Making Organics Accessible to All

Reducing inputs and increasing outputs, and the future of organics

A report for

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Executive Summary

The aim of this study was to make organics accessible to all, by reducing inputs, increasing outputs and suggest pathways for the organic vegetable industry in Australia.

Focus areas for reducing inputs included:

1. Compost
2. Cover cropping and mulch
3. Microbiology and biofertilisers
4. Weed control
5. Reduced tillage/ no tillage
6. Natural pest and fungus methods

Focus areas for increasing outputs to ensure profitability included:

1. Direct to market
2. Packaging / private label
3. Farmers markets
4. Diversity of crops but also be more presentable to customers.
5. Basket of crops versus one crop
6. The retail produce buyers/ the end consumer
7. Farmer - distributor model
8. Niche products

A number of farms were visited as part of this research. Almost all mentioned the importance of having a genuine production story to tell, having an open gate for consumers, diversifying the product offering for convenience purposes and making products look fresh and appealing. These were the main take home messages from a range of businesses visited.

Into the future, there will be continued discussion around organic produce and produce grown in sustainable or regenerative methods. The role of the small family farm will also be under the spotlight. In a post-COVID19 world, there is every chance that consumers will prefer to buy local, sustainably grown produce direct from farm, but only time will tell. It is hoped through this research, that organics can indeed be accessible to all.

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Foreword

In 1972 my mother, Rita (小辉) flew to Australia. She was here for one purpose: to successfully process divorce papers out of the People's Republic of China. She left with a promise to my 姥姥 (Grandmother) that she would be back within the week. That was 47 years ago.

My mother brought her experience as a rural nurse in China to market gardening in Australia. Traditional Chinese medicine has always been rooted in the harmony created between plants and people and her goal was to grow nutritious food as medicine.

Starting with half an acre in our backyard, she grew organically and brought medicinal and Asian greens to the local market. We started hauling produce in the back of our family car, dirtying up the seats and making only $50 on our first day. I can remember my father imploring my mother to give up and return to her role as a housewife.

Two years later my father sold his tractor dealership and joined the new family business: Rita's Farm. Now, a 55-acre market garden and a household name across farmers markets in Sydney and Canberra, shipping certified organic produce to four states.

I returned to the farm on the back of their "retirement" after studying business at the University of New South Wales and working abroad in the not-for-profit industry.

I write this report as a 27-year old small town organic grower ready to take on the world and make my parents proud.

Acknowledgments

To this day I am still humbled and amazed that Hort Innovation and Nuffield Australia took a chance on a small scale, inexperienced and young grower such as myself.

I will forever remember this experience and the people who backed me and believed that I could be part of the Nuffield network. Becoming a Nuffield Scholar has given me a quiet confidence and a nudging push to accomplish bigger and better things, I hope to do you proud.

To the troopers back home Old Tim, Young Tim, Elizabeth, Thanh, Alex, Alaa, (Tim's Wife) Meng Yu, Jason, Heath, Daniel, Lauren, Alison, Eva, Nick Gary, Jane, Jelmer, Juan, Mac, Shreya, Stavone, Vinnie, Yani, Xiao Yu, Da Wang and Yesica and all our pick and packing crew.

Everyone who makes Rita's Farm run you inspire me with your work ethic and make up our larger family.

Abbreviations

ASD – Anaerobic Soil Disinfestation

CSA – Community Supported Agriculture

EM – Effective Microorganisms

IPM – Integrated Pest Management

USA – United States of America

Objectives

The objectives of this report can be found in the title. The report aims to make organics accessible to all. To achieve this BHAG (big hairy audacious goal), the research has investigated how growers can:

- **Reduce Inputs**: Find techniques and methods for growers to reduce inputs on certified organic farms and therefore increase efficiency.
- **Increase Outputs**: Research ways for organic farms to increase the value and profit of their produce as well as methods to increase the yield output of their production systems.
- **For organics to be accessible to all**: Suggest the way forward for the fresh vegetable organics industry in Australia.

Each chapter falls under one of these headings. Under each chapter, questions are posed that ran through the author's head as a grower. It is hoped this report is a useful guide for all growers.

Chapter 1: Introduction

When interviewing for Nuffield the author was asked:

> ***"Are you in organics because you're a true believer or for the money".***

The author is not particularly interested in the dogma in agriculture. Since entering the agricultural industry, there appeared to be restrictions by labels such as organic, conventional, biodynamic, chemical, no-till, regenerative, small-scale, sustainable and local. Each system defined by its own set of rules on what can and cannot be done.

Consumers and the market dictate the quality and conditions of the produce they eat, and growers dictate how they want to run their business, farm and stewardship of the land.

This report is not an endorsement of certified organic agriculture, nor is it a calling for everyone to follow a certain path. It is a way forward for vegetable growers to reduce inputs and increase outputs to match and surpass the current yields and profits achieved in horticulture currently.

Chapter 2: Reducing Inputs

2.1 What does ‘reducing inputs’ mean?

One of the big arguments against “*can organics feed the world*” is the additional cost associated with organic agriculture including expensive biological herbicides and pesticides, botanical oil inputs, chicken and fish inputs and the extra cost associated with no chemical weed control methods. Reducing Inputs is a look into the systems of productive organic farms and how it can be done for less or the same cost as conventional agriculture.

At the core of these productive organic farms was an idea that plants have an immune system just as humans do. Do you know people that always seem to be sick and some that never seem to get sick? Plants function just as the human body and the resistance to pests and disease is dependent on the nutrition they receive across their whole lives.

The process of photosynthesis means that healthy plants with ideal mineral nutrition produce enough sugars for fruit or vegetative production and store the remaining glucose through root exudates in the soil to be taken up by healthy plants and the process continues. Healthy plants equal healthy soils equal healthy people.

Therefore, with the correct mineral nutrition and a strong microbial presence in the plant’s microbiome, plants can reach an advanced stage of immunity from pathogens and pests reducing the need for chemical pest and disease control. In this chapter we will explore mineral nutrition, soil structure and microbiology as three way to reduce overall inputs for plant and soil health.

Finally, we look at how successful organic farms have managed weed control, mechanically and autonomously as well as successful management systems and culture to optimise the additional labour.

2.2 Mineral Nutrition – Hacking photosynthesis at the right times

The yield and quality of your crop is determined by the application of correct mineral nutrition at the correct stages of plant growth. Most reproductive plants follow the same growth cycle which when managed correctly can affect its yield potential or disease susceptibility. In different moments of the growth cycle different minerals are needed to run systems in the plant. This is referred to “*Critical Points of Influence*” by John Kempf.

The Growth Cycle:

Bud Set

1. Blossoming
2. Pollination
3. Embryo Cell Division
4. Cell Expansion/ Fruit Fruit

	Lettuce Stages
Pre-plant	
Sowing	**Seed Germination –** the right combination of temperature and moisture stimulate germination
Seedling Stage	**Lettuce develops roots and seed leaves (**cotyledons)
Rosette Stage	Forms a Rosette pattern that the lettuce grows in
Head Development	lettuce leaves start to form a cup shape and develop into the head
Harvest	Lettuce takes 65 to 120 days to mature from seed germination through harvest. The plant is harvested before its final growing stage; if you don't harvest, it will developing a flower stalk and seeds about a month after the heads form.

1. Bud set – increase quantity of manganese and phosphorus at bud initiation period
2. Blossoming – disease resistance,
3. Pollination – disease resistance, = pregnancy, hormonal shift, needs to be focus on protein shift. Could be more susceptible during this period.
4. Embryo cell division – cell division begins in the fruit embryo. 10-14 days. Determined by temperature, nutritional availability, and availability of water. After 14 days there is no more cell division. That contains all the cells in the fruit. # of cells will determine the potential fruit size. You need to have more cells to have the potential to have a large fruit. Limiting nutrient = calcium for cell membrane production.
5. Cell expansion/ fruit fill - determines shelf life and firmness

With the correct management of mineral nutrients to the plant via foliar sprays at the correct times, this can significantly increase the yield response of the crop as well as improve the fungal and pest resistance reducing the need for additional fungicides and pesticides later.

However, as a grower this theory can be slightly impractical when growing quick harvest leafy vegetables.

Nutrients for veg growth:

1. Nitrate
2. Potassium
3. Chloride
4. Calcium

Reproductive:

1. Manganese
2. Phosphorus
3. Ammonium

Compost

- Why should I do it?
- Can I afford it?
- Levels of compost
- Aerobic and anaerobic compost??

A basic principle of agriculture is that a healthy crop comes from healthy soils. Healthy-ish soils can be accomplished through temporary surges of nutrients through fast acting fertilisers and inputs designed to be taken up by the crop immediately. The alternative or complementary strategy is to invest in low-cost long-term techniques to big healthy soils. One of these methods is compost.

Farmers extract organic matter from the soil every time we harvest. As we extract this organic matter it must be replaced. A helpful analogy is to think of soil as a bank, we withdraw from that bank as we harvest healthy cabbages, kale, bock choy etc. however with no deposits to the bank such as compost or green manure, further withdrawals will not meet expectation.

At Rita's Farm 3- 5 tonne of product is harvested per acre per year, therefore that is 3-5 tonne of organic matter extracted from the soil that should be replaced.

Further elaboration on the benefits of composting is not needed, so we will focus on commercial applications and methods of composting and its practical implementation.

2.2.1 BASIC COMPOST RECIPE:

Ingredients, your materials should follow a general rule of 25:1 C:N ratio.

- 1/4 high nitrogen materials (animal manure)
- 1/2 high-cellulose material (plant matter)
- 1/4 soil
- Moisture (If you squeeze material in your hand, it should hold together but no water should squeeze out)

Optional Ingredients:

- Rock Phosphate as a calcium source
- A compost starter e.g. A compost tea or bacterial brew.
- biochar

If the conditions are ideal, you will temperatures inside the compost pile rise to 68 degrees. Once it reaches that you should turn the pile to cool it down.

Methods:

2.2.2 SOUTH AMERICA BOKASHI COMPOSTING

The technique explored in high productive organic farms in South America was bokashi composting as not all compost is created equally. The bokashi is a strict 21-day process and then 100% gets used day 22, so it needs planning. It can be made inside a shed on a concrete floor.

1. Make a 1m3 pile first.
2. Spread it out on day 4 to only max 30cm height.
3. Turn it by flipping it over with a broad shovel once a day for the next 18 days. A job that takes a few minutes on a cold morning.
4. Then when you plant you can use 2kg/m2 in the ground before planting into soil above bokashi. The roots will drive down.

2.2.3 COMMCERICAL ON-FARM WINDROW COMPOSTING

Raw organic matter is piled in such a way that a large surface area is exposed. Low windrows about 1.5 m high and 3m wide. This can be done with a commercial compost turner or two tractors and a manure spreader.

You load the right proportion of raw materials into the spreader and then when the pile reaches 1.5m x 3 m the spreader moves forward and repeats the process.

2.2.4 ANAEROBIC STATIC PILE:

Make a pile with the appropriate ingredients, cover with a fastened tarp and leave for a year, pile should be looked at periodically to check moisture content.

2.2.5 RURAL CHINESE ANAEROBIC PILE:

a) Dig a pit 1 metre deep
b) First layer is green manure crop 15cm
c) Second layer is a straw mixture
d) Third layer is animal dung
e) Then a top layer of mud is added with a water layer of 4 cm to maintain anaerobic conditions.
f) Turn once every month for 3 months

There are many methods of on-farm composting or you can choose to buy in commercial compost. The following table compares popular composting methods to select the best method for the farming operation.

Process	Odour	Pests	Maintenance	Best Location	Input	Time Period
Aerated Static Pile	High	High	Moderate	Outdoors/Warehouse	Organic Waste	1-3 Months
Bio-Digesters	Moderate	Moderate	Moderate	Outdoors/Warehouse	Plant Based Waste	8-12 Weeks
Bokashi	High	Low	High	Any	Soft Organic Waste	4-6 Weeks
In-Vessel	Low	None	Low	Outdoors/Indoors	Organic Waste	24 Hours to 3 Months
LFC	None	None	Low	Commercial Kitchen	Organic Waste	24 Hours
Vermicomposting	Moderate	Moderate	Moderate	Outdoors	Soft Organic Waste	1-2 Months
Windrow	High	High	High	Outdoors	Organic Waste	6-9 Months

Method	**Salient features**					**Duration**
	Substrate size reduction	**Turnings at intervals of (days)**	**Added aeration provision**	**Microbial inoculation**	**Supporting microbial nutrition**	
Indore pit		+15, +30, +60		Inoculum from old pit		4 months
Indore heap	Shredded	+42, +84				4 months
Chinese pit		+30, +60, +75			Superphosphate	3 months
Chinese high temperature compost	Shredded	+15	Aeration holes in heap through bamboo poles/maize stalks		Superphosphate	2 months

Ecuador on-farm composting		+21	Lattice of old branches/poles at heap base			2-3 months in summer; 5-6 months in winter
Berkley rapid composting	Shredded to small size	Daily or alternate day turning				2 weeks with daily turning & 3 weeks with alternate day turning
North Dakota State University hot composting	Shredded	+3 or +4	4-5 holes punched in centre of pile		0.12 kg N per 90 cm dry matter	4-6 weeks
EM-based quick composting		+14, +21		EM	Molasses	4-5 weeks
IBS rapid composting	Shredded	+7, +14, then every 2 weeks	Raised platform ground/perforated bamboo trunks	*Trichoderma* sp.		3-7 weeks

Table 1: Comparing popular composting methods to select the best method for the farming operation (source: author)

2.2.6 Vermicomposting: Case Study, Spiral Path Farm

Anaerobic static piles are ideal for unbalanced C:N content.

- How does it improve soil nutrition?
- Compost % matter

The ability of nutrients to be absorbed by planmts (plant availability) is dominated by the activities of soil microorganisms –

Whereas the plant availability of other microorganism is governed by inorganic chemical reactions.

2.3 Cover Cropping

The benefits of cover cropping is a low cost input for nitrogen, biofumigation. The business case for cover cropping is clear and more so for the planet. Consider:

- What is the timing of your next crop?
- How will you terminate the cover crop?

2.4: Microbiology

A perfectly balanced soil test will be useless with poor biology, however aggressive biology will overcome some mineral imbalances. It is important to note that the area of microbiology is highly under researched (statistic of research) but seems to be investigated by all the innovative growers visited as part of this research. However, it is well established that biology will trump chemistry every time.

Approximately 85% of plant nutrients required for growth are acquired through the carbon exchange in which plant root exudates provide energy to soil microbes in exchange for minerals and trace elements otherwise unavailable. When farms use high rates of synthetic fertilisers or fungicides, we destroy this bridge and therefore blowing natures preferred way of absorbing nutrients.

Healthy plants, which have an energy surplus, can release 60 to 70 percent of their total energy production into the soil as exudates (Marschner, 1986). However, a focus is the practical applications of microbiology through the creation of Effective Microorganisms in biofertilisers and compost teas. Effective Microorganisms (EM) are mixed cultures of beneficial naturally occurring organisms that can be applied as inoculants to increase the microbial diversity of soil ecosystem. The following EM's are useful in application to farm systems:

1. Lactobacillus inoculum recipe / 1000L
2. Effective Native Microorganisms

Batch Recipes

Step	5 - 6 Litres		180 Litres		1000L	
1	Rice	1 Cup	Rice	1.5 - 2 kgs	Rice	5 kgs
	Water	1 Litre	Water	35 L	Water	175
2	Milk	2 Litres	Milk	70 L	Milk	350
	Lacto Culture	1 Litre	Lacto Culture	35 L	Lacto Culture	175
3	Whey	Approx. 2.7 litres	Whey	Approx. 90 L	Whey	Approx. 450 L
	Water	Approx. 2.7 litres	Water	Approx. 90 L	Water	Approx. 450 L
	Molasses	300 ml	Molasses	9 L	Molasses	50 L

Table 2 Lactobacillus inoculum recipe / 1000L (Nutri Tech Solutions)

Method:

1. Put rice in container with clean (unchlorinated) water. Leave for 3-5 days in a dark place with a loose lid. The liquid will change and start smelling slightly sour with a milky colour. Decant the water, throw away rice, this liquid is a Lacto Culture mainly of the Lactobacillus species.
2. Feed the inoculant with milk, molasses and water.
3. Store product in a cool place with the lid tightly on (you can use an air lock) to ensure it is an anaerobic process.
4. After 30 days it should be ready to use, test pH should be sitting around 4.

Practical Uses:

- As a fertiliser for crops.
- Allows for slow release of nutrients found in the rhizosphere to be absorbed by the plants slowly over time.
- Having a soil that is populated with Lacto starves out unbeneficial bacteria and pathogens supressing soil-born diseases.

Effective Native Microorganisms:

There are various beneficial microorganisms found in virgin soils or forest decomposing organic matter. These organisms can assist farmers in speeding up the process of breaking down organic matter such as post-harvest residues or ion inoculating compost piles.

- 1 bucket of decomposing forest leaves (debris).
- 10 kg of rice/wheat or maize bran.
- 1 L of Molasses.
- 3 L of clean water.

Method:

1. Mix the ingredients together on a concrete floor or bucket.
2. Put this solid mixture in a small plastic drum.
3. Compact it as much as possible to eliminate air.
4. Cover the bucket tightly to prevent entry of air.
5. Store in a cool and dry place for a period of 30 days.

Next step:

- 2kg of the anaerobic solids (made in the previous step).
- 1 L of molasses.
- 20 L of clean water.
- Potato sack.

Method:

1. Fill the solids into a potato sack/ hessian bag.
2. Add molasses, milk.

Practical Uses:

- Use post-harvest to quickly breakdown residues.
- Use in compost piles to inoculate piles and speed up digestion process.

Another cost-effective method is to purchase effective microorganisms species and brew them on farm to increase populations, using molasses and whey (similar to the recipes above) to use on farm. These bacteria include:

- Azotobacter: free living nitrogen fixing bacteria.
- Bacilli – Bacteria that assist in soil conditioning, accessing phosphorus reserves and building soil structure.
- Mycorrhizae – Fungi that assist in plants' mineral nutrient uptake, improve soil health and nutrient recycling processes.
- Pseudomonas – Soldier bacteria that help protect the plant root zone and solubilise phosphates within the soil profile.
- Rhizobium – Symbiotic bacteria that fix nitrogen in the root nodules of leguminous plants.
- Trichoderma – Symbiotic fungi that improve plant health.

As part of this research, this was seen with compost teas on Brazilian farmers.

2.5 Weed Control

Perhaps the closest to a magical solution for sustainable organics horticulture is weed control. The farms with the best yields and most sustainable business had a weed control plan down.

> *"Get them early and often" - organic farmer (anon)*

The common denominator through every solution was the quote above. However, as advice to organic growers, a combination of the following is recommended by the author:

2.5.1 Stale Seed Bed

To understand how to create a stale seed bed, it is important to understand how weed seed banks work.

a) About 80-95% of weed seed are dormant at any given time. This is a protective mechanism by weeds and is their main life cycle, therefore it is important to recognise that the weed seed bank is the root of the 'weed problem'.

b) Tillage is the number one means of allowing weeds to germinate as it increases temperature, introduces oxygen to the soil, provides direct sunlight and eliminates existing vegetation.
c) Due to the weight and size of weed seeds there is a hard physical limit on weed seeds at depth to germinate and only the top 5cm weed seeds are going to engage in germination.

Understanding these key principles, it is possible to use a stale seed bed to get non-dormant seeds at soil-surface to germinate without bringing up more non-dormant seeds from deeper in the soil.

For false seedbeds (Figure 1) the seedbed is prepared ready for planting, (a), non-dormant weed seeds in the top 5 cm / 2" of soil germinate (b-c) and then emerge (c-d), weedlings are killed by tillage (e), the crop is then sown or planted (f) crop germinates and emerges (g).

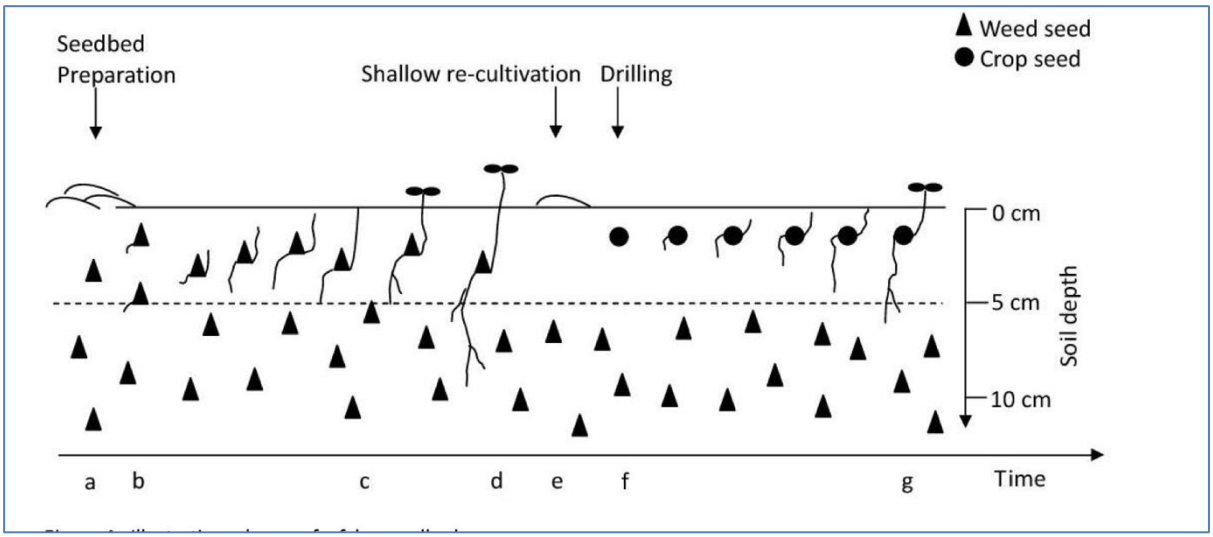

Figure 1: Illustrative scheme of a false seedbed (source: www.sciencedirect.com)

What's important to get right here is the re-tillage depth, too deep and more weed seeds are brought up, and not deep enough you haven't disturbed current vegetation. Ideally, 2cm is the tillage required to kill as many weedlings as possible.

Many growers will irrigate from the process b-c to ensure the most amount of viable weed seeds has risen to the surface.

The stale bed technique can be used using the following technologies:

- Lely Tine Weeder
- Treffler Tine Weeder (Implementated at Rita's Farm)
- Flame Weeder (Implementation at Rita's Farm)
- Certified Organic Weed Sprays (Implemented at Ritas Farm)

2.5.2 Cultivators

Once the seedling is established, most organic farms visited looked at how to reduce inter and intra row weeds in the most efficient way possible. It was noticeable that most organic farms were very well equipped with cultivation equipment.

The most popular tools available were:

1. Finger Weeder
2. Basket Weeder
3. Rotary Hoe Weeder
4. Tyre – thing above your head
5. Clipper

2.5.3 Plastic Mulch

The use of plastic mulch for vegetable growing was pretty much commonplace in the United States of America (USA) during the research. Whilst plastic mulch is common in Australian horticulture for specific crops, in the USA it was typical to have an entire production system centred around plastic mulch used for every crop from tomatoes to cabbages to lettuce.

Plastic mulch is usually applied by a tractor drawn mulch layer implement which lays the plastic and drip tape into beds while anchoring the edges with soil. Benefits of this method include increased soil temperature to allow for season extension, weed suppression and better soil moisture retention. The colour of the plastic mulch produces different effects: clear (higher temperatures), black (weed suppression), white (cooler temperatures to not overheat roots), silver/ metallic (confuses and repels pests), coloured (distinct radiation to reflect into crop canopy) or biodegradable (designed to be tilled).

The main concern for plastic mulch production is cost and disposal of plastic. The cost of the plastic, installation and removal of plastic can be expensive and labour intensive particularly as it is only designed for one crop use. Another downside is the disposal of plastic waste that is in line with organics values and the implied environmental impacts.

2.5.4 Mulch Layer

The alternative to plastic mulch is a no-till mulch layer produced by green manure. As seen at ‘Live2Give’, an innovative no-till organic vegetable farm in Germany, it was something impressive. Instead of plastic mulch a 20mm thick mulch layer created from cut green manure is laid one day before a seeder knife cuts into the mulch layer to plant seedlings before closing that hole. Depending on the vegetable, it lays roots in between the mulch layer and soil below, no light can penetrate the mulch layer supressing weeds and creating a warm, moisture retaining mulch layer.

Their premise is that organic farming globally relies on intensive soil tillage to mineralise nutrients and suppress weeds however in the long term this has a negative impact on soil

organic carbon content and therefore soil fertility. The consequences of an organic yet heavily tilled system and on the long-term sustainability of these farms.

2.5.5 Hand Weeding

Regardless of how well equipped the farms visited were with the newest technologies, the oldest trick was hand weeding and how to make this as efficient as possible. The use of weeding beds, wheelie seats or the good old chipping hoe. There are two principles:

1. The main life stage of a weed is not its plant vegetative state but its seed dormancy in the soil, therefore it is imperative to ensure that weeds do not go to seed.
2. Once the vegetable crop has established a plant canopy (usually between 4-6 weeks after planting), the green-filtered light usually prohibits new weed seeds to germinate, allowing your crop to be relatively weed-free.

Therefore, the original advice stands, and repeated once more as it has been the most useful piece of advice for organic agriculture during this Nuffield journey:

"Get them early and often"

However, weeds are trying to pop up to correct a problem in a rotation. Cultural practices form the basis of all weed control, including tending a field and crop rotation.

2.6 Disease Control

Disease control not only affects the yield but also impacts on the marketable yield of any crop. In organic horticulture many of the tools used to control soil-borne pathogens are not permissible, leaving organic growers to come up with new methods of controlling soil borne pathogens. Apart from substituting conventional sprays for certified organic sprays these are a few innovative examples of methods used to control various diseases.

2.6.1 Case Study: Wouters Green

Peter Wouter from the Wouters Green uses Anaerobic Soil Disinfestation (ASD) to increase yields of up to 80% in their organic capsicum and tomato high-tech greenhouse operation.

ASD a process designed by Wageningen University is now commonplace in California conventional and organic operation as the most effective soil fumigation technique available for organic growers and is considered as one of the most promising non-chemical methods for control of soil-borne pathogens.

Before methyl bromide and other soil fumigation techniques were developed, farmers used flooding and soil solarisation to activate soil microbes to reduce pathogen populations in soil which eventually led to the development of the ASD method which involves:

- Soil Amendment: Incorporation of organic matter (carbon source) at 5-9 tons per acre.
- Soil Irrigation: Irrigation to soil saturation to reduce available oxygen.

- Soil Tarping: Covering soil with plastic film to prevent air exchange.
- Leave for 3-5 weeks.

ASD has proven to be effective against all key soil borne pathogens, nematodes and weeds including Phytophthora blight (P. capsici) ⎮Fusarium wilts (F. oxysporum) ⎮Southern blight (Sclerotium rolfsii) ⎮Charcoal Rot (Macrophomina phaseolina) ⎮Root-knot nematodes (Meloidogyne spp.) ⎮Yellow and purple nutsedges. This was also tested at Ritas Farm in March 2020 and proven successful in reducing populations of root knot nematode.

Figure 2: ASD was tested at Ritas Farm in March 2020 (source: author)

2.7 Pest Control

2.7.1 Case Study: ESG Broccoli - Scotland

The East of Scotland Growers group faced insects from cabbage white fly to aphids to slugs affecting their 500 acres of broccoli. Due to the muddy conditions reducing the amount of tractor field time, ESG opted for a more passive pest control method – insect netting.

The nets are approximately 200m long x 20m wide and are drawn out and retracted using machinery. The nets are taken off twice during the broccoli lifecycle for hand weeding and then replaced. Each net has a 10-year lifecycle or more, and means that for ESG they require no pesticide sprays or biological controls.

2.7.2 Case Study: Integrated Pest Management, Tomato World – Netherlands

Every organic farm visited had an Integrated Pest Management (IPM) plan and was able to accurately describe the pests and pest management plan they had for their crops. Perhaps the more advanced pest management systems were in the Netherlands greenhouse growers that used a combination of (organic) chemical control and beneficial insects.

2.8 Natural pest and fungal remedies

2.8.1 Organic Varieties

Organic farmers are challenged by a lack of organic seed sources but also by a lack of information on the performance and resilience of that seed in the field. The philosophy behind using organic seed is that conventional seeds have been bred for use in conventional systems and have been designed to work well with the use of synthetic nitrogen sources or synthetic chemicals to control pests, diseases, and plant nutrition. Whilst conventional seed is bred for a critical production factor such as yield. Organic varieties are bred with the critical production factors of disease resistance, nutrition, and flavour characteristics.

2.8.2 Case Study: Shinta Kawahara Family Farms

Rob Koda, organic strawberry grower in Watsonville, California sees a big difference between the ‘Albion’ and ‘Monterey’ Varieties. Whilst Monterey now makes up 90% of the strawberry varieties grown in California due to its outperformance in yield, Rod says the taste of a Albion is incomparable to the Monterey. Performance and Disease Resistance statistics of strawberry varieties are displayed below.

Performance of Aromas, Diamante, and Albion compared with Monterey, San Andreas, and Portola at the Watsonville Research Facility in 2005–2007

Item	Yield (C/Acre)	Late Yield (C/Acre)	Appearance Score (5=best)	Fruit Size (g/fruit)	Firmness
Aromas	9,495	2,401	3.1	27.6	9.5
Diamante	8,313	2,420	3.5	31.5	11.0
Albion	7,783	2,247	3.9	30.6	11.2
Monterey	10,554	3,062	3.4	32.6	10.8
San Andreas	10,414	3,238	4.4	30.8	11.6
Portola	10,335	3,324	3.6	31.5	10.2

Disease resistance scores for Albion compared with Monterey, San Andreas, and Portola in 2005–2007

Cultivar	*Phytophthora* Resistance Score(5=best)	*Verticillium* Resistance Score(5=best)	*Colletotrichum* Resistance Score(5=best)
Albion	4.3	3.8	3.4
Monterey (CN222)	3.2	3.4	2.4
San Andreas (CN223)	3.8	3.8	2.9
Portola (CN224)	4.4	3.3	2.7

Figure 3: Performance and Disease Resistance statistics of strawberry varieties (Source: Koda)

However, 82% of organic vegetable growers still depend on conventional seed for part of their production, this is due to the higher cost to purchase organic seed over conventional.

Chapter 3: Increasing Outputs

3.1 What does 'increasing outputs' mean?

Perhaps one of the forgotten parts of regenerative agriculture is the ability to regenerate bank accounts for farmers. Chapter three is an exploration into the ways growers have explored retail routes, marketing and even how their methods of growing and managing the farm have changed to increase outputs, otherwise known as profitability.

Whilst reducing costs and inputs is an important area of farming and running a business. It is ultimately those farms and business that focus on achieving higher profitability that succeed.

Many of the successful growers visited stressed the importance of selling direct to market and the success they have found in those endeavours. Joel Salatin of Polyface Farms in Virginia grew his farm on that premise.

> *"25% or less of the profit captured through selling produce is returned to the farmer, the rest goes to the marketer, the distributor and the retailer, you have the opportunity to capture that". Joel Salatin*

Many of the farms I visited understood that and impressed on me the importance of being direct to market especially if you cannot capture the economies of scale from being a larger monoculture grower.

However, there was a growing sentiment amongst many growers that visited that there was a change in recent years. A slowing of business or decline in the popularity of direct market channels: less people showing up at farmers markets or less subscriptions in Community Supported Agriculture (CSA).

There are a few theories about the changing attitudes of consumers who buy organic produce. Joel Salatin attributes this decline to the cheap adoption and promotion of organic produce by large retail chains in the USA.

> *"Whilst the enemy of the day was Monsanto, we have a new enemy now: industrial organics"*

However, in the USA this has come at a cost to the organic brand and stretching of the fundamental organic principles to include hydroponic vegetable production and feedlot operations.

Joel recommends that growers arm themselves with 100% transparency to fight against "green-washing". For growers that are looking to go direct, Joel has three points:

1. Get IT in order: use social media to provide 100% transparency and storytelling about the product.
2. Partner with people who can do it better. Have the self-awareness of strengths and weaknesses and utilise networks to reach more consumers. For example, use local chefs or restaurants who want to value-add your products.
3. Diversify and be a one-stop shop: Do what is best for the customer and understanding that consumers want convenience. Diversify and partner with those who can complement your products to fulfil consumer needs.

New markets need:

1. Care
2. Community
3. Connection

3.2 Case Study: Direct to Market, JSM Organics

> *"$0 to $2 million in turnover in four years, I came from nothing" Javier Zamora, JSM Organics.*

In his first year of farming on just half an acre of land, Javier was aware of the unprofitability of his product being sold through wholesalers/brokers. He started utilising farmers markets and was able to cultivate his brand, bring customers (retail stores and chains) to him through his story. He is able to tell his story of growth and what he stands for succinctly.

He has four key lessons:

3.2.1 What is your story as a grower?

Javier Zamora tells his story of being taken advantage of as a strawberry harvester when he first arrived in the USA. He vowed that when he opened his own farm, he would provide a place of work that provided healthcare and pays above minimum wage. He pays workers fairly, cares about its employees and trains and encourages new talent to build their own farms. This story as a grower is critical as it allows the direct consumer to justify the cost of products. It changes from a price taker to price setter, as now a punnet of strawberries is a box of strawberries that pays it workers well.

3.2.2 Have an open gate.

Have an open gate to consumers, but this strategy does come at a cost to ensure the farm is all above board. It is an expense that needs to be factored in, but also evaluate it as a possibility in terms of the proximity of the farm to local areas and population.

3.2.3 Diversify the product offering.

It is difficult to become a household name without a range of products. The end consumer of today is used to buying all items at a supermarket where convenience is king. As a grower ensure you are able to offer a range and convenience.

3.2.4 Make it look good!

Invest in packaging to reflect the business story. Javier at JSM Organics had innovative cardboard designs for strawberries, Brussel sprouts and capsicums. Styrofoam or plastic was not in sight, a good strategy for the modern consumers attitudes towards unrecyclable and plastics.

3.3 Case Study: Pleasant Valley Farms, New York

Attending two markets a week, 52 weeks a year, Sally & Paul Arnold at Pleasant Valley Farms have made a living off four acres of land producing more than 100,000 USD per acre. They can manage their property and farmers markets using integrated 'Point of Sale' systems to track what they produce, sell, and return every week. Although small in acreage but big in heart and profit, the Arnolds have been able to keep their equipment investment at a minimum whilst still providing a full wash, pack, and delivery facility for the farm. Interestingly the washing facility is run entirely by young women from the ages of 12-18 years old.

3.4 Case Study: Howe Family Farm

A few years ago, Howe Family Farm was 100% focused on selling fresh strawberries to the wholesale market. Now, they sell 50% direct to retailers and 50% wholesalers with a specific chunk reserved for their own two farm shops they established under their brand in Ontario Canada. With just under four acres of hoop houses of berries they are able to secure their supply chain of strawberries with direct delivers to 23 grocery stores across Ontario. However, the lesson about diversity of crops was a big economic learning for the author at Howe's. Aside from the crop rotation and pest and disease management benefits, it is important to think about a farm from a buyer's perspective. Their job to is "buy" a list of items on their list for a specific price and quality. The more you are able to fulfil on that list by offering a basket of crops, the more you are protected in the market. It is important to understand the consumer. Either a consumer at the farmers market or a produce buyer for Woolworths.

3.5 Case Studies: CSA: Riverford UK, Crop Thorne Farm Canada

Starting as a small box program for a few families in the United Kingdom, Riverford started now supplies 55,000 boxes across the UK. The farm operation is now focused specifically on salad production, specialty leafy greens and niche fruit bearing crops e.g., baby cucumbers, cherry tomatoes. They specialise in packing set boxes e.g., a "Number 15": Medium Fruit & Veg box which contains up to ten items. These are packed by specialty equipment. This has involved Riverford to source fruit and vegetables from a variety of growers and countries.

Another CSA operation which consists of vegetables only is Crop Thorne Farm, who has diversified her direct to market sales between farmers markets (50%), CSA (30%) and direct to restaurants (20%). They explained that there is no correct way to sell farm produce, however it is about finding the balance required for the farm operation.

3.6 Niche Products

Growers can use niche products to diversify their direct-to-consumer model. The author visited Bear Creek Organics, a 3-acre operation in Petoskey, Michigan, offering (apart from their range of greenhouse and outdoor vegetables) organic micro-greens, black garlic, seedlings and potted plants. Although only a three acre operation, the farm has been growing by US $500,000 revenue every year, and the potted plants and micro herbs make up more than 50% of total farm revenue.

Into the future, there will be continued discussion around organic produce and produce grown in sustainable or regenerative methods. The role of the small family farm will also be under the spotlight. In a post-COVID19 world, there is every chance that consumers will prefer to buy local, sustainably grown produce direct from farm, but only time will tell. It is hoped through this research, that organics can be accessible to all.

Conclusion

The aim of this study was to make organics accessible to all, by reducing inputs, increasing outputs and suggest pathways for the organic vegetable industry in Australia.

One of the closest magical solutions for sustainable organic horticulture is weed control. As part of this research, those farms with the best yields and most sustainable business had a weed control plan being successfully implemented.

Once the seedlings are established, most organic farms visited then focused at how to reduce inter and intra row weeds in the most efficient way possible. It was noticeable that most organic farms were very well equipped with cultivation equipment.

The use of plastic mulch for vegetable growing was commonplace in the USA. Whilst plastic mulch is common in Australian horticulture for specific crops, in the USA it was typical to have an entire production system centred around plastic mulch used for every crop from tomatoes to cabbages to lettuce. The colour of the plastic mulch produces different effects: clear (higher temperatures), black (weed suppression), white (cooler temperatures to not overheat roots), silver/ metallic (confuses and repels pests), coloured (distinct radiation to reflect into crop canopy) or biodegradable (designed to be tilled). However, the main concern for plastic mulch production is cost and disposal of plastic. The alternative to plastic mulch is a no-till mulch layer produced by green manure, as seen in Germany.

Perhaps one of the forgotten parts of regenerative agriculture is the ability to regenerate bank accounts for farmers. Chapter three is an exploration into the ways growers have explored retail routes, marketing and even how their methods of growing and managing the farm have changed to increase outputs, otherwise known as profitability.

In organic horticulture many of the tools used to control soil-borne pathogens are not permissible, leaving organic growers to come up with new methods of controlling soil borne pathogens. Apart from substituting conventional sprays for certified organic sprays these are a few innovative examples of methods used to control various diseases.

Whilst reducing costs and inputs is an important area of farming and running a business. It is ultimately those farms and business that focus on achieving higher profitability that succeed. This research also explored ways growers around the world have explored retail routes, marketing and even how their methods of growing and managing the farm have changed to increase profitability. Many of the farms visited explained the importance of being direct to market, especially if economies of scale from being a larger monoculture grower cannot be captured. However, there was a growing sentiment amongst many growers that visited that there was a change in recent years. A slowing of business or decline in the popularity of direct market channels: less people showing up at farmers markets or less subscriptions in Community Supported Agriculture (CSA).

Having a genuine production story to tell, having an open gate for your consumers, diversifying the product offering for convenience purposes and making products look fresh and appealing were just some of the main take home messages from a range of businesses visited.

Into the future, there will be continued discussion around organic produce and produce grown in sustainable or regenerative methods. The role of the small family farm will also be under the spotlight. In a post-COVID19 world, there is every chance that consumers will prefer to buy local, sustainably grown produce direct from farm, but only time will tell. It is hoped through this research, that organics can indeed be accessible to all.

References

Arnold, Sally & Paul, Pleasant Valley Farms, New York, USA 2019. Personal Communication (http://pvfproduce.com/contact/)

Bear Creek Organics, Whitehaven, PA USA. Personal communication (https://bearcreekorganics.com/)

Crop Thorn Farm Delta British Columbia, Canada. 2019. Personal communication (https://cropthornefarm.com/)

ESG Broccoli – Scotland 2019. Personal communication (https://www.eastofscotlandgrowers.co.uk/)

Howe Family Farms, Ontario, Canada 2019. Personal communication (https://www.howefamilyfarms.ca/)

Koda, Rob and Gwen, organic strawberry growers in Watsonville, California 2019. Personal communication.

Live2Give, no-till organic vegetable farm in Germany 2019. Personal communication

Marschner, H. (1986) Mineral Nutrition of Higher Plants. Academic Press, London

Nutritech Solutions, Lactobacillus inoculum recipe / 1000L (online)

Riverford, UK 2019. Personal communication (https://www.riverford.co.uk/)

Salatin, Joel, Polyface Farms in Virginia, 2019. Personal communication (https://polyfacefarms.com/)

Tomato World, The Netherlands 2019. Personal communication.

Wouter, Peter, Wouters Green 2019. Personal communication.

Zamora, Javier, JSM Organics 2019, personal communication (https://www.jsmorganics.com/our-story/)