Hort Innovation

Final Report

Coir Waste Management for Hydroponics in Berries

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Delivery partner:

RM Consulting Group

Project code:

MT17016

Project:

Coir Waste Management for Hydroponics in Berries – MT17016

Disclaimer:

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Content

Summary

Over the past 25 years, the use of coir as a hydroponic substrate has increased internationally. In Australia, coir has been used for vegetable and flower crops for some time. Since 2010, its use is increasing in the berry industry is increasing rapidly. Coir is becoming a preferred substrate because it produces good results and it is considered the most environmentally sustainable option. Still, the management of spent coir has become a challenge for many producers. This project looked into opportunities for the beneficial reuse of spent coir. It provides recommendations for its reuse and briefly discusses plastic waste issues.

Project aim

The main project aim was to enable hydroponic berry producers to:

- Reduce on-farm coir related waste and associated costs, and
- Reduce the coir waste related risks and costs associated with pest and disease management.

Project methods

The project used consultation and desk top reviews to collect information on the opportunities and challenges of reusing spent coir.

Opportunities

According to estimates made for this report, the berry industry produces about 2,500 to 3,500 tonnes of coir waste nationally each year. Berry producers expect this to increase. An estimate for coir use in the vegetable industry came up with a figure of 30,000+ tonnes of coir used for hydroponic vegetables. Data allowing a similar estimate for coir use the in the nursery industry (e.g. for flowers or potting mix) could not be found. Estimates for other industries have been included here to highlight the potential for a collaborative approach to solutions.

The project identified and discussed the following potential reuse opportunities for spent coir.

Reuse option	Comments
Addition to commercial compost	Yes, logistics and arrangements with local compost producers need to be established; composting on farm is possible – training of interested growers required.
Composting on farm	Yes, needs to be done as per composting guidelines (active composting) to kill pathogens or left for a long time to passively compost. Composting can occur together with other organic residues or on its own. If on its own, the C/N ration needs to be suitable.
Mulch or soil amendment	Yes, if free of pathogens and used for a different plant species, unless sterilised or composted prior to use; potential to supply local garden centers or landscaping operations a or local organic recycling business. Potential to control pathogens via solarisation or fumigation
Activated carbon / biochar	Yes, if economical e.g. a biochar producer is in the region and prepared to take the used coir, or a new biochar plant can be set up to run profitably in the region (by a group of growers?)
Potting mix	Yes, as shredded additive (up to 30% of volume) if free of foreign matter and pathogens – potting mix producers may want to run trials before taking larger volumes.
Mushroom cultivation	Yes, as additive or 'capping' if free of pathogens and foreign matter, shredded and consistent – trials required.
Material for animal husbandry	Potentially, if free of foreign matter, shredded, not dusty and used locally e.g. as bedding or litter for chickens

Reuse option	Comments
Briquetted or pelleted fuel	May be economical if briquettes or pallets are already produced in the region e.g. from timber waste – trials would be required.
Biogas production	May be viable on its own or mixed with other materials, if biogas is already generated close to the hydroponic production area and the resulting gas / electricity and process residues e.g. ash can be used efficiently and profitably – research required.

Challenges

The following challenges have been identified:

- Time required to deal with a solution and associated costs
- The need to separate coir from plastic for many reuse options, and the technology and cost of doing this
- The need to sterilise the spent coir for many reuses and the technology and cost of doing this
- The costs of handling and transport of used coir if the berry producer has to pay for it all
- No reliable data on the 'make up' of spent coir from different production systems (i.e. typical chemical and biological properties) and therefore it's value
- Regulations are not uniform in each state; regulations from different organisations may apply (e.g. in charge of Environment, Biosecurity, Food safety)
- Lack of applied research e.g. 'profiling' spent coir, value of coir for different reuses such as recycled organic products (i.e. soil amendments, composts, mulches, potting mix), bioenergy, biochar
- Apparent lack of communication between those who want to get rid of the 'waste' and those who can put it to good use as well as across industries with similar waste challenges.
- Even if the relevant research has been conducted and reported, e.g. by the vegetable industry on plastic waste or the nursery industry on general waste, implementation of recommendations does not seem to happen. A person or organisations needs to drive implementation or get the mandate to do so.

Solutions to challenges are discussed in the report or, as required, have been identified as research needs.

Project recommendations

Recommendation 1

Berry producers to link up with organic recyclers in their region to determine the most suitable, cost efficient way of collection and recycling. Appendix 6 of this report provides relevant reginal information. The maps are available in an interactive format via https://tinyurl.com/berry-waste-recycling-map.

Berry producers should explore opportunities in the vicinity of their berry operation e.g. with landscape companies, chicken producers, orchardists. Profiling of the used coir would be beneficial before engaging with potential users or decide on reuse on farms. Composting on farm is an option for those who can use or sell the compost. Co-composting with materials with high nitrogen content e.g. manure may be required. Reuse on farms as a soil amendment without composting is suitable.

Linking in with the recycled organics sector has been identified as the currently best option to deal with used coir in the most cost-effective way. Composting eliminates the need to sterilise used coir.

Recommendation 2

This project highlighted that the protected fruit, vegetables and flower industries have a similar waste management problem to the berry industry. Solutions should be addressed holistically.

A voluntary stewardship program should be explored, involving the entire supply chain. A start could be made by the following players:

- The three major coir importers
- Berries Australia
- Protected Cropping Australia (PCA)
- Nursery and Garden Industry Australia (NGIA)

- Australian Organic Recycling Organisation (AORA)

The peak industry bodies could explore how to deal with other common waste issues in their respective industries.

Recommendation 3

The berry industry should utilise resources produced by NGIA and published on the NGIA website:

- An investigation into waste management in Australian production nurseries (provides an overview of wastes steams and potential solutions)
- An economic analysis of changing waste management practices in an Australian production nursery (includes information on sterilization of substrates, pots and equipment as well as compacting and baling plastic wastes.)
- Fact Sheet - Waste disposal in production nurseries
- Fact Sheet - Steps to reduce waste management and disposal costs.
- Nursery waste self-assessment survey form
- Waste management cost estimate worksheet
- Waste management cost calculator

The report VG13109 "Innovative ways to address waste management on vegetable farms" includes a set of recommendations on addressing plastic waste issues in the protected cropping sector; they should be revisited and implemented as appropriate.

Research, Development and Extension (RD&E)

R&D topics identified by this project are:

- Profiling of typical spent waste material from different berry crops to provide to potential re-users
- Type and longevity of pests, diseases and weeds in coir from different crops and effectiveness/costs of sterilisation options apart from composting
- Development of mobile equipment that can be used near greenhouses or tunnels to remove plant debris, foreign matter and plastics with coir/root residue collected in suitable containers for shredding or being shredded in the process
- Investigating the economic feasibility of producing biogas and biochar from spent coir
- Investigating the feasibility of using spent coir for mushroom production
- Investigating the economic feasibility of producing pellets or briquettes to be used by households instead of firewood; https://pellet.com.au/ provides an example of producing pellets from timber waste.

Research results need to extend effectively. Extension is not communication of results and recommendations to a passive audience. Extension is about active engagement and facilitation of adoption including supporting the adaptation of R&D outputs if required.

Keywords

Berry fruit, hydroponic production, substrate, coir, coconut fiber, waste, recycling, reuse, compost, biogas, biochar, stewardship program.

Introduction

Overview

The Strawberry and Raspberry/Blackberry Strategic Investment Plans (SIP's) include strategies aimed at informing growers of emerging options, risks and opportunities afforded by protected cropping systems. Hydroponic production is such an opportunity. One challenge for this production system is the disposal or reuse of spent substrates in an economically and environmentally acceptable, risk free manner.

Avoidance, reduction and beneficial reuse of wastes from horticultural production is important because:

- Accumulation of preventable waste means lost income and or additional costs for the producer
- Landfill is discouraged and therefore expensive
- Environmental sustainability, and evidence of it, is becoming a necessity for horticultural industries.

Undercover hydroponic production of raspberries and blackberries (Rubus) is quickly becoming the preferred production system with coir fiber the favourite type of substrate. According to Strawberries Australia, strawberries are still mainly grown in soil, with a small proportion produced undercover or hydroponically. This is expected change quickly in the coming years with hydroponic production increasing.

Reasons for change to hydroponics are that effective management of soil borne diseases via fumigation or cultural practices is becoming challenging, crop rotation options are limited and the use of alternative management approaches such as biofumigation, solarilisation, soil amendments and biopesticides are considered challenging. Production in substrate under cover is viewed as less risky, more productive, efficient and profitable. With increased restrictions on use of soil fumigants and herbicides, it is expected that substrate culture will continue to expand[1]. Hydroponic production occurs off the ground which makes it easier to find pickers.

Most hydroponic production systems require an inert growing medium with good water and air holding properties. Apart from coir (cocopeat), rockwool, peat, perlite, pumice and even vermiculite are used. Weight of the growing medium, sustainability of supply, and disposal/recycling options for waste materials are important selection criteria.

Over the past 25 years, the use of coir, as a substrate has increased internationally[1]. It is a plentiful, renewable resource with high structural stability. Coir can be transported in a compressed state, thus has competitive transport costs. It expands by about five times after adding water.

Coir is becoming a preferred substrate because:

- Peat is a limited resource, and there are strong environmental pressures to reduce its use in horticulture.
- The production of rockwool and other inorganic substrates are energy demanding; disposal after use is a problem because it does not break down. Some compost producers are trialing to add rockwool to compost and reuse options are explored in the Netherlands.
- Coir is considered the most environmentally sustainable substrate[2] because it uses a waste product and is biodegradable. The required transport from coconut production areas is considered a negative aspect.

Trials have shown that coir may produce superior yields and quality compared to other substrates[3] [4].

Hydroponic production using coir has been used for protected fruiting vegetable and leafy greens as well as flower growing for many years[5]. Coir is also used in many pine bark based potting mixes.

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1 Lieten P. 2013. Advances in Strawberry Substrate Culture during the Last Twenty Years in the Netherlands and Belgium, International Journal of Fruit Science, 13:1-2, 84-90, DOI: 10.1080/15538362.2012.697024.
2 Barrett et al. 2016. Achieving environmentally sustainable growing media for soilless plant cultivation systems – A review. Scientia Horticulturae 212 (2016) 220–234.
3 Jing Xiong et al. 2017. Comparison of Coconut Coir, Rockwool, and Peat Cultivations for Tomato Production: Nutrient Balance, Plant Growth and Fruit Quality. Front Plant Sci. 2017; 8: 1327.
4 Kleiber T. et al. 2012. Organic Substrates for Intensive Horticultural Cultures: Yield and Nutrient Status of Plants, Microbiological Parameters of Substrates. Pol. J. Environ. Stud. 2012;21(5):1261–1271.
5 Abad M. et al. 2002. Physico-chemical and chemical properties of some coconut coir dusts for use as a peat substitute for containerised ornamental crops. Bioresour. Technol. 82 241–245. 10.1016/S0960-8524(01)00189-4.

Project aim

The main project aim was to enable hydroponic berry producers to:

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Methodology

Project inception and framework

Inception Meeting

A project inception meeting was held on the 28 August 2018 with Hort Innovation R&D Manager Byron de Kock to confirm project context and core stakeholders for engagement, refine the project methodology and discuss expectation important to project delivery.

Project Plan

A project plan was developed outlining project objectives, how to measure success, how to mitigate risks, timelines for key activities and communication methods with stakeholders. It is included as Appendix 1. The plan consists of several sub-plans, including:

- Monitoring and evaluation plan
- Risk management plan
- Stakeholder consultation plan
- Communication plan
- Project work plan

Project Reference Group

Project Reference Group (PRG) members were selected and approved by Hort Innovation. The terms of reference (ToR) which lists members and outlines the purpose and objectives for the group is included as Appendix 2.

Scan of coir reuse opportunities

Consultation

Consultation covered the following topics:

- type, composition and volumes of coir waste
- potential reuse options for opportunities already existing in a region, including challenges, barriers and how to overcome them:
    - reuse/recycling options tried and used already
    - where the waste is going at the moment, if not re-used
    - reuse and recycling options within berry producing businesses
- any constraints and ideas producers and others have, e.g.
    - logistics, transport
    - volumes, costs/economics
- managing pest and disease risks
- networks
- technologies and resources available and/or required e.g. shredders, plastic removal, sterilisation.
- new concepts.

Those who made themselves available for an in-depth interview are listed under "Acknowledgements" in this report.

National consultation included:

- Rubus growers
- Strawberry growers
- Coir importers
- The organics recycling sector via Australian Organics Recycling Association, the peak body for the organics recycling industry in Australia (AORA www.aora.org.au) via Peter Wadewitz, National and SA State Chair
- Individual waste management companies that recycle organic waste, produce composts, potting mixes and mulches, some of which already recycle coir
- Consultants and researchers
- Industry Associations (Berries, Nursery and Garden Industry, Protected Cropping Australia)
- Producers of composable plastics
- Steritech, Trical (disinfestation/fumigation)
- Vegetable producers (Adelaide Plains area, SA).

International consultation took place with:

- Wageningen University, Netherlands to understand current practices and research in the recycling of used substrates
- A Hungarian coir importer who developed a method of collecting and processing spent coir for re-use in potting mix
- A Dutch coir importer and distributor with office in Queensland
- Galuku International
- Haygrove UK, a company growing berries, cherries and organics in the UK for the past 20 years, totalling about 500 ha. Haygrove also design and manufacture field scale commercial polytunnels, substrates and develop growing systems which they supply worldwide. Haygrove acquired the coir product manufacturing and export company company Galuku in 2018

Other information sources

- Australian Bureau of Statistics (ABS)
- Literature
- Other types of hydronic producers, given that
- They have already explored and or established reuse/ recycling systems
- A minimum volume may be required in a region for some opportunities and economies of scale may exist
- Indian Coir Board to check whether agricultural and industrial uses they are researching are relevant for coir waste.
- The Hortidaily Global Greenhouse News newsletter[6] was used to reach out to organisations with information on coir recycling (commercial or research information).

Communication of findings

Information about the project and a summary of findings were published via the 'Strawberry Innovation' Project[7] and 'Simply Red' newsletters. Raspberries and Blackberries Australia (RABA) was not able to communicate information at the time. This was potentially due to changes to three peak bodies i.e. the strawberry, raspberry and blueberry associations forming one peak body, Berries Australia.

Information on feasible reuse options for Australian berry growers via recycling was synthesised in spatial maps to show organic recyclers in berry production regions and providing contact details (as static map with contact list included in this report and interactive map[8] for inclusion on websites and in e-communication).

6 https://www.hortidaily.com
7 BS15002 Facilitating the development of the Australian strawberry industry.
8 https://tinyurl.com/berry-waste-recycling-map

Findings were presented to the combined Hort Innovation Strategic Investment Advisory Panels (SIAPs) for strawberries and raspberries.

During the duration of the project, berry industry peak bodies amalgamated into a single body, 'Berries Australia'. Project outputs will be provided to the new peak body for communication as easy to read information developed from project findings e.g. in newsletters, information for the Berries Australia website and e-communication platforms. The information will cover opportunities, risks, logistics, economic considerations and information on regulatory requirements (e.g. biosecurity, compost).

Outcomes - Findings

Coconut fibre origin and uses

Overview

The Philippines, Indonesia and India produce about 90% of the world harvest of coconuts and thus a range of coir-based products including coir pith substrates. Other producers are Sri Lanka, Vietnam, Philippines, Mexico and Ivory Coast.

Coconut producing countries are conducting research into value adding of coir. The main targets are the local building industry and export of building materials, matting and geotextiles. Figure 1 provides an overview of the coconut fiber value chain and value-added products.

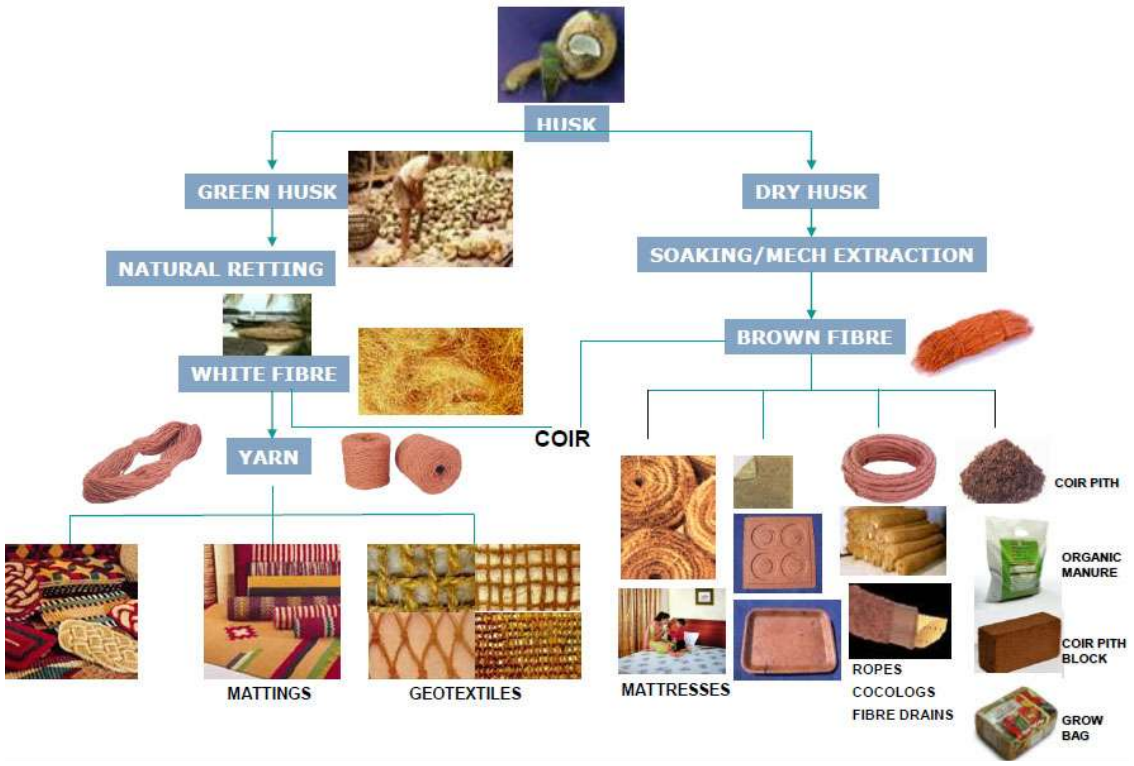


Figure 1: The main coconut fiber value chain ***(Source: National Coir Board, Ministry of MS&ME, Govt of India)***

Coir substrates

Coir substrates are a mix of coir fiber/dust and chips (from husks). Typically, at least four different coir substrate types with different particle size distribution are produced.

Raspberries and blackberries require a proportion of chips in the mix as they remain in the same substrate for 3 or more years in most areas. Often a mix of 70% fibre and 30% chip is used. Strawberries are usually grown in fibre only.

Given coir substrate is a natural product that is processed in a variety of ways, chemical properties can vary considerably. In addition, the growing conditions of coco palms can have an effect on chemical properties of coir. A range of pretreatments are used to achieve a physically stable product with the right chemical attributes for uses as different substrates. Coir substrate is compressed for transport.

Coir is high in carbon in the form of lignin and cellulose, the C/N ratio is around 120/1, therefore it needs plenty of nitrogen to reach a ratio of 1: 20 or lower to break down. It is pH stable and maintains an adequate air-filled porosity for a long time. Coir is low in nutrients but accumulates them during its use as substrate. An example of a hydroponic coir substrate analysis is included in Appendix 3. Coir substrates are usually high in potassium and contains micronutrients, including iron, manganese, zinc, and copper compared to other organic substrates e.g. peat moss or wood/bark based substrates.

Prior to use, blocks of compressed, treated (leached) coir are, moistened and fertilized. Blocks may be broken apart for some uses. The volume to volume expansion ratio on reconstitution of compressed coir is about four to six time the compressed volume, depending on the proportion of coir fibre/dust and coir chips. The mixing proportions also affect physical properties such as bulk density, air, water and nutrient holding capacity and stability (resistance to decomposition). Decomposition of coir affects physical and chemical properties e.g. air holding capacity would decrease over time and water holding capacity of a coarse substrate would increase in the early stages of decompositions; the plant available water capacity would then decrease towards the end of its useful life.[9]

Coir supply, use and 'waste'

The information in this section is based on feedback from consultation.

Supply

According to Protected Cropping Australia, 80% of substrate used is coir (compared to about 20% fifteen years ago) because it is cheaper and produces better results tahn other substrates. A number of different coir specifications/custom requirements exist for different crops re composition size, shape, number of holes in slabs, drainage patterns, slab or bag volumes and whether the blocks are plastic wrapped or not.

In Australia, coir is supplied by importers (mainly Galuku, Ceylon Coco Peat Australia, Eco Mix, Garden City Plastics, Shakti Cocos B.V.) directly to large scale hydroponic producers and many agribusinesses that supply the nursery and protected cropping industry.

Garden City Plastics (GCP) estimated that they supply about 25% of the coir market, Galuku supplies 25%, Eco-Mix supplies 25%, and others the remaining 25%.

According to Eco-Mix, the current annual size of coir market for berries (in bags) is estimated at ~ 1.5 million bags in Tasmania, about the same in NSW, 500,000 bags in QLD, 500,000 bags in WA (70% of coir used in WA is in bags) and < 500,000 bags in Victoria and SA combined.

Some suppliers (e.g. Galuku) are starting to work with growers who use coir slabs or blocks in gutters or pots without plastic wraps to reduce the plastic waste issue. Many growers shy away from this option due to the capital investment required to set up suitable gutters (e.g. for strawberries) or use pots.

Galuku is investigation compostable plastic. Their view is that the additional cost for a 'bio/eco' bag would be more than offset by on-farm costs involved in bag, plastic and plant material removal; all currently done by hand or via capital intensive machines. A challenge is that the compostable bag would have to be applied in the country of coir origin, not Australia due to the 'bagging' costs. This means the compostable plastic

9 Prasad, M. 1997. Physical, chemical and biological properties of coir dust. Acta Hortic. 450, 21-30
DOI: 10.17660/ActaHortic.1997.450.1
Shinohara, Y & Hata, T & Maruo, T & Hohjo, M & Ito, T. 1999. Chemical and physical properties of the coconut-fiber substrate and the growth and productivity of tomato (Lycopercicon esculentum Mill.) plants. Acta Horticulturae. 481. 145-150. 10.17660/ActaHortic.1999.481.13.

material would have to be sourced in the coir supplier countries. Another issue is that the plastic solutions would have to be stable for different time periods, depending in the intended use (e.g. from months to years).

Consultation with several plastic producers conducted as part of this project was not encouraging. A compostable bag or slab wrap may be some time off. Use of gutters or pots may be the better solution.

Coir use patterns

Typically, coir substrate is used only one year for strawberries, one to four years for Rubus spp. and up to five years for blueberries. Individual growers use substrates for longer than described above, if plants remain healthy and yields and quality remain high.

Blueberries have been included in some of the analyses in this report, given that their hydroponic production is increasing. Even cherry and vine grape producers are now exploring hydroponic production systems. This means volumes of spent coir from fruit production is likely to increase in the future.

Vegetable crops such as tomatoes, cucumbers, eggplants, herbs and lettuce as well as flower crops have been grown in coir substrates for some time. These remain in the substrate for several months (cucumbers, tomatoes, eggplants, flowers) or just weeks (lettuce, some herbs).

Coir reuse in Australia

Characteristics of used coir

The following changes will occur to varying degrees during the use of coir for hydroponic production:

- nutrient enrichment
- pH change – depending on the pH of the nutrient solution
- changes in structure due to decomposition – the resulting structure depends on the original structure, length of use, temperatures and inputs
- addition of root mass – the longer the crop remains in the substrate, the greater the root mass and, in the case of Rubus crops, the more woody the resulting 'waste'
- changes in the rhizosphere i.e.
    - changes of the surface charge and chemical properties of the coir through adsorbed ions/molecules
    - accumulation of root exudates and decomposition products
    - changes in microbial composition and potentially introduction of root pathogens
    - potential development of allelopathy (due to exudates and microbial changes) which could cause replant problems especially when spent coir from growing crops of the *Rosaceae* family is reused for crops from the same plant family e.g. apples, almonds, cherries, pears, raspberries, blackberries, strawberries, roses.
- Potential build-up of pesticide residues.

The actual chemical and physical characteristics of spent coir varies widely depending on crops, timeframes of use and crop management inputs. If spent coir is stockpiled with or without plastic, further changes will occur depending on the climate and how the stockpile is managed.

Spent coir from berry production varies in composition depending on its use. If from raspberries and blackberries it has a very high root content, especially when used for 3+ years. The nutrient profile, C/N ratio, pH and EC will vary accordingly. Recyclers who are using coir mentioned contamination with plastics and other non-organic waste such as string, metal clips, rockwool plugs (from propagation) to varying degrees, depending on the individual crop and farm. Some used coir will carry pests, weeds and diseases, such as nematodes species, Western flower thrip (WFT) larvae (*Frankliniella occidentalis*) and potentially soilborne fungi (e.g. *Phytophthora*, *Pythium*, *Verticillium*, *Fusarium*). Liver moss may accumulate on substrates and stockpiled coir can become weed infested.

Given the variations in the characteristics of spent coir the substrate should be analysed prior to direct reuse on farms as soil amendment, substrate or mulch. Information on sampling and analysis is included in Appendix 4. Correct sampling and sample handling are essential for getting meaningful results. The analysis should be conducted from the material that is to be reused.

Reuse

Growers commented during consultation that 'coir waste' is not a good term to use. Therefore, the terms of 'used coir' or 'spent coir' have been substituted for 'coir waste' in this report.

Organic recycling companies consulted were all interested in using coir in compost, potting mix or mulch, depending on its condition, especially level of contamination. Growth in the use of compost in horticulture makes the recycling of coir if a 'clean' material attractive.

Some recycling companies already have experience with used coir, but many have not reused it yet. They would like to understand the composition of the waste before using it, especially C/N ratio, pH, EC and nutrient levels.

Many recycling companies would pick up the used coir but ask to be paid for it. They would charge a lower gate fee than for greenwaste (e.g. $40-$60/t for used coir). Some recyclers would pick up large volumes for free, especially if it is free of physical contamination (plastics and other non-organic waste such as string, metal clips).

Freight/transport logistics and costs appears to a major obstacle for recycling of spent coir. The predominant view was that transport distances for the used coir should not be above 100 km.

Potting mix experiences

Coir can be used at 5-25 to 30% by volume in potting mixes e.g. together with composted pine bark and some sand. Due to its still good nutrient and water holding capacity it improves the potting mix and therefore its value. Sometimes used coir can be too salty (high EC) to be used in high proportions in a potting mix.

Bio Gro Australia (Vic, SA) is using fresh coir in their potting mix but would consider used coir. Australian Growing Solutions (AGS) is already using spent coir. Bio-grow and Australian Growing Solutions (AGS) are the major commercial organic waste processors who produce large volumes of potting mix.

Compositing experiences

Those who have added spent coir to materials for composting said that Coir mixes very well for composting. There are no issues with pathogen contamination of the finished product as long as it is composted properly e.g. reaches temperatures above 55 °C for 10-14 days in a vessel or for 12 weeks outside (moisture and oxygen supply need to be right as well). Appendix 5 provides further information on composting.

A company called Waterhold Pty Ltd currently assists producers in other industries to compost their organic wastes on-site. The company would be interested in talking to berry producers about composting their organic waste on farm.

Reuse by the company

Larger scale producers have set up systems to reuse the spent coir as a soil amendment or mulch within their company (e.g. Costa) or supply neighbouring producers with the shredded material for the same purpose (smaller scale producers). Usually the spent coir is stockpiled before or after shredding, depending on set up. If a shredder has to be brought in, spent slabs or blocks are stockpiled, otherwise bag removal and shredding are one process.

Smaller scale operators are sometimes able to offer spent coir to private household gardeners in their area or even sell it at local farmers'' markets or to local landscapers.

Other options

Some mushroom composters overseas use fresh coir as a capping on top of the mushroom compost. Mushroom producers in Australia currently use straw as a carbon source. They could try waste coir if it was sterilised and relative consistent, comparable to straw. This reuse option would require trials to be done.

No reuse

In spite of feasible reuse options, many growers here (and overseas) stockpile used coir slabs or bags. "Currently we stack all in a heap in bags (up to 300,000 bags annually); it is becoming a big problem".

The main issues for growers are the cost and technique of plastic removal, as well as transport costs combined with a lack of time to look into recycling opportunities and the logistics of getting rid of the waste efficiently. For some companies, management of unregulated waste like coir residues is not a priority until stockpiles are getting too large. Especially if berry growing companies are in a growth phase, recycling of organic materials as well as plastics can be a major challenge due to the funds and time commitment required.

Coir reuse overseas

In Europe, used coir with no contamination issues is recycled in potting mixes and composted. Hydroponic growers work with coir suppliers and potting mix producers on solutions.

In the Netherlands, rockwool appears to be still a major substrate. Researchers at Wageningen University are developing reuse options for it. There, used coir is composted with other organic wastes after mechanical plastic removal by a custom-made machine. The Netherlands like most other European countries have a well-established recycling culture which is driven by EU environmental policies. The high density of agricultural production makes recycling and reuse more economical. This situation fosters the development of networks, supply chain solutions and technologies that help dealing with removal of crop residues, plastic/foreign matter and sanitation/sterilisation. Transport distances are typically short.

The EU compost network facilitates development of the organics recycling sector. As an example, Figure 2 provides an overview of the market for compost in Germany. There, and in other EU countries, the agriculture sector is the greatest user of compost. There, the costs of composting is heavily subsidised by contributions from those who create the waste, including private households who pay for green waste removal by weight.

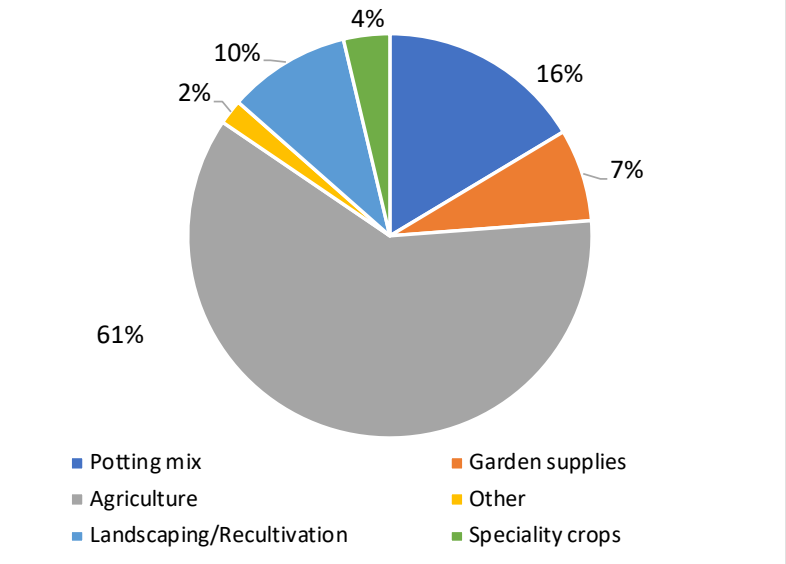


Figure 2. Market distribution of compost use in Germany

In Europe, the organics recycling sector is advanced with well-established systems for processing, quality control and reuse. However, in spite of these systems, some growers still stockpile used slabs or bags on farm as reported in the UK, because logistics are not established.

Challenges for the reuse of spent coir substrate

Costs

The costs of dealing with waste such as separating coir and plastics, logistics, transport costs and potentially gate fees are major challenges for individual producers. Often producers do not budget for waste management.

Publicly available gross margins and investment analyses for hydroponic berry production (e.g. on government department websites) do not include waste management cost.

The actual waste management costs can vary widely depending on business size, location and the type or mix of waste to dispose of.

Regulation

State legislation relating to environmental protection, and biosecurity as well as food safety need to be considered when exploring recycling and reuse options. Environmental concerns relate to leaching of nutrients into water resources and potentially to dust and plastic contamination, especially when composting on-farm. Biosecurity concerns relate to transport and reuse of not sterilised materials. Food safety concern relate to contamination with manures and other wastes potentially containing human pathogens.

Regulations are not uniform across the country.

Environmental Protection Authorities and individual councils provide information on specific requirements.

Biosecurity legislation may apply when coir or compost are to be transported across state borders or across 'pest free areas of production'. Relevant information will be available from state government departments in charge of agriculture and biosecurity.

Food safety standards deal with reuse of recycled organics.

Research, Development, Extension and Implementation

While a great body of work has been produced on properties and best use of different hydroponic substrates, and how to manage and recycle water in the hydroponics and nursery industries, Australian RD&E and subsequent initiatives to implement economically viable recycling options for organic waste streams from protected crop production is lacking. The National Centre for Greenhouse Horticulture, Gosford does currently not conduct research on organic waste management for the industry.

Applied research such as 'profiling' spent coir, understanding the comparative value of coir for different reuses such as recycled organic products (i.e. soil amendments, composts, mulches, potting mix), bioenergy or biochar would help growers to make good decisions about reuse.

Even if relevant research has been conducted and reported, e.g. by the vegetable industry on plastic waste and the nursery industry on general waste, implementation of recommendations does not seem to happen. A person or organisations needs to drive implementation or get the mandate to do so.

Communication and networks

It appears that a lack of communication between those who want to get rid of the 'waste' and those who can put it to good use has been hampering the implementation of solutions.

Lessons from previous projects

The following project reports were reviewed to understand whether outcomes from these projects can be applied to management of coir waste. Findings from the were considered in 'outputs' and 'recommendations' in this report.

Project Number	Title	Findings
VG13109	Innovative ways to address waste management on vegetable farms	Plastic waste from protected cropping is included in the study. It therefore is relevant to plastic waste from the berry industry. It is of special interest for a horticulture wide approach to managing plastic waste, which should be considered.
VG13049	Biogas generation feasibility study – vegetables	The opportunity to include coir waste in biogas production could be investigated in more detail. The outcomes of the study VG13049 indicate that large volumes of relative uniform biomass available all year round would be required to make biogas production an economically viable proposition. The energy would best be used by the producer or electricity users nearby. One reason for the need of large volumes and 'instant' reuse is that, at the time of the study, the returns from feeding energy into the public grid were too low to make small biogas operations viable. "Coconut husk and shells are a suitable biomass fuel and are also a good source of charcoal.[10]" Studies have been conducted on coconut waste created during the processing of coconuts in Asian countries. Given that the composition of used coir is quite different to that of fresh coir waste, and differences in how the energy market works in respective countries, the outcomes of the overseas research into using coir for biogas production are not directly applicable. The following opportunity was identified: Australian Tartaric Products (ATP) in Colignan, near Mildura, installed a grape biomass boiler in 2015 at a total cost of about $10 million, including public subsidies. The company, which supplies tartaric acid, cream of tartar and food-grade spirit to the wine industry, previously ran a gas-powered steam plant but found that energy costs became too high as the gas price rose. The company started feasibility studies in 2008. Waste from the wine industry used to produce their products as well as energy and agricultural inputs. The relative value and feasibility of biogas production from (or including) used coir compared to using used coir as a soil conditioner or to improve potting mix would need to be investigated in more detail.
VG13050	Production of fish food for aquaculture from vegetable waste - feasibility study	This project examined the potential to use vegetable waste to grow insect larvae, which can then be used in aquaculture feeds. Larvae of black soldier fly (BSF) can live on vegetables alone, however, an addition of a protein rich food source improved growth. VG13050 concluded that "An economic analysis indicates that BSF are currently a risky option for an individual vegetable grower." Coir waste alone would not be as palatable as vegetables on their own given the high C/N ratio. It would need to be mixed with an additional more nutritious food source. This would make the conversion process more complicated than composting and not viable.

10 https://www.bioenergyconsult.com/coconut-biomass/

Project Number	Title	Findings
MT09068	Comparisons of biodegradable mulch products to polyethylene in irrigated vegetable, tomato and melon crops	A number of biodegradable products were evaluated, to identify potential replacements for polyethylene mulch films in irrigated vegetable production. These replacement films needed to have the same desirable traits, with the benefits of no disposal issues and costs. Mater-Bi(c), a biodegradable product produced by Novamont and marketed by Australian Bio-Plastics, was the most successful product in the trials. Mater-Bi(c) complies with Australian Standard AS 4736 'Biodegradable plastics suitable for composting and other microbial treatment' and produced good results (yield & quality) compared against traditional plastic products. This plastic film is not produced as grow bags for nursery and hydroponics because suitability would need to be investigated first. Galuku is currently following up on opportunities of producing and applying compostable bags in their factories in Asia.
VG990016	Identifying the benefits of composted soil amendments to vegetable production	This project evaluated the benefits of compost on vegetable production demonstrating the ability of compost to consistently increase marketable yield and achieve improvements in soil quality.

Outputs

Outputs combine lessons from consultation with information from the desktop research.

The outputs presented in this report will be disseminated by Berries Australia in newsletters, as factsheets and e-communication.

Spent coir substrate volumes

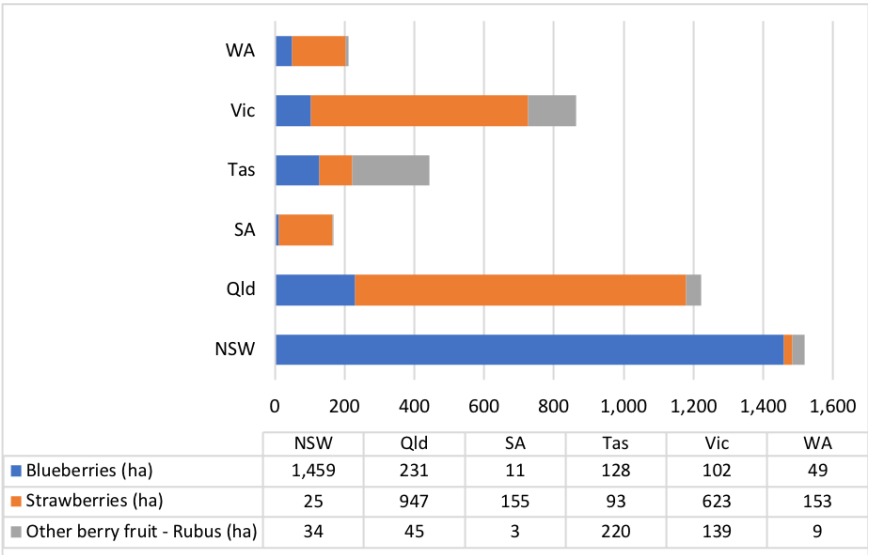
Berry production regions and estimated volumes of spent coir

Rubus production occurs along the Eastern Seaboard, with the majority of production in Victoria and Tasmania.

Queensland and Victoria are growing 77 % of the national strawberry volume (Beerwah, Stanthorpe and Sunshine Coast regions, Qld; Yarra Velley, Vic). Of the remainder, WA accounts for 11 % (Wanneroo and Albany), the Adelaide Hills, SA for 7%, Tasmania for 4% cent, the Camden region, NSW, for 1%.

The majority of blueberries are grown in NSW. All other states have smaller scale blueberry production areas.

All berry production is concentrated in coastal regions. Figure **1** illustrates berry production areas (ha) by state.



	NSW	Qld	SA	Tas	Vic	WA
Blueberries (ha)	1,459	231	11	128	102	49
Strawberries (ha)	25	947	155	93	623	153
Other berry fruit - Rubus (ha)	34	45	3	220	139	9

Figure 1. Total berry production area Australian Bureau of Statistics (ABS) 2015-16, Catalogue number 7121.0

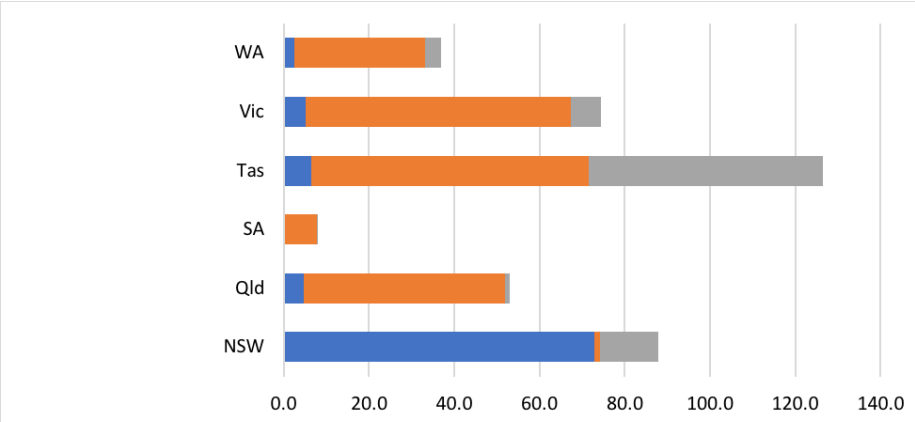
Estimate of hydroponic berry production areas

The estimated percentages of current hydroponic berry production in Table 1 are based on industry consultation. These percentages were used to estimate coir volumes currently used in each state.

Table 1. Estimated hydroponic berry production percentages

Crop	NSW	Qld	SA	Tas	Vic	WA
Blueberries (ha)	5%	2%	0%	5%	5%	5%
Strawberries (ha)	5%	5%	5%	70%	10%	20%
Rubus (ha)	40%	2.5%	2%	25%	5%	40%

According to feedback from industry and coir importers, hydroponic production is on the increase.



	NSW	Qld	SA	Tas	Vic	WA
Blueberries (ha)	72.9	4.6	0.0	6.4	5.1	2.4
Strawberries (ha)	1.2	47.3	7.7	65.0	62.3	30.7
Other berry fruit - Rubus (ha)	13.6	1.1	0.1	55.1	6.9	3.7

Figure 3. Estimated hydroponic berry production areas (ha)

Estimated hydroponic berry production areas in Figure 3 are based on ABS statistics used in Figure 1 and estimated percentages used in Table 1.

In Tasmania, the main berry crops grown in hydroponics are strawberries and Rubus crops, raspberries. In NSW, blueberries are increasingly grown in hydroponics. In Queensland, Victoria and WA the majority of hydroponic crops are strawberries. SA has a small berry producing sector consisting of strawberry production.

Table 2 provides information on the estimated area grown hydroponically for each crop nationally and the average frequency of substrate replacement.

Table 2 Estimated area of hydroponic berry production nationally

AU	Area in coir (ha)	Replacement frequency
Strawberries	214	annually in all states
Rubus	81	every 1-3 years in Tas, Vic, SA annually in Northern NSW and Qld
Blueberries	92	every 4-6 years (average 5) (will vary depending on location)
Total	**342**	

Estimate of coir volumes from hydroponic berry production

Estimated areas used for hydroponic berry production illustrated in Figure 3, replacement frequencies from Table 2 and base data presented in Table 3have been used to calculate annual coir volumes used for production which would have to be disposed of (Table 4). The estimate shows that nationally, about 2400 tonnes of coir could be recycled by the berry industry.

The assumption was made for Table 4 is that substrates would be replaced annually for strawberries in all regions, every 3 years for Rubus in Tasmania, Victoria, Western Australia and South Australia and annually in Queensland and New South Wales; blueberry substrates would be replaced every 4 years on average in all regions.

Table 3. Estimated coir use base data by crop

Crop	Slabs or bags (#/ha)	Coir per slab or bag (m^3)	Coir use (m^3/ha)	Coir bulk density (kg/ m^3)
Strawberries	7000	0.015	105	80
Rubus	7000	0.01	70	
Blueberries	2800	0.01	28	

The coir volume per slab or bag in Table 3 is based on a slab dimension of 100 cm x 15 cm x 10 cm and 10 L bags. Some larger volume bags are also used depending on the crop and growers' preferences. Subject to the proportion of growers using bags with greater coir volumes than used for Table 4, annual volumes and weights estimated for Table 4 could be 20-30% higher i.e. 38,000 to 40,000 m^3 (3,000 tonnes) nationally.

Table 4. Estimated annual coir volumes used for hydroponic berry production by state

	Strawberries		Rubus		Blueberries		Total	
	(m^3)	(t)	(m^3)	(t)	(m^3)	(t)	**(m^3)**	**(t)**
NSW	130	10	954	76	511	41	**1,594**	**128**
Qld	9,943	795	78	6.3	32	2.6	**10,053**	**804**
SA	812	65	1.19	0.1	0	0.0	**813**	**65**
Tas	6,825	546	1,286	103	45	3.6	**8,156**	**652**
Vic	6,539	523	162	13	36	2.9	**6,737**	**539**
WA	3,222	258	87	7.0	17	1.4	**3,326**	**266**
Total	**27,470**	**2,198**	**2,569**	**205**	**641**	**51**	**30,679**	**2,454**

The strawberry industry is currently the largest substrate user in the berry industry (Table 4). However, according to consultation feedback, other berry fruit is expected to increase hydroponic production.

A greater proportion of strawberry production is expected to occur in hydroponics in the future.

Coir use in the vegetable industry

Coir use in the vegetable industry has been included in this report to provide context for the volume of coir used by the berry industry. It may be of advantage to link with vegetable producers in a region to negotiate economically viable options with organic recycling companies.

Greenhouse production is on the rise in Australia[11]. Data compiled by Hickman (2017)[12], showed the rapid increase in protected vegetable production in recent years (Table 5). A percentage of protected production occurs in hydroponics (Table 6).

The vegetable industry preceded the berry industry in the use of hydroponic production systems. This industry is still using substrates other than coir, especially rockwool. The hydroponic vegetable industry shares waste management challenges with other protected cropping industries, including berries.

11 Graham Smith, Protected Cropping Australia, pers. comms

12 Hickman GW 2017. Australia Greenhouse ("undercover") Vegetable Statistics (2017 edition). Accessed 14 July 2017 https://cuestaroble.com/australiastats.htm

Table 5. Changes in the main vegetable crops grown in Australia under cover

"Under Cover" vegetable crop area (hectares):				% change	
Period:	2007-08	2014-15	2015-16	2008 to 2016	2015 to 2016
Crops					
Capsicum:	151	149	172	+14 %	+15%
Lettuce:	125	52	75	-40 %	+44%
Tomato:	193	196	251	+30 %	+28%
Total Area (ha.):	469	397	498	+6 %	+25%

The vegetable crop statistics for Australia released July 2017 covers the period of 2015-2016 and includes vegetables grown "under cover". This category is defined by ABS as: "greenhouses, cold frames, cloth houses and lath houses."

According to this data, the main hydroponic vegetable crop production areas are the Sydney region (west and south-west suburbs), the NSW Central Coast and North Coast regions, South-East Queensland, the Werribee district west of Melbourne (Victoria), and the Virginia / North Adelaide Plains districts of (SA). A major production area has been developed near Port Augusta (SA). Costa produces tomatoes hydroponically on a large scale near Guyra (NSW) and with grower partners in South Australia, Tasmania, Queensland and Western Australia. Flavorite Hydroponic Tomatoes is a major player with 8.5% of production in Australia.

Even though large-scale producers have a market share of about 20-30% and operate greenhouse complexes of up to 20 ha in area, the majority of producers still operate on small areas of less than 5 ha. The land neighbouring most hydroponic vegetable farms is rural or semi-rural land, often used for field vegetable production in the open or production in soil under cover. Small farms occur in peri-urban areas.

For this report it was assumed that 50% of vegetables produced hydroponically under cover are grown in coir substrate. Lettuce crops grow for 3-8 weeks, cucumbers, tomatoes, eggplants for several month in the substrate.

Table 6. Estimated hydroponic vegetable production in coir substrate

	15-16	16-17
Total (ha)[13]	118,500	93,791
Hydroponic %[14]	6%	7%
Hydroponic (ha)	7,110	6,565
Coir (ha)	3,555	3,283
Coir (m^3)	373,275	344,682
Coir (t)	29,862	27,757

Assuming usage of 7,000 bags or slabs per hectare of an average volume of 0.015 m3, and the same bulk density as used for berries (80 kg/m^3), the hydroponic vegetable industry would use about 350,000 m^3 or 28,000 t coir annually, about 10 times the amount estimated for the berry industry (Table 6).

13 Horticulture Innovation Australia 2019. The Australian Horticulture Statistics Handbook.
14 Australian Bureau of Agricultural and Resource Economics and Sciences. Vegetable growing environment, Australian vegetable-growing farms, 2016–17

Spent coir substrate reuse overview

Fresh coconut fiber/pith has many uses. Some uses are, in principle, suitable for spent coir. A prerequisite for most reuses is the removal of crop residues and plastic coverings as well as absence of other non-organic foreign matter in the coir. Rockwool plugs used for transplant production can be prohibitive for recycling options. Used coir should never be mixed with other types of wastes occurring on farms.

For many reuse options, the used coir has to be 'shredded' to a consistency that suits the re-use option. Depending on the health status of the crop that grew in the coir, the spent substrate may have to be sterilised (e.g. fumigated, heat treated) or composted (pasteurized and stabilised) before use.

Table 7 provides an overview of uses for coconut fiber/pith and potential for comparable reuse of spent coir.

Table 7: Uses of 'fresh' coconut fiber and potential for comparable spent coir reuse

Use of 'fresh' coconut fiber / pith	Potential for spent coir
Addition to commercial compost	Yes, logistics and arrangements with local compost producers need to be established; composting on farm is possible – training of interested growers required.
Composting on farm	Yes, needs to be done as per composting guidelines (active composting) to kill pathogens or left for a long time to passively compost. Composting can occur together with other organic residues or on its own. If on its own, the C/N ration needs to be suitable.
Mulch or soil amendment	Yes, if free of pathogens and used for a different plant species, unless sterilised or composted prior to use; potential to supply local garden centers or landscaping operations a or local organic recycling business. Potential to control pathogens via solarisation or fumigation
Activated carbon / biochar	Yes, if economical e.g. a biochar producer is in the region and prepared to take the used coir, or a new biochar plant can be set up to run profitably in the region (by a group of growers?)
Potting mix	Yes, as shredded additive (up to 30% of volume) if free of foreign matter and pathogens – potting mix producers may want to run trials before taking larger volumes.
Mushroom cultivation	Yes, as additive or 'capping' if free of pathogens and foreign matter, shredded and consistent – trials required.
Material for animal husbandry	Potentially, if free of foreign matter, shredded, not dusty and used locally e.g. as bedding or litter for chickens
Briquetted or pelleted fuel	May be economical if briquettes or pallets are already produced in the region e.g. from timber waste – trials would be required
Biogas production	May be viable on its own or mixed with other materials, if biogas is already generated close to the hydroponic production area and the resulting gas / electricity and process residues e.g. ash can be used efficiently and profitably – research required.
Mulch to preserve the moisture and soil conditioning	Yes, if free of pathogens and used for a different plant species, unless sterilised or composted prior to use; potential to supply local garden centers or landscaping operations a or local organic recycling business.
Erosion control	Yes, e.g. together with processed green waste via a local organic recycling business.

Use of 'fresh' coconut fiber / pith	Potential for spent coir
Extracting lignosulphonates (used as non-toxic dust suppression agent and soil stabilizer)	Not considered economical for a waste product
Use of 'fresh' coconut fiber / pith	Potential for spent coir
Pallets (https://www.cocopallet.com/)	No, given that the used coir is quite different from fresh coir and of variable quality
Integration with materials for building purposes esp. insulation or particle boards ('coir 'wood'), concrete	
Matting for different purposes	
Textile industries	
Organic wetting agent for foliar sprays	
Dispersing agent	
Adhesion compounds in pesticides, fertilisers	

The recycling options considered most feasible are discussed below.

Working with organic waste recycling companies

Compost and potting substrate producers are able to recycle used coir. The main issues to overcome are transport costs, the requirement to remove grow bags/slab plastic and other contaminants either on farm or at the recycling company. Some organic waste recycling companies have systems to remove plastic. Gate fees would depend on the 'quality' of the spent coir i.e. a fee similar to that charged for green waste if the quality is similar to greenwaste and less if 'clean' and or shredded. The fee for greenwaste is usually about 50% of fees for landfill, 'clean' organic waste would have a gate fee of 50% of that of greenwaste.

Some recycling companies will pick up large quantities of 'clean' organic waste for free depending on the location, type of waste and volumes. The 'cleaner' the waste and the higher the volume, the more likely is a free pickup because it offers higher value processing options i.e. bagged potting mixes are of higher value than mulches used for landscaping. Several smaller scale growers may be able to cooperate to enable free pick-ups.

Some recycling companies will accept private deliveries of smaller quantities at no charge but then will only accept 'clean' organic material and may have restrictions relating to the use of growth regulators or agrichemicals during production.

Producers of substrate (potting media) primarily use composted pine bark plus some green waste and often add fresh coir. They can replace fresh with used 'clean' and shredded coir. They would need to run trials to develop the best approach with the used coir supplier. Most recycling companies produce potting mixes.

Knowing the composition, density and any possible chemical or other contamination of the organic waste will help when dealing with composting facilities. It is important to find out about specific requirements and opportunities by contraction a recycling company in the region.

Finding a local recycling company

Organic material recycling operations in berry producing areas can be found in Appendix 6 or via the interactive map using the URL: https://tinyurl.com/berry-waste-recycling-map. Clicking on the black dots on the interactive map will bring up the contact details for the recycling company.

An overview over organic recycling companies by state is also available via visiting the AORA website: https://www.aora.org.au/compost-for-soils/find-a-composter/.

The main national potting mix producers can be found via:

Biogrow: http://www.biogro.com.au/

Australian Growing Solutions (AGS) https://www.agsolutions.net.au

Direct reuse of coir in the production region

Clean, shredded used coir is suitable for direct reuse in the region or composting on farm. Some recycling companies mentioned that this may be the most economical approach from smaller scale operators who cannot combine with others for 'waste' pick up and or producers who are too far away from a recycling facility.

Examples of direct reuse

Hydroponic growers could link in with other horticultural or agricultural enterprises in the region who might use spent coir in various ways.

A purpose-built set up can be used to remove the plastic and shred the spent substrate. Some growers are already doing this. A shredder operating on side is an option for producers that do not use coir wrapped in soft plastic (i.e. using pots or gutter). It is possible to stockpile the used coir (without plastic) until the volume is large enough to justify hiring a commercial shredder e.g. as used for tree waste. When stockpiling, the operator has to be aware that dry used coir is flammable. It also can absorb moisture and damp used coir left to sit could end up infected with fungi that are harmful to humans when spores are inhaled.

The following options have been identified

- Use as a soil amendment on own or neighbouring land e.g. before planting perennial crops (fruit, nuts, grapes) or for annual crops as long as the planting equipment for the annual crop can handle a certain amount of fibrous material in the topsoil
- Use as a mulch in orchards and vineyards in the region
- selling it to a regional garden centre or partnering with a local landscape company or a park manager who will collect the shredded material and use it as mulch, soil amendment, addition to potting mix, erosion control or compost it for later use.
- Spent coir, free of contaminants, may be used as animal 'bedding' e.g. in nearby chicken sheds or for free range chickens runs as deep litter
- Composting on farm and reuse on the farm or in the region; the composting process has to be controlled as per Appendix 5. Co-composting using manures or spent mushroom compost may be needed to achieve the required C/N ratio or to improve the finished product.

The economic viability of different reuse options has to be investigated on a case by case basis. Labour, logistics, transport cost and opportunities for reuse nearby will be the main variables affecting viability of reuse options.

Other

Alternative disposal options may be found via local business recycling websites, planet ark[15] or local council websites.

Getting rid of pathogens in used coir

Some reuse option may require sterilisation or fumigation to kill fungal diseases and nematodes.

Custom made bins could be used to steam sterilise used but clean, shredded coir. The sterilised substrate may then even be reused as growing medium, if the structure was still suitable.

When used as a soil amendment a fumigant like chloropicrin/telone may be used to fumigate the soil after spreading.

15 : https://planetark.org/campaigns/rny.cfm

Alternatively, coir may be spread on the soil surface and left exposed to the sun for several days to kill pathogens before incorporation. This approach requires trials to validate efficacy of this simple solarisation approach.

A 6-week period of composting as a heat treatment (refer to Appendix 5 for details) will kill pathogens like damping off fungi (*Pythium* spp. *Rhizoctonia* spp., *Fusarium* spp., *Verticillium dahliae*) *Phytophthora* spp. and nematodes.

The cost/benefit of pathogen removal options would have to be investigated on a case by case basis. The nursery industry has investigated options of sterilising substrates[16].

Alternative disposal options may be found via local business recycling websites, planet ark or local council websites.

Future options

While producers can connect to organic recycling companies without delay and explore local opportunites, the future options listed here require further investigation and or coordination.

Reduce coir substrate use

Aeroponics or deep-water culture systems do not rely on substrates at all or use reduced amounts of a growing medium to allow roots to anchor. Only a small layer of substrate is often needed, and the root network is primarily in air or water. Perforated cups or baskets hold the plants and roots are submerged in an aerated or oxygenated hydroponic solution.

Water based culture could be investigated as an option to using coir, especially for crops that remain in culture for one year of less.

Energy from organic waste

A currently not used method of 'disposal' is to use used coir as a biofuel in a co-generation system with other suitable organic wastes to produce electricity or fuel to replace diesel or even aviation fuel[17].

Biogas

Bioenergy Australia[18] is an organisation that can provide information on the suitability and economics of using spent coir for biogas production and locations of current biogas producers.

Bioenergy Australia developed a calculator that estimates the potential volume of methane, the energy content and the electricity generation based on the amount of residue available at a given time. Attributes required are volumes and tonnes per year and percentage of total solids (dry matter content). The calculator does not include coir waste. Attributes of coir for biogas generation would need to be investigated.

Biochar

Woody greenwaste is used as a feed source to produce biochar. Spent coir could be used in the same way, if a processor was already in the area or a producer or group of producers was able to set up a viable biochar operation. Biochar production may an option worth investigating further. The economics of producing biochar depends on the suitability of coir as a substrate in the first place.

A major biochar producer, Green Man Char[19] is located in Victoria near Melbourne. This company may be interested in trialing coir as a feed stock and provide feedback on the feasibility and economics of using it.

Mobile and static biochar kilns are offered by several companies around Australia. The feasibility and economics of running a small plant on-farm needs to be investigated by individual businesses.

16 https://www.ngia.com.au/
17 Waste Management Review, March 2019 http://wastemanagementreview.com.au/plant-waste-to-power-planes/
18 Bioenergy Australia https://www.bioenergyaustralia.org.au/resources/biogas/
19 https://greenmanchar.com.au/

Opportunities

Working with the nursery industry

The complex nursery industry encompasses a broad range of businesses producing and marketing ornamental plants from seedling to mature trees and turf. The industry produces many crops in substrates. Flower crops are produced in hydroponic systems using coir.

Different sectors of the nursery industry use or produce and or trade in substrates.

Figure 4 provides an overview of the growing media supply chain. It highlights the complexity of relationships and that opportunities may exist to engage with the sector on potentially combining waste streams or providing substrates made from or with spent coir.

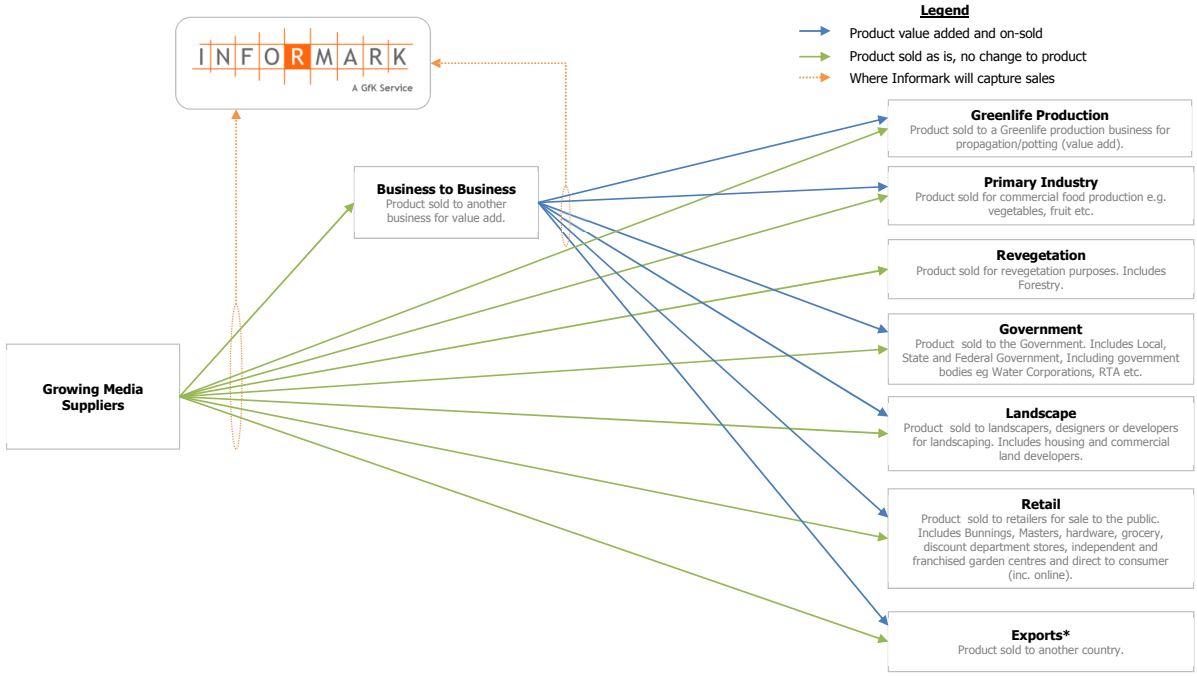


Figure 4. The growing media supply chain[20]

Stewardship programs

Product stewardship is a regulation and code of practice introduced under the Product Stewardship Act 2011[21]. The act provides a framework to manage the environmental and community impact a product has over its life-cycle. It states that anyone who is involved with the production, sale, use or disposal of a product has a responsibility to manage and limit the impact the product has on the environment and human health.

The 'Product Stewardship Advisory Group' is an independent group that develops lists of products to be regulated under the Act. Waste streams currently regulated are the national television and computer recycling scheme, and the national tyre product stewardship scheme.

Coir recycling would not 'qualify' for a regulated scheme but would be well suited to a voluntary scheme.

Several voluntary product stewardship schemes currently exist. These include the mobileMUSTER, drumMUSTER[22], Flurocycle, used battery collection program and the Australian packaging covenant. Farm

20 INFORMAR 2012

21 Department of Environment, Product Stewardship legislation https://www.environment.gov.au/protection/national-waste-policy/product-stewardship/legislation

22 Farm Waste Recovery https://farmwasterecovery.com/ (Stephen Richards, stephen@farmwasterecovery.com 0499 053 255)

Waste Recovery is an example of stewardship programs for plastic waste. A similar stewardship approach may be taken to recycle coir.

Information on how to set and run a voluntary scheme can be obtained from the Australian Department of Environment and Energy[23].

The berry industry may want to explore a cross industry stewardship program for coir reuse involving the coir supply chain, the vegetable and nursery industries as well as key organic recycling organisations and potentially biochar and biogas producers. Consulting for this project showed that coir suppliers and organic recycling companies would in principle be interested in being part of a solution to the coir/substrate waste problem.

A major requirement for developing and maintaining a stewardship scheme is the need for an organisation or person driving such a 'closing the loop' approach. This organisation or person would drive communication between suppliers, growers and organic recyclers as well as others interested in using the spent coir 'products'. Peak industry bodies could play a major role in setting up a stewardship scheme and explore funding opportunities to get a scheme started.

Plastic waste

Many growers mentioned that plastic waste is becoming a major issue for them. This project did not investigate plastic management options given the relevance of recommendations from project VG 13109 "Innovative ways to address waste management on vegetable farms". These recommendations have so far not been followed up on.

The below additional links may be of use for plastic waste managment.

1. Farm Waste Recovery - https://farmwasterecovery.com/
2. Planet Ark - https://planetark.org/campaigns/rny.cfm, https://recyclingnearyou.com.au/
3. Sustaining Endeavour - https://sustainingendeavour.com.au/ facilitating circular economies for businesses in the Australian plastics industry and for wine-grape growers

Bioplastics

While this project did not get encouraging feedback from bioplastics producers, the situation may change in the future. The following links may be of use:

- Australian Bioplastics Organisation - https://www.bioplastics.org.au/
- Australian Bioplastics producer - http://www.austbioplas.com.au/
- Cardia Bioplastics - http://www.cardiabioplastics.com/products

Bioplastics have to comply with "Australian Standard AS 4736 'Biodegradable plastics suitable for composting and other microbial treatment".

General information on recycling

For general information on the recycling sector, it is worthwhile to subscribe to the Waste Management Review newsletter via http://wastemanagementreview.com.au

A waste self-assessment pack developed for the nursery industry[24] including all relevant documents can be found in the report "Assessing waste streams in Australian production nurseries" available from the Nursery and Garden Industry Australia (NGIA) website (https://www.ngia.com.au/).

23 http://www.environment.gov.au/protection/waste-resource-recovery/product-stewardship/voluntary-product-stewardship
24 Hort Innovation 2014; Assessing waste streams in Australian production nurseries. Final report for NY13003.

Monitoring and evaluation

Evaluation QUESTION	ANSWER
Effectiveness	
1. To what extent has the project achieved its expected outcomes, or will do so in a foreseeable time?	The project outputs support the immediate outcome stated in the project logic: Identification and effective communication of used coir management options – communication of outputs has been arranged to occur via the new peak industry body, Berries Australia, their website newsletters and e-information / social media. The project produced linkages / networks that enable growers to act on used coir management, especially with the recycled organics sector. Berries Australia may follow up on linkages and recommendations developed from this project i.e. connecting with recycling organisations via the peak industry body AORA as well as linking with the protected cropping and nursery industries, who have similar waste problems, through the respective peak bodies. A voluntary stewardship program has been suggested as one approach to manage coir 'waste', closing the loop between imported coir substrates, hydroponic production and reuse. While there is no peak body representing coir importaters that can be approached, there are only few major importers in Australia; it should be possible to talk to one or two of them about a stewardship program. Galuku showed serious interest already. The project identified RD&E opportunities which are included in the report. Investigating the potential to produce energy from waste or biochar with good economic outcomes for all involved are the two main prospects to investigate. The project did not go into detail about dealing with plastic waste. This is an issue already investigated by the vegetable and nursery industries with support from Hort Innovation. The next step for the industry would be to take up recommendations from respective reports and commence work on implementation. Plastic waste is an and all of horticulture issue. A solution for all of horticulture should be identified and implemented. The project did not achieve the longer-term aim of reducing on-farm waste, however it provided information and recommendations that make this an achievable objective. The project identified that the process would have to be driven by commitment from several key organisations, with one of them taking the lead. The reason is that even if relevant research has been conducted and reported, e.g. by the vegetable industry on plastic waste and the nursery industry on general waste, implementation of recommendations does not seem to happen.
Relevance	
2. How relevant was the project to the needs of hydroponic berry growers (intended beneficiaries)?	The project has been relevant given the increasing use of coir fiber and prevalent stockpiling of used coir. It highlighted the role linkages between peak bodies from different sectors can play to solve a wider problem, as well as the potential to adopt a stewardship program to 'close the loop' i.e. engage all involved in the importing, sales, use and reuse of coir (supply chain). It is relevant that the project emphasised the main barriers to change in waste management. They are:

	• the costs of handling and transport • time required to deal with it • a lack of technology to separate coir from plastic (on most farms and by many recycling companies) • limited data on the 'make up' of spent coir from different production systems ((chemical, biological) and therefore it's value • Regulations are not uniform in each state; regulations from different organisations may apply (e.g. in charge of Environment, Biosecurity, Food safety) • Lack of applied research e.g. 'profiling' spent coir, value of coir for different reuses such as recycled organic products (i.e. soil amendments, composts, mulches, potting mix), bioenergy, biochar • in many cases, lack of communication between those who want to get rid of the 'waste' and those who can put it to good use.
Process appropriateness	
3. How well have intended beneficiaries been engaged by the project?	The major engagement has been via consultation and the Strategic Industry Advisory Panel. The main written communication took place via the current strawberry communication project. RABA did no engage with the project. Berries Australia had just been formed towards the end of the project. Industry engagement would have been better, had the organisation existed at the outset. However, Berries Australia has indicated that it will disseminate outputs once an effective communication and extension system has been set up.
4. To what extent were engagement processes appropriate to the target audience/s of the project?	Engagement took place vie phone, email, face to face discussions as well as visits to berry growers and organic recyclers. Engagement processes are considered appropriate given the timing of the project, especially consultation. However, engagement with the issue and potential solutions needs to continue after the project has finished to make sure all berry producers and the organic waste industry are aware of opportunities, can eliminate challenges and work on the implementation of effective waste management e.g. via peak industry bodies. The project PRG was to meet three times during the course of the project. However, given the project ran during the busiest time for producers, only one meeting with all members took place. However, individual conversations took place with all members prior to the meeting. PRG insights were valuable and used.
Efficiency	
5. What efforts did the project make to improve efficiency of delivery and were they adequate?	The project manager engaged with other industries that have similar waste problems; Nursery and Garden Industry Australia (NGIA) and Protected Cropping Australia (PCA). NGIA has recognised waste management as a key issue and has identified key research needs. The NGIA website provides useful resources on waste management which are relevant to the berry industry. Rather than researching the plastic waste issue again in detail, the project took up information from work done for the vegetable industry on plastic waste management. Knowledge of what other industries have been researching and good networks, including with the recycled organics sector, provided efficiencies and added valuable information and linkages for industry to follow up on.

Recommendations

General

Recommendation 1

Berry producers to link up with organic recyclers in their region to determine the most suitable way of collection and recycling. Appendix 6 of this report provides relevant reginal information. The maps are available in an interactive format via https://tinyurl.com/berry-waste-recycling-map.

Berry producers should explore opportunities in the vicinity of their berry operation e.g. with landscape companies, chicken producers, orchardists. Profiling of the used coir would be required before engaging with potential users.

Recommendation 2

This project highlighted that the protected cropping (fruit, vegetables, flowers) and nursery industries have a similar waste management problem to the berry industry. Solutions should be addressed holistically. A voluntary stewardship program should be explored, involving the entire supply chain. A start could be made by the following players:

- The three major coir importers
- Berries Australia
- Protected Cropping Australia (PCA)
- Nursery and Garden Industry Australia (NGIA)
- Australian Organic Recycling Organisation (AORA)

The peak industry bodies could explore how to deal with other common waste issues in their respective industries.

Recommendation 3

The berry industry should utilise resources produced by NGIA and published on their website:

- An investigation into waste management in Australian production nurseries (provides an overview of wastes steams and potential solutions)
- An economic analysis of changing waste management practices in an Australian production nursery (includes information on sterilization of substrates, pots and equipment as well as compacting and baling plastic wastes.)
- Fact Sheet - Waste disposal in production nurseries
- Fact Sheet - Steps to reduce waste management and disposal costs.
- Nursery waste self-assessment survey form
- Waste management cost estimate worksheet
- Waste management cost calculator

The report VG13109 “Innovative ways to address waste management on vegetable farms” includes a set of recommendations covering issues for the protected cropping sector; they should be revisited.

Research, Development and Extension (RD&E)

The organisations listed above should communicate about RD&E needs in the area of common waste management strategies and activities.

R&D topics identified by this project are :

- Profiling of typical spent waste material from different berry crops to provide to potential reusers
- Type and longevity of pests, diseases and weeds in coir from different crops and effectiveness/costs of sterilisation options apart from composting

- Development of mobile equipment that can be used near greenhouses or tunnels to remove plant debris, foreign matter and plastics with coir/root residue collected in suitable containers for shredding or being shredded in the process
- Investigating the economic feasibility of producing biogas and biochar from spent coir
- Investigating the feasibility of using spent coir for mushroom production
- Investigating the economic feasibility of producing pellets or briquettes to be used by households instead of firewood; https://pellet.com.au/ provides an example of producing pellets from timber waste.

Research results need to extend effectively. Extension is not communication of results and recommendations to a passive audience. Extension is about active engagement and facilitation of adoption including supporting the adaptation of R&D outputs if required.

Refereed scientific publications

References have been provided as footnotes throughout the report where used to support the information provided in the text. These and additional references reviewed as part of the project are listed below.

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Intellectual property, commercialisation and confidentiality

No project IP developed

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We would like to acknowledge all growers, coir suppliers, association members, recycling specialist and consultants for their time and insights. We apologise to those we have spoken to in details and not listed here.

We acknowledge the valuable direction provided by the project reference group and the Horticulture Innovation strawberry and Rubus Strategic Investment Advisory Panel (SIAP) members.

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Aileen Reid	WA Strawberry Growers
Alison Holstrom	Dulverton Waste Managment, Tas
Andrew Olley	Myriad International Pty Ltd
Andy Gulliver	C-Wise WA
Angela Atkinson	Vic Strawberry Growers
Andreas Wrede	Landwirtschaftskammer Schleswig-Holstein (Agricultural Council of Schleswig-Holstein)
Anthony Corrone	Indulge Farms
Anthony Yewers	Berry Sweet
Bruce Wallace & Sage Hahn	Bio-Gro
Cameron Folder	Costa Group
Chris	Kelpomix
Daniel Rolek	Sunny Ridge Farm
David Bardon	Galuku
David Bonser	AORA
Gary Edwards	Garden City Plastics
Gearge Jesset	Costa Group
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Jan Davies	PCA Tasmania
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Jen Rowlings	QLD Strawberry Growers
Jim Ripepi	ASD

Name	Organisation
Joe	Australian Bio-Plastics
John Elford	Hydroponic Farmers Federation (HFF)
Jonathan Eccles	RABA
Justin Jones	Just Waste
Lachlan Jeffries	Jeffries Group
Lee Peterson	Berry World Australia
Lien Ko	QDAF
Martin	Eco-Mix
Matt Holmes	Costa Group
Michael Oakwood	Oakwood Consultants
Mick Surridge	Scato Plus
Nadia Boscaini	Fresh Produce Markets ADL
Peter Vaughan	NGIA
Peter Wadewitz	Peats Soil & Garden Supplies and AOARA
Renga Ramasamy	Jeffries Group
Ronan Hoyle	Galuku
Ross O'Halloran	Waterhold Pty Ltd
Rowan Willams	BASF - AU marketing manager (bioplastics)
Scott Mattner	Victorian Strawberry Industry Certification Authority (VSICA)
Simon Dornauf	Hillwood Berries
Stephen Richards	Farm Waste Recovery
Uma Preston	Sustaining Endeavour (plastic recycling)

Appendix 1: Project Plan

RMCG

AUGUST 2018

Coir waste management for hydroponics in berries – MT17016

Project Plan

Hort Innovation

Level 1, 357 Camberwell Rd, Camberwell, Victoria 3124
(03) 9882 2670 – rmcg.com.au

Table of Contents

1 Introduction

1.1 THE PROJECT

Project Background, Methodology and Outputs for MT17016 'Coir waste management for hydroponics in berries' can be found in Attachment 1. Milestones for the project can be found in Section 5.

The overall objective of the work is to assist hydroponic berry producers to adopt innovative, novel approaches to coir management. The opportunity and expected outcome is that producers will:

- Reduce on-farm coir related waste and associated costs, and
- Reduce the coir waste related risks and costs associated with pest and disease management.

1.2 PURPOSE AND STRUCTURE OF THIS PLAN

This plan is a foundational, guiding document that describes what success will look like, how to measure it, how to mitigate risks, timeliness for key activities that will be undertaken and consultation/communication methods with stakeholders.

This plan details:

- Introduction - this section
- Program logic and monitoring and evaluation (M&E) framework (section 2)
- Risk management plan (section 3)
- Stakeholder consultation plan (section 4)
- Communication plan (section 4)
- Project work plan (section 5).

2 Project monitoring and evaluation

2.1 PROGRAM LOGIC

The program logic forms the high-level framework for the Project and governs the subsequent Monitoring and Evaluation (M&E) framework. This includes consideration of the hierarchical connection between the project activities and the Berry Industries' Strategic Investment Plan (SIP) outcomes. The logic for the project is illustrated in Figure 2-1.

The relationship to strategic investment plans (SIP) is via the overarching strategic goal of increasing productivity. While productivity is often expressed in yield increase, it actually relates to improving marketable yield while reducing operational costs. The management of waste is an operational cost. Poor waste management, if seen to impact on the environment, may also lead to reputational damage and affect how customers and consumers view the product.

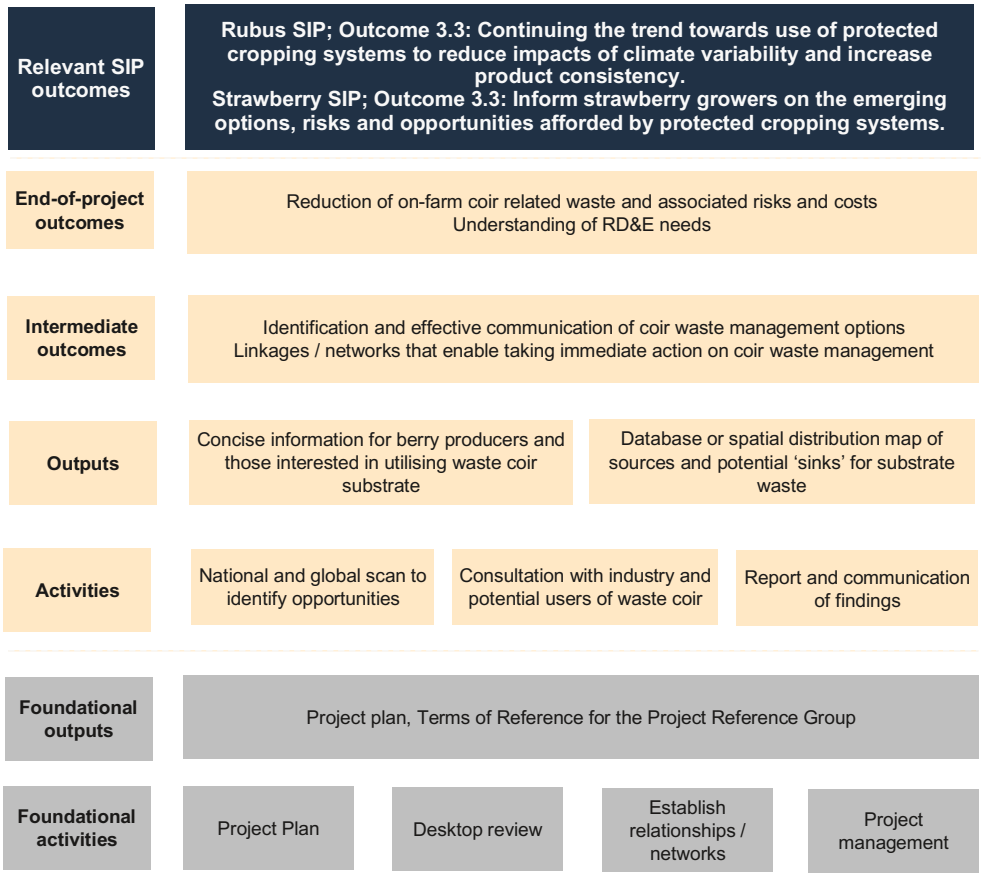


Figure 2-1: Program logic for MT17016 'Coir waste management for hydroponics in berries'

2.2 MEASUREMENT AND EVALUATION (M&E)

2.2.1 AUDIENCE

Key audiences and their required information needs (outputs) in relation to the M&E Plan are listed in Table 2-1. The Primary audience will have input into the project and provide direct input and or feedback for the M&E. They will comment on the project delivery process, outputs and how outputs will be used to make decisions on coir waste management, and ultimately have the expected outcome. The Secondary audiences will have an interest in the project and M&E findings; they may comment on the project (via consultation or proactively) but do not have a direct influencing role on delivery.

Table 2-1: Monitoring and Evaluation audience and their information needs

AUDIENCE	INFORMATION NEED / OUTPUTS
Primary	
Project Team (RMCG)	Project progress, performance against milestones, extent of levy payer engagement and participation, stakeholders engaged and consulted, relevancy of project data produced, reporting, project cost control
Project Reference Group (PRG)	Project progress, performance against milestones, extent of levy payer engagement and participation, stakeholders engaged and consulted, relevancy of project data produced, reporting
Hort Innovation	Project progress, performance against milestones, extent of levy payer engagement and participation, stakeholders engaged and consulted, relevancy of project data produced, reporting, project cost control
Secondary	
Industry Associations, e.g. Strawberry and Rubus Associations	Project progress, stakeholders engaged and consulted, relevancy of project information received

2.2.2 KEY EVALUATION QUESTIONS

The key evaluation questions (KEQs) are arranged by key themes in Table 2-2.

Table 2-2: Project key evaluation questions

KEY EVALUATION QUESTIONS
Effectiveness
1. To what extent has the project achieved its expected outcomes (see Logic), or will do so in a foreseeable time?
Relevance
2. How relevant was the project to the needs of hydroponic berry growers (intended beneficiaries)?
Process appropriateness
3. How well have intended beneficiaries been engaged by the project?
4. To what extent were engagement processes appropriate to the target audience/s of the project?
Efficiency
5. What efforts did the project make to improve efficiency of delivery and were they adequate?

2.3 KEY PERFORMANCE INDICATORS, DATA COLLECTION AND ANALYSIS

Key performance indicators (KPIs), have been set to assess the performance of the project in achieving its intended outcomes. The key performance indicators for the question, and how the evidence of progress towards these indicators will be collected is described in Table 2-3.

Given the short timeframe of the project, M&E will occur towards the end of the project and results will be reported with the final report (Milestone 109, 21-12-18). Earlier milestone reports will state on progress (KPI's achieved) as occurring and required in the agreement with Hort Innovation. The project manager is responsible for M&E.

Table 2-3: Project monitoring plan

LOGIC LEVEL	WHAT TO MONITOR	KPI'S AND/OR MONITORING POINTS	EVIDENCE TO CHECK
Foundational activities	Planning Desktop review Establishment of relationships/networks Project management	Documentation Relationships & networks established, (industry associations producers, potential off-site users of coir, others)	Records Reports Feedback from networks (subsample sample)
Activities and outputs	Feedback from global scan Number of key stakeholders consulted Number of responses to online requests (newsletters or survey) Number of face to face visits Communication products	Communication by stakeholder category and type (email, phone, visit) Communication via articles in newsletters	Project records and documents Feedback
Intermediate outcomes	Changes in knowledge of and/or use of waste management options in key regions	Number of growers changing or planning to change waste management Usefulness/relevance of information produced for levy payers	Observations Feedback from industry – informal and formal

Longer term outcomes would have to be assed several months after the project has finished. This could be conducted via industry associations.

LOGIC LEVEL	WHAT TO MONITOR	KPI'S AND/OR MONITORING POINTS	EVIDENCE TO CHECK
Longer-term outcomes	Coir waste reduction Relevant R&D	Decrease in waste problems R&D happening	Feedback from industry Hort Innovation R&D projects

2.4 REPORTING AND CONTINUOUS IMPROVEMENT

Communication of project performance and key findings will be through various channels as outlined in Table 2-4. Findings from the project evaluation/feedback during delivery will be used to improve it as outlined in Table 2-5.

Table 2-4: Project progress reporting

REPORT TYPE	TO WHOM	TIMING
Milestone reports	Hort Innovation	As scheduled
Final report	Hort Innovation	At end of project
Articles	Industry newsletters	At the start, middle and end of the project
Oral and written communication	Growers & stakeholders, Hort Innovation, PRG	During the project as part of delivery

Table 2-5: Project continuous improvement activities

CONTINUOUS IMPROVEMENT PROCESS	DETAILS	TIMING
Team meetings	Project team meetings to tasks and progress	Weekly and as required during the project.
Reflection meeting with Hort Innovation R&D Manager	Hort Innovation Manager and Project Manager telephone meetings to discuss progress to date and what's working well/not, and agree any follow up actions	Bi-monthly, or as required.
PRG	Telephone meetings	Start and towards end of project; other as required

3 Risk Management

Project risks range across technical, biophysical, extension, partnerships and internal. The likelihood and consequence of these risks were analysed using a risk matrix as outlined in Table 3-1.

Table 3-2 highlights the risks that were identified and how these will be managed (mitigation strategies). These risks will be reviewed at a Project Reference Group meeting with the mitigation strategies being the responsibility of the project team.

Table 3-1: Risk matrix

RISK	CONSEQUENCE				
Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Low	Medium	High	Very High	Extreme
Likely	Low	Medium	High	Very High	Very High
Possible	Low	Low	Medium	High	High
Unlikely	Minimal	Minimal	Low	Medium	High
Very unlikely	Minimal	Minimal	Low	Low	Medium

Table 3-2: Risk management plan

ID	RISK DESCRIPTION	SOURCE OF RISK	IMPACT OF RISK	CONTROLS	TREATED RISK ASSESSMENT	RESPONSIBLE PERSON
1	Networks not developed	Stakeholders and growers unwilling or unable to engage for various reasons or not aware of the project	Lack of realistic solutions Communication opportunities not optimised Lack of uptake of findings	Utilise and build on existing relationships Early engagement with stakeholders via phone calls, visits and written communications Use of multiple communication channels to engage with growers and stakeholders	Moderate Unlikely = LOW	RMCG Project Manager
2	Unable to identify feasible coir waste management options for all or some parts of the industry	Poor data/information collection, findings not suitable to achieve desired project outcomes or show limited options	Inability to improve coir waste management Inability to address key barriers that allow alternate waste management options	Experienced project team who have undertaken similar projects in the areas of organic waste recycling Good networks Good technical knowledge of berry industries and potential options Creativity and tenacity	Moderate Possible = MEDIUM	RMCG Project Manager
5	Lack of stakeholder participation in consultation activities	Stakeholders unable / not interested in engaging with the project to develop options	As above	Utilise and build on existing relationships Promotion of opportunities for engagement through existing established channels, e.g. newsletters, working groups, individuals	Minor Possible = LOW	RMCG Project Manager
6	Loss of key project personnel	Key staff resign or retire	Loss of knowledge and skills	Other RMCG staff with the required skills are available Comprehensive data documentation and storage to ensure data integrity maintained	Low Unlikely = LOW	RMCG Project Manager
7	Project management risks (budget, time, quality, scope)	Budget: Budgets not regularly monitored; activities cost more than originally anticipated; lack of control over budget allocation Time: Schedule dominated by critical tasks; tight timeframes Quality: Poorly skilled people; lack of reviews and monitoring; low commitment to quality standards Scope creep: poor definition of expectations; poor documentation; lack of scope control measures	Collecting information that is 'interesting' but not clearly correlated to the research question may create additional work for RMCG and project participants Cost of industry consultation may be higher and take longer than budgeted	Adhere to RMCG Quality Management System (QMS) to ensure rigorous and consistent processes are followed in the delivery of the project Key personnel experienced in project management Good communication with Hort Innovation Project manager and amongst team	Moderate Unlikely = LOW	RMCG Project Manager RMCG Project Team

4 Stakeholder Engagement and Communications Plan

The stakeholder engagement plan of the project is outlined in Table 4-1. The plan outlines:

- Why stakeholders will be engaged
- The level of engagement, and
- Proposed method of engagement.

Table 4-1: Stakeholder engagement plan

STAKEHOLDER GROUPS	PRODUCERS AND INDUSTRY ASSOCIATIONS & PRG	COIR SUPPLIERS	ORGANIC WASTE MANAGERS	RELEVANT TECHNOLGY COMPANIES	HORT INNOVATION
Why engage with this group?	To identify current practices and feasible solutions To inform about the need for RD&E	To identify current challenges and needs of the sector in utilising coir waste To come up with solutions	To identify current challenges and needs of the sector in utilising coir waste To come up with solutions	Awareness of industry needs Identify solutions identification	Keep informed of progress, issues and opportunities To inform about the need for RD&E
What is the level of engagement*	Consult, empower involve and inform	Inform and involve	Inform and involve, empower	Inform Involve Collaborate	Collaborate
Proposed method of engagement	Direct contact via a range of channels (in-person, telephone, email) and using industry networks and communications, reports and factsheets throughout the project. Growers directly or via Australian Rubus Growers Association (RABA) and Strawberries Australia Inc. using the 'Strawberry Innovation' and 'BerryLink' Newsletters as well as Hort Innovation communications as appropriate.				Regular updates with Hort Innovation Project manager PRG meetings

*** Levels of engagement:**

- **Inform** – To provide information to assist stakeholders to better understand the issue, and/or identify alternatives, opportunities and/or solutions to the issue.
- **Consult** – To obtain feedback from key stakeholders on the issue, alternatives and/or outcomes.
- **Involve** – To engage directly with key stakeholders throughout the project to ensure that major concerns and needs are understood and considered.
- **Collaborate** – To partner with key stakeholders to develop/evaluate solutions to problems, to make decisions, provide advice and to identify preferred solutions.
- **Empower** – To deliver solutions and/or the ability for informed decision-making in the hands of the stakeholder. Stakeholders are then enabled to directly contribute to the achievement of project outcomes.

5 Project Workplan

The summary workplan is outlined in Table 5-1. A detailed workplan to guide activities has been prepared in Smartsheet, an online project management system. The Hort Innovation project manager has access to the Smartsheet.

Table 5-1: Summary workplan

MILESTONE	TASK	ACHIEVEMENT CRITERIA	COMPLETION DATE
101	Agreement Signed. IP Arrangements in place.	▪ Executed agreement between Hort Innovation and RMCG ▪ Inception meeting minutes	20 July 2018
102	Project Plans approved by Hort Innovation with input from PRG	▪ Program logic, detailed work plan, M&E plan, risk management plan, engagement / communication plan ▪ Media release about the project for inclusion in industry communication approved ▪ 1st PRG meeting held / PRG members consulted ▪ Brief activity summary	28 August 2018
103	Investigation of innovative coir waste management options completed, industry resource development in progress	▪ Completed national scan of practices and potential opportunities in berry production regions ▪ Completed global scan of novel, innovative options ▪ Factsheet template approved and draft fact sheets available for review ▪ 2nd and 3rd PRG meetings held / PRG members consulted	20 November 2018
190	Final Report Received by Hort Innovation Final Statement of Receipts and Expenditure received	▪ All project outputs provided to berry producers and Hort Innovation as user friendly factsheets /resources and in an updatable format ▪ Final report describing research methods, discussing findings and the rationale for the choice of resources for growers; it includes RD&E investment recommendations for the Strawberry, Raspberry & Blackberry SIAPs and outcomes from the M&E.	21 December 2018

Attachment 1: Project Background, Methodology and Outputs

BACKGROUND

Strawberry and Raspberry-Blackberry SIP's include strategies to inform growers of emerging options, risks and opportunities afforded by protected cropping systems. Hydroponic production is such an opportunity. One challenge for this production system is to dispose of spent coir substrate in an economically and environmentally acceptable, risk free manner.

Avoidance and beneficial use of waste products from horticultural production processes is important because:

- Waste means lost income or additional costs for the producer
- Landfill is discouraged and therefore expensive
- Environmental sustainability is a requirement ('right to farm'), whether we like it or not.

Our involvement with the Rubus industry, especially strategic investment planning and consulting to Costa Group berry production operations over the past 10 years, confirms that undercover hydroponic production of raspberries and blackberries (Rubus) will be a preferred production system with coir fibre the best type of substrate[1]. According to Strawberries Australia, strawberries are still mainly grown in soil, with a minor proportion produced undercover or hydroponically. This will change in the coming years. One reason is that effective fumigation and management of soil borne diseases is becoming challenging, crop rotation options are limited, and soilless production can be more efficient (nutrition, picking).

Hydroponic production requires an inert growing medium with good water and air holding properties. Apart from coir, rockwool, peat, perlite, pumice and even vermiculite can be used. Weight of the medium, sustainability of supply, and disposal of waste materials are important selection criteria. Peat is a limited resource, and there are strong environmental pressures to reduce its use in horticulture. However, some growers still mix coir and peat. The production of rockwool is energy demanding; its disposal after use is a major problem. Therefore, over the past 25 years, the use of coir dust / coco peat as a substrate has increased internationally. It is a plentiful, renewable resource; has high structural stability and can be transported in a compressed state. It expands by about five times after adding water. Typically, coir substrate is used for one year with strawberries, three to four years with Rubus spp. and up to 5 years with blueberries before being discarded. Blueberries are mentioned given many berry producers grow them and hydroponic production is increasing. Even cherry producers are now looking at hydroponics.

The Philippines, Indonesia and India produce about 90% of the world harvest of coconuts and thus coir pith and coir peat. Coir is high in carbon in the form of lignin and cellulose, C/N is around 120/1, meaning it needs additional nitrogen to break down. It is low in nutrients but will have accumulated some during its use.

[1] Mann, A.-N. 2015; Intensive Berry Production Using Greenhouses, Substrates and Hydroponics. Is this the Way Forward? Nuffield Australia Project No 1415

Coir currently has many uses including but not limited to:

- Mulching effect to preserve the moisture and soil conditioning
- Potting mixture for seedling growth mushroom cultivation
- Bedding material for animals
- Erosion control
- C source for compost
- Briquetted fuel, Bio-gas production
- Integration with material for building purposes esp. insulation or particle boards, concrete
- Activated carbon
- Textile industries
- Extracting lignosulphonates
- Wetting agent
- Dispersing agent
- Adhesion compounds in pesticides, fertilizers.

Coir producing countries are conducting research into value adding of coir. These options will be investigated to determine whether any of them may be suitable for spent coir.

Berry production locations are an important consideration when looking at re-use options for coir. Long transport routes for the waste or recycled product are not economically viable and in the case of waste, may pose a biosecurity risk. Rubus production occurs along the Eastern Seaboard, with the majority of production in Victoria and Tasmania. Queensland and Victoria are growing 77% of the national strawberry volume (Beerwah, Stanthorpe and Sunshine Coast regions, Qld; Yarra Valley, Vic). Of the remainder, WA accounts for 11% (Wanneroo and Albany), the Adelaide Hills, SA for 7%, Tasmania for 4%, and the Camden region, NSW, for 1%; all production is concentrated in coastal regions.

It may appear that spent coir could be used similarly to fresh coir. However, spent coir will be entangled in roots, especially after Rubus production, and contained in plastic (PE, HDPE) growbags (slabs) or planterbags. Pots are used infrequently. Biodegradable bags may be an option. Ideally, we will find a use for the entire bag and its contents or a cost-effective way to separate the plastic from the organic material. Prototypes exist to do this. The separation of organic and PE waste could be done as part of composting if with composting operations that have state of the art separation equipment. Spent coir is also enriched with nutrients, which will assist breakdown. Nutrient content and pest and disease risks have to be considered for all reuse options.

Based on our experience with managing organic wastes, many of them with a more challenging composition than coir waste, the organic proportion of the discarded substrate & roots & bags 'package' should have economically viable uses. These uses will not be one-fits all solutions. Depending on location of production, waste volumes, logistics and reuse options, opportunities will differ.

We will investigate novel and innovative global approaches to coir waste management applying the 'avoid, reduce, reuse, recycle' principles. We will refer to previous work in this area by Hort Innovation (e.g. as per RFP; VG13109, VG13049, VG13050, MT09068; and VG990016 "Identifying the benefits of composted soil amendments to vegetable production"). We will confer with organisations we know who are working in the area of resource recycling, especially waste management companies who have a composting business. As required, we will consider regulatory requirements and guidelines e.g. Environmental Protection Authority. Galuku will be a valuable co-operator given their interested in the sustainability of the total lifecycle of their products and economic success of their customers.

METHODOLOGY AND OUTPUTS

The following table provides an outline of the methodology and schedule of work. All activities will be completed by the nominated RMCG team.

	PROJECT INCEPTION, SCOPING AND MILESTONE (MS102) DELIVERABLES
Activity 1	Doris Blaesing will liaise with the Hort Innovation project manager to determine key industry representatives to engage with in a project reference group (PRG). The Hort Innovation project manager will be a PRG member. Doris will prepare 'Terms of Reference' for PRG members and call the first meeting to confirm project scope and discuss activities 2-4. After the first PRG meeting, MS102 deliverables (outputs) will be produced. The Hort Innovation project manager will endorse the outputs.
Outputs	Minutes from the 1st PRG meeting (confirmed by members). MS102 comprising a brief activity summary, a program logic, a detailed work plan in SmartSheet software, a monitoring and evaluation plan with linkage to Hort Innovation and industry/fund objectives, a project risk management plan, a stakeholder engagement/communication plan and a media release about the project for inclusion in industry communications. MS102 outputs will be made available to the PRG.
Timing	Activity and outputs completed within the 6th week from execution of the RD&E agreement with Hort Innovation
Activity 2	**National scan potential opportunities in berry production regions**
	Investigate the type, composition and volume of coir waste in the berry production regions, where the waste is going at the moment, costs, alternatives tried already, any constraints and ideas producers have, as well as logistics, economics and networks. This should include checking with all types of hydronic producers, not only berries, given that a minimum volume may be required for some opportunities and economies of scale may exist. Our review will include reuse and recycling options within berry producing businesses. Investigate the organics recycling sector and other potential reuse options for opportunities already existing in a region, including challenges, barriers and how to overcome them.
Outputs	A database or spatial distribution map of sources and potential 'sinks' for substrate waste; including availability of technologies and resources available and/or required. A synthesis of findings and their implications for the focus of the global scan will be provided to the PRG for comment during the 2nd PRG meeting (meeting minutes) and included with Milestone 103.
Timing	Activity 2 will be completed within 6 weeks from submission of MS102 to Hort Innovation (9/10/18).
Activity 3	**Global scan**
	We will investigate approaches to coir waste recycling in major hydroponic production regions globally. Galuku will provide insights into which regions to focus on. This will be via desk top research and especially via accessing contacts in key countries such as Netherlands, Germany, the US and Canada. Doris Blaesing already plans to travel to Germany and Holland in July 2018. She will be able to investigate options and relevant research 'in situ' without adding costs to this work. Her contacts in both countries, being able to observe waste management technologies, discuss their applicability for Australia and asking questions about operational issues and costs are a valuable opportunity. Reuse of coir waste and managing pest and disease risks within berry producing companies will be part of the scan. We will investigate coir use research in coir producing countries, especially the Indian Coir Board to check whether any of the agricultural and industrial uses they are researching are relevant for coir waste. Galuku has already researched and implemented some options.

Outputs	Report on global hydroponic coir waste management approaches, reconciling these with findings from Activity 2. The synthesis will describe realistic, economically viable opportunities for Australian berry growers. This report will be made available to Hort Innovation as part of Milestone 103 and to the PRG for comment by return email. The project team will complete activities and outputs for MS103 within 12 weeks from submission of MS102 to Hort Innovation.
Timing	End October 2018
Activity 4	**Produce concise information and resources for Rubus and strawberry producers and those who are interested in utilising waste coir substrate**
	We will supply information for industry newsletters and electronic media including relevant industry websites at the start and finish of the project. The PRG will have input into communications, i.e. content and delivery format during the 3rd PRG meeting. Practical, coir waste management information will be produced as easy to read factsheets. A factsheet template will be approved by Hort Innovation. Decision trees and images will be included as appropriate. The factsheets will discuss opportunities, risks, logistics, economic considerations and regulatory requirements (if needed). They may include case studies, if suitable to demonstrate opportunities. Given industry and regional differences, several targeted factsheets may be required. The budget provided with this proposal covers six factsheets. The information for industry newsletters and the factsheets will provide information on linkages / networks that help producers to get started with novel coir waste management approaches. They will be communicated via established berry industry communications channels and available for respective websites, including Hort Innovation.
Outputs	Project summary and factsheets for industry communications e.g. newsletters, websites, e-communication etc., six targeted fact sheets have been included in the budgeted.
Timing	Mid-November 2018
Activity 5	**Reporting including RD&E recommendations**
	Produce a draft report for review by the Hort Innovation project manager and interested PRG members and incorporate feedback provided by return email into a final report. The report will describe research methods, a discussion of findings and the rationale for the choice of communications and resources for growers. It will include RD&E investment recommendations for the Strawberry, Raspberry and Blackberry SIAPs.
Outputs	Draft and final report to Hort Innovation
Timing	Final report by 21 December 2018, draft for review 2 weeks prior
Activity 6	**Project management and communication with the client and PRG**
	Three to four - weekly project activity updates, depending on activities, to ensure the project stays on track, and the Hort Innovation project manager and the PRG have the opportunity to comment
Outputs	Email updates, time and budget information, notes on issues and solutions in project delivery
Timing	Over the duration of the project

Appendix 2: Terms of Reference - Project Reference Group

RMCG

Terms of Reference

Project Reference Group

MT17016 Coir waste management for hydroponics in berries

27 August 2018

This Terms of Reference (ToR) sets out the arrangements for the project reference group (PRG) and lists information about its purpose, chair and membership and meeting schedule.

Background

RM Consulting Group (RMCG) is delivering "MT17016 Coir waste management for hydroponics in berries" for the Rubus and strawberry industries.
This project is funded by Hort Innovation, using strawberry and Rubus industry levy funds and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture

GENERAL PROJECT OVERVIEW

Hydroponic berry production will increase over the coming years. Producers have already identified that coir is the most suitable substrate and that the management of spent substrate is a challenge that needs addressing.
As a result, Hort Innovation provided the RFP MT17016 – Coir waste management for hydroponics in berries. The overall objective of the work is to assist hydroponic berry producers to adopt innovative, novel approaches to coir management. The opportunity and expected outcome is that producers will:

- Reduce on-farm coir related waste and associated costs, and
- Reduce the coir waste related risks and costs associated with pest and disease management.

We will investigate new, creative approaches to coir waste management from hydroponic production via understanding regional contexts (incl. logistics/economics) and opportunities as well as a global scan. A core project activity is consultation with the suppliers and users of coir as well as companies who can reuse, recycle or treat coir and make these processes economical. The main deliverables are

- Grower facing reporting (as factsheets and media release summaries for Industry articles) outlining practical, viable and novel options for coir waste management and alternatives.
- A final project report describing research methods, discussing findings and the rationale for the choice of communications and resources for growers; it will include prioritised RD&E investment recommendations for the berry fruit SIAPs for follow-up Strategic Investment consideration.

Project Reference Group

The Project Reference Group (PRG) is a principal group providing guidance and information on project direction, plans, outputs and activities.

Terms of Reference

PURPOSE

Three PRG meeting will be held via phone conference, one each in September, October and November 2018. The Group brings together key persons with expertise and experience relevant to the objectives of the project.

SCOPE

The scope of the PRG is to provide input into planning and execution of the project. Including but not necessarily limited to:

- Direction the project takes to achieve its objectvies
- Ensuring that the projects meet the needs of the Rubus and strawberry industries
- Making sure that sound science / credible sources are used as a basis for advice; and
- Ensuring the projects stay focussed on required outcomes.

TERM

This Terms of Reference is effective from 01 September 2018 and continues until the 21 December 2018.

PRG MEMBERSHIP

NAME	ORGANISATION	POSITION TITLE
Byron de Kock	Hort Innovation	R&D Manager
Doris Blaesing	RMCG	Associate (Project Manager)
David Bardon	Galuku AUS	Managing Director
Cameron Folder	Costa Group	Production Manager
Lee Peterson	Berry World	Technical Manager

ROLES AND RESPONSIBILITIES

The PRG will:

- Attend meetings by phone and contribute experience and expertise to the project
- Provide advice on how to most effectively deliver the project
- Act as a 'sounding board' to the project manager
- Confirm that project outputs are 'fit for purpose', useful and relevant.

MEETINGS

- All meetings will be chaired by Doris Blaesing and Karl McIntosh from RMCG will act as proxy if required
- A meeting quorum will be three (3) non-RMCG members of the reference group plus one (1) RMCG member
- Decisions, if required, will be made by consensus (i.e. members are satisfied with a decision even though it may not be their first choice). If consensus is not possible, the Hort Innovation project manager makes a final decision
- Meeting agendas and minutes will be provided by RMCG, this includes preparing and distributing:
    - Agendas and supporting papers at least three (3) days before meetings
    - Meeting notes and relevant information after meetings.
    - Meetings will be held quarterly for a maximum of 1 hour. Meetings will mostly be held by phone, as face-to-face meetings may be difficult to arrange.
    - If required for a specific purpose, subgroup meetings may be arranged outside of these times at a time convenient to s

Appendix 3: Fresh coir profile

Cocopeat Profile

Test Type AS3743 - NDI asap
Sample Name Cocopeat 2001
Sample No. 61539
Date 08/06/2001
Client: Galuku Pty Ltd
Joe Davids
PO Box 253
Grosvenor Place
SYDNEY NSW 2000

Sydney Environmental and Soil Laboratory Pty Ltd
(Inc in NSW)
ACN 002 825 569
16 Chilvers Road
Thornleigh NSW 2120
Australia
Address Mail to
PO Box 357
Pennant Hills NSW 2120
Telephone (02) 980 6554
Facsimile (02) 484 2427

Characteristic	Unit	Results:	Requirement Regular	Requirement Premium	Comments
Air Filled Porosity	%	20.6	≥13	≥13	good
Wettability	min	1	≤5	≤2	
Total WHC	%	58.4	≥40	≥50	good
pH	pH units	5.8	5.3-6.5	5.3-6.5	OK
EC	dS/m	.56	≤2.2	≤2.2	Low - good
Toxicity Index	–	80	≥75	≥75	good
N-NH4	mg/l	1.7	≤100	≤100	OK
NH4 + NO3	mg/l	<5.0	NR	≥50	low in N - OK
N Drawdown index	–	1	≥0.2	≥0.7	good -no immobilisation
Phosphorus -PO4	mg/l	1.6	NR	8-40	of N
Potassium	mg/l	193.5	NR	≥50	low - OK
Sulfur-SO4	mg/l	2.9	NR	≥40	ample potassium
Calcium	mg/l	<8.0	≥50	≥80	low
Magnesium	mg/l	5.3	≥15	≥15	low
Ca/Mg ratio	–	0.9	1.5-10.0	2.0-10.0	low
K/Mg ratio	–	36.50	NR	1.0-7.0	low - needs calcium
Sodium	mg/l	87.4	≤130	≤100	high - needs magnesium
Chloride	mg/l	134.1	≤200	≤200	OK
Iron	mg/l	12.4	≥25	≥25	OK
Copper	mg/l	<0.4	0.4-15	0.4-15	low
Zinc	mg/l	1	0.3-10	0.3-10	low
Manganese	mg/l	2.4	1-15	1-20	OK
Boron	mg/l	0.06	0.02-0.65	0.02-0.65	OK

Summary and Recommendations

This material has very good physical properties (AFP & WHC) that would be suitable for incorporation into a potting media. The pH is also very good and does not need alterations at this stage. This material, if anything has a slight ability to supply the mix with nitrogen as the NDI is very good and is not consuming soluble N. Calcium, magnesium, iron and copper all fail, however being an ingredient for a mix, this is not a problem. All that needs to be added is a well balanced N:P:K:Ca:Mg:&T/E fertiliser either as a CRF or as a granular supply at batch formulation. There are no toxic nutrient levels, only quite low levels which can be easily amended. Do keep an eye on zinc, manganese and boron as they are all well within desired range, however are at the lower end of adequate and can be boosted.

Wet = Within the Error of the Test
Checked: by principal Simon Leake Date of report: 08/06/01 Consultant: S.Flanagan
Method: AS3743-1996:

Appendix 4: Sampling and analysis of used substrate

Correct sampling and sample handling are essential to getting meaningful test results. The below procedure should be followed. Several environmental analysis laboratories offer correct analyses of composts, soil conditioners and mulches as per the Australian Standard AS 4454—2003 as well as potting mixes / substrates as per AS 3743—2003. Laboratories provide advice on sampling and sample handling.

Recycled Organics Unit
PO Box 6267
University of New South Wales
Sydney, NSW 1466
Phone 0414 385 226
a.campbell@recycledorganics.com

ROU Information Sheet No. 3-11

Sampling and Sample Management for Consistent Analysis of Recycled Organics Products

The Australian Standard AS4454 (2012) Composts, soil conditioners and Mulches includes a new *Appendix A*: Sampling, Sample Handling and Preparation which provides general guidance on sampling, and specific guidance on sample quantities (derived from international standards). However, *Appendix N*: Maturity Index in the standard provides specific guidance on sample handling and preparation for biological stability tests, without which test results will be unreliable.

Neither appendix provides information in a form that can be directly implemented.

This ROU information sheet provides principles and operational practice for sampling, sample handling and shipping methods that are consistent with the requirements of AS4454 (2012) standard.

These methods are consistent with the requirements for sampling, handling and analysis of samples for the respirometry test options specified in the *Maturity Index* of the revised AS4454 (2012) standard for the assessment of biological stability (O2 uptake, CO2 evolution, NDI, Solvita ®).

Section 1 Sampling and Sample Management

1.1 Purpose of sampling

The first step in analyzing compost quality is to obtain a representative sample from the compost pile. The sample (and sampling points) should reflect the overall or average characteristics of the material being tested. Due to natural variation in raw materials and in environmental conditions within the compost pile (albeit within an expected range) properly representative sample must be formed by mixing numerous incremental samples to form a composite sample for analysis.

Laboratory testing is expensive. Tests performed on a sample that is not representative of the bulk of material, or that has not been correctly handled will produce unreliable results that may misrepresent the characteristics of the compost batch as a whole. This is undesirable for manufacturer's quality control purposes and for generating product information; and for selection and use by customers.

1.2 Definitions

Batch: A quantity of goods manufactured from known materials by the same process under the same conditions and assumed to have the same characteristics. The source/s of supply and period over which the materials have been received for an individual batch should be known for traceability.

Incremental sample: a discrete quantity of material taken from one discrete **sampling point**.

Combined or **composite sample**: combination of mixed the incremental samples from a single batch.

Sampling site/sampling area: an area of a compost windrow or pile that is deliberately prepared to expose an internal cross section of the pile from which incremental samples can be taken.

1.3 Safety / disclaimer

Care should be taken when handling waste materials and samples that may contain sharps and sharp fragments, chemical contaminants or possible pathogenic organisms. Facility operators should ensure that sampling and associated operations are carried out in a safe manner that protects staff and minimises risks. Such risks are dependent upon engineering arrangement and equipment used at the facility, and should be addressed via risk assessment by managers of the facility.

1.4 Sample management for maturity test accuracy

Compost maturity is now assessed in AS4454 (2012) by assessing both the biological stability of a product, and also complementary assessment of plant growth response attributes relevant to the relative presence/absence of phytotoxic characteristics (see AS4454 Appendix N).

Biological stability can be defined as the extent to which readily biodegradable material has decomposed. A material is considered unstable if it contains a high proportion of biodegradable matter that can sustain high microbial activity. If the material contains mainly recalcitrant or humus-like matter, it is not able to sustain high levels of microbial activity under suitable environmental conditions (temperature and moisture), and therefore it is considered biologically stable.

Respirometry test methods assesses the level of biological activity in a sample of material under specified conditions that are conducive to microbial activity by measuring the rate of respiration in the form of carbon dioxide evolved or oxygen consumed by microorganisms, or in the form of the heat generated by this biological activity. Respiration is directly related to the metabolic activity of a microbial population, the micro-organism population will collectively respire at higher rates in the presence of higher levels of biologically available organic matter, while microbiological activity and total respiration will be lower where such material is scarce (under equivalent conditions).

Tests specify the quantity of suitably moist compost that is incubated at a specified temperature under specific conditions for measurement. Respirometry tests can provide a repeatable and quantitative or semi quantitative measure of the degree to which a material has been decomposed and stabilized.

Respiration determination is reported to be sensitive to the time lag between sample collection and analysis. To minimize changes in the sample due to microbial activity over time, samples should be analysed as soon as possible after collection. For reliability of results, ideally samples should be prepared and assessment begun within 48 hours of sampling. This requires prior arrangement with the laboratory so that they are expecting the sample to arrive and have the test apparatus available to conduct the test in a timely manner.

Temperature and moisture content during sample transport, handling and preparation are widely reported throughout the literature as critical for reliability of respiration test indices as biological activity is a function of both parameters.

Adequate sample moisture is critical. Test methods specify sample preparation requirements including moisture and temperature adjustment, and lag time for microbial acclimatisation. Acclimatisation is particularly important where samples have dried to < 40% moisture, or where samples have been enclosed in a sealed container without adequate air for an extended period of time, or have been frozen during transport.

Samples for microbial testing must not be frozen. To minimize changes in the sample due to microbial activity with samples maintained at temperatures of >1°C and <4°C during handling and transport; and packaged and handled in a manner to best avoid risk of freezing, high temperatures, drying out, and the development anaerobic conditions.

The methods described aim for increased validity and consistency in laboratory testing by ensuring a representative sample is obtained and by minimising risk of damaging impact on samples in transport.

There are known interferences that can distort respirometry test results, including the following:

a) **Time lag between sampling and testing**: respiration determination is reported to be sensitive to the time lag between sample collection and analysis. To minimize changes in the sample due to microbial activity over time, samples should be analysed as soon as possible after collection. Ideally samples should be prepared and assessment begun within 48 h of sampling. If this is not possible, a sample management plan should be agreed with the laboratory conducting the test.

b) **Temperature and moisture content during sample transport, handling and preparation** are widely reported throughout the literature as critical parameters for respiration test indices, as biological activity is a function of both temperature and suitable moisture content. To minimize changes in the sample due to microbial activity, samples should be maintained at temperatures of

>1°C and <4°C during handling and transport, and packaged and handled in a manner that best avoids both drying out and the onset anaerobic conditions. Test methods specify sample preparation requirements, including moisture and temperature adjustment, and lag time for microbial acclimatization. Acclimatization is particularly important where samples have dried to < 35% moisture, have been enclosed in a sealed container without adequate air for an extended period of time, or have been frozen during transport.

c) **Volatile ammonia** can be a significant cause of noxious odours and is known to be phytotoxic and to inhibit microbial activity at elevated levels. Trials and laboratory experience have shown false positive results from respirometry-based tests due to the suppression of biological activity from elevated volatile ammonia levels. Volatile ammonia assessment should be implemented to inform the validity of results from respirometry tests.

d) **Particle size for test:** respirometry tests for composts in UK, EU and USA standards are commonly conducted on compost products of ≤ 10 mm particle size grade. As requirements in Table N3.2 are based on international standards and research, it is recommended that respirometry assessments for compliance with this Standard be carried out on a ≤ 10 mm particle size fraction of the specimen for test.

e) **Acclimatization and rewetting of dry samples**: where the received sample is assessed to have a moisture content below 40%, the sample should be remoistened and thoroughly mixed to a moisture content of 50%. To acclimatize microbial activity prior to testing, place the remoistened sample in an unsealed container that avoids contamination, is out of direct sunlight and is in a draught-free environment at a temperature of (25°C ±2°C) for 48 hours prior to conducting tests specified for biological stability. NOTE: this requirement applies irrespective of any other requirement specified in an individual method.

Laboratory tests where respiration is calculated per quantity of volatile solids

f) Carbonates can increase volatile solids determinations due to the release of CO2 during sample combustion at 550°C in the LOI (Loss on Ignition) method specified for BVS. Samples with significant carbonate content must be pre-treated (leached with acid) prior to analysis to remove carbonates.

g) Inert materials, including petroleum-based materials such as film and hard plastics can increase volatile solids determinations due to the release of CO2 during sample combustion at 550°C in the LOI method specified for BVS, therefore plastics and other contaminants should be removed to the greatest extent possible prior to combustion. The mass of contaminants removed prior to sample combustion should be recorded and test results adjusted to account for the mass of inert materials in the original sample.

1.5 Working with your lab

Sample management practices should be agreed with the laboratory conducting the test, and should be documented on the purchase order. In addition, the laboratory should be advised upon dispatch of the sample from the facility and arrangements made for the laboratory to confirm receipt of sample.

One advantage of the current AS4454 (2012) standard is that simple tests are now available for on-site assessment of product maturity. This includes TMECC 05-05B bioassay, and the Solvita ® maturity index test kit (which provides two tests, assessing both CO2 evolution and also volatile ammonia).

This allows manufacturers to readily test products prior to sale for compliance with maturity specifications. To best correlate the results with full characterisation test conducted by your laboratory service provider, check and ensure the temperature settings in your on-site “lab” room are equivalent to those of your independent laboratory service provider for more comparable biological stability results; and make sure you are using the same seed variety and conditions as your lab for the bioassay.

1.6 Determining the number of incremental samples required per batch

The number of sampling points required to obtain a representative sample of compost from a batch is calculated from international standards[1], note that these quantities

A minimum of 12 and a maximum of 30 *incremental samples* shall be obtained from a compost batch of defined volume (of up to 5,000 m^3), then thoroughly mixed into a representative *composite sample*:

Number of incremental samples required for piles of different size

Windrow or pile volume	No. of increment samples required
≤ 575 m^3	12
600 m^3	13
1000 m^3	16
1500 m^3	20
2000 m^3	23
2500 m^3	25
3000 m^3	28
≥ 3600 m^3	30

The international standards for sampling from which these calculations are obtained is relevant for sampling materials where the properties being tested for are consistently distributed throughout the material.

The AS4454 (2012) standard provides guidance for the minimum required size of each *incremental sample* on the basis of the maximum particle size range of the material being sampled, as shown in the table below. The objective is to ensure the sampling method is not biased towards avoiding larger particles:

Minimum incremental sample size for materials of different particle size

Largest size mm	70	50	20	10	5
Litres per increment sample	6	4	2.5	1.25	0.6

Note that all incremental samples should all be of a consistent size.

Sampling operations shall be carried out over a sufficiently short period of time and in such a way as to avoid any alteration in the characteristics of the product. During sampling, all incremental samples shall be handled and stored in a manner that avoids contamination and maintains their characteristics.

[1] British Standards Institution. (2000). British Standard BS EN 12579:2000 Soil improvers and growing media: Sampling. British Standards Institution (BSI), London, United Kingdom www.bsi-global.com This is the English language version of the DIN EN 12579 : 1999 European Standard.

1.7 Sample division method: coning and quartering

The result of collecting and mixing the specified number of *incremental samples* each of consistent volume of the specified minimum required size may result in a composite sample of significantly larger quantity than is required for testing.

After thorough mixing, the resulting representative *composite sample* (or *combined sample*) can be divided into representative sub-samples via the coning and quartering method.

1.7.1 Apparatus

All apparatus must be clean

- 20 L plastic pails with lids; Spade/s; Plastic sheet (use the thickest available polyethylene builders plastic); Means of cleaning the apparatus

1.7.2 Method – coning and quartering

a) Empty the increment samples onto a clean plastic sheet to avoid contaminating the sample with material from the ground. Using a clean spade, arrange into a conical pile and thoroughly mix by working the pile whilst moving through two full 360^0 circuits around the pile.

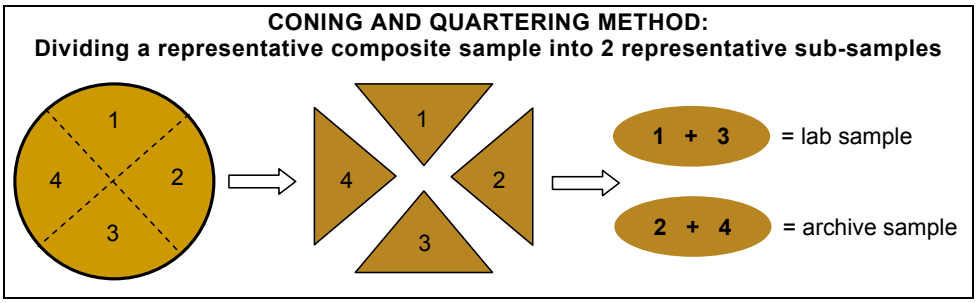
b) Cut the pile into 4 segments of equal size using the spade (as though cutting slices of a cake), and pull the segments apart with the blade to separate from each other;

c) Take two equally sized opposite segments and combine them to form a representative sub sample (*final sample*) that is approximately half of the composite sample in volume. This combined *final sample* for test is then packaged and transported to the laboratory.

d) Take the other two equally opposite sized segments and combine them and retain this composite *final sample* (approximately half of the composite sample in volume) at the facility as an '*archive sample*'. This is important in case the *final sample* sent to the laboratory is lost in transit or the laboratory experiences difficulties, or if re-testing of the sample is required for any reason. If possible it is preferable to refrigerate the archive sample in a suitably labelled and sealed container (ideally less than 4^oC but not below 1^oC); otherwise store the container in a dark, dry, cool location out of direct sunlight at a temperature of less than 10^oC but not below 0^oC to reduce any change in characteristics over time.

e) Coning and quartering can be repeated sequentially to halve the sample again as required to further reduce the *composite sample* into smaller representative *final samples* of suitable quantity.

f) Discard the unneeded or remaining material, or otherwise add back to a new batch of incoming raw materials for reprocessing.



Section 2 Windrow sampling methods and diagrams

2.1 Method A: sampling completely mixed compost piles

2.1.1 Apparatus

- All apparatus must be clean
- 20 L plastic pails with lids.
- Trowels or trenching shovel.
- Means of cleaning the apparatus.
- Suitable means of turning the compost pile.

2.1.2 Sampling method A

Arrange for the pile to be turned to break up clumps and completely mix and homogenize the materials.

For a pile that has been so thoroughly mixed with clumps broken up and distributed with a windrow turner (or equivalent), *increment samples* of consistent size can be taken from random positions (*sampling sites*) from along the exterior of the length and height of the pile immediately after mixing.

Ideally sample within 2 hours of mixing as a range of characteristics such as moisture distribution, O2 availability and biological distribution can alter rapidly, and certainly within a few hours of mixing.

Use a clean trenching shovel or trowel to extract *incremental samples* of consistent volume at various, evenly spaced locations from the sides of the windrow. Dig a plug from the pile for each *incremental sample* rather than simply scaping from the surface.

During sampling take care to handle and store *incremental samples* in a manner that maintains their characteristics, being careful to avoid cross contamination of the *sampling sites* prior to sampling (eg with turner wheels or mechanism), and of the *increment samples* during sampling and mixing (eg. from windblown materials).

Avoid sampling from the ends of the windrow where conditions are unique (in terms of surface area to volume ratio) and are not representative of conditions in the greater composting mass.

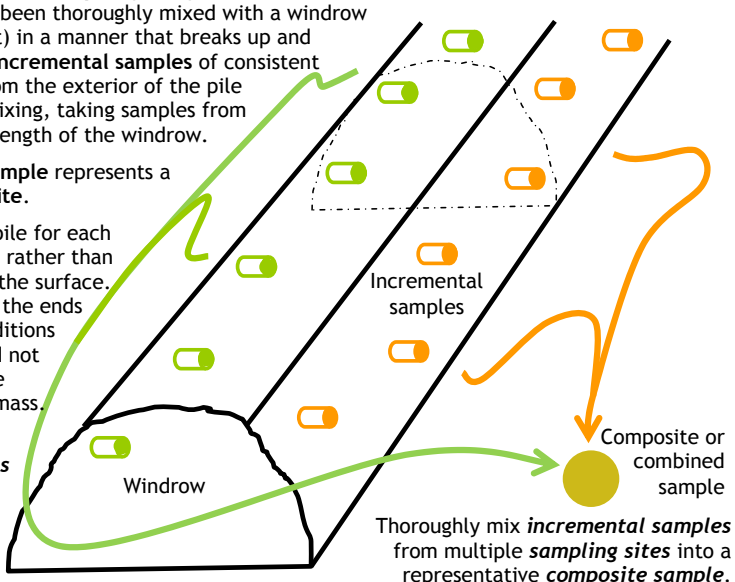
Method A: compost sampling diagram

For a batch that has been thoroughly mixed with a windrow turner (or equivalent) in a manner that breaks up and distributes clumps, **incremental samples** of consistent size can be taken from the exterior of the pile immediately after mixing, taking samples from each side along the length of the windrow.

Each **incremental sample** represents a different **sampling site**.

Dig a plug from the pile for each ***incremental sample*** rather than simply scaping from the surface. Avoid sampling from the ends of a windrow as conditions there are unique and not representative of the greater composting mass.

The number of ***incremental samples*** required for a representative ***composite sample*** depends on the size of the compost pile.



Recycled Organics Unit © (2011)

Use a clean trenching shovel or trowel to extract *incremental samples* of consistent and adequate volume, taking care to handle and store samples in a manner that maintains their characteristics, and being careful to avoid cross contamination of the *sampling sites* prior to sampling (eg with turners); and of the increment samples during sampling (eg. from windblown materials).

2.2 Method B: Sampling compost piles without complete mixing

2.2.1 Apparatus

- All apparatus must be clean
- 20 L plastic pails with lids. Trowels or trenching shovel. Means of cleaning the apparatus.
- Suitable means of turning the compost pile.

2.2.2 Method B: sampling compost piles without adequate mixing

A different sampling method is required where the windrow or pile is unturned, or turning methods do NOT completely break up and distribute clumps and homogenize the materials.

Arrange for a wheel loader or excavator to dig or back-blade half way in to a section of the pile exposing a near vertical cross section face (alternatively, for smaller piles, a loader may cut a cross section through the entire windrow).

This vertical face represents a *sampling site* that allows *increment samples* to be extracted from the cross section of the windrow. Sampling should occur immediately after opening and exposing the sampling site with the machinery (ideally within 2 hours as a range of characteristics such as moisture distribution, O2 availability and biological distribution can alter rapidly, and certainly within a few hours of mixing).

Use the clean trenching shovel or trowel to extract between three and five *increment samples* of consistent volume at various, evenly spaced locations from the exposed cross section face of the windrow.

Use a clean trenching shovel or trowel to extract *increment samples* of consistent volume at various, evenly spaced locations from the exposed cross section faces of the windrow.

Dig a plug from the pile for each incremental sample rather than simply scaping from the surface. During sampling take care to handle and store *incremental samples* in a manner that maintains their characteristics, being careful to avoid cross contamination of the *sampling sites* prior to sampling (eg with turners), and of the *increment samples* (eg. from windblown materials).

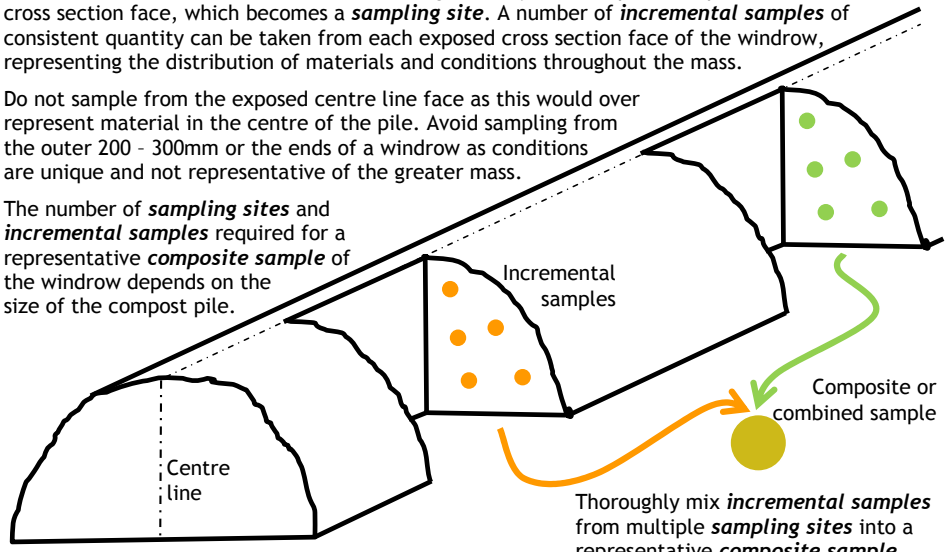
Note that samples are extracted from the cross section face, and NOT the centre line face within the windrow (as this would over represent material from the centre of the pile). Avoid sampling from the outer 200 - 300mm layer when sampling (top, bottom and sides), and avoid sampling from the ends of the windrow where conditions are unique (in terms of surface area to volume ratio) and are not representative of conditions in the greater composting mass.

Method B: Windrow compost sampling diagram

For use where a windrow or pile is unturned, or turning methods do **NOT** completely homogenize the materials. Use a loader or excavator to dig half way into the pile to expose a near vertical cross section face, which becomes a ***sampling site***. A number of ***incremental samples*** of consistent quantity can be taken from each exposed cross section face of the windrow, representing the distribution of materials and conditions throughout the mass.

Do not sample from the exposed centre line face as this would over represent material in the centre of the pile. Avoid sampling from the outer 200 – 300mm or the ends of a windrow as conditions are unique and not representative of the greater mass.

The number of ***sampling sites*** and ***incremental samples*** required for a representative ***composite sample*** of the windrow depends on the size of the compost pile.



Recycled Organics Unit © (2011)

Use a clean trenching shovel or trowel to extract *increment samples* of consistent volume, taking care to handle and store samples in a manner that maintains their characteristics, and being careful to avoid cross contamination of the *sampling sites* prior to sampling (eg with loader or excavator), and of the increment samples (eg. from windblown materials).

2.2.3 Method C: sampling compost piles assessment of beneficial microorganisms

Note, this is not relevant for pathogen or indicator pathogen assessment, which must be conducted on a representative sample obtained in accordance with methods above.

In the instance that a customer requests an assessment of the microbial communities of a compost for identification of microorganisms that are beneficial to soil health, such as counts of total or active fungal and/or bacterial communities:

a) Samples should preferably be taken from locations in the pile that most closely represent environmental conditions (moisture, air, heat) that will occur when the compost has been applied. This will better represent the microbial activity that the compost is able to support once applied.

b) There is little value in assessing compost sampled from locations in the pile where environmental conditions are irrelevant to application conditions and may be entirely unsuitable for the organisms being tested for.

c) Generally follow method B above, sampling only from areas of the cross section face of the compost pile that best represent relevant environmental conditions.

2.3 Packaging and shipping

The *composite sample* for testing by the laboratory must be packaged in such a way that characteristics are unaltered on arrival at the laboratory, and must be clearly labelled for identification and to maintain chain of custody.

Arrangements for testing should be made with the laboratory prior to sampling and shipping, including written confirmation of the analysis to be conducted, how the sample is to be managed on arrival, and expected date of sample delivery (to ensure test apparatus is available).

- Use a 10 litre sealable container (a robust plastic "handy pail" with sealable lid is suitable where samples are sent and received on the same day by road transport. Where samples are sent by air or overnight transport a fully enclosed EPS (polystyrene) container with tight sealing lid that can be securely taped to seal is preferred to avoid extremes of temperature. A small EPS esky is suitable for small samples, or a fully enclosed "ice pack broccoli" EPS vegetable box for larger samples.
- Load sample into strong high density polyethylene sampling bags then place bags into the container. Where containers have been previously used, thoroughly clean the containers[2], and rinse 3 times with clean water drain and air dry prior to loading the combined sample (with clean shovel) directly from the coning and quartering process above. For new containers, clean and then rinse with clean water prior to use.
- Securely attach shipping labels with tape to the outside of the container (1 on top, 1 on side).
- The label should clearly identify the delivery address and contact details for the laboratory.
- Place a similar label inside the container, with a letter providing sample and client details, and specifying the analysis to be conducted enclosed in a zip-lock plastic lunch bag.
- For chain of custody, the labels and/or enclosed paperwork should also clearly identify:
    - The source facility (facility name);
    - A unique batch identification number;
    - The type and grade of material;
    - The number of incremental samples combined for this representative laboratory sample;
    - The date and time of sampling;
    - The person responsible for sampling and packaging (name and signature); and
    - The facility contact person/number.
- Place pre-frozen, sealed gel type ice-pack/s on top of the sample in the packaging container (do not include ice that can melt and leak), then immediately prior to shipping securely install the lid to seal, and tape around the lid to ensure it cannot be dislodged.
- For respirometry tests, samples should be received by the lab and sample preparation begun within 48 hours of sampling. During this period, some methods specify that samples must not be frozen, and that temperatures above 4°C are permitted for no more than 24 hours.
- Keep the container and sample in a dark, dry, cool location out of direct sunlight whilst awaiting collection (ideally refrigerated between 1 and 4°C, or otherwise less than 10°C, but not frozen).
- Arrange for collection on the same day of sampling, or the morning following.
- Use a delivery service that will deliver it to the laboratory within 24 hours.

[2] Where containers are simply soiled washing and brushing with mild detergent solution prior to triple rinsing is sufficient. Cleaning solutions such as *Decon* are suitable for sterilising containers where there is concern over the potential presence of chemical or biological residues, see www.sterile.com

- Upon dispatch or collection by delivery courier, contact the testing laboratory to confirm that the sample is in transit and to provide an ETA for delivery (eg. *tomorrow*).

2.3.1 Packaging for analysis of chemical contaminants

Where a sample is to be tested for potential presence of chemical contaminants, ideally pack a portion of the laboratory sample into a glass jar sealed with a metal cap or with aluminium foil under the cap to avoid inadvertent secondary contamination as organic pesticides can migrate through plastic lids.

500 ml is sufficient for mulch samples and 250 ml for soil conditioner samples.

2.3.2 Shipping label: top of container:

Print and complete for each sample, and attach to sample for transport to lab, consistent with the packaging and shipping instructions above.

DELIVERY ADDRESS

Laboratory delivery address:

Lab contact person: _____

Lab contact number: _____

Sample for analysis:

Please keep cool and out of direct sunlight

Project code: _____ Sample #: _____

Please advise by email when sample is received to confirm analysis required.

Contact email: _____

2.3.3 Shipping label: side of container:

Print and complete for each sample, and attach to the side of the package.

DELIVERY ADDRESS

Laboratory delivery address:

Lab contact person: _____

Lab contact number: _____

Sample for analysis:

Please keep cool and out of direct sunlight

Please open samples when received to allow exchange of air. Sample preparation and analysis should begin within 48 hours of sampling.

Samples should be kept contained in a dark, dry, cool location out of direct sunlight (ideally less than 10°C but not below 1°C. Do not freeze samples).

Sample has been shipped on day of collection, and should arrive at the laboratory by courier the day after sampling.

Sample details (and chain of custody):

Please advise by email when sample is received to confirm analysis required.

Contact email: _____

Project/batch code: _____ Sample #: _____

Details to be completed by person responsible for sampling and packaging:

Facility name: _____

Batch number: _____

Material type and grade: _____

_____

Sample quantity: _____

Number of incremental samples combined in this sample: _____

Sampling date and time: _____

Name: _____ Signature: _____

Appendix 5: Composting overview

Summary

Correct composting procedures can inactivate most pathogens effectively.

Important factors for microbiological processes that kill pathogens during composting are the moisture content, temperature and treatment time. Minimum compost temperatures of 55-65°C for periods of 3 to 14 days depending on the composting process (turned windrow, in-vessel, static aerated piles) will kill pathogens that do not form spores, if the composting process is managed and monitored carefully (Strauch, 1991[25]).

Compost definition

The controlled process whereby compostable organic wastes are pasteurised and microbiologically transformed under aerobic and thermophilic conditions for a period not less than six weeks, including the pasteurisation phase. Pasteurisation refers to the process whereby organic materials are treated to significantly reduce the numbers of plant, animal and human pathogens and plant propagules.

Pasteurised, young compost is not stabilised (mature). This means it will still undergo changes in composition, microbial activity and particle size until mature and stable, this can take several weeks to months, depending on conditions.

Active composting

Active composting refers to treatments where the compost pile is managed to create conditions that speed the process of decomposing. Moisture, temperature and aeration are controlled. Active treatment involves frequent turning of the material to maintain adequate oxygen levels within the pile. Moisture levels are monitored, and water is added when necessary to maintain levels within the optimum range. Nutrients may be added to obtain the ideal C:N ratio of for microbial activity (25-30 parts Carbon to 1part Nitrogen).

Temperature is monitored and when the pile stops heating the composting process is complete. Composting guidelines require the composting process to have a duration of at least six weeks. Carbon dioxide and ammonia levels may also be monitored to determine completeness and curing stability. The turning is important to make sure all parts of the compost are exposed to the required temperature.

Microbial analysis e.g. via DNA testing of the compost may be performed to determine if the procedure was effective in the elimination of target pathogens. If manures are used in the composting process, e.g. as nitrogen source, presence of E. coli and Salmonella are used as indicators for kill of human pathogens. If these pathogens are present in the compost should not be applied to crops without additional treatment.

One of the parameters identified in many composting procedures is to maintain temperature above 55ºC for at least 3 days when using aerated or in-vessel systems. In open windrow systems, the core of the windrow may reach these temperatures, but surface zones and the area near the base of the windrow will have lower temperatures. Turning or mixing the windrow will introduce oxygen to the windrow and quickly increase temperatures in the earlier stages of composting. Turning with equipment that moves material from the surface to the core of the windrow will expose more materials to higher temperatures. Repeated turnings are necessary to ensure all materials are exposed to at least 3 consecutive days of high temperature.

It is recommended that windrows maintain a core temperature of 55ºC for 15 days with at least 5 turnings. Due to the need for proper mixing and consistent high temperatures, pathogen reduction in windrow composting is sometimes less consistent than when using well-managed, aerated static pile or in-vessel systems.

In the EU for example the PAS 100 (British Standards Institute, 2005[26]) recommends the following alternatives for pasteurisation/sanitation:

1. ≥55°C for at least 14 days in windrows with at least five turnings,
2. ≥65°C for at least 7 days in windrows with at least two turnings,
3. ≥60°C for at least 7 days an aerated static pile with insulating layer (no turning),
4. ≥60°C for at least 2 days for in-vessel systems,

25 Strauch, D., 1991. Survival of microorganisms and parasites in excreta, manure and sewage sludge. Rev. Sci. Tech. Off. Int. Epiz. 10, 816-846.
26 BSI, WRAP, 2005. PAS100:2005. Specification for composted materials. British Standards Institution.

5. ≥70°C for at least 1 hour for in-vessel systems.

In most EU countries and the US, a combination of a specified temperature/time regime and end product tests (typically using Salmonella spp and E. coli) are used to guarantee sanitisation.

Passive composting

Passive composting treatments require very little inputs. Organic waste is simply held under natural conditions. The piles are not turned, and oxygen is depleted, resulting in anaerobic conditions that slow the composting process. Given enough time, environmental factors, i.e. temperature, ultraviolet radiation and humidity, inhibit the growth of pathogens and eventually they die off.

The disadvantage of passive composting is that much time is required and it is difficult to know when the pathogens are finally killed throughout the pile. The amount of time needed depends upon the climate, region and season, as well as the type of organic materials used.

Because of the many uncertainties passive composting treatments are not recommended if the compost is destined for fresh produce production, e.g. vegetables, especially those likely to be eaten raw. A microbial analysis should be obligatory if passively produced compost is to be used with fresh produce and it should never be used on high risk crops unless sterilised e.g. via adequate heat treatment, which may be cost prohibitive.

Composting guidelines, standards and fresh produce safety

The Australian Standard AS4454 (2012) for composts, soil conditioners and mulches provide information on:

- Quality assurance
- On site field testing and quality monitoring (sampling and monitoring: temperature, moisture, oxygen, pH and compost maturity
- On site laboratory testing for quality (moisture content, visible contamination, pH, electrical conductivity and particle size grading)
- Commercial laboratory testing for quality: recommended tests and how to select an independent laboratory (in to be updated, current testing recommendation is: pH, EC, ammonium-N, nitrate-N)

Note: testing for human pathogens or indicators is not required by the standard. Following the procedures in the standard is meant to kill human pathogens. However, pathogen testing may be required by food safety standards, if compost is to be used for fresh produce production.

The pasteurisation process to kill human and plant pathogens prescribed in the Australian standard is:

Subjecting all materials to a minimum of 55°C for at least 3 consecutive days. 'Appropriate' turning has to be conducted to achieve the required exposure. It the feedstock contains manures, animal and food waste and or grease trap waste, a temperature of 55°C or higher has to be maintained for 15 days or longer and the windrow shall be turned at least 5 times during that period.

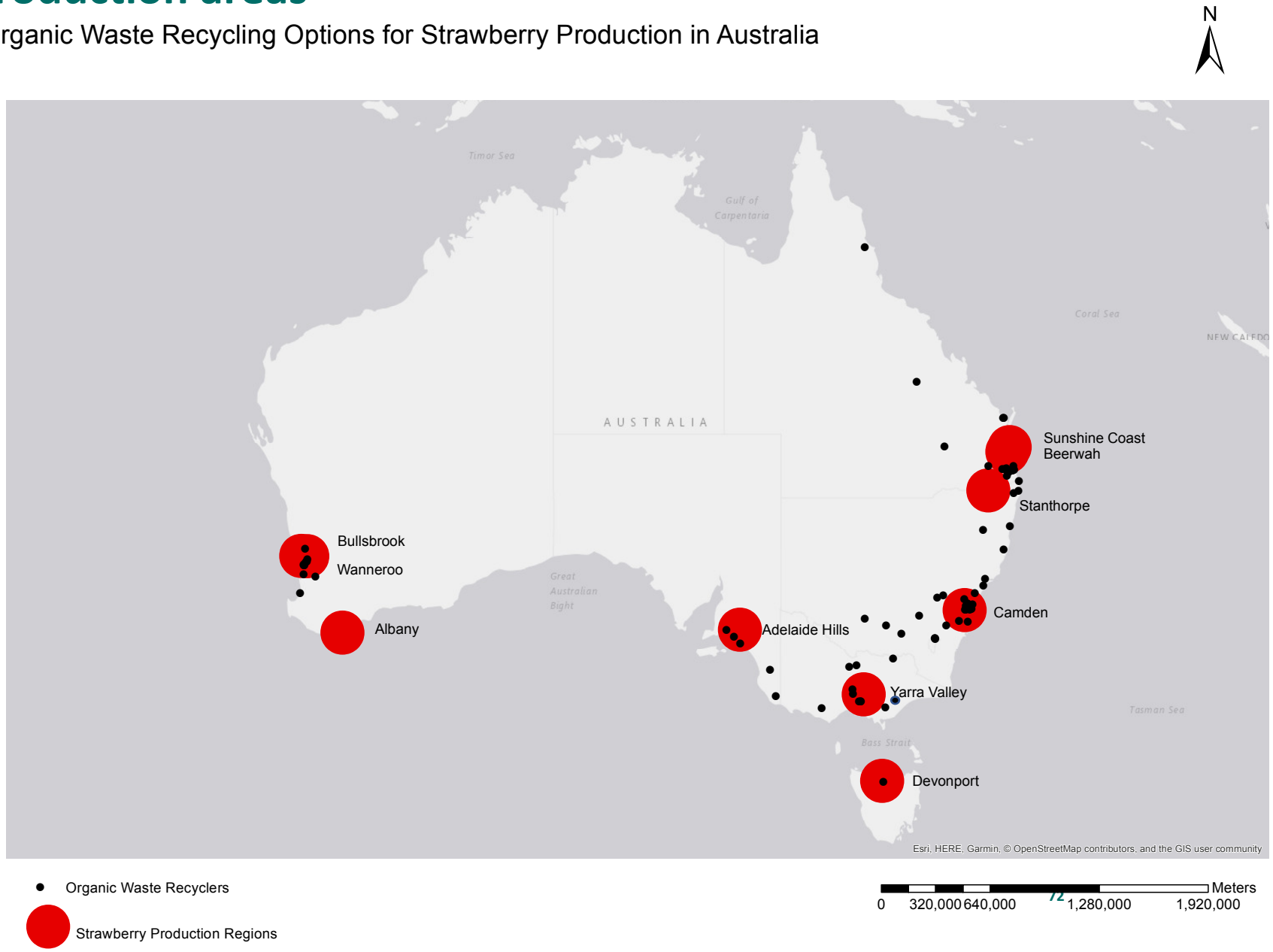
The Australian Standard AS4454 (2012) has to be purchased from Standards Australia. The Recycled Organics Unit (ROU) provides free information sheets on all important aspects of the Standard on its website.

For information on the strengths and weaknesses of the current standard refer to: "Raising the bar for composting in Australia" http://wastemanagementreview.com.au/raising-bar-composting-australia/

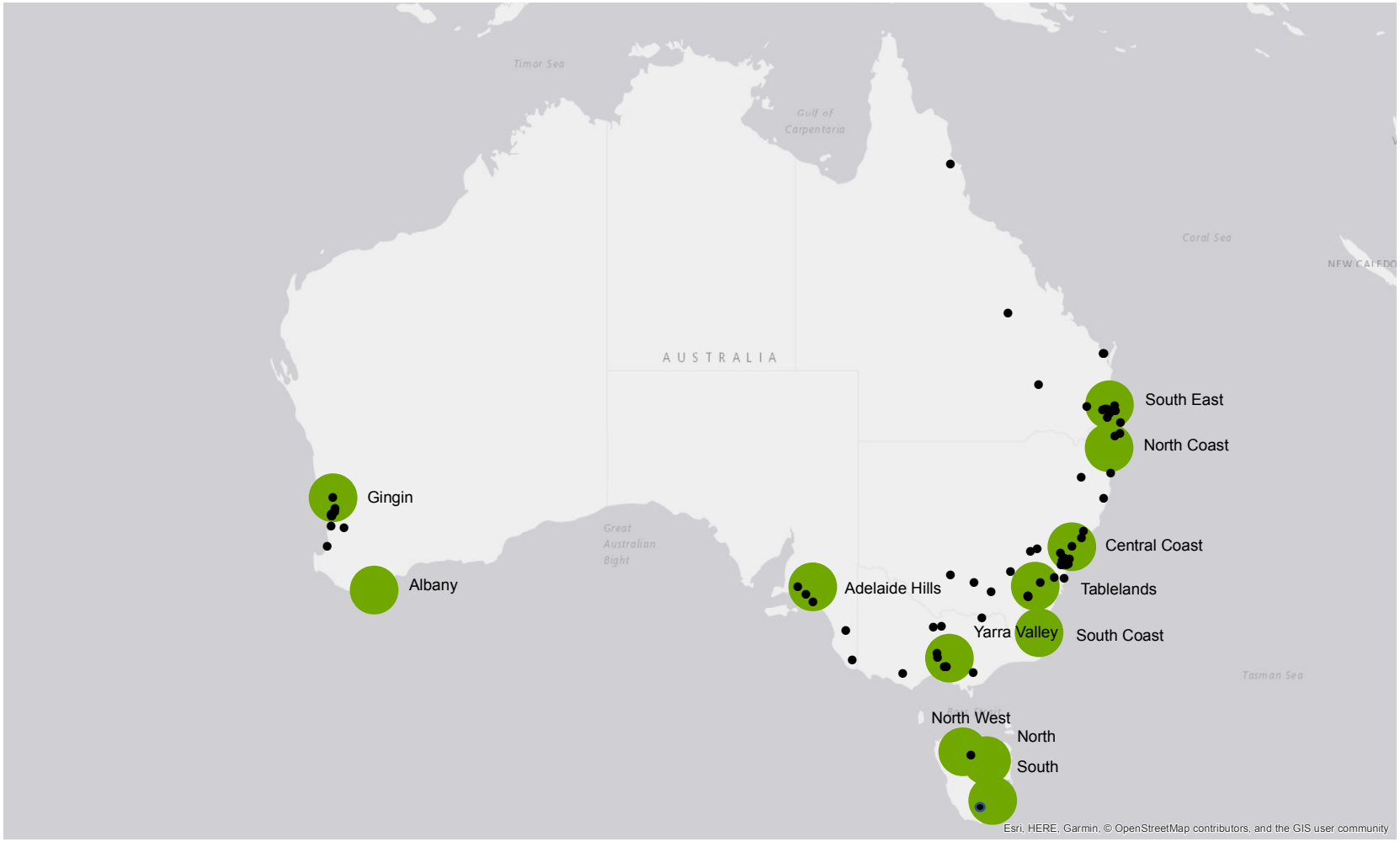
State Environmental Protection Authorities provide composing guidelines aimed at protecting the environment from off-site effects from the composting process. These can be obtained from the relevant state authority or their website,

Appendix 6: Organic recycling company locations near berry production areas

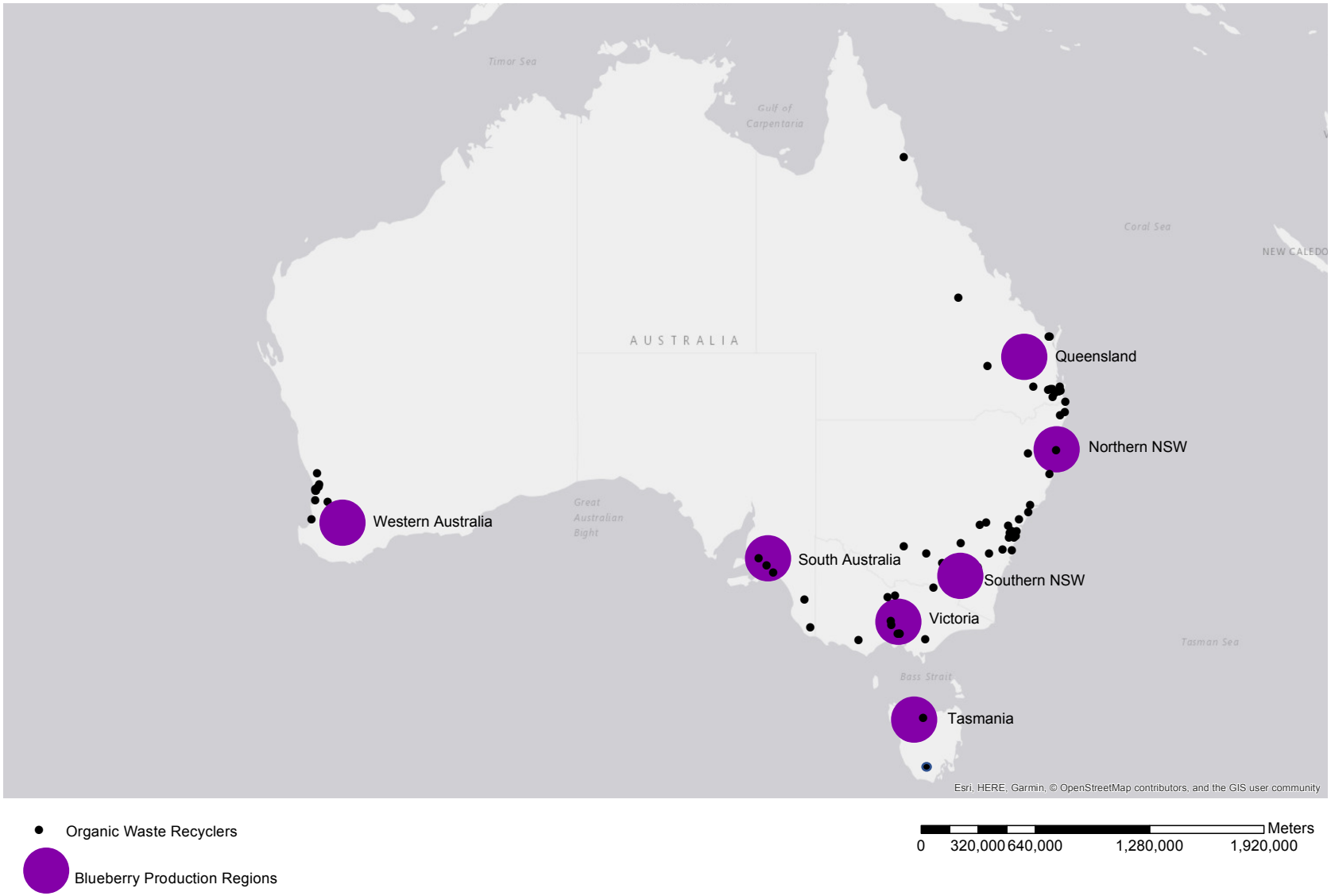
Organic Waste Recycling Options for Strawberry Production in Australia



Organic Waste Recycling Options for Raspberry Production in Australia



Organic Waste Recycling Options for Blueberry Production in Australia



Appendix 7: Organic recycling company contact details

New South Wales

Name	Location	Website	Email
Amiterre Ag Solutions	Moss Vale	http://amags.com.au	info@amags.com.au
Australian Native Landscapes Pty Ltd	Badgery's Creek	https://anlscape.com.au	Rob@anlscape.com.au
Australian Native Landscapes Pty Ltd	Blayney	https://anlscape.com.au	
BiGrow Recycling	Narrandera		cphartin@bigpond.com
Biomass Solutions	Boambee		sales@biomassch.com
Brandown Pty Ltd	Cecil Park	www.brandown.com.au	terry@brandown.com.au
Carbon Mate Pty Ltd	Wagga Wagga	www.carbonmate.com.au	admin.carbonmate@bigpond.com
Cleanaway	Bathurst	www.cleanaway.com.au	geoff.hemm@cleanaway.com.au
Denrith Pty Ltd	Goulburn	www.divalls.com.au	gss@divalls.com.au
Food Beverage Institute Pty Ltd	Jannali	www.foodbeverageinstitute.com	mwebber@foodbeverageinstitute.com
Garden Mediums Pty Ltd trading as Go Grow	Armidale	www.gogrow.com.au	orders@gogrow.com.au
Global Renewables	Eastern Creek	www.globalrenewables.com.au	
JR Richards & Sons	Central Coast	www.jrrichards.com.au	Matt.Hogan@jrrichards.com.au
Lismore City Council/Northern Rivers Waste	Lismore	www.lismore.nsw.gov.au	kevin.trustum@lismore.nsw.gov.au
NALG Australia Pty Ltd	Ryde	www.nalggroup.com	philip@nalggroup.com
Port Stephens Gardenland	Eagleton		bowtell1@bigpond.com
Re Group Pty Ltd	Canberra	www.re-group.com	romily.webster@re-group.com
Re Group Pty Ltd	Shellharbour	www.re-group.com	romily.webster@re-group.com
Re Group Pty Ltd	Eastern Creek	www.re-group.com	romily.webster@re-group.com
Resource Recovery Management Pty Ltd	Grose Vale	www.resrecovery.com.au	paul@resrecovery.com.au
SUEZ	Eastern Creek	suez.com.au	duncan.legood@suez.com

SUEZ	Spring Farm	suez.com.au	duncan.legood@suez.com
SUEZ	Lucas Heights	suez.com.au	duncan.legood@suez.com
SOILCO	Grange	www.soilco.com.au	sales@soilco.com.au
Solo Resource Recovery	Chinderah	www.solo.com.au	tenders@solo.com.au
Solo Resource Recovery	Gateshead	www.soilco.com.au	sales@soilco.com.au
Solo Resource Recovery	Bangalow	www.solo.com.au	tenders@solo.com.au
Worm Tech Pty Ltd	Carathool	www.wormtech.com.au	adrian@wormtech.com.au
Ylad	Young	www.yladlivingsoils.com.au	Rhonda.daly@yladlivingsoils.com.au

South Australia

Name	Location	Website	Email
The Jeffries Group	Wingfield	www.jeffries.com.au	enquiries@jeffries.com.au
Mulbarton Compost	Padthaway	www.mulbartontransport.com.au	phil@mulbartontransport.com.au
Peats Soil and Garden Supplies	Willunga	www.peatssoil.com.au	admin@peatssoil.com.au
Southern Region Waste Resource Authority	Onkaparinga	www.srwra.com.au	mark.hindmarsh@srwra.com.au
Van Shaik's Bio Gro	Wandilo	www.biogro.com.au	service@biogro.com.au

Victoria

Name	Location	Website	Email
Van Shaik's Bio Gro	Dandenong	www.biogro.com.au	service@biogro.com.au
Argus Recycling	Dandenong	www.argusrecycling.com.au	ptasios@argusrecycling.com.au
Biomix	Stanhope	www.biomix.com.au	info@biomix.com.au
Camperdown Compost Company	Camperdown	www.camperdowncompost.com.au	admin@camperdowncompost.com.au
Elmore Compost	Elmore		sales@elmorecompost.com.au

Enviromix	Dingley	www.enviromix.com.au	info@enviromix.com.au
Greenchip Recycling	Bandiana	www.greenchiprecycling.com.au	info@greenchiprecycling.com.au
Gippsland Water	Traralgon	https://www.gippswater.com.au/sorf	sorfenquiries@gippswater.com.au

Queensland

Name	Location	Website	Email
Candy Soil	Ipswich	www.candysoil.com.au	sales@candysoil.com.au
Coastal Sand, Soil & Mulch	Craignish	www.coastalssm.com.au	robbie@coastalssm.com.au
Compost Direct	Jimboomba		compostdirect@bigpond.com
CQ Compost Pty Ltd	Emerald	www.cqcompost.com.au	matthew@cqcompost.com.au
Fraser Coast Regional Council	Hervey Bay	www.frasercoast.qld.gov.au	sue.paul@frasercoast.qld.gov.au
Gelita Australia Pty Ltd	Josephville	www.gelita.com	natasha.smith@gelita.com
Green Fingers Potting Mix	Woongoolba	www.greenfingerspottingmix.com.au	info@greenfingerspottingmix.com.au
J. J. Richards	Cleveland	www.jjrichards.com.au	richard.taylor@jjrichards.com.au
NuGrow	Brookwater	www.nugrow.com.au	sustainability@nugrow.com.au
Orgro	Toowoomba	www.orgro.com.au	manuel@orgro.com.au
Phoenix Power Recyclers Pty Ltd	Yatala	www.phoenixpower.com.au	njbrownlow@phoenixpower.com.au
Shark Recyclers	Bibhoora	https://www.sharkrecyclers.com.au	sales@sharkrecycling.com.au
WestRex Services	Jackson	www.westrex.com.au	david.powell@westrex.com.au
Wood Mulching Industries	Swanbank	www.woodmulching.com.au	chaye@woodmulching.com.au

Tasmania

Name	Location	Website	Email
Dulverton Organics	Latrobe	www.dulverton.com.au	admin@dulverton.com.au
Horticultural and Landscape Supplies (Seagreens)	Brighton	www.horticulturalsupplies.com.au	sales@horticulturalsupplies.com.au

Western Australia

Name	Location	Website	Email
C-Wise	Nambeelup	www.cwise.com.au	info@cwise.com.au
Eastern Metropolitan Regional Council		www.emrc.org.au	stephen.fitzpatrick@emrc.org.au
Intuit Earth Pty Ltd	Bunbury		louise.edmonds@intuitearth.com.au
Intuit Earth Pty Ltd	Gin Gin		louise.edmonds@intuitearth.com.au
J. D. Organics			donovan@brunningswa.com.au
Nutrarich Pty Ltd	Baskerville	www.nutrarich.com.au	sales@nutrarich.com.au
Purearth	High Wycombe	https://purearth.com.au/	
Richgro and Amazon Soils	Jandakot	www.richgro.com.au	customerservice@richgro.com.au
Southern Metropolitan Regional Council		www.smrc.com.au	bdoherty@smrc.com.au
SUEZ Recycling and Recovery (WA)	North Bannister	www.suez.com.au	cscperth@suez-env.com.au

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