cedar Meadow Farm have not had traditional tillage for over 35 years.

Cedar Meadow Farm, whilst a working farm, contains experimental plots for Steve's cover crop trials. A lot of his trial work has been done in conjunction with the Penn State University to scientifically record the types of cover crops and how the cover crop interacts with the soil and proceeding crops.

The first question that Steve will ask concerning cover crops is, what are you trying to accomplish in using one? The next question is, what is your planting window of opportunity? The answers to these questions then allow the plant species to be determined. The closer one gets to winter the less choice there will be in cover crop species. The species used will be also determined by whether nitrogen is being scavenged or accumulated. Included in this decision process will be questions such as 'Do I want to keep soil cover through winter?', 'Do I want a dead cover crop in the spring?', or 'Do I want a living cover crop in the spring?'

The benefits of cover crops are numerous.

- **Improve health of agricultural systems**: Cover crops work to increase soil aeration, moderate soil temperature, improve soil structure by adding organic matter and

increase water penetration. These improvements help to reduce soil loss due to erosion and tillage.

- **Reduce pests and pathogens**: Certain cover crops can suppress insect, nematode and pathogen populations; e. g. for bio fumigation select *Brassica* cover crops (i. e. white mustard and brown mustard)
- **Reduce weed pressure**: Cover crops fill an open niche and protect areas from weed invasion.
- **Cash crop production**: Cover crop production may provide an additional income source as many cover crops are utilized as forage and animal feeds.

Cover crops that have a strong root system that are allowed to decompose in the field increase soil stability and water retention.

Steve demonstrates on his farm the importance of cover crops for soil health. Soil health is the '*capacity of a soil to function'* (USDA, 2010). Soil is a '*living factory of macroscopic and microscopic workers who need food to eat and places to live to do their work'* (USDA, 2010). An interesting point made is the fact that there are more individual organisms in a teaspoon of soil than there are people on the earth. With this in mind it stands to reason that the soil is influenced by these organisms.

Quite a bit of Steve's work has been done in conjunction with the Penn State University. This has enabled him, along with researchers, to set up extensive trials on his farm and in other sites to continuously examine the role of cover crops. The trial work currently under way was replicated three times to provide statistical data for comparison once the cash crop was planted. There were three mixes of cover crops: the first was a four species mix, the second a eight species mix and the last had 40 species in it. In these mixes were Sudan grass, Sunn hemp, pearl millet, red clover, tiller radish, cow pea, sunflowers and field beans. Steve believes that diversity is the key to a good cover crop; e. g. five species or more work well together.

Figure 7: Steve Groff in a multi-species cover crop, Cedar Meadow Farm, Holtwood Pennsylvania (Samwell, 2012)

Some recommendations for cover crops for southern Australia in intensive vegetable productions were Sudan/sorghum grass, cereal rye + hairy vetch, and/or millets, which provide huge amounts of biomass; crimson clover with barley, and rye corn as a quick green manure crop which provides quick bulk. His suggestions would depend on species availability and sowing conditions.

Rodale Institute – Owen Maguire

Rodale Institute is the birthplace of the Organic Movement in America. It was founded in 1947 by J. I. Rodale to study the link between healthy soil, healthy food and healthy people. The institute is situated on 133ha in Kutztown, Pennsylvania. Their mission statement reflects what they are about: *"Through organic leadership we improve the health and well-being of people and the planet"*. For more than 60 years Rodale has been researching the best practices of organic agriculture and sharing their findings with farmers and scientists throughout the world.

The key project at the Rodale Institute would have to be the Farming Systems Trial (FST) which is the longest-running side-by-side US study comparing conventional chemical

agriculture with organic methods. The FST has focused on some of the main crops grown in the U. S. which are corn, soy beans and wheat.

Key findings from this show that, in the United States at least:

- Organic yields match or surpass conventional yields.
- Organic yields outperform conventional yields in years of drought.
- Organic farming systems build rather than deplete soil organic matter, creating a more sustainable system.
- Organic farming is more efficient, using 45 percent less energy than equivalent conventional methods.
- By comparison, conventional agricultural systems produce 40 percent more greenhouse gases.
- Organic farming systems are more profitable than conventional farming systems.

Figure 8: The Farming Systems Trial (FST), Rodale Institute, Kutztown, Pennsylvania (Samwell, 2012)

Owen Maguire is the Farm Operations manager and oversees the day to day operations of farm. This includes plantings, cultivations, weed and pest control, on-farm training, harvesting and everything in between these major tasks. Nutrients come in the form of green

manure crops e. g. hairy vetch and compost which is made by Owen on-farm from autumn leaves from the local city council, some chicken manure, food wastes and soil inoculants.

Figure 9: Compost windrows, Rodale Institute, Kutztown, Pennsylvania (Samwell, 2012)

Virginia

Parker Farms – Rafe Parker

Headquartered in Oak Grove, VA, their facilities process, inspect and ship fresh grown produce to major retail and wholesale outlets. With over 3,000 acres of production in Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia and Florida, their produce starts locally and ships to the customer. The family farm consists of about 1,400 acres of vegetable production including broccoli, cauliflower, squash, sweet corn which is situated in Virginia.

Parker Farms is able to offer services which include hydro-cooling (water cooled) and fan forced cooling, storage, packing and transport. Produce is grown under centre pivot in sandy and sandy loam soils. Their land is relatively flat with some undulation. The farm would be classed as conventional in that they use synthetic fertilisers in the form of traditional NPK and chemical protectants; however cover crops of wheat, barley and crimson clovers are used in crop rotation. Humic acid is used in foliar applications to provide general soil microbe activation.

Figure 10: Broccoli plantings under centre pivot, Parker Farms, Virginia (Samwell, 2012)

Blenheim Farm – organic vegetables

Blenheim Organic Gardens is part of Blenheim Farm, a 160 ha farm long associated with the Washington family in Westmoreland County, Virginia. They are USDA certified organic. It is a family farm where sustainable agriculture and wildlife conservation are their top priorities. The farm is protected in a permanent conservation easement. They grow a large variety of crops on about 4 ha although 8 ha is USDA certified organic. Selected areas of the 8 ha that is not in vegetable production, is planted in cover crop to increase field fertility. The vegetables that are grown are chosen for their beauty and their flavour, including lettuce mixes, elephant garlic, spring onions, tomatoes, basil, green beans, black eye peas, sweet potatoes and specialty eggplants, to name a few. Succession planting is practised to ensure a constant harvest for their markets. They have been part of the Williamsburg Farmers' Market since its inception in the summer of 2002, and are part of a local CSA in the surrounding towns and county. Their vegetables are sold also to FoodE, a farm-to-table restaurant, in Fredericksburg.

The soil is sandy silt so requires a good amount of cover crops, composting and mulches to increase the organic matter. Cover crops grown are rye which has good soil penetration. In the

summer buck wheat is grown which can be sold as a commercial crop if required but also can easily be incorporated into the soil for organic matter (OM). Through winter, clovers are planted to provide a nitrogen source. Another source of nitrogen is composted chicken manure which they have found to be very good on broccoli, cauliflower, lettuce and salad mixes. Other cover crops can include tillage radish and Johnson grass. As with all organic farms weeds are a major problem and this is the area where a lot of time is taken up either with mechanical or hand weeding. The owners are content with this time consuming task as it fits in with their philosophy of environmental sustainability. Intensive weeding (hand weeding) is possible on a small scale but in a large conventional production system it is not economical unless the value of the crop is high and/or the labour is cheap. This is one of the many obstacles that needs overcoming to be organic on a large scale.

California

Brock Taylor (consulting agronomist) – cover crops, San Joaquin valley

Brock runs a consulting business which is employed by a number of large growers in the San Joaquin valley. Using cover crops in rotation with cash crops on some properties has increased the organic matter from less than 0. 5% up to 3% in fewer than five years. This is good considering that there is always a cash crop being grown in the fields with a cover crop grown off season. The number of days for the cover crops is a maximum of 60 days with some being up to 90. Brock has indicated that it would be greater help if the number of days was extended to 120 days if possible. He felt that an issue was convincing growers that cover crops, whilst not providing a cash crop, were helping in setting up the fields for the next commercial crop by providing nutrition and organic matter.

In Brock's experience he found that the cover crops being used by his growers were helping to change the soil structure and crops were responding to this. A great cover crop to use is triticale (wheat/rye cross) as it creates ample roots which in turn feed the soil organisms, and with its powerful root system provides channels for air and water to improve soil structure and reduce compaction. In California it is planted at 68 – 90 kg/ha in autumn and then terminated in mid-march when it is about 300 mm – 600 mm high.

Dan Rodoni – sprout grower just north of Santa Cruz

Dan grows 90 ha of Brussels sprouts. In rotation with these he also grows strawberries and artichokes. Dan grows on land about 15 km west of Santa Cruz, CA. His land has three distinct growing areas; on the coastal cliffs, coastal plain and coastal foothills, creating three different microclimates. This provides him with the ability to plant according to season timing and to have alternatives in his production schedule. The soils are sand over clay. All the produce is grown using conventional methods. The soil has to be fumigated for nematode control in both sprouts and strawberries. Liquid nitrogen is knifed into the soil for the Brussels sprout crops. For weed control the rows are cultivated 4-6 times depending on the weed pressure. Composted chicken manure is used pre-plant in sprout ground as a source of nitrogen, phosphorus and potassium as well as providing some organic matter.

One of Dan's family members grows about 8 ha of sprouts organically, however, his observation was that they are always full of aphids. The pest pressure was too high to make the crop viable and so the venture was not profitable.

Steve Bontadelli – grower and packer Santa Cruz (packing facility) and Watsonville (production fields)

Steve grows around 128 ha of Brussels sprouts in two locations west of Watsonville, California, Sunset and Manresa State Beaches. He also grows in Mexico to provide all year round supply. He uses bell beans as a cover crop in between Brussels sprout crops. The cover crop is a leguminous crop, and so returns nitrogen back into the soil, helping the next crop of sprouts. There will be some benefit to the soil in terms of a small amount of organic matter entering the system, however, any advantages are totally negated because the fields are fumigated each season to eradicate nematodes. This fumigating process destroys not only the nematodes but also any beneficial bacteria, fungi and the many other forms of soil life.

The practice of fumigation is quite prevalent in the sprout and strawberry growing areas. Arable land is scarce so maximising the number of crops per year is critical to making a profit. Rent prices are high: $6250 - $8750 ha. Steve used to use chicken manure as a simple fertiliser for his soil, howeve,r with the increasing tight food safety issues this practice has had to be abandoned. In some cases composted chicken manure can be used, however, there is some risk if the composting is not done properly. This then makes it more difficult to use and tends to deter farmers from using it entirely. Steve uses a NPK post-plant fertiliser (12/12/12) going out at 575 kg/ha at 60 days after transplanting.

Figure 11: Steve Bontadelli expounding the virtues of Brussels sprouts (Samwell, 2012)

USA Summary

- Farm size and vegetable type are determined by the markets which are supplied. In the CSA and farmers market models the grower can select multiple vegetable lines and supply a large number of small quantities for the individual consumer. In this model intensive organic practices are used which appeals to the consumer and can be covered by the asking price of the grower.
- At the other end of the spectrum are the large scale vegetable farms supply processing companies, direct to supermarkets or into wholesale markets. These farms which work on high volume mostly use conventional methods with some alternative practices used such as green manure crops, cover crops and composted material.
- The large commercial growers of brassicas used conventional growing methods. Farms implementing other growing techniques only grew small quantities of brassicas.
- The large population in the US enabled CSA and growers markets to thrive. Australia's small population and large distances are a deterrent for these models to become a huge success. However, there is a place for them in locations around Australia.
- Heavy chemical application is used in some parts of California because of continuous cropping. Fumigation of soil is required for sprout production for protection from nematodes. This destroys most soil life and is not a desirable practice for sustainability.
- Some farms are incorporating quick cover crops into the cropping rotations with promising results. There is benefit to leave cover crops in as long as possible.

Chapter 3: United Kingdom

England

Garford Farm Machinery – Chris Lunn.

Garford Farm Machinery provides equipment that enables a grower to reduce chemical use for weed control in vegetables, cereals and row crops. They specialise in row crop equipment which will handle inter row weeds as well as equipment which is specially designed to handle in-row weeds. All their machines are built to customers' specifications to ensure a machine perfectly suited for the job. Their top of the range machines are the 'Robocrop' Precision Guided Hoes and the Robocrop InRow Weeder which are guided by cameras and computer software. Garford gives growers the flexibility to build hoes from 1. 5 m up to 12 m, which can be used at high speeds (up to 12 kph) in crops such as cereals, sugar beet, lentils or beans. With increasing chemical restrictions in the United Kingdom these large weeding hoes offer an attractive alternative.

Figure 12: Garford Robocrop Precision Guided hoe, Tillett and Hague Technology Ltd

The Robocrop InRow Weeder is designed for crops such as lettuce, brassicas and celery. This machine can be used on any crops where there are plantings of regular plant and row spacing. Both of these machines, whether standard driver guided or camera steered, offer the organic industry a viable alternative to expensive hand hoeing which is the only other way to accurately remove weeds from fields.

Figure 13: Garford Robocrop in-row hoe, FARMERS WEEKLY

Gavin Hutson – grower for Lincolnshire Field products (LFP) based in Algarkirk

Gavin supplies Brussels sprouts directly to LFP. He grows 30 ha per year and also runs a sprout harvesting contracting business. His business is based in Algarkirk, Boston, UK. All his planting for the season is done in three weeks, so the length of his season is determined by the varieties he plants. Gavin noted that the height of the plant is set by the planting date which dictates the amount of light the growing plant will receive (this idea of limited light is foreign to an Australian sprout grower!). Gavin uses wheat as a break crop and also is experimenting with clover as green manure crop. The straw from the harvested wheat is ploughed back into the soil. He said that it is worth £30 /acre to him as OM.

Gavin uses a NPK blend of 16. 16. 24 + 7. 5% sulfur @ 750 kg/ha or 22. 4. 14 + 7. 5% sulfur @ 875 kg/ha for the base blend. Top dressing is done through the growing period where more nitrogen is added to bring the total N to about 270 kg/ha. When asked about reducing inputs or moving to organics Gavin said that location was very important to grow a clean crop. His neighbour was an organic grain grower and always seemed to be battling a weed problem. He mentioned that organics was reducing in the UK because it was too costly.

Figure 14: Clover field planted by Gavin Hutson, Algarkirk, Boston, UK (Samwell, 2012)

Staples

Two brothers George and Vernon Read own and operate Staples; a farm which operates across the best production areas of the UK with a total production area in excess of 4,000 ha. The business is both vertically and horizontally integrated which gives them control from beginning to end. George handles all the production side of the business which includes the 20 vegetable lines. Some of the nutrition requirements for these crops are sourced from their recently completed anaerobic digestion (AD) plant. Not only does the AD plant provide **e**nergy for the packing facility but the excess is sold into the electricity market and the by-products **(**liquid and compost) are used in the production of vegetables. Out of specification vegetables, together with an energy crop (maize) are used as fuel for the plant. This makes Staples 100% self-sufficient in green electricity, as well as providing heating, refrigeration and fertiliser.

In conjunction with the AD by-products, George uses Perkla (a calcium cyanamide product) as a pre-plant 300-400 kg/ha, at planting (banded @ 80 kg/ha) and at cultivation time (banded 80-100 kg/ha). OM is maintained through crop rotation, decomposing roots from maize crops and grass which is overwintered. Yearly soil tests are done to ensure fertility is maintained and only the required amount of fertiliser is applied.

John Clappison

John owns and runs Park Farm Risby in the Yorkshire district. He grows 2. 8 million sprout plants on 80 ha. In rotation with sprouts John also has 200 ha of wheat and barley. Vining peas and winter beans are also grown to put nitrogen into the ground for the next crop. The soil is classed as grade 2: it ranges from a medium clay loam to a clay loam with gravel

patches. It is commonly known as *wold* land. The abundance of chalk keeps the pH elevated thereby reducing the incidence of clubroot in sprouts. Soil tests are performed prior to sprout planting. John's fertiliser is banded at planting, two rows either side of the planting row. A high analysis compound fertiliser is applied at 700kg/ha.

Scotland

East Lothian Produce

Billy Logan is the unstoppable force behind East Lothian Produce. He produces 160 ha of sprouts, 240 ha of potatoes and 120 ha of white, savoy and red cabbage across a range of soil types such as sandy loams, sandy clay loams and clay loams. The soils vary in OM from 0%-7% depending on location. The subsoil is either clay or stone. On his own land, certified composted green waste is spread annually for soil improvement at a rate of 25 tonnes/ha. Billy is very keen to get this OM into the subsoil to help with drainage and overall soil health.

Figure 15: Compost spreading at East Lothian Produce, Haddington, Scotland (Samwell, 2012)

Nutrition is applied according to soil sampling and electrical conductivity (EC) scanning. This produces management zones which are sampled and tested. Soil maps are created from this data so that fertiliser can be variably applied according to area-specific recommendations. This is not new technology, especially in broad acre applications, and it is being taken up extensively in intensive row cropping.

Figure 16: An example of an EC scanner (Samwell, 2012)

Drysdales

Drysdales is a large vegetable grower business situated in the south of Scotland. They supply over 14,000 tonnes of fresh vegetables to the British markets all year round. They are a fully integrated business controlling the growing and processing of all the products they supply. Their vegetables are Swedes, sprouts and leeks. Drysdales supply sprouts all year round growing more than any other company in Europe; around 360 ha. They are at the forefront of product innovation, being the largest sprout peeler, at around 2,000 tonnes of sprouts per year in the UK.

Whilst Drysdales are considered conventional growers they do experiment with some organic sprouts. They plant about 6 ha and control pests by completely covering the field with netting which is fine enough to stop even thrips from passing through it. This was the first and only example of a physical form of pest control encountered. This netting is also used in their 480 ha of swede plantings, and is re-used year on year. This is the only way to protect the crop from pests to ensure a harvestable crop.

Figure 17: Netting covering swede providing a physical barrier to insects (Samwell, 2012)

Granular NPK fertiliser is used pre-plant and topped up throughout the growing season. Calcium nitrate + boron is used as a top dress with sulfur being added late in crop development for protection from frost. Prilled lime is used for calcium nutrition. A seven year rotation has been implemented which is a follows: sprouts – wheat – wheat – potatoes – wheat – wheat – swede. The land on which they grow is all rented as the land which they own is unsuitable for vegetable production. On their own land they have built a wind farm, providing on-farm diversity.

Drysdales promote a policy of Lean Green Thinking. An example of this sustainability policy is GPS variable mapping. This has greatly reduced their nutritional inputs and allows them to place the right amount in the right place.

Figure 18: Lean Green Thinking, courtesy Drysdales.

UK Summary

- All the large brassica growers visited would be classed as conventional growers. Some of these used compost as a soil amendment, for its nutritional value and to improve OM. Most of the growers had a crop rotation in place but used these different crops as a cash crop. Clover was used to build nitrogen by one sprout grower.
- Controlled traffic combined with GPS variable mapping is used to place fertiliser exactly where required. This has resulted in reducing fertiliser use and using the fertiliser that is applied to the soil to its maximum potential. Another benefit of this type of application is a reduction of nutrients entering the environment because the fertiliser applied is enough for the crop. There is no leaching of excess nutrient into water ways and underground water.

Chapter 4: Europe

Netherlands

Bejo

Bejo is one of the leading companies in breeding, production, processing and sale of premium quality vegetable seeds and their experience in the seed sector spans more than 100 years. Each year they hold open days for a period of 5 days in September at their head office in Warmenhuizen, Netherlands. This annual event is an opportunity to showcase many of their seed selections as well as give the technicians for Bejo from around the world, growers from around the world and the public to see what they are doing in seed production. An interesting part of this open day is the organic trials and flower beds. Andre Dekker was able to outline the main aspects of the flower bed trials.

1. Aim of the project
    a. *Pest control*: in nature insects eat plants, but also there are predatory insects that eat these plant eating insects. With modern agricultural methods these predators are not systematically encouraged. Flower borders can increase the number of predators and hence control the pest insects.
    b. *Water quality*: the flower borders are a buffer between agricultural areas and watercourses, reducing chemical drift.
    c. *Biodiversity*: in countries with minimal natural habitats like the Netherlands, wild animals can survive in these flower borders.
    d. *Bees*, necessary for pollination, are under threat, and flower borders provide food.
    e. The flower borders can be used by farmers as driving lanes.
2. Species planted and reason for the mixes, investigating the choice between
    a. *Annual flower borders*. These grow and flower quickly which is advantageous in spring and summer in that it supports predatory insects. It gives them an extra source of food (many insect eating insects also survive on nectar and pollen of flowering plants). Annual borders give more flexibility in choosing a location, but the costs are higher and they are mostly not suitable to drive on.
    b. *Perennial flower borders*. Fewer flowers, and grasses start to dominate after a few years, but they can supply shelter and food year round. This can be an

advantage in wintertime when habitat is scarce. Perennial flower borders are less costly and can eventually be used as drive paths.

c. The species planted will depend on a number of factors:
    i. Which insects need to be supported;
    ii. Plants which can survive under seasonal stresses;
    iii. Plants which are not hosts for diseases;
    iv. Plants which provide a good mix of early, mid and late flowering;
    v. Plants which will grow well in the chosen soil.
d. These are a selection of flowers used in the mixes in the Netherlands. The species in Australia may be different.
    i. Annuals: Buckwheat, cornflower, bishop's flower, corn marigold, baby's breath, corn/field poppy and common sunflower.

       Perennials: Common yarrow, oxeye daisy, Boston or Paris daisy, fennel, meadow buttercup, wild parsnip, bird's-foot trefoil, white clover, musk mallow, crested dog's-tail, colonial bent grass and red fescue.
    ii. Results are positive but the more people are involved and the larger the area where this system is used the better the results. If there is only a small flower border next to a field it will give disappointing results. Support of natural predators should be part of a growing system.

In conclusion, flower borders provide good possibilities but need to be an integral part of the growing technique of a larger area to obtain good results.

Figure 19: An example of a flower border, Bejo open day, Warmenhuizen, Netherlands 2012 (Samwell, 2012)

France

Jean-Marc Morrand

Jean-Marc grows 50 ha of yam, 140 ha of wheat and barley, leeks and peas, beans and small carrots for processing factories. Other vegetables also include cabbage, zucchini, onions, white asparagus and potatoes. He is also involved with a CSA vegetable basket going into Paris. Most of his produce is grown organically which is marketed under the 'Agriculture Biologique' standard. Soil health is critical for his operation; as his soils are sandy, inputs are critical to good yields and quality. He applies 30-40 tonnes/ha of compost for his vegetable production which is made up of composted wood and plant materials. This is specially made for use by organic growers. Manures are also available however there must be no use of antibiotics in the animal production as this would void the organic standard. This is put out at 25 tonnes/ha. Chicken manure can be used as well as a source of nitrogen and this is put out at 5-6 tonnes/ha. Jean-Marc uses rotations in all his crops and to start these rotations green cover crops are used. In particular, a two-year lucerne pasture followed by tiller radish, which stores the nitrogen in the tubers ready for the coming commercial vegetable crop. A rye crop is used as a source of OM.

Another organic fertiliser which is available is a by-product of sugar beet which contains 5. 5. 8 NPK and is on average put out at 1-2 tonnes/ha. There seems to be quite a lot of nutritional inputs but this is understandable since the soil is very sandy with a low level of OM. He started with a level of 1% which has increased but not a great deal. Weed control is done mechanically and using hand hoe weeding if necessary. Jean-Marc explained that labour is his biggest cost and one of the biggest challenges in his organic production system.

An interesting observation which Jean-Marc made concerning the organic standards in France and indeed the EU was that each country had a different interpretation of organic production and therefore this provided a challenge for growers in countries with strict and comprehensive measures. This enabled countries with relaxed regulations to classify their product as organic and sell it in countries with strict regulations such as France. This creates an unequal playing field in the vegetable markets and a tough environment in which to make a profit.

Jean-Marc has capitalised on the solar industry in the EU and installed 600 m^2 of solar panels on his production sheds. This more than covers his energy requirements and provides an alternative income for his business.

Figure 20: (left to right) author, Jean-Marc Morrand and Benoit Presles (Nuffield Scholar), holding yams (Samwell, 2012)

Guenot Nature

This family-run business is the largest salad/vegetable farm in France. The production area is about 800 ha which is tile drained and all irrigated. This is divided into 600 ha of vegetables and salads and 200 ha of cereals. The vegetables grown are salads, radish, carrots, spinach, onions, parsley and parsnips. To maintain year-round production, plastic tunnels are used through the coldest parts of winter. From planting to harvest takes 60 days whereas in the warmer months, salads grow in 35 days. The farm produce is grown using conventional methods. The soil is sandy with an OM of 2%. A five year rotation is used on the farm: e. g. radish, wheat, wheat, salad and then carrot. The straw from the two wheat years is incorporated back into the soil for OM. Sorghum is grown in the plastic houses, which is cut twice to mulch onto the ground and then rotary hoed into the ground for OM. Green waste compost is applied every three years at a rate of 20 tonne/ha. Animal manure is applied every two years at 20 tonnes/ha. A base blend of NPK is applied prior to planting vegetable crops. Soil samples are taken before the crop is planted, during the growing season and after harvest.

Figure 21: Plastic tunnels growing lettuce, Guenot Nature (Samwell, 2012)

Delahaye

Angelique Delahaye, along with her husband runs this third generation business on two farms on the outskirts of Tours, France. They have 75 ha of arable land for production and a 4 ha greenhouse for cucumber production. This land is split for production: half for sweet corn and half for vegetables. The two farms supply the produce for the packing facility which is on the main farm. They grow six vegetables; lettuce (different colours), celery (long and yellow), fennel, cucumbers, Mache lettuce, chicory (white) and cauliflower. All the produce is for the fresh market so this dictates that all is handpicked.

Figure 22: white chicory growing in a dark room (Samwell, 2012)

Angelique noted that they are not organic because the French regulations are too strict compared to other countries. However, the business is involved with FARRE (Forum de l'Agriculture Raisonnée Respectueuse de L'Environnement) which is the French national farmer's organization. FARRE supports EISA (European Initiative for Sustainable

Development in Agriculture). Integrated Farming is part of EISA's agenda and is a holistic, sustainable farming system which produces sufficient high quality food whilst maintaining and enhancing biodiversity and the natural environment (EISA, 2001).

The guidelines of EISA for cover crops of rye and mustard are used. Compost is used as required which is dependent on the crop being planted.

Ferme de la Motte

This family business started in 1967 with two brothers and now is being run by five Lemaire family members. What makes this business interesting is production is both conventional and organic. Potatoes, garlic, onions, shallots and echalions are grown conventionally on 600 ha. These vegetables plus squash, zucchini and carrots are grown organically on 83 ha. This business markets more than 40,000 tonnes of product with two thirds of this coming from their own farm. Their products are all for the fresh market with 80% for domestic and 20% exported. The organic production grew out of a request from the Carrefour supermarket group in 1997.

Their conventional production system uses holistic methods to ensure sustainable agriculture, including practices like compost at 4-5 tonnes per hectare per year spread over the fields, and six-year rotations as a minimum for vegetables. In fact this is recognised by FARRE and is able to be promoted by their business.

Figure 23: La Motte Bio 'for the best and for nature', organic label, courtesy Ferme de la Motte

Figure 24: Bringing in a load of echalions for processing and packing (Samwell, 2012)

Germany

Henry Becker – Perkla

Henry works for AlzChem which, among other products, makes Perkla, a calcium cyanamide product for use in agriculture. This product has been used as a fertiliser for more than 100 years. It has the benefit of supplying nitrogen as well as calcium in the form of lime to the soil. In Germany, it is used not only as fertiliser but also to suppress weeds and soil-borne pathogens such as club root in brassicas. This process occurs in the decomposition phase of Perkla in the soil as the cyanamide is transformed into plant available nitrogen. The flow chart below shows this process.

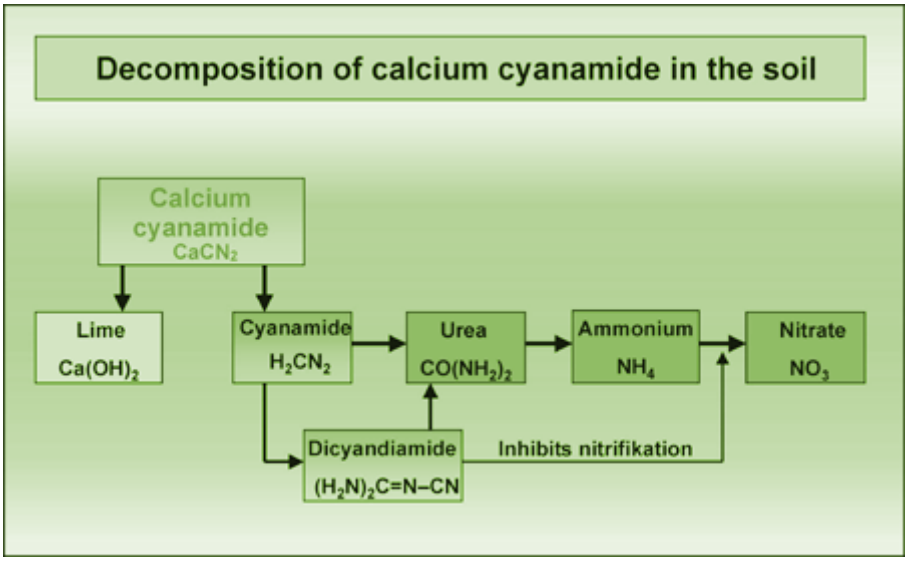

Figure 25: Scheme of Perkla decomposition in the soil, courtesy AlzChem.

Plant available nitrogen can be present for up to eight weeks after soil application of Perkla which gives the plants a steady supply for growth. This slow release is particularly beneficial in sandy soils where nitrogen can easily be lost due to leaching.

Christian Ufen – cabbage grower

Christian farms in Kronprinzenkoog, Dithmarschen district, Germany. This district produces approximately 3,000 ha of cabbage per year and is the largest cabbage growing area in Germany. This area is very close to the North Sea. As a result the soils are comparatively young having come from the last polar event so there is a good mix of sand and clay in the soil. The soils along the edge of the sea are known as marsh soils. These soils rank among the most fertile in Germany. They have an OM of 5% and are very stable. In some areas cabbage on cabbage has been planted for the last 50 years with no adverse effect on production or the soil. Christian grows cabbage (fresh and storage) and broccoli for the fresh market. He is a conventional grower and uses Perkla for all his brassica crops. He applies the product 2-3 weeks after transplant at a rate of 500-600 kg/ha over the top. He ensures that the plants are dry so that no leaf burn occurs. Nitrogen requirement for cabbage growth is around 300kg/ha and broccoli is 270 kg/ha. His fields are in continuous cropping with no break crops. This is able to be maintained probably due to the fantastic soils and use of Perkla.

Switzerland

Research Institute of Organic Agricultural (FiBL) – Martin Koller

FiBL is an independent, non-profit, research institute with the aim of advancing cutting-edge science in the field of organic agriculture. FiBL's research team works together with farmers to develop innovative and cost-effective solutions to boost agricultural productivity while never losing sight of environmental, health and socio-economic impacts. Alongside practical research, FiBL gives high priority to transferring knowledge into agricultural practice through advisory work, training and conferences. FiBL has offices in Switzerland, Germany and Austria and numerous projects and initiatives in Europe, Asia, Latin America and Africa.

Martin Koller, a Scientist and adviser in vegetable and ornamental crops from the Horticulture Science Department, explained that the soils around Frick are not suitable for vegetable growing at 40%-50% clay, so all research is on-farm at various locations around the country. Most Swiss farms are quite small around 20 ha with the largest being 250 ha of vegetables. There is basically no vegetable export with all local produce staying in the country for Swiss consumption.

Martin has been working on a project examining the use of winter peas in vegetable production. After experiments with maize in 2009, Martin began to study how cauliflower, leek, celery and beets responded to green manuring. The results have been promising with lush leaves on cauliflowers resulting in white heads (Koller, 2010). Winter pea as a nitrogen collector is very effective in rotation with a heavy consumer e. g. cauliflower, and it forms a green cover in the winter (Koller, 2010). As well as providing organic nitrogen it also increases biomass. However, there is a catch to green manuring. It reduces the flexibility for adapting to weather conditions on short notice e. g. if a crop needs to go into the ground in spring and the peas which had been planted in autumn need to be incorporated this cannot be done until the soil is dry enough to work. Using green manure crops does require careful management.

Another area of interesting work being done at FiBL is in companion planting in cabbages. Celine Geneau, a PhD student, has been working on planting cornflowers in with cabbages with surprisingly good results. "*We have clear indications that deliberately planted wildflowers not only bring about a significant increase in biodiversity – they also increase the parasitisation rate of pests"* (Balmer, 2010). Among the favorites for flower species are cornflower, common buckwheat, common vetch and bishop's flower. Initial results from trials on Swiss organic farms show that pests in areas with cornflowers were indeed more heavily parasitised than in areas without flowers. Further trials have shown that the inclusion of flowers in field have not impacted negatively on crop yield.

It is interesting to note here, as well as mentioned under the Bejo heading, that this area of research is being explored by various companies in Europe.

Dr. Andreas Fliessbach who works in soil science has been involved with soil fertility research for FiBL for many years. His latest research has been in minimum-till organic farming. He explained the importance of carbon in the soil and the need to nourish the soil and promote the activity of the soil organisms. Winter peas fix 100 -120 kg/ha of N and do so even under freezing conditions. A good sowing rate is about 150 kg/ha.

Hans Muller – organic vegetable grower

Hans started growing vegetables organically in 1993 as a result of the decline in returns on wheat and cows. This has now expanded to around 27 ha of organically grown produce. In this 27 ha he has five hectares of grass for young cows up to two years old. On the rest of the land he has onions, potatoes, spinach, beans, fennel, cabbage, Brussels sprouts, salads, early

strawberries and white asparagus. His market is split into supplying 40% to small shops and 60% to farmers markets. Hans has a six-year rotation in all his fields. This is done to prevent disease, allow for organic matter increase and increase soil health.

First year – spinach/ beans or red beets; Second year – cabbage or Brussels sprouts; Third year – carrots / fennel; Fourth year –potatoes; Fifth year – grass; Sixth year – grass

For field preparation Hans carries out the following treatments:

1. Cultivation. This is achieved with a four mouldboard plough and a power-hoe, then wait to get the first weed flush;
2. Then scarify and wait to get the second weed flush;
3. Then sow the desired vegetables in the form of seed or transplants.
4. Upon the third weed flush, and depending on type of planted vegetables, he will use a flame weeder for small weed control.

Figure 26: Hans Muller in his Brussels sprout field and sprout bush exhibiting some leaf diseases (Samwell, 2012)

For further weed control in row crops such as cabbage and Brussels sprouts, Hans uses a mid-mounted rotating brush type of cultivator which pulls out the weeds as well as covers weeds in-row. For insect and disease control in brassica crops he uses *Bacillus thuringiensis* (Bt), Entrust® (active: *spinosad*) and soap. Drop nozzles on a boom sprayer are used with a water rate of 600 l/ha in Brussels sprouts. Brussels sprouts are a nitrogen hungry crop and as such Hans puts out around 300 kg/ha of nitrogen. This comes from chicken manure which goes out at 20 tonnes/ha and a Biosol product, an organic nitrogen form of bagged fertiliser which is applied at 150 kg/ha. Compost is used for nutrient inputs and organic matter. Hans is an

accomplished grower with very neat fields which are weed free with good quality crops; a fine example of an organic system.

Hans is certified Bio Suisse which is one of the European standards. This label is used on packaging and promotions for business. It is a recognised brand in Switzerland.

Italy

Valagro – Giampiero Sera

Valagro is an Italian company based in Atessa in Abruzzo, Italy. Its company motto says a lot about the direction and purpose of the company: Valagro – *Where science meets nature.* Valagro's approach to their products and research is extremely scientific. This was very evident in the presentations organised and explanations given by Giampiero Sera who is the Business Development Manager. They have a fully working laboratory which is equipped with state of the art research tools and equipment. In this laboratory many of the initial investigations are carried out for new products.

One of their product ranges is Biostimulants. Agricultural biostimulants include diverse formulations of natural compounds that are applied to plants or soils to regulate and enhance the crop's physiological processes, thus making them more efficient. Biostimulants act on plant physiology through different pathways than nutrients to improve crop vigour, yields, quality and post-harvest shelf life/conservation. Biostimulants foster plant growth and development throughout the crop life cycle from seed germination to plant maturity in a number of demonstrated ways, including but not limited to:

- Improving the efficiency of the plant's metabolism to induce yield increases and enhanced crop quality.
- Increasing plant tolerance to and recovery from abiotic stresses.
- Facilitating nutrient assimilation, translocation and use.
- Enhancing quality attributes of produce, including sugar content, colour and fruit seeding.
- Regulating and improving plant water balance.
- Enhancing certain physicochemical properties of the soil and fostering the development of complementary soil micro-organisms.

A powerful technology that Valagro has developed is called ‘Geapower’ which is used in the development of their biostimulants. It is a mixture of science and nature. They use science to understand and make full use of the potential in nature, whilst keeping a watchful eye on environmental sustainability. The development of a new product follows a rigorous path:

- Knowledge about and access to raw materials
- Careful selection of extraction methods
- Implementation of investigative strategies
- Solutions for the intended use

A very objective tool used in Geapower is a 3D ‘Scanalyzer’ System which looks at plants using cameras and analyses the images digitally to determine the plant’s response to the administered compound. This is known as phenomic analysis.

Three biostimulants that are beneficial for the vegetable industry are Kendal®, Megafol® and Radifarm®. Kendal® nourishes and strengthens the plant, by promoting endogenous defence mechanisms in the plant. Kendal® activates plant defences in a natural way. Megafol® is a growth activator and anti-stress biostimulant. It stimulates plant growth, helps overcome plant setback due to environmental stress and improves the effectiveness of treatments. Radifarm® is a rooting promoter. It is designed for application during transplanting and/or in the very early stages of development of different crops. The product promotes the formation of a rich and early root system through the elongation of lateral roots and the emission of adventitious roots.

EU Summary

- Many of the growers visited were using crop rotations, green manure crops and compost in their production systems.
- Science combined with nature (as seen in Valagro and AlzChem) can play a very important role in a production system. The products from these companies can enhance a growers ability to produce a uniform crop, higher yields and potentially reduce some inputs such as granular fertilisers.
- Using natural inputs such as flower borders and planting flowers in amongst the crop have the potential to reduce chemical inputs by providing a food source and habitat for natural predators.
- Brussels sprouts and cabbage are a challenging crop to grow and in most circumstances require chemical pesticides to reduce pest levels. There are options

available to reduce the severity of the pesticides such as using soft pesticides such as Bt's or Entrust.

- Supermarket demand for a blemish free product puts enormous pressure back onto the grower.

Chapter 5: Conclusions

- Across the globe there is a general desire from the public to know where their food is coming from. There has been an increase in farmers markets, farm shops and CSA box styled agriculture.
- The hope of finding commercial brassica farms which grew large scale produce using organic and biological principles was not realised. However, many of the businesses using conventional methods realised the importance of soil health and the need to improve their soils to maintain current production. Some of this was achieved through cover cropping, green manure crops, crop rotation or compost spreading.
- Farming sustainably is the way of the future not only in Australia but throughout the world.
- The phrase 'sustainable' is used extensively in agriculture, by the media and agronomists and means different things to the producer and the consumer. Even across nations the concepts of sustainability have different perceptions. Organic standards vary between countries which cause problems for growers who must adhere to the stricter standard, e. g. France compared to Spain. How a grower will approach their production practices will be determined by location, vegetable type, markets, cost of production and cultural trends.
- Many of the businesses seen demonstrated the need to conserve soil fertility and health. They managed this in different ways but the end goal was the same. A sprout grower from the UK used clover as a green manure crop. Many used compost to help with soil health and implemented crop rotations.
- The nature of the market means that many farms are operating on high volume/low return business models, leaving minimal time and resources for experimenting with soil amendments or new techniques in their operations.
- This study has in some ways raised more questions than answers. We will be carrying out trials on our home farm in relation to green manure cropping and alternative cover crop species.
- Advancements in computer programming have enabled small and large cultivators such as Robocrop from Garford to become viable for large farms for weed control. As a result reductions in pre and post emergence herbicides are possible.

Chapter 6: Recommendations

- Organic growing of sprouts is extremely difficult and unless the consumer is prepared to accept defects will not be a viable option on a large scale. However small scale growing might be achieved using netting as a physical barrier to protect the crop from DBM and aphids.
- Cover crops and green manure crops can play a very important role in Australian horticulture. Mixed cover crops which include nitrogen fixing species will improve soil OM and increase soil nitrogen for the forthcoming cash crop. The benefits of cover crops cannot be ignored and should be in some way incorporated into the growing system.
- No one type of production system holds the answer to sustainable growing. Rather, a hybrid, i. e. fusion farming is a very real alternative. As growers we need to be able to react quickly to changes in markets and in growing conditions. Adjustments need to be made to keep abreast of changes such as variations in weather or increases in input costs.
- Further work needs to be undertaken to understand the implications of soil health on crop productivity. These need to be demonstrated on farm and not in a laboratory.
- Flower beds will be more thoroughly investigated, and there already has been some work done in Australia on this matter.
- Diverse cover crops need to be looked at. Species suited to Australian conditions need to be investigated.
- Treating compost as a soil inoculant rather than just an OM builder will help the soil biota, further improving soil health and creating a sustainable soil environment. The cost effective way to build OM is to use cover crops.
- A grower needs to develop their own production system which can incorporate many practices not necessarily from the current system that they are using. It is up to the grower to experiment with different techniques and to test what will work effectively on their own farm.
- The importance of networking with overseas growers and visiting abroad cannot be overstated. The benefits that this journey has provided far outweigh the time spent off farm exploring alternative farming practices. These travels have provided an excellent opportunity to compare current and possible future practices.

Appendices

The following farms and individuals have been included to show that many of the brassica growing farms are using similar growing practices as we do and that this was a common thread throughout the large commercial farms across the northern hemisphere.

Sunset farms – Ellio

Sunset farms situated in Moss Landing, CA are one of the largest Brussels sprout growers in the US with approximately 400 ha of production. Eighty per cent of this goes to processing whilst the remaining 20 per cent is sold on the fresh market. It is a family run business and Ellio heads up the site at Moss Landing. The other crop which he grows in rotation with sprouts is strawberries. In a field Ellio will plant one year strawberries then two years of sprouts. There is no cover crop break and the plant material from the sprouts is felt to be enough to contribute to the soil organic matter. Under this intense farming system the soil needs to be fumigated for nematode control. The two crops are conventionally grown using artificial fertiliser and pesticide applications. During the harvest seasons up to 300 people will be employed. Coming into the Christmas period close to 150 tonnes per day of sprouts is harvested.

Lincolnshire Field products

Lincolnshire Field Products (LFP) is near the town of Spalding in Lincolnshire, UK. At the heart of the business is a 6,500 ha farm which produces over 3,000 ha of brassicas, 1,200 ha of cereals, 1,200 ha of sugar beet and 600 ha of potatoes. The business turns over £95m from the farm alone. All production is conventional; however organic produce is distributed by LFP which comes from other growers. Paul Langford, farm manager said that no cover crops were grown. Their NPK fertiliser is all liquid applied in the form of 9. 3. 6. Nitrogen is soil tested each year however the other elements are not.

Matthew Rawson

Matthew is the chairman of the Brassica Association in the UK, is an agronomist and also grows about 45 ha of sprouts and 140 ha of wheat and barley with his father in the Yorkshire region. Matthew is a conventional grower but is very focused on reducing soil impact. Timing is everything so he will only work dry soil even if it means delaying planting. He believes the land needs to be fit for working.

Eric Müller – sprout grower

Eric is a Brussels sprout grower who farms in Helse which is the next town east of Kronprinzenkoog, Germany. He grows 100 ha of sprouts using conventional methods. When

asked about the possibility of alternative production systems he believed that it would be very challenging to achieve high quality and yields. The supermarkets e. g. Aldi and Coop demand a certain quality so this creates an environment where there can be very little blemish, marks or insect damage.

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Plain English Compendium Summary

Project Title:	**Name of project: Fusion farming in brassicas: sustainable agriculture for the future?**

Nuffield Australia Project No. : 1118

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Objectives

To visit and observe farms growing brassica crops, in particular Brussels sprouts and cabbage, which utilise conventional, biological, organic and biodynamic principles.

To investigate how the grower is managing their soils in relation to soil health and sustainability.

To examine the viability of these farms and to consider if any alternative practices are commercially viable.

Background

Sustainable agriculture is the way forward. How is this to be done in brassica growing, especially in Brussels sprouts, a very challenging crop to grow?

Research

Businesses such as large commercial operations, organic Community Supported Agriculture and small scale farms growing these vegetables were visited throughout the USA, UK, Netherlands, France, Germany, Switzerland and Italy.

Outcomes

No one business was exactly the same. Most were aware of the importance of soil health for the future of long term farming. Cover cropping, green manure crops, crop rotations and compost spreading were a common theme amongst many of the businesses. Understanding the soil on any farm is critical to positive production, high yields, quality and sustainability.

Implications

This research suggests that no one existing farming system provides a suitable mix of environmental and economic sustainability for Brussels sprout growing in Australia. Fully organic farming, whilst highly environmentally sustainable, creates an expensive end product which, in this market, cannot sell in sufficiently high volumes to be economically sustainable. Conventional, high-input systems are economically more viable but can create long-term environmental problems, along with suspicion or mistrust in the consumer. In our situation in particular, I propose that a ‘happy medium’ exists somewhere between the two, which creates a healthy, low-impact farm producing high quality, marketable, and accessibly priced produce.