Final Report

Alternative growing media for hydroponic berry production- a desktop review

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RB21002

Project:

Alternative growing media for hydroponic berry production- a desktop review (RB21002)

Disclaimer:

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Public summary

RB21002 – Alternative growing media for hydroponic *Rubus* production – a desktop review – was funded in response to increasing costs and supply-chain interruptions of sourcing coir, the preferred substrate for a vast majority of not only *Rubus* hydroponic production, but other berries, vegetables and mushrooms.

Background

Substrate choice is a critical component in any hydroponic production system. Substrate properties and performance have to meet the needs of the respective crop. Given the *Rubus* industry's heavy reliance on coir as a substrate, a review into current and emerging suitable substrate options for *Rubus* production was deemed necessary as a risk-management strategy in case coir availability and reliability of timely supply declined further or costs continued to increase. Additionally, coir shipped over large distances internationally carries a large carbon emissions profile. Given the increasing spotlight on embedded carbon emissions within agricultural production systems, there may be a risk to social licence and cost increases should changes in carbon taxation policies be implemented.

Desktop analysis and consultation

A national and global scan was undertaken to identify and analyse previously and currently used growing media, as well as emerging alternatives. Consultation with growers, substrate producers and industry representatives were undertaken in addition to an extensive desktop review. The review considered all potential substrate alternatives, not only those which had been used or developed specifically for *Rubus* hydroponic production.

SWOT analyses were undertaken on all growing media options identified as potentially suitable. A comparative gross margin (GM) analysis model was constructed to assess production systems using coir against a wood-fibre substrate which was identified as the most viable replacement at this stage.

Economic analysis and emissions

An economic threshold analysis was included to show at which substrate and berry price and yield the GM would not be adequate to cover variable costs (cost of sales). The analysis was based on accessible financial data for production in coir substrates, both published and obtained from industry sources; a set of assumptions had to be made for the wood-fibre substrate, given it had not yet been used for commercial Rubus production.

The GM analysis demonstrated that wood-fibre is likely to be cost-competitive when compared to coir assuming yield performance and durability as well as management of spent substrate are equivalent to coir. A high-level emission assessment was included for coir transport.

Conclusions

The project findings demonstrated that wood-fibre substrates most likely present a great opportunity for *Rubus* growers to diversify their substrate use. Further development and refinement of the substrates and their use as well as regional production options (circular economy) will be required along with production, economic and emission assessment data collection and analysis.

Recommendations

Long-term (over 3-4 production years) controlled trials are required to quantify any potential yield or production impacts when using 100% wood-fibre in comparison with coir and to understand any required changes in management practices including potentially mixing wood fibre with other materials e.g. spent coir or substrates identified in this study.

Outputs

Apart from this report, a factsheet and a recorded webinar detailing and discussing the findings is available here: https://youtu.be/2BK38KSDTLI. The recording webinar will also be hosted on the Berries Australia and Protected Cropping Australia websites.

Technical summary

For a technical summary of the project, refer to the comprehensive substrate factsheet included as Appendix 8.

Keywords

Rubus, coir, substrate alternatives, recycling, circular economy, hydroponic production, wood fibre, economic analysis, emissions

Introduction

Background

The majority of *Rubus* crops are grown in the eastern states of Australia, primarily in NSW, Victoria and Tasmania[1].

The current Berries Strategic Investment Plan (SIP) 2022 – 2026 includes strategies aimed at informing growers of emerging options, risks and opportunities offered by protected cropping systems. Hydroponic production falls within this category and the selection of substrates is vital for the viability of this system. To ensure Australian *Rubus* production is following international best practice, Hort Innovation commissioned a global scan of current and emerging alternative growing media used within *Rubus* hydroponic production or adaptable to *Rubus* production systems.

Hydroponic production requires an inert growing medium with good and stable water, air and nutrient holding properties. Apart from coir, rockwool, peat, perlite, pumice and even vermiculite can be used. Weight of the medium, sustainability of supply, and 'sustainable recovery' of spent materials are important selection criteria.

Transportation is a large portion of the cost of substrates. Currently, most *Rubus* hydroponic producers are using coir as the preferred growing medium. Coir is largely sourced from India, Sri Lanka, Indonesia, the Philippines and other tropical coconut-growing regions. For *Rubus* spp. production, coir substrate is generally used for 3-4 years and must be replaced after this because it has lost structure due to decomposition[2]. With rising shipping costs, the cost of purchasing fresh coir has doubled and is expected to continue to increase. A shortage of shipping containers and vessels combined with a focus on the more lucrative Northern Hemisphere markets for shipping lines exacerbates the problem. The time from ordering coir to it arriving on farms has extended. Further, supply of coir may become more uncertain because Sri Lankan farmers want to use the resource to improve productivity due to a government directive that enforces organic production.

In assessing alternative growing media, *Rubus* production locations are a key consideration, as this can impact the ease and cost of accessing alternative options and dealing with spent substrate. Long transport routes could be a significant issue for substrate alternatives which are costly or difficult to transport.

Rationale - why was the project was undertaken?

The 2018 National Waste Policy[3]: Less waste, more resources developed by Department of Environment and Energy on behalf of the Australian government, state and territory governments and the Australian Local Government Association outlines the current waste issues, sets key targets in relation to waste reduction and resource recovery, and provides a framework for collective action by businesses, governments, communities and individuals. It was developed in response to Australia's waste management and resource recovery challenges, a global shift towards circular economies and addresses Australia's international obligations, particularly in line with the United Nations Sustainable Development **Goals.**

The National Waste Policy Action Plan 2019[4] sets out targets and actions that support the strategies from the Policy. Relevant Targets for the organic sectors include:

Target 2: Reduce total waste generated by 10% per person by 2030

Target 3: 80% average resource recovery rate from all waste streams, following the waste hierarchy, by 2030

Target 4: Significantly increase the use of recycled content by government and industry

Target 5: Phase out problematic and unnecessary plastics by 2025

Target 6: Halve the amount of organic waste sent to landfill by 2030

Target 7: Make comprehensive, economy-wide and timely data publicly available to support better consumer, investment and policy decisions.

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[1] Hort Innovation. 2020/21 Australian Horticulture Statistics Handbook. Accessed 10 August 2022. <https://www.horticulture.com.au/contentassets/a68c8934a8bf40b4becdc487bacdb60f/hort-innovation-ahsh-20-21-fruit.pdf>

[2] https://www.nurserymag.com/article/core-facts-about-coir/

[3] Australian Government. 2018. National Waste Policy <https://www.dcceew.gov.au/sites/default/files/documents/national-waste-policy-2018.pdf>

[4] Australian Government. 2019. National Waste Policy – Action Plan <https://www.dcceew.gov.au/sites/default/files/documents/national-waste-policy-action-plan-2019.pdf>

The National Soil Strategy[5] and interim action plan sets goals to prioritise soil health an includes actions that are relevant to the recycled organics sector through the ‘Food waste for healthy soils’ fund and projects.

The 2021 Australian Organics Recycling Association Vision 2031[6]: The 10-year roadmap for Australia’s world lead organics recycling industry builds on the findings of previous works in economic and capacity assessment. The Vision includes 29 actions that aims to support maximum recycling at the highest quality.

Circular economy

Currently, there is a significant push across all industries for increased recycling of organics and circular economy processes.

The circular economy is a concept used to model production and consumption. The model can guide redesign of systems and facilitate collaboration and holistic business strategies to better manage resources. Rather than working in silos and disposing of waste, three principles, aligned to the waste hierarchy, can be applied:

1. Design out waste
2. (Re-)Circulate products and materials, and
3. Regenerate nature.

Figure 1: Illustration of circular design for organic materials[7]

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[5] Australian Government. 2021. National Soil Strategy <https://www.agriculture.gov.au/sites/default/files/documents/national-soil-strategy.pdf>

[6] AORA. 2021. Australian Organics Recycling Association Vision 2031. <https://www.aora.org.au/sites/default/files/uploaded-content/website-content/AORA%20Vision%202031%20Roadmap%20web.pdf>

[7] Agrocyle Led by the School of Biosystems and Food Engineering at University College Dublin, the http://www.agrocycle.eu/; adapted by Optimum Standard & RMCG for the Tasmanian Organics Research Report, RMCG Consortium 2022 https://nre.tas.gov.au/Documents/Tasmanian%20Organics%20Research%20Report%202022.PDF

Organic waste

RMCG has recently completed a research report and strategic framework on organic waste reduction and reuse for the Tasmanian Government (Natural Resources and Environment Tasmania)[8]. Similar initiatives are underway in other states. The focus on agricultural organic (and inorganic) waste will intensify in future years and hence reuse options for alternative media will be a key consideration.

This project

Hort Innovation previously conducted an investment assessing coir waste: “MT17016 - Coir waste management for hydroponics in berries” which was completed by RMCG in late 2018. The investment identified various methods of coir waste management reuse options, including:

- Addition to commercial compost
- Composting on farm
- Mulch or soil amendment
- Activated carbon/biochar
- Potting mix or addition to potting mix
- Mushroom cultivation
- Material for animal husbandry.

The project however identified several challenges with managing coir waste:

- Time and costs required to deal with a resource recovery solution e.g. handling and transport
- Separating spent coir from plastic
- The potential need to cooperate with other industries using coir to make reuse/recycling options feasible.

These challenges, in addition to existing issues relating to access and costs of transporting coir from overseas countries, highlight that using alternative substrates with greater reuse options, potentially within the same business, may present an opportunity to hydroponic *Rubus* producers in Australia.

Emissions

There is increasing scrutiny and interest by the public in embedded emissions within the food supply chain, both on-farm and also from farm inputs. Carbon emissions policy is likely to tighten on agricultural production (and other industries) in coming years. Given coir is transported from other countries in Asia, there are high carbon emissions associated with transporting this substrate to Australia. This represents a risk if alternative carbon pricing policies are implemented. Additionally, maintaining social licence to operate is crucial for community-support and marketability of food products and there is increased interest in how food is produced. Identifying a substrate with a lower emissions profile than coir is therefore, alongside the circular economy principle, preferable and represents a key consideration in selecting alternative substrates.

Significance for Rubus industry

Identifying emerging alternative growing media options for the *Rubus* hydroponic industry that can be used in the Australian production environment is needed to increase sustainability and resilience for the industry. Currently, coir is considered the best (yield) performing substrate and has so far been the cheapest option available to growers, however, based on various verbal accounts, coir costs (delivered on-farm) have doubled in the past 3-4 years. In addition, timeframes of supply from order to delivery have ballooned from 2 to 6 months. If coir prices and delivery times continue to increase, and reliable supply becomes more uncertain, growers will face increased margin pressures and production risks.

In summary, the industry is currently highly dependent on both the availability and cost of coir, and whilst other substrate options are available, these are not comparable to coir from a yield-performance or cost perspective. Therefore, this project aims to provide information and increase knowledge on emerging substrates which may become economically viable alternatives to coir and mitigate any risks to cost increases or a lack of reliable supply of coir.

[8] Department of Natural Resources and Environment Tasmania. 2022. Tasmanian Organics Strategy Framework https://nre.tas.gov.au/Documents/Tasmanian%20Organics%20Strategic%20Framework%202022.PDF>

Methodology

The project methodology was as described below.

Activity 1 - Project Inception, scoping and milestone (MS) 102 deliverables

Following the commencement of the project, Doris Blaesing and Jake Gaudion liaised with the Hort Innovation project manager to discuss the rationale for the project, identified key outcomes needed in the project and agreed on a work plan to progress the project. The work plan was captured in Smartsheet to be used as a dynamic organisation tool during the project.

Activity 2 - National scan – currently used growing media (for all hydroponic crops & nursery industry) and media previously trialed in Australian *Rubus* hydroponics or other crops.

At the commencement of the project, from previous information gathered by RMCG from *MT17016 – Coir waste management for hydroponics in berries,* most growers used coir as their preferred growing substrate in hydroponic *Rubus* production systems. Current economic costs, technical, management and yield information for current substrate (coir) use was needed to assess the qualities of potential emerging alternative substrate options against within the current hydroponic production system.

A project summary (Appendix 1) and grower survey were created and distributed through Berries Australia's Berry Burst newsletter, Fruit Growers Tasmania weekly newsletter and through individual Berry Industry Development Officers, as well as grower contacts within the berry industry. The aim of the survey was to identify currently used and previously trialed growing media, as well as understanding growers' technical requirements, preferred management practices, in addition to identifying desired traits in potential alternative substrate options. The survey questions are provided in Appendix 2. Organic processors, substrate producers, coir importers and individual farms were also consulted by email and phone interviews during this stage.

A SWOT analysis including financial data was completed, comparing the currently and previously used media alternatives across the hydroponic industry within Australia, and included both organic and artificial substrates. The SWOT analysis considered various components impacting the feasibility of using alternative media types, including cost, transportability, ease of access, ease of management, durability and recycling options.

Whilst the national scan was primarily a desktop exercise, we consulted with key producers / stakeholders to supplement our desktop findings prior to completing the analysis.

The SWOT analysis table for each previous and current growing media for hydroponic production, including availability of media and potential implications of use, including economics were the key output from this activity.

The SWOT analysis and implications for the focus of the global scan (Activity 2) was discussed with key industry representatives including Burlington Berries, Costa Berries, Tasmanian Berries and Hillwood Berries. We approached Berry Industry Development Officers (IDOs) to contribute their insights or provide contact details of growers we should talk to. However, following a number of attempts to connect (via email, SMS and phone), we only received feedback from the Tasmanian IDO and communication with the West Australian IDO.

Activity 3 - Global scan – mainstream and emerging alternative growing media types

A desktop review was undertaken to identify current and emerging growing media for hydroponic *Rubus* production. Primarily the review focused on European countries, however the scan also included hydroponic substrates used globally, and included substrates used and produced in America. While the global scan sought to identify and evaluate media for hydroponic *Rubus* production, substrates used for other hydroponic crops were also researched. A SWOT analysis was undertaken on current and emerging alternative substrates for hydroponic crop production globally and their suitability for *Rubus*. Economics and circular economy principles were considered in the analysis. A key focus was that solutions are practical, meet all criteria mentioned previously (e.g. cost, transportability, ease of access and management, durability and recycling) and would not negatively impact cost of production.

A SWOT analysis table for current and emerging growing media used or emerging for international hydroponic (Rubus and other crop types) production was the main output from this activity.

Activity 4 - Determine and investigate priority options in-depth including an economic analysis

Following the national and international scans and SWOT analyses, a comparison/review of all identified substrates was undertaken to determine feasible alternatives. Substrates were assessed based on obvious economic feasibility, yield considerations if available, durability, recycling/reuse characteristics, accessibility and transport.

A preferred emerging alternative substrate was then identified, which is a wood fibre-based substrate. Industry Development Officers and Growers were consulted to ground-truth the current costs of various production inputs. Feedback was received from the Tasmanian IDO and Tasmanian growers. We also consulted with two current manufacturers of the alternate substrate to get relevant information for the economic analysis, and an NSW substrate producer who has used wood fibre products in mixes supplied to *Rubus* growers.

A Gross Margin (GM) comparative analysis and threshold analysis were undertaken, comparing economic costs and benefits between the 'current case' (i.e. using coir as substrate) and of the preferred substrate ('future case'), assuming it was used as a substitute. The analysis included capital and operating costs, costs of management of spent substrate, and alterations to the production system. A sensitivity analysis was also undertaken to assess the impact of changes in substrate costs, yield, irrigation and fertigation rates to provide information for a range of potential future situations. A high-level carbon emissions analysis of coir shipping was also undertaken.

The findings from the national and international scan (SWOTs), meetings and conversations with industry representatives, the Tas IDO and a 'waste' organic recycling company (Dulverton Waste Management) representative were used to identify of future R&D priorities to increase knowledge and refine the commercial use of alternative growing substrate requirements.

The main outputs from this activity are the economic analysis, the emission analysis and identification of future RD&E priorities.

Activity 5 - Conduct online webinar/workshop with industry and develop a concise factsheet

A webinar and feedback session (workshop) was conducted in cooperation with Protected Cropping Australia (PCA) to communicate all findings, get feedback from *Rubus* producers and other hydroponic growers on all outputs including the RD&E recommendations. Feedback was especially sought on the feasibility of the identified, preferred substrate and economics in the Australian regional context.

The feedback was used to review outputs where required, finalise the project report, produce a project summary for industry newsletters and electronic media including relevant industry websites, and develop a concise factsheet for the industry. These outputs were provided to national and state industry bodies and IDOs use in communication and distribution to growers.

Activity 6 - Reporting including RD&E recommendations

We produced a draft of this report for review by the Hort Innovation project manager and incorporated feedback provided by return email into a final report. The report includes RD&E investment recommendations for consideration by the Raspberry and Blackberry SIAPs.

Results and discussion

Findings

Activity 1 - National Scan:

Information gathered from the national scan stage (from desktop research/literature the grower survey, discussions with growers, substrate producers and organic recyclers) was used to identify several 'ideal' technical parameters desired for a *Rubus* hydroponic substrate. These include:

- A balanced mix of particle size is desired for Rubus crops: coarser particles assist with increased air-filled porosity; smaller particles increase water-holding capacity.
- Water-holding capacity should range between 20-40% (by volume) range and air-filled porosity at 13-28% (coir air-filled porosity) or greater. The combined water-holding capacity and air-filled porosity percentages are needed to ensure the substrate is free draining whilst maintaining water access for plant roots and sufficient space and oxygen availability for optimal root development.
- Durable, stable structure with low rate of decomposition (able to last at least 3-4 growing seasons in cool-climate conditions).
- Bulk density comparable to the 80 kg/m^3 of coir. The substrate must be light enough to be included with existing production infrastructure (filling and removing of pots or grow bags) and comparable or cheaper to transport, and heavy enough to provide adequate stability for the plant over 3-4 years.
- pH range – Rubus plants desire slightly acidic to neutral pH (5.5 – 6.5). Substrates not in that range can be buffered prior to planting by adjusting the nutrient solution to match plant requirements.
- Compressible to a volume several times smaller than its usable volume to reduce transportation costs (coir can be compressed by 5-6 times of its usable volume).
- Substrate has characteristics or can be treated such that nitrogen drawdown does not occur – all nutrients within nutrient solution must be plant available.
- Free from weeds, pests and disease to guarantee plant heath and biosecurity are not at risk; sterilisation of the substrate may be required (especially important for imported products or those recycled after use for the same or related crops e.g. *Rosacea* for *Rubus*)

Other important characteristics in an 'ideal' substrate include:

- Cost: similar to or lower than current substrate costs.
- Availability: production capacity sufficient to accommodate *Rubus* industry requirements, in addition to those competing (for the substrate) industries (other berries, vegetables, nursery industries).
- Locally produced: preferably produced near berry production regions. Reduces transportation costs and risks to supply chain interruption, reduces carbon emissions from shipping and risk to social licence, allows for recycling of 'waste organics' e.g., from timber production or those used in other substrates or composts.
- Recycling / re-use options: substrates which can be re-used again or recycled (i.e., used as soil amendment) are preferable. Substrates not currently used that cannot be recycled or reused were not considered. Landfill disposal costs are increasing, and this trend is expected to continue in coming years. As such, disposal to landfill is not considered to be a sustainable option (as per the National Waste Strategy 2018[9]). Substrates unable to be recycled or reused were therefore not considered as viable alternatives.
- Insulation properties: important to a lesser extent, substrates which insulate the plant and roots from extreme temperatures are beneficial.

Current and previously used substrates identified as part of the national scan included coir, peat, rockwool, perlite, vermiculite, sawdust and pine-bark. The feasibility of using a substrate free system such as Nutrient Film Technology (NFT) or even Aquaponics was discussed with growers. The response was that these systems are not considered suitable for perennial, long term crops. Relying on electricity to provide the water and nutrient exchange without a buffering substrate was also seen as risky.

The results of the national scan clearly conveyed that coir currently is the preferred growing substrate for *Rubus* hydroponic growers, however it was also clear that the increased cost and concerns about availability and consistency of

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[9] Australian Government. 2018. National Waste Policy <https://www.dcceew.gov.au/sites/default/files/documents/national-waste-policy-2018.pdf>

supply of coir has producers considering alternate options, particularly should the price of coir continue to increase and access becomes more uncertain.

The national scan SWOT analysis for previously and currently used growing media can be found in Appendix 4. The SWOT analysis showed that coir is still the dominant substrate in use across Australian hydroponic production systems. Its technical characteristics (i.e. water-holding capacity, air-filled porosity, bulk density) as a stand-alone substrate and comparatively low costs out-perform all other options currently or previously in use. Even despite coir's recent cost increases and considering that it has to be shipped from Asian countries to Australia, the SWOT analysis found that its ability to be compressed for transport, durability and yield-performance mean that it is clearly the leading substrate option overall. Growers consulted indicated that any identified alternative substrate would need to be at a similar price-point to coir for it to be considered. As an organic substance, coir can be reused and recycled; however, it must be noted that the cost of transport to send it to organics recyclers is a major cost to producers. Inorganic substrates such as perlite, vermiculite and rockwool were found to have some excellent technical qualities as substrates (either in a substrate mix or on their own), however their higher costs and inability to be reused or recycled means that they weren't considered as viable future options. The SWOT analysis demonstrated that any emerging alternative substrates need to have similar yield-potential, durability and cost characteristics to coir.

Activity 2 - Global scan – mainstream and emerging alternative growing media types

The desktop review for emerging alternative substrate options in international *Rubus* and other hydroponic crop production identified alternative substrate options. Several emerging substrates were identified, with a majority of these derived from untreated timber. It is virtually free of contaminants, due to the use of untreated wood and heat applied during substrate production. The first industrially made wood fibre product was launched in 1983. A host of other such products followed, but their market acceptance was low to moderate, and most are no longer available[10].

Advanced wood fibre substrates have been developed and used in hydroponic systems in Europe for about 5-10 years, and whilst they have not succeeded coir as the preferred substrate for hydroponic *Rubus* production, they have been trialled and performed well, particularly in mixed substrates, e.g., with peat or composted bark, used for several other hydroponic crop production systems (vegetables, flowers). The production methods and the wood type used in the various wood fibre substrates differ – with some wood fibre products using spruce timber, some using pine and some using other soft wood timbers as available.

Wood Fibre Substrates

Two companies, one in the Netherlands (1) and one in Germany (2) are producing a wood fibre-based substrate under the Name of GreenFiber and GreenFibre respectively:

1. Bolpeat in the Netherlands - https://www.bolpeat.nl/en/products/wood-fibre/
    - GreenFiber fine - for pressed pots and tray substrates
    - GreenFiber medium - or bedding plants and potting soil substrate
    - GreenFiber coarse - for coarse container substrates
    - The Dutch substrates are currently not used for hydroponic production
2. Klasmann Deilmann in Germany - https://klasmann-deilmann.com/en/products-solutions/alternative-raw-materials/greenfibre/
    - The substrates are promoted for the same grades and applications as the Dutch products. However, Klasmann Deilmann have also developed the product for application in hydroponic strawberry and blueberry production https://klasmann-deilmann.com/en/fields-of-application/soft-fruits/.

The investigation of the above wood fibre substrates gave us a lead to two Australian producers of these type of substrates who are still in the product development proof of concept and early commercialisation phase.

Australian Growing Solutions (AGS), based in Tyabb, Victoria, produce a wood fibre substrate, named GrowFibre, which is made from *Pinus radiata* (Monterey Pine) and sourced from Gippsland, Victoria. AGS has recently been taken over by the German company, Klasmann Deilman and has access to their technology such as a reverse extruder system (Retruder®).

The target markets for the identified wood-fibre substrate are the nursery and hydroponic industries in Australia. AGS

[10] Schmilewski, G. and Nordzieke, B. (2019). Researched, developed and commercialized: GreenFiber. Acta Hortic. 1266, 361-368

have begun supplying their product to several farms for trials in strawberry, raspberry and blackberry hydroponic production. Controlled, replicated trials on a large scale have not been conducted yet. Therefore, there is a lack of reliable performance and yield data for the substrate. Anecdotal information from some growers indicated there was not a discernible yield difference between strawberry crops grown in coir and the currently preferred wood-fibre substrate types.

According to those who have been trialling the currently preferred wood-fibre substrate there were several noted differences between their management requirements. The currently preferred wood-fibre substrate tended to dry down quicker than coir, the top portion of the substrate lost moisture more quickly, which meant that crop establishment was slower than for crops grown in coir substrate. Growers also noted that capillary action of water in the wood-fibre substrate was decreased, which was particularly noticeable in strawberry crops grown in troughs, where horizontal water movement is important (see Appendix 3). Growers were able to mitigate these differences by irrigating at a greater frequency in shorter bursts, to ensure the top portion of the substrate did not dry out, and by inserting additional irrigation drippers for crops grown in containers with larger surface areas (such as strawberries in troughs). It was noted by growers that once plant establishment had taken place, performance between coir and the currently preferred wood-fibre substrate appeared to be roughly equivalent. It must be noted that the results communicated here were not part of controlled trials and conducted on a small demonstration scale. Further replicated and commercial scale trials are needed to determine the substrates comparative usefulness for *Rubus* production.

Figure 2: Strawberry plants grown in coir (left) vs plants grown in the identified wood-fibre substrate (right). Some plants appear smaller and show signs of slower establishment in the identified wood-fibre substrate.

HydraFiber, developed in the US (https://www.hydrafiber.com/), is similar to a product by Australian Wood Fibre (AWF) located in south-east Queensland. HydraFiber is manufactured with a patented Thermally Refined® process that combines wood and bark and refines them in a pressurised vessel to create singulated, small diameter, long, thin strands with large surface area.

AWF currently produce a substrate made from a combination of Pine and Eucalyptus spp. wood chips. AWF's wood fibre product differs from the currently preferred wood-fibre substrate product – it is a finer substrate and is less 'chippy' than GrowFibre. Their product is primarily used for soil erosion control during mining rehabilitation but has also been supplied to horticultural hydroponic grower clients through a substrate producer, GoGrow. GoGrow have included it as part of a substrate mix with coir for hydroponic raspberry and blackberry production. In raspberries, it was trialled as part of a 75% mix of cocopeat and 25% mix of wood fibre. Anecdotal information from its use in raspberries suggests it achieved similar yields to a 100% coir substrate. Similarly to GrowFibre, there was a noticeable dry-down effect in the top layer of the substate, which slowed plant establishment. However, it was suggested that as the plant roots developed further, there was noticeable visual difference between the plants in both substrates, with plants in the wood-fibre mix substrate appearing to grow slightly better. It was thought that the extra air-filled porosity may have benefitted the *Rubus* plants post-establishment. Both HydraFiber and the AWF wood fibre product currently experience some 'clumping' issues when wetted on its own, which mean they are currently not suitable as a stand-alone substrate. Once mixed with another substrate (such as coir), the 'clumping' is no longer an issue. Based on this information, AWF's substrate may currently have some value as an additive to other, complementary substrate mixes.

The international scan SWOT analysis for emerging growing substrates can be found in Appendix 5. The SWOT analysis shows that the technical characteristics and specifications of individual wood fibre substrates can vary substantially. This variation is primarily driven by the wood feedstock used (i.e. pine, eucalyptus) and the manufacturing method. There is insufficient data and information available for many of the identified options to compare directly to coir. Further analysis is required to determine whether the emerging substrates can be used as a substrate on their own or in a mix, understand their durability and how suited they are for *Rubus* crops.

Activity 3 – Determine and investigate priority options in-depth including an economic analysis

A review of the SWOT analyses for each substrate type identified a wood-fibre substrate that currently is in the proof of concept/early commercialisation stage for berry fruit as the priority option to evaluate further. The currently preferred wood-fibre substrate possessed most of the required characteristics for an ideal Rubus hydroponic substrate, including suitable water-holding capacity and air-filled porosity percentages, bulk density, being locally produced, renewable, recyclable and at an apparently competitive cost relative to current substrate costs. Currently the identified- wood-fibre substrate option costs approximately $130 per cubic metre, ex works. If including transportation costs to growers the costs are likely to make this equivalent to, or potentially more expensive than coir, depending on both the location of substrate production and of the berry production.

The producer of the identified wood-fibre substrate, other substrate producers and growers who have used it were consulted to understand their experiences with using the new substrate. Current issues identified are:

- **Transportability of the substrate:** the currently preferred wood-fibre substrate can only be compressed 1.4 times its usable volume, in comparison to coir which can be compressed by 5 or 6 times its usable volume. Anecdotal information suggests it currently is not economically competitive for the currently preferred wood-fibre substrate to be shipped from Melbourne to Tasmania for use as a *Rubus* hydroponic substrate.
- **Observed low water-holding capacity in field:** It was observed that the currently preferred wood-fibre substrate dried out quicker than coir at the top portion of the substrate, resulting in slower plant establishment which may potentially lead to yield losses
- **Lack of data on the durability of the substrate:** there is a lack of data currently to determine whether the currently preferred wood-fibre substrate will possess a similar structural durability to coir, which can last up to 5 years as a substrate for Rubus production. Anecdotal information suggested that GreenFibre (the comparable European product) was able to last for 7 years in a substrate mix with peat for a blueberry crop, and one Australian grower said they expect that the identified wood-fibre substrate may maintain greater structural stability into the 3rd and 4th year of production than coir, which may result in increased yields during those years.
- **Particle mix size of the substrate:** some growers have suggested that on its own, the currently preferred wood-fibre substrate is too coarse and does not possess the smaller particles sizes which are required to increase water holding capacity and capillary action.

It should be noted that the currently preferred wood-fibre substrate has been trialled in hydroponic *Rubus* systems for one full growing season only and is in the early stages of commercialisation. The wood-fibre producer is seeking to upgrade their production facility to enable the production of a finer diameter wood fibre, which may be added to the currently preferred wood-fibre substrate to increase the diversity of particle sizes in the mix and improve the capability of the substrate. They are seeking to establish production centres in other berry producing states, such as New South Wales, Queensland and Tasmania; states which also have close access to raw pine wood material. Alternatively, the wood-fibre producer is also exploring whether there is potential to create a mobile production facility which can travel between states and growing regions. Further trials and refinement are required for this promising substrate.

Economic analysis

An economic assessment using comparative gross margin analysis was undertaken on the currently preferred wood-fibre substrate to determine how it might impact the overall economic feasibility of the current production system. The full analysis can be found in Appendix 6. Some assumptions were required, such as similar yield output and longevity of substrate, given the lack of trial data using the new substrate.

The comparative Gross Margin analysis determined that the currently preferred wood-fibre substrate is economically competitive with the current production system using coir, with some key assumptions required. Assuming the identified wood-fibre substrate is produced within the same state and at a distance not too far from berry producing regions (approximately 100-200km), it is currently conservatively at cost-parity with coir. Provided there are no yield or durability decreases with using wood-fibre, or other production changes required which are currently not known, the currently preferred wood-fibre substrate appears to be economically viable as a substrate alternative.

A threshold analysis was also included within the economic analysis to demonstrate the 'threshold' levels (yield and substrate price) the growing system would need to operate at under a generic new substrate to be viable.

Table 1: Coir vs the currently preferred wood-fibre substrate technical specifications comparison

Components	Coir	Currently preferred wood-fibre[11]
Air-filled porosity	13-28%[12]	30 – 35%
Water holding capacity	Approximately 40%	20 – 25%
Bulk density	80 kg/m^3	100 – 150 kg/m^3
pH range	6.0 – 6.8[13]	5.0 – 7.5
Durability	Up to 4-5 years in Rubus crops in Vic/Tas, less in northern NSW and QLD	Not yet known
Country of origin	Southeast Asia (Sri Lanka / India / Indonesia / Philippines)	Australia
Cost	\$180 - \$220 per m^3	\$130 per m^3 (excluding freight) – plus indicative freight costs of \$50 per m^3 [14]

What the results mean for *Rubus* producers

Wood-fibre

Wood-fibre products are potentially an option for future use, especially if locally produced at a competitive price. Wood fibre is promising if production inputs (e.g. pine) also occur near berry farms. Pine wood chips are required for production. Eucalyptus and pine bark may also be suitable (as per HydraFiber). Pine wood production occurs on a large scale in Tasmania and Victoria. In NSW, radiata pine is mostly grown in large plantations located on the Southern Slopes and Central Tablelands near Tumut and Bathurst, but it is also found in other areas of NSW. Smaller plantations are grown on the Northern tablelands, hence locally sourced woodchips appear to be available for local production of the currently preferred wood-fibre substrate or alternative wood fibre products.

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[11] AGS the identified wood-fibre substrate Brochure. Accessed 1st September 2022. <https://www.agsolutions.net.au/_files/ugd/c85030_c5735490105146a882287898b8611da0.pdf>

[12] Physical properties of growing media. Accessed 10 October 2022 <https://www.pthorticulture.com/en/training-center/greenhouse-herb-and-vegetable-production-part-44-growing-media/>

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[14] Information supplied by Australian Growing Solutions. Freight costs are a conservative estimate, assuming substrate is produced in same state and transported 100km to farm: \$50/m^3

Photos/images/other audio-visual material

Photographs taken during the project can be found in Appendix 3. The photographs show various substrate mixes in use being trialled for strawberry production.

Outputs

Table 2: Output summary

Output	Description	Detail
SWOT analysis table (national) – previous and currently used growing media	A SWOT analysis table for emerging and current growing media for hydroponic production, including availability of media and potential implications of use, including economics.	The SWOT analysis and implications for the focus of the global scan (Activity 4) where discussed with key industry representatives (refer to Methodology). The synthesis of the SWOT analysis was used in the webinar and it is included in the project summary for peak bodies and IDOs and the factsheet for growers.
SWOT analysis table (international) – current and emerging media (global scan)	A SWOT analysis table for current and emerging growing media used or emerging for international hydroponic (Rubus and other crop types) production. The SWOT analysis and implications for the industry will be finalised in mid-September 2022.	The synthesis of the SWOT analysis was used in the webinar and it is included in the project summary for peak bodies and IDOs and the factsheet for growers.
Webinar/Workshop (information and feedback session)	On line event using Zoom; presentations by the project team and producers of wood fibre substrates followed by a facilitated discussion and collection of comments and feedback in the chat function. The webinar and feedback were recorded. held in conjunction with Protected Cropping Australia (PCA).	A webinar/workshop was conducted following the international and global scans to communicate information about current and emerging substrates. Invitations to the webinar were circulated via Protected Cropping Australia, Berry Australia newsletter subscribers and IDOs. The recording can be found on this link (https://youtu.be/2BK38KSDTLI). The webinar recording will also be hosted on Berries Australia and Protected Cropping Australia websites. The feedback was incorporated in the final report. Presentation slides as part of the webinar can be found in Appendix 7.
Economic analysis	Gross margin, sensitivity and threshold analysis tables (Appendix 6) using MS Excel based models. The Excel models can be made available to Rubus growers so they can use their own data.	The gross margin and sensitivity analyse are comparing coir with an alternate substrate made from wood fibre. The threshold analysis shows the maximum competitive substrate cost. The analyses are based on available industry data and stated assumptions.
Fact sheet and summary of findings in MS Word and PPT format	Fact sheet and summary containing summarised characteristics of alternative growing media, including e.g. ease of access, ease of management, sustainability, disposability, durability differences in characteristics to coir and explanation of, compatibility with existing systems and altered management practices as well as the economic analysis information.	Fact sheet and summary of findings were distributed via Berry Australia newsletter subscribers, IDOs, RMCG social media and published online by Berry Australia
Draft report	Draft report for review by the Hort Innovation project manager.	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 Raspberry and Blackberry SIAPs

Outcomes

Table 3: Outcome summary

Outcome	Alignment to fund outcome, strategy and KPI	Description	Evidence (extension materials produced)
Increase grower knowledge of viable alternative substrates	Berry S.I.P 2022-2026 Outcome 2: Industry supply, productivity and sustainability – improve industry production efficiency (inputs/outputs) to maintain local and international competitiveness and viability of supply.	Increased knowledge on alternative substrates to coir, including production characteristics, changes in management practices required.	Availability and use of Webinar recording (https://youtu.be/2BK38KSDTLI) project summary (in this report), factsheet (Appendix 8) and final report (this document) available to *Rubus* growers.
Economic insights on comparative costs of alternative substrates		Increased knowledge on costs and benefits of alternative substrates compared to coir. Importantly, if an alternative substrate causes as little as a 2% decrease in marketable yield, it severely impacts the economic viability of production. Growers can absorb increases to substrate costs, but there is significant sensitivity to even small decreases in marketable yield.	Economic analyses available to Rubus growers (Appendix 6): - Gross margin comparison - Threshold analysis.
Identify alternate pathways to improve re-use of coir	Strategy 3: Inform berry growers on the emerging options, risks and opportunities afforded by protected cropping systems. Strategy 7: Develop a long-term sustainability program that includes a set of values, practices and communication activities that support a well-respected and sustainable berry industry (e.g., recycling of coir, plastics and water).	MT17016 – Coir waste management for hydroponics in berries" completes 2018 covers recycling pathways. Composted or sterilised coir can be reused in substrates like potting mixes or potentially with wood fibre.	The opportunity of reusing coir in substrates was described in MT17016. The option of mixing spent coir has to be investigated (refer to recommendations).
Inform future R&D substrate requirements	Strategy 3: Inform berry growers on the emerging options, risks and opportunities afforded by protected cropping systems.	This report and especially recommendations on how to address knowledge and data gaps and identified opportunities to refine substrates to better suit Rubus production requirements.	Recommendations in this report, project summary, webinar recording and factsheet.

Monitoring and evaluation

Table 4 provides information on key evaluation questions.

Table 4: Key Evaluation Questions

Key Evaluation Question	Project performance	Continuous improvement opportunities
Effectiveness To what has the project succeeded in producing a desired outcome?	The project identified a promising alternative substrate to coir which can be produced locally. The project established via consultation that Rubus growers are interested in trying the substrate, they believe it has potential. One wood fibre producer is interested in setting up substrate production facilities in major berry / hydroponic production areas. We identified that the wood fibre substrate can be processed by compost producers and should have the same recycling / reuse potential as coir.	Improved responsiveness by mainland industry IDOs and through that, access to more Rubus growers.
Relevance How important are the outcomes for *Rubus* producers?	Given the rising costs of coir, the potential uncertainty of supply and disruptions of supply chains, outcomes are highly relevant; this was confirmed by major Rubus producers. The results are also relevant to growers of other hydroponic crops.	See above
Process appropriateness Were suitable methodologies used?	We believe that the mix of desktop research, contacting and informing industry bodies, consulting with growers throughout the project, as well as talking to substrate producers and a recycling company was appropriate for the scope and objectives of the project	See above
Efficiency Were time and resources used effectively and with competence?	The project team worked efficiently by producing an internal, shared project plan (Smartsheet) that allowed each team member to concentrate on their tasks. The team caught up regularly vie Teams to monitor progress, stay focussed, deal with issues and ensure the project delivers for the industry. The Hort Innovation project managers was kept informed of progress and issues via email after an initial on-line inception meeting	Not needing to chase some people for information or contribution may have improved efficiency somewhat.

The degree of success is also evident from outcomes and intended adoption:

Rubus grower plan to trial wood-fibre substrates within their hydroponic production
The project outputs will lead to increased knowledge of:

- Accessibility, compatibility and sustainability of the identified alternative substrate, and
- Economic understanding of costs and benefits of using alternative substrates.

The project provided the Rubus SIAP with RD&E investment recommendations on substrates for hydroponic production.

Recommendations

The primary recommendations for this project are centred around establishing replicated trials for identified alternative substrates, including wood-fibre substrates, for use in hydroponic *Rubus* production in the Australian production context. R&D activities should include:

- Controlled larger-scale, long-term replicated trials to be undertaken using various wood fibre substrates.
- Trials should also investigate different substrate mixes (e.g., 50:50, 75:25 ratios of coir or other organic substrate and wood-fibre) to identify production impacts over a 3-4 year growing cycle.
- Feedback on trial results should be provided to substrate manufacturers to enable them to better understand technical requirements and refine their substrates accordingly.
- Growing trials should occur across different geographic areas, differing methods of berry production (long-cane, floricane, primocane, different container sizes) and focus on establishing optimal management practices for the alternative substrate (e.g. determining optimal irrigation duration, frequency, fertigation requirements). Different management practices to coir may be required for emerging substrates.
- A feasibility assessment of setting up wood-fibre production facilities to supply substrate to *Rubus* producers in each state – which is crucial to reduce transportation and (therefore overall) substrate costs.
- Future Gross Margin tools must include the costs of spent substrate management (recovery, re-use, recycling) for assessing viable substrate alternatives. They should consider emission impacts of different options.
- Any future research and investments on alternative substrates must focus on the substrates' yield potential and durability. Grower feedback from the webinar highlighted that if using an alternate substrate causes as little as a 2% decrease in marketable yield, it severely impacts the economic viability of production. Growers can absorb increases to substrate costs, but there is significant sensitivity to even small decreases in marketable yield.

Practical application of the project findings

Development and adoption activities

Activities to improve development and adoption of alternative growing media options should centre on increasing knowledge and communicating any differing management practices required for individual substrates. Industry extension, workshops and case studies should be produced demonstrating optimal substrates and mixes and highlighting changes in production practices required (e.g. increased irrigation frequency but in shorter bursts).

Research needs

Controlled, large-scale replicated R&D trials across varying production environments are required to ascertain substrate yield-impact performance specifically for *Rubus* crops. Research is also required to understand the durability of wood-fibre substrates, particularly whether these are shorter or longer lasting than coir in *Rubus* production. Any research results should include communication of findings with substrate producers to inform them of *Rubus* hydroponic substrate and growers requirements to assist with development.

Refereed scientific publications

Journal articles

No refereed scientific publications were submitted during this project.

References

References have been supplied 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

No project IP or commercialisation to report

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Laurie Adams – Burlington Berries

Lou Theron - Australian Wood Fibre

Mark Salter – Berries Australia IDO – Tasmania

Matthew Layton – Dulverton Waste Management

Rohan Davies - Australian Growing Solutions

Stephen Welsh - Costa Berries

Sandra Alfonso – Tasmanian Berries

Appendices

Appendix 1: Project summary supplied with grower survey.

RM Consulting Group (RMCG) are currently delivering the Hort Innovation project *RB21002 - Alternative growing media for hydroponic berry production - a desktop review*. The aim of this project is to identify emerging substrate alternatives for hydroponic Rubus crops that can be adopted or adapted to Australian production conditions. To determine what emerging substrates might be suitable, we have put together a grower survey to gain an understanding of existing substrate use, preferences and requirements.

Appendix 2: Grower survey questions

How your data will be used

The information collected from this survey will inform an understanding of grower requirements, preferences and barriers to using alternative growing media in hydroponic production. Individual responses are confidential, will not be made public and all data provided will be de-identified and aggregated for reporting purposes.

Please note that you do not need to answer any questions you are not comfortable providing information on.

RM Consulting Group (RMCG) is delivering this project with funding through Hort Innovation, using the Raspberry and Blackberry research and development levy and contributions from the Australian Government. If you provide permission in the survey, an RMCG consultant may contact you to discuss the survey questions further.

Please contact Jake Gaudion (0425 121 448, jakeg@rmcg.com.au) or Doris Blaesing (0438 546 487, dorisb@rmcg.com.au) if you would like any further information on this project.

This survey will take approximately 20 minutes to complete.

Thanks in advance for your time.

Substrates

1. What substrate(s) do you currently use?
2. Who supplies the substrate?
3. How long do the plants stay in the substrate?
4. How much substrate do you use annually (m3)?
5. Are you intending to increase the amount of substrate you are using over the coming 3-5 years?
6. If yes, by how much (%)?
7. If currently using coir, what characteristics make it favourable for you? (Cost, durability, ease of management, accessibility, yield benefits, less disease pressure, weight, consistency, volumes available)
8. What are the disadvantages to using coir?
9. Would you consider using an alternative substrate to coir?
10. What are your key management considerations in choosing a substrate?
11. What are some emerging substrates currently in use or trials (other than coir) in Australia or overseas that you are interested in?
12. What technical characteristics would need to be present in an alternative substrate for it to be considered in commercial use? (Physical, chemical, biology)
13. If you were to move to a higher-cost substrate than coir, what characteristics would need to be present? (Less management/handling requirements, longer durability (e.g. 5 years), less space required, local supply, good reuse or recycling options)
14. What are you currently doing with used coir/substrate?
15. What would you like to do with used coir/substrate?

Economic considerations

16. What is the cost of coir per m3?
17. How much of the total coir cost is in transport? (%)
18. What costs are associated with handling of fresh coir (i.e. planting, labour, fuel)?
19. Of the total costs associated with handling fresh coir, how much do the below (labour, machinery/equipment, fuel) contribute? ($ or %)
20. What costs are associated with handling of used/spent coir (i.e. labour, fuel)?
21. Of the total costs associated with handling used/spent coir, how much do the below (labour,

machinery/equipment, fuel) contribute? ($ or %)

22. What is the maximum amount you would pay for substrate?
23. As a percentage, how much do substrate costs comprise of your total production costs?
24. What are your total variable costs for hydroponic Rubus production, excluding harvest and post-harvest losses?

General production information

25. What type of *Rubus* berries do you grow hydroponically?
26. What is your total raspberry production area?
27. What is your total blackberry production area?
28. What is your total production area for *Rubus* fruit other than raspberries or blackberries?
29. If using bags: which type (material) do you use and what size (L)?
30. If using containers: which type (material) do you use and what size (L)?
31. In which month(s) does planting occur?
32. In which month(s) does main harvesting occur?

Summary

33. What do you want to get out of this project?
34. Please add any other comments or queries you might have regarding the project

Appendix 3: Photographs taken during project (photographs taken by Doris Blaesing and Jake Gaudion)

NB.: We did not see trials with Rubus using wood-fibre during the project.

Figure A3-1: Strawberry plants grown in 100% coir substrate

Figure A3-2: Strawberry plants grown in 100% the currently preferred wood-fibre substrate substrate.

Figure A3-3: Strawberry plant grown in 50:50 mix of coir and GrowFibre.

Figure A3-4: Strawberry plants grown in 100% GrowFibre

Figure A3-5: Strawberry plants grown in 100% GrowFibre. Note the distinct wet patches around drippers.

Figure A3-6: Strawberry plants grown in 50:50 the currently preferred wood-fibre substrate and coir.

Appendix 4: National Scan SWOT Analysis

Table 5: Coconut coir (pith and chips) SWOT Analysis

Strengths	**Weaknesses**
• Excellent water-holding capacity • Sufficient air-filled porosity • Biodegradable (can be composted) • Low bulk-density • Can be used as stand-alone substrate or mixed with others • Overall excellent combination of technical qualities • Can be compressed up to 6x its normal state size – excellent for transportation • Renewable material (produced from coconut husks) • Various particle sizes produced from coir – both pith and chips.	• Produced internationally – must be shipped into Australia (anecdotal information suggests up to 50% of the cost to growers is in shipping currently) • Shipping costs are continuing to increase • High cation exchange capacity - requires buffering (calcium nitrate) to remove large amounts of sodium ions bound to ensure it is a neutral substrate • Increasing timeframes of supply – in 2019 it took approximately 9-10 weeks from order to delivery on-farm, in 2022 this is now 6-7 months • Variable quality at times • High costs of handling/recycling spent coir • Increasing competition for coir from other hydroponic industries.
Opportunities	**Threats**
• Scope for increased re-use of spent coir substrate within production system – mixing with fresh substrate in *Rubus* crops. Spent strawberry coir substrate could be then used in Rubus crops (pending root separation, sterilisation).	• Increased competition from other hydroponic industries for coir causing an increase in price • Shipping/supply chain disruptions leaves industry at severe risk • Increases in price (has doubled in price in past 3-4 years).

Table 6: Perlite SWOT analysis

Strengths	**Weaknesses**
• High air-filled porosity % • Good wicking action to reduce risk of root rot • Relatively inexpensive • Can potentially be re-used – is able to be steam pasteurised • Sold mixed with coir to enhance draining • Relatively inexpensive.	• Low water-holding capacity – dries out very quickly between waterings. Needs to be mixed with other substrates (such as vermiculite) • Dust from perlite a known risk to human health • Prone to algal growth • Light-weight – can wash away in hydroponic system causing blockages • Not renewable – made from volcanic rock • Unable to be composted – must be disposed of in landfill, also renders other substrates mixed with perlite non-recyclable
Opportunities	**Threats**
• Can be used as additive to many substrates to increase drainage.	• Increased competition for raw material

Table 7: Vermiculite SWOT analysis

Strengths	Weaknesses
• Light weight • Sufficient availability • Relatively inexpensive.	• Cannot be steam-sterilised (disintegrates during heating) – limited reuse options • Retains too much water, can suffocate plant roots if used on its own • Needs to be mixed with other substrates.
Opportunities	**Threats**
• Could be used as an amendment and mixed with other, lower water-holding capacity substrates.	• Restrictions to production.

Table 8: Rockwool SWOT analysis

Strengths	Weaknesses
• Light weight • Sterile • Insulates well against heat • Easily available • Considered by many commercial growers to be technically the ideal substrate for hydroponic production • Rockwool can hold water and retain sufficient air-space (at least 18%) to promote root growth • Can be re-used – steam sterilising of slabs between crops	• Unable to be recycled when substrate unable to be reused and must go to landfill • Never truly decomposes • Relatively higher price to coir • High pH – constant pH adjustment in solution may be required
Opportunities	**Threats**
• If economically viable sterilisation process is created, rockwool can be re-used multiple times and made highly durable	• Increased costs to dispose would decrease economic viability

Table 9: Pine bark SWOT analysis

Strengths	Weaknesses
• Once considered a waste product – circular economy • Berry production areas overlap with pine bark production areas – reduced transport costs • Pine resists decomposition better compared to other tree bark • Biodegradable product – can be used as mulch after substrate use • Good air-filled porosity • Relatively cheap and easy to source in all production regions.	• Becoming more expensive and greater difficulty sourcing currently • Absorbs water very easily and may become waterlogged • pH is acidic – requires buffering • Nitrogen drawdown a common issue in wood-based substances not heat-treated – there is a tendency to become N-deficient as a result of high levels of N immobilisation – increased fertigation costs to compensate.
Opportunities	**Threats**
• Investigate treatment options to fix nitrogen drawdown issue.	• Increased demand from other industries (i.e. nursery) for pine-bark could increase price.

Appendix 5: International scan – emerging substrates SWOT analysis

Table 10: Rice hulls SWOT analysis

Strengths	Weaknesses
• By-product of rice production/milling • Free-draining – low to moderate water-holding capacity • pH slightly acidic – good for most plants • Air-filled porosity % suitable for most crops.	• Not pre-sterilised – needs to be boiled • Tendency to build up salt in the substrate – must be replaced after 1-2 crops • High levels of manganese often – issue if pH not managed correctly. • Low cation exchange capacity
Opportunities	**Threats**
• Can be used as part of a mix for shorter-rotation crops	• Competition for product, as it can also used for other purposes (i.e. animal bedding) may increase price and decrease availability

Table 11: Currently 'preferred wood-fibre substrate' – SWOT analysis

Strengths	Weaknesses
• Locally produced in Victoria, Australia • High air-filled porosity 30-35% • Water-holding capacity 20-25%[15] • Renewable – made from *Pinus radiata* (Monterey pine) wood chips sourced from plantations in Gippsland, Victoria • Coarse material • Produced through thermal and mechanical defibration of wood chips, produces a sterile material • Indicative price of $130 per m^3, ex works • Anecdotal information from trials suggests yield performance is roughly equivalent to coir.	• Anecdotal information suggests there may be reduced capillary action (horizontal water movement) in substrate – potentially causing uneven water distribution • Top portion of substrate dries out quicker than coir – increased watering frequency in shorter-duration required. Can be an issue for short-rooted less-established seedlings • Low compressibility (only to 1.4 times its expanded form) • Slower plant growth and establishment.
Opportunities	**Threats**
• GrowFibre material, being coarser than coir, may have increased structural durability • Finer diameter wood fibre processing technology exists in Germany and is planned to be used in Australia – may improve substrate water holding capacity and overall yield-capability • Substantial pine forestry production in QLD, NSW and TAS present opportunities to open production facilities in local proximity to hydroponic *Rubus* producing regions.	• Due to low compressibility, it is not currently financially competitive in comparison to current substrate (coir) costs if production centres are not in close proximity (i.e. same state) to berry producing regions. Anecdotal information from growers suggest it is currently not economically feasible to sell product produced in Melbourne to Tasmanian growers • Competition for wood products a potential threat • Sustainability of timber supply.

[15] AGS the identified wood-fibre substrate Brochure. Accessed 1st September 2022. <https://www.agsolutions.net.au/_files/ugd/c85030_c5735490105146a882287898b8611da0.pdf>

Table 12: Alternative wood fibre product - SWOT analysis

Strengths	Weaknesses
• Finer diameter fibres • Extra air-filled porosity in comparison with coir may assist early root development • Has been used in 25:75 mix with coir in raspberry and blueberry production in NSW with no yield difference noted • Relatively cheaper cost - \$40-80/m^3. • Can be compressed	• Cannot be used on its own due to clumping issues. Clumping means the product going into each individual pot is not universal. • Specialised equipment required to decompress product
Opportunities	**Threats**
• Could be mixed with coarser material (such as GrowFibre) which would solve the clumping issue • Explore other substrate blends with locally produced materials (rice hulls).	• Competition for wood products a potential threat • Sustainability of timber supplies.

Table 13: Hydrafibre – produced in United States – SWOT analysis

Strengths	Weaknesses
• Higher air-filled porosity than coir • Can be compressed for transport • Renewable product • Strong adoption in US nursery industry.	• Compressed bales require specialised machine supplied by Agrinomix from Ohio, US, to be 'spun back out' into its usable form • Must be used in a mix with coir (at maximum 50% ratio) due to challenges with irrigation, fertigation and container filling • Durability may be as little as 1 year • Only produced in US currently.
Opportunities	**Threats**
• Could be mixed with coarser wood-fibre substrate, such as GrowFibre.	• Growers not purchasing the required machine to convert it from compressed into usable form means it would be not viable.

Appendix 6: Economic analysis – preferred currently preferred substrate

Economic analysis of hydroponic substrates for Rubus production - case study

The economic and financial impact of introducing an wood based growing medium (such as *GrowFibre*) to a *Rubus* berry farming system was analysed using a case study approach. A case study approach was chosen on the basis that any horticultural economic model that starts its life based on a real production business, has a much better chance of representing what might occur in reality[16]. It can also be easily used by other businesses using their own data.

Hydroponic *Rubus* production systems commonly use coir substrate in 7-10 L pots or grow bags. The plants remain in the substrate for 3-4 years. In most cases, the spent substrate is either stockpiled, removed to landfill or sent an organics recycling company.

As there was limited data on using the proposed new substrate, it has not been used for commercial *Rubus* production, two methods were used to test different aspects of the change from coir to the new growing medium:

- Phase 1 - A comparative Gross Margin (GM) analysis to decipher the direct costs to the production system
- Phase 2 - Threshold analysis to demonstrate the 'threshold' levels at which a growing system using a generic new substrate would need to operate at to be viable.

Both analyses can be used to test the economic viability of other substrates using average industry data or data from individual Rubus producers.

Analysis

The economic analysis first quantified a base case where operating costs and benefits were estimated for the 'normal' operation. This was done in conjunction with the case study farm operator. Gross margins are used to compare the relative contribution of a farm activity to a farms profit, before overhead costs are considered. The GM of an activity is the difference between the gross income (yield x price) less the cash costs of growing the commodity (variable costs) The base case GM is shown below in Table 14. Gross margin (base case).

Table 14: Gross margin (base case)

Description	Cost
Substrate	$6,353
Plants	$16,941
Nutrients	$10,482
Pest and disease control	$1,224
Beneficials (soil amendments)	$6,400
Irrigation	$1,258
Water cost	$629
Packing and transport	$84,716
Repairs and maintenance	$6,196
Tractor and plant - fuel & repairs	$4,535
Casual labour	$41,749
Levies	$36,593
TOTAL COST	**$217,080**
Berry sales	$609,890
TOTAL GROSS MARGIN	**$392,810**

[16] A. Sinnett, B. Malcolm, C. Lewis, C. Ho. "The whole farm case study as the unit of analysis for research in farm management economics" 2019. AgEcon search

Once the base case had been established, a scenario was developed that looked at the changes that occur when the new substrate is introduced. Assumptions that were used in the modelling are detailed below in Table 15.

Table 15: Economic model assumptions

Assumption	Description
Yield	The model assumes no yield difference between production in coir and wood-fibre substrates. There is no official trial data, however anecdotal information from informal grower trials suggests yields are similar between the two substrates in the first two years of production. The model assumes a yield of 1.5kg per plant, with 2 tips per pot
Pot size	The model uses 7 L pot size (common for raspberries, though blackberries are often larger). Noted that some producers use 10L pot sizes, the case study farm uses 27L pots for their blackberry plant production.
Planting cost	The model uses the assumption that approximately $0.50 per plant for substrate placing and planting. This is supported by information from growers.
Substrate, removal and cleaning	The model assumes 125 hours of labour per hectare per year on average (with substrate and pots changed every 4 years).
Longevity of plant in system	The model assumes 4 years. Noting that production systems may vary between farms. • Noted in northern production areas with higher average temperatures and increased disease pressure (northern NSW, QLD), substrate longevity for rubus crops is generally only 2 years. The model • The economic model is not set-up for long-cane production, which involves the production of long-canes grown in containers in a nursery before being shipped on to farm. They are placed in cold storage to force fruit production. By varying the time and length of cool-storage, fruit production can occur across a wide timeframe, enabling growers to target specific production windows with higher price premiums. Wood-fibre has not been trialled in Rubus long-cane production as such this was excluded from the model.
Substrate cost	• Existing substrate cost for coir of $1.50 per 7L pot used (price for premium coir, which comes pre-buffered, with better quality and consistency, may be slightly higher than this). Cost for the currently preferred wood-fibre substrate of $1.33 per cubic metre is excluding shipping costs. Given the currently preferred wood-fibre substrate cannot be compressed for transportation like coir, it is assumed that local production of the currently preferred wood-fibre substrate is occurring in the same state of berry farms.
Transport cost	Transport costs of $50 per cubic meter were added for the new substrate. This cost occurs once in each growing cycle (every 4 years).
Fertigation cost	Fertigation costs are assumed to be $2,500 per ML water applied on average, covering the cost of water and fertilisers. Feedback from growers provided costs between $500 and $5,000. • Differences in fertigation costs between production in coir and wood-fibre substrates are thought to be marginal, based on discussions with growers.
Irrigation and pumping cost	Irrigation pumping costs assumed to be $300 per ML. Anecdotal information from growers trialling wood-fibre substrate suggests that whilst an increased in frequency of irrigation is required for wood-fibre substrates, the overall irrigation requirement between coir and wood-fibre substrate production is negligible. More frequent irrigation bursts with a shorter duration occur for production in wood-fibre substrates. Note that this may result in faster degradation of pumping infrastructure, but overall variable cost differences are thought to be insignificant.
Substrate disinfestation cost	The model assumes that there are no differences in substrate disinfestation costs between coir and wood fibre substrates. No Disinfestation is currently not occurring on site.

Assumption	Description
Recycling/reuse/removal costs	The model assumes that once substrate is spent there are no differences in recycling/reuse costs between substrates. A cost estimation of $5/m³ for an organics processor to pick up the spent coir from the farm is estimated, however it is noted this value would vary significantly between farms given this value is largely comprised of transportation costs. Exact costs would depend on a farm's proximity to an organics processor and/or recycler. This cost used is for the organics processor to take the spent substrate away – not for it being pasteurised and sent back on farm.

Results

Phase 1

When considering a change to a production system, the returns from changes in yields and gross margins of activities within that system are assessed in terms of the net contribution of that activity, with all parts across the production system in each year. When activity gross margins are the basis of the comparison, the implicit assumption is being made that there are no implications for extra machinery and equipment required after the initial investment is made. The results of the GM analysis are shown in Table 16 below.

Table 16: Gross Margin comparison

Description	Base case (coir)	New substrate
Total variable cost	$217,078	$216,037
Total income	$609,890	$609,890
Gross margin	$392,810	$393,850
Marginal impact		**$1,040**

The GM analysis shows that when including transport and purchase cost of the modelled new substrate, assuming no other changes to the growing system, the impact of the change of substrate on the modelled gross margin is negligible ($1040).

Phase 2

As there are a range of possible alternative substrate options for berry production, a threshold analysis has been undertaken to incorporate the impact of increased substrate costs on the GM. We have developed GMs for a range of alternate substrate prices along with the impact on changing yield and price of product. Table 17 and Table 18 show the results.[17]

[17] Red cells indicating a net loss when compared to the base case Gross Margin

Table 17: Threshold analysis, showing the effect of substrate cost and berry price on GM.

Gross Margin GM ($/ha)		Substrate price ($/unit)							
		$1.5	$2.0	$2.5	$3.0	$3.5	$4.0	$4.5	$5.0
Berry price ($/punnet)	$3.0	$250,540	$248,780	$247,010	$245,250	$243,490	$241,720	$239,960	$238,190
	$3.5	$322,200	$320,440	$318,670	$316,910	$315,140	$313,380	$311,610	$309,850
	$4.0	$393,870	$392,100	$390,340	$388,570	$386,810	$385,040	$383,280	$381,510
	$4.5	$465,520	$463,760	$461,990	$460,230	$458,460	$456,700	$454,930	$453,170
	$5.0	$537,190	$535,420	$533,660	$531,890	$530,130	$528,360	$526,600	$524,830
	$6.5	$752,170	$750,400	$748,640	$746,870	$745,110	$743,340	$741,580	$739,810
	$7.0	$823,830	$822,070	$820,300	$818,540	$816,770	$815,010	$813,240	$811,480

Table 18: Threshold analysis, showing the effect of substrate cost and yield on GM

Gross Margin		Substrate price ($/unit)							
		$1.5	$2.0	$2.5	$3.0	$3.5	$4.0	$4.5	$5.0
Yield (trays/ha)	14,000	$411,180	$409,410	$407,650	$405,890	$404,120	$402,360	$400,590	$398,830
	13,000	$407,500	$405,740	$403,970	$402,210	$400,440	$398,680	$396,910	$395,150
	12,706	$403,820	$402,060	$400,290	$398,530	$396,760	$395,000	$393,230	$391,470
	11,000	$400,140	$398,380	$396,610	$394,850	$393,080	$391,320	$389,550	$387,790
	10,000	$393,870	$392,100	$390,340	$388,570	$386,810	$385,040	$383,280	$381,510
	9,000	$392,780	$391,020	$389,250	$387,490	$385,720	$383,960	$382,200	$380,430
	8,000	$389,100	$387,340	$385,580	$383,810	$382,050	$380,280	$378,520	$376,750

From an economic perspective, introducing a new growing substrate to hydroponic berry production system, is viable based on the available information. The threshold analysis demonstrates that the system is robust in terms of being able to withstand a high ($5) substrate price without a drastic loss in GM. Table 19 below shows that if the substrate price was increased to $5 per block the impact on profit would be approximately 3%.

Table 19: Marginal change to GM under increasing substrate price

Substrate price	$1.5	$2.0	$2.5	$3.0	$3.5	$4.0	$4.5	$5.0
Gross margin	$393,870	$392,100	$390,340	$388,570	$386,810	$385,040	$383,280	$381,510
Change to GM	0%	0%	1%	1%	2%	2%	2%	3%

Other considerations

Risk

Any Horticultural system operates within the confines of a risk profile. Risk being the 'normal' fluctuations in economic performance over a period of time. The main types of risk that are commonly associated with production systems are business risk and financial risk:

- **Business risk** - including:

- Production (climate, pests, genetic variation and disease);
- Prices (product sale – output - and input prices); and
- Institutional settings (legislation that impacts production e.g. Marketing, workplace health and safety, biosecurity and environmental regulation).

- **Financial risk** refers to the variability in returns to owner's equity resulting from meeting interest charges, financial obligations or from servicing debt. Financial risk is a direct result of gearing, the higher the proportion of debt to total capital, the higher the financial risk.

Different factors, some within a managers control and some outside a mangers control, will influence the success of an individual business over time. Changing substrate may be a small part of the total cost of production, however, the result of interrupted supply could have significant impacts to the long-term success of a production system. The extra costs associated with changing substrates (from an international supply chain to a locally sourced product) can be thought of, in an economic sense, as the cost of reducing the risk profile of a production system. The right decision for an individual farm business manager will come down to an individual's preference for risk over time and the eventual outcomes of normal supply and demand.

GHG emissions

A high-level desktop investigation into the associated GHG emissions from transporting coir from Sri Lanka to Australia was conducted. Table 20 shows the approach taken and results.

Table 20: Carbon emission calculations for transport of coir from Sri Lanka to Australia

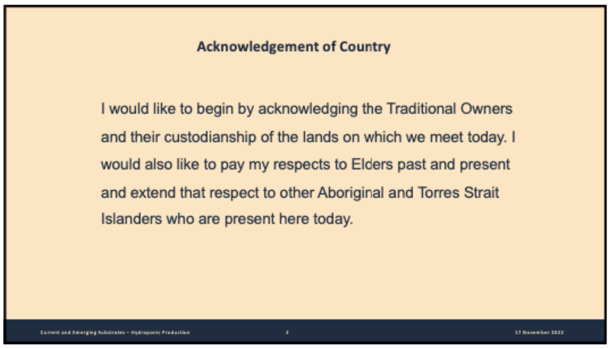
Factor	Value
CO2 eq g/tonne/km	16
Total km	10,480
Total GHG	171,880
Total tonnes	14.7
Total emissions (grams)	2,526,632
GHG emissions tonnes CO2 eq/ha	2.53
Value of GHG emissions[18]	$37
Cost of GHG ($/ha)	**$93**

The results show that for a one-hectare production system the approximated GHG emission of transporting coir are 2.53 tonnes of CO_2 equivalent, with an economic value of $93/ha based on current carbon pricing.

[18] Asian Development Outlook (ADO) 2016 Update: Meeting the Low-Carbon Growth Challenge

Appendix 7: Webinar presentation slides

1



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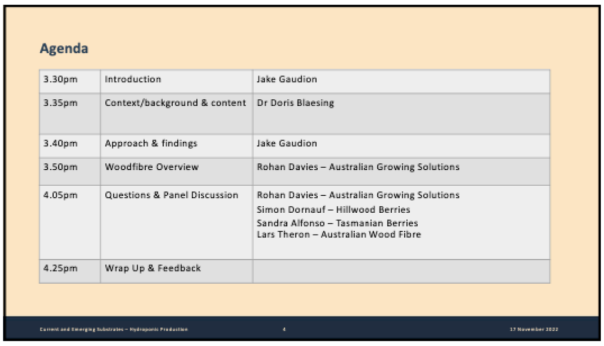

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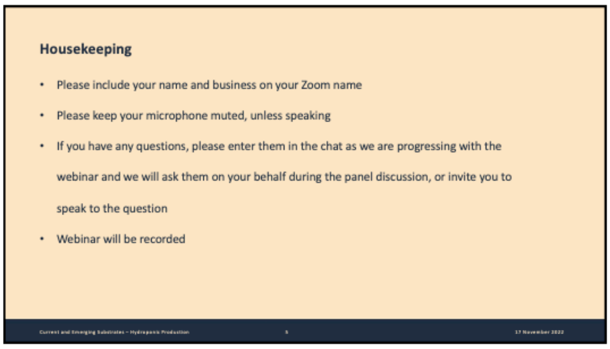

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6

Approach

1. National scan
   - SWOT Analysis on each substrate
2. International scan – emerging substrates
   - SWOT Analysis on each substrate
3. Determine and investigate priority options including an economic analysis
4. Webinar with growers
5. Reporting and RD&E recommendations

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Main Findings - National Scan

Identified desired characteristics in a substrate for *Rubus* hydroponic production:

- Durable, stable structure (able to last 3-4 years in some growing conditions)
- Water-holding capacity between 20—40% (by volume)
- Air-filled porosity (by volume) 13-28% or greater (coir air-filled porosity)

Coir, perlite, vermiculite, rockwool, pine-bark were analysed

Coir #1 – both technically and economically

Current and Emerging Substrates – Hydroponic Production 8 17 November 2022

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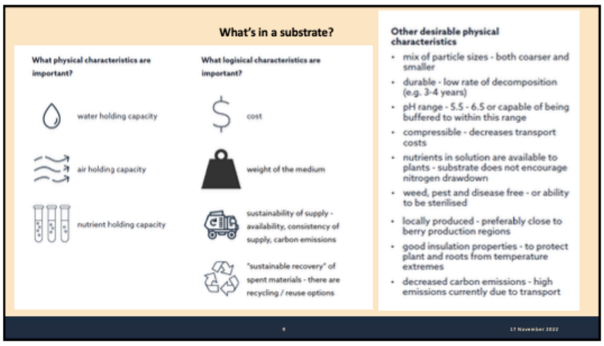

What's in a substrate?

What physical characteristics are important?

water holding capacity

air holding capacity

nutrient holding capacity

What logisical characteristics are important?

cost

weight of the medium

sustainability of supply - availability, consistency of supply, carbon emissions

"sustainable recovery" of spent materials - there are recycling / reuse options

Other desirable physical characteristics

- mix of particle sizes - both coarser and smaller
- durable - low rate of decomposition (e.g. 3-4 years)
- pH range - 5.5 - 6.5 or capable of being buffered to within this range
- compressible - decreases transport costs
- nutrients in solution are available to plants - substrate does not encourage nitrogen drawdown
- weed, pest and disease free - or ability to be sterilised
- locally produced - preferably close to berry production regions
- good insulation properties - to protect plant and roots from temperature extremes
- decreased carbon emissions - high emissions currently due to transport

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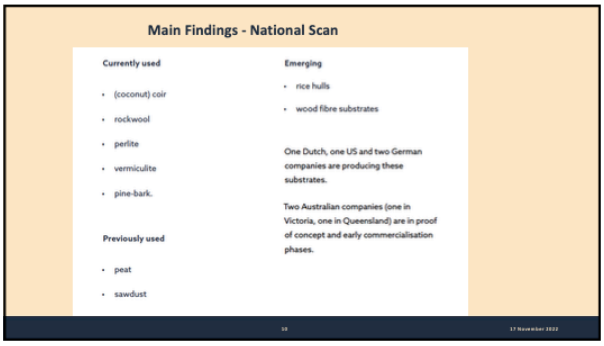

Main Findings - National Scan

Currently used

- (coconut) coir
- rockwool
- perlite
- vermiculite
- pine-bark.

Previously used

- peat
- sawdust

Emerging

- rice hulls
- wood fibre substrates

One Dutch, one US and two German companies are producing these substrates.

Two Australian companies (one in Victoria, one in Queensland) are in proof of concept and early commercialisation phases.

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Main Findings – International Scan

- Wood Fibre – in USA and Europe
- Rice hulls have also been trialed in some crops
- Wood fibre brands:
  - HydraFiber (USA), GreenFibre (Europe), Hortifibre (Europe), Forest Gold (Europe)
- Wood fibre overseas mostly used in mixes with peat, coir or composted bark
- Two Australian wood fibre substrate producers identified –
  - Australian Growing Solutions (Tyabb, VIC)
  - Australian Wood Fibre (QLD)

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Examples of wood fibre products

HydraFiber (USA) – similar to Australian Wood Fibre product

GrowFibre (AUS) – similar to GreenFibre (Europe)

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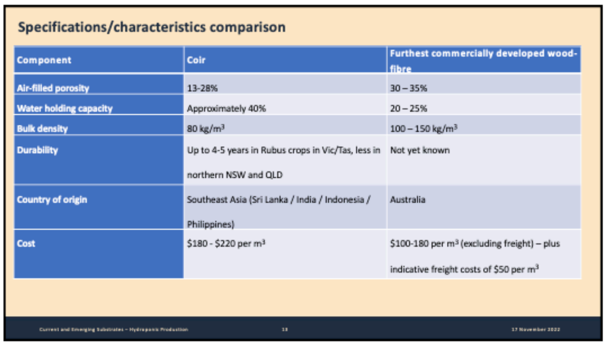

Specifications/characteristics comparison

Component	Coir	Furthest commercially developed wood-fibre
Air-filled porosity	13-28%	30 – 35%
Water holding capacity	Approximately 40%	20 – 25%
Bulk density	80 kg/m³	100 – 150 kg/m³
Durability	Up to 4-5 years in Rubus crops in Vic/Tas, less in northern NSW and QLD	Not yet known
Country of origin	Southeast Asia (Sri Lanka / India / Indonesia / Philippines)	Australia
Cost	\$180 - \$220 per m³	\$100-180 per m³ (excluding freight) – plus indicative freight costs of \$50 per m³

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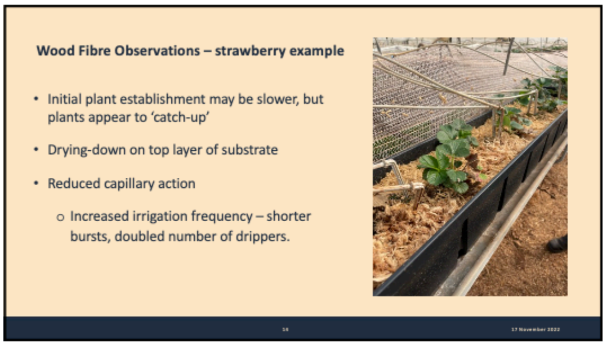

Wood Fibre Observations – strawberry example

- Initial plant establishment may be slower, but plants appear to 'catch-up'
- Drying-down on top layer of substrate
- Reduced capillary action
  - Increased irrigation frequency – shorter bursts, doubled number of drippers.

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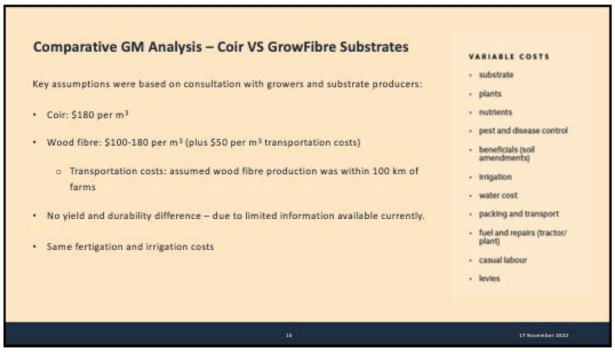
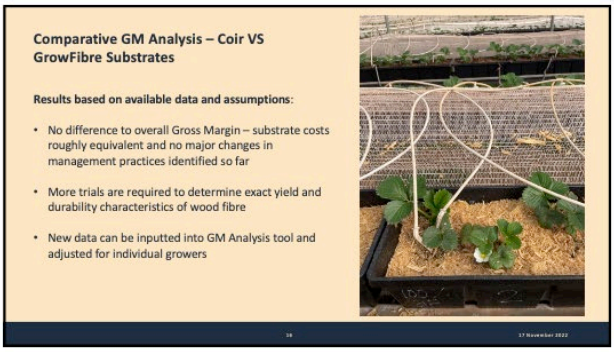
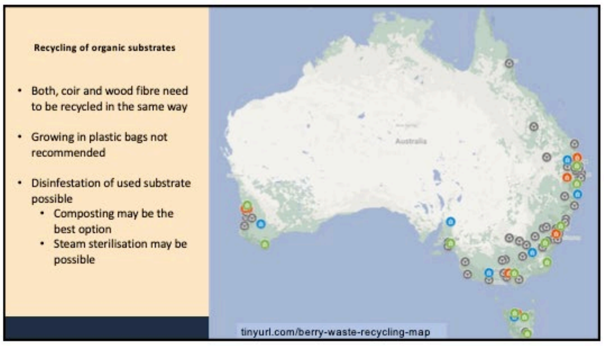
14


Comparative GM Analysis – Coir VS GrowFibre Substrates
Key assumptions were based on consultation with growers and substrate producers:
• Coir: $180 per m³
• Wood fibre: $100-180 per m³ (plus $50 per m³ transportation costs)
o Transportation costs: assumed wood fibre production was within 100 km of farms
• No yield and durability difference – due to limited information available currently.
• Same fertigation and irrigation costs
VARIABLE COSTS
• substrate
• plants
• nutrients
• pest and disease control
• beneficials (soil amendments)
• irrigation
• water cost
• packing and transport
• fuel and repairs (tractor/ plant)
• casual labour
• levies

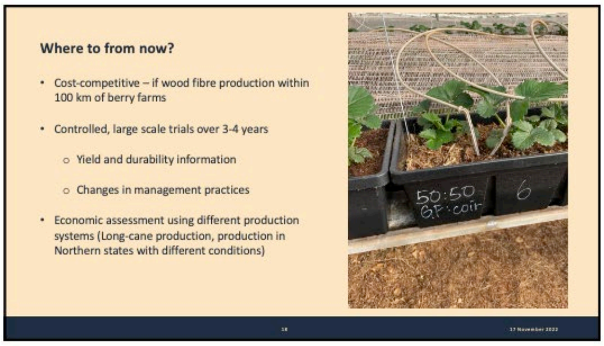
15


Comparative GM Analysis – Coir VS GrowFibre Substrates
Results based on available data and assumptions:
• No difference to overall Gross Margin – substrate costs roughly equivalent and no major changes in management practices identified so far
• More trials are required to determine exact yield and durability characteristics of wood fibre
• New data can be inputted into GM Analysis tool and adjusted for individual growers

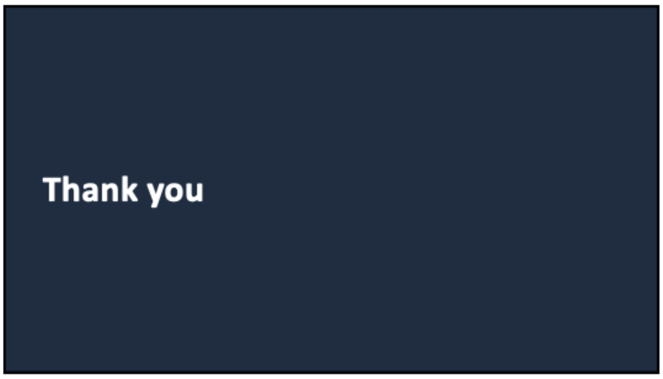
16


Recycling of organic substrates
• Both, coir and wood fibre need to be recycled in the same way
• Growing in plastic bags not recommended
• Disinfestation of used substrate possible
• Composting may be the best option
• Steam sterilisation may be possible
tinyurl.com/berry-waste-recycling-map

17


Where to from now?
• Cost-competitive – if wood fibre production within 100 km of berry farms
• Controlled, large scale trials over 3-4 years
o Yield and durability information
o Changes in management practices
• Economic assessment using different production systems (Long-cane production, production in Northern states with different conditions)
50:50
GF: coir
6

18


Thank you

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Appendix 8: Substrate factsheet

The “Coir and its alternatives” factsheet is included in this Appendix with two factsheet pages to a report page in landscape. The printed version of the factsheet will be in a booklet format with each page of A4 size.

RMCG

Coir use - a risk for hydroponic producers?

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.

Currently, most *Rubus* hydroponic producers are using coir as the preferred growing medium. It produces good results and it is considered the most environmentally sustainable option.

However, transportation is a large portion of the cost of substrates. Coir is largely sourced from India, Sri Lanka, Indonesia, the Philippines and other tropical coconut-growing regions.

Cost to get coir on-farm, delivery timeframes and reliability of supply have all experienced large changes in the last 3-4 years.

The *Rubus* industry's reliance on coir presents an increasing risk, particularly as it is competing with other industries for the substrate.

RMCG conducted a national and international scan to identify previous, current and emerging alternative growing media. Growers, substrate producers and industry representatives contributed industry insights.

The identified substrates were compared using a SWOT analysis (strengths, weaknesses, opportunities, threats).

Further analyses of coir and the preferred option included:

- comparative gross margin
- economic threshold analysis
- high level emission assessment.

1

What substrate characteristics are important?

What physical and chemical characteristics are important?

- water holding capacity
- air holding capacity
- nutrient holding capacity

What logistical characteristics are important?

- cost
- weight of the medium
- sustainability of supply - availability, consistency of supply, low carbon equivalent emissions
- "sustainable recovery" of spent materials - recycling / reuse options

Other desirable physical characteristics

- compressible - saves space, decreases transport costs
- mix of particle sizes - coarse, medium and fine
- durable - low rate of decomposition (e.g. over 3-4 years of use)
- pH range - 5.5 - 6.5, or able to be buffered to within this range
- nutrients in solution are available to plants - substrate does not encourage nitrogen drawdown
- weed, pest and disease free - or ability to be sterilised

Other desirable logistical characteristics

- locally produced - preferably close to berry production regions
- good insulation properties - to protect plant and roots from temperature extremes
- low carbon emissions compared to coir

Which substrates?

Currently used

- coir (coconut fibre)
- rockwool
- perlite
- vermiculite
- pine-bark.

Previously used

- peat (not considered here as it is a non-renewable resource)
- sawdust.

Emerging

- rice hulls
- wood fibre substrates.

One Dutch, one US and two German companies are producing wood fibre substrates.

Two Australian companies (one in Victoria, one in Queensland) are in proof of concept and early commercialisation phases with wood fibre substrates.

SWOT analysis - coir

STRENGTHS

- Excellent water-holding capacity
- Sufficient air-filled porosity
- Biodegradable (can be composted)
- Low bulk-density
- Can be used as stand-alone substrate or mixed with others
- Can be compressed up to 6x its normal state size – excellent for transportation
- Renewable material (produced from coconut husks)
- Various particle sizes produced from coir – both pith and chips.

OPPORTUNITIES

- Scope for increased re-use of spent coir substrate within production system – mixing with fresh substrate in *Rubus* crops. Spent strawberry coir substrate could be then used in *Rubus* crops (pending root separation, sterilisation).

WEAKNESSES

- Produced in Asia – must be shipped to Australia and transported from the port of entry to *Rubus* growers (anecdotal information suggests up to 50% of the cost to growers is in shipping in 2022)
- Shipping costs are currently expected by industry to continue to increase
- High cation exchange capacity - requires 'buffering' (with calcium nitrate) to displace large amounts of bound sodium ions to ensure it is a neutral substrate
- Variable quality
- Perceived high costs of handling/recycling spent coir
- Increasing competition for coir from other hydroponic industries.

THREATS

- May pose a biosecurity risk as coir is imported
- Increased competition from other hydroponic industries for coir
- Shipping/supply chain disruptions leave *Rubus* industry at severe risk
- Increasing timeframes of supply – in 2019 it took approximately 9-10 weeks from order to delivery on-farm, in 2022 this is now 6-7 months.

Substrate comparison

	Coir	Wood fibre	Rockwool	Perlite	Vermiculite	Pine bark	Sawdust
Physical properties							
Water holding capacity	excellent (~40%)	good (20-25%)	good	low	too high	variable depending on grade	variable depending on grade
Air-filled porosity	good (13-28%)	high (30-35%)	good	high	low		
Mix of particle sizes	yes	coarse	uniform	uniform	uniform		
Weight	light		light		light		
Compressibility	6x	1.4x (low)	no	no	no	negligible	negligible
Insulation properties	good	good	good	no data	no data	good	good
Chemical properties							
Nutrient holding capacity	good - high CEC - requires "buffering"	good (lower CEC than coir)	moderate	none	good	moderate	moderate
pH range	6.0 - 6.8	5.0 - 7.5	high – requires adjustment	neutral	alkaline	acidic – requires pH adjustment	variable depending in timber source
Degradation rate	low	not yet known	n/a	n/a	n/a	higher than coir	higher than coir
Other properties							
Useable lifespan for *Rubus* production	3-4 years	no data yet	very long lasting	very long lasting	very long lasting	acceptable, depending on grade	acceptable, depending on grade
Consistent quality	variable depending on source	consistent within each type of wood and manufacturing process	yes	yes	yes	variable depending on source	variable depending on source
Weed, pest, disease free	yes, need import phytosanitary certificate	sterile, as heated during manufacturing	yes	no data	yes	may contain weed seeds, depending on production process	yes
Able to be sterilised	yes	yes, via composting	yes	yes	cannot be sterilised	yes, via composting	yes, via composting
Sustainability of supply – availability, consistent	variable, increasing competition & shipping times	dependent on timber supply	easily available	increasing competition	good	easy to source in all Australian production regions, but may change	easy to source in all Australian production regions, but may change
Transport and costs							
Cost (relative to coir)	increasing due to other hydroponics industries use	approx. $130/m3, ex works	relatively high	relatively inexpensive	relatively inexpensive	currently relatively cheap	currently relatively cheap
Locally/ Australian made	no	yes	no	no	no	yes	yes
Transport costs	high	lower than imported products	high	high	high	lower than imported product	lower than imported product
Recycling							
Recycling options	yes, biodegradable, compostable	yes, biodegradable, compostable	no – to landfill	no – to landfill, (all substrates containing perlite)	no data	yes, biodegradable, compostable	yes, biodegradable, compostable
Reuse options	yes	yes	yes	no	limited	yes	yes
Recycling/reuse costs	high (if in plastic) moderate if no plastic	high (if in plastic) moderate if no plastic	n/a	n/a	n/a	high (if in plastic) moderate if no plastic	high (if in plastic) moderate if no plastic
Renewable resource	yes	yes	no (made from mineral/rock)	no (made from volcanic glass)	no, requires mining	yes	yes
Other	can be dusty, can heat up during transport in compressed form			dust – human health issue; prone to algal growth	needs to be mixed with other substrates		

Economics - assumptions

These assumptions were made after consultation with growers, including those trialling wood fibre substrate(s):

- yield of 1.5 kg/plant, 2 tips/pot - no yield difference between coir and wood fibre substrates
- 7 L pot size
- $0.50 to plant and place substrate
- 4 yrs effective plant life / growing cycle*
- 125 hrs labour/ha for substrate removal and cleaning every 4 yrs
- $1.50 / 7 L pot of coir, delivered on farm
- $130 / m^3 of new substrate, plus $50 / m^3 for transport every 4 yrs^
- $2,500 / ML fertigation costs for both substrates
- $300 / ML irrigation pumping costs+
- $5 / m^3 for organics processor collection cost (will vary with distance)#

Not examined:

- long cane production

Footnotes

* it is noted, but not modelled, that plant life is usually 2 yrs in northern production areas

^ transport cost of fresh substrate - wood fibre production assumed within 100 km of farm

+ wood fibre substrate may require increased frequency of irrigation but in shorter bursts, overall variable costs are assumed to be comparable

cost is only to take substrate away, not pasteurise and return to farm

Economics - gross margin

Coir gross margin

64.4%

Data and assumptions

New substrate gross margin

64.5%

negligible change in gross margin (64.4% vs 64.5%)

Gross margin % =

$$\frac{\text{net berry sales (\$) - direct, variable costs (\$)}}{\text{net berry sales (\$)}}$$

VARIABLE COSTS

- substrate
- plants
- nutrients
- pest and disease control
- beneficials (soil amendments)
- irrigation running costs
- water cost
- packing and transport
- fuel and repairs (tractor/ plant)
- casual labour
- levies

Economics - threshold analysis

A threshold analysis was conducted to investigate the effects of variations in substrate costs, berry yield and on the gross margin %.

Based on the analysis, a *Rubus* production system could withstand a substrate price of up to $5 as long as there were no other changes in berry price and variable costs and/or no additional fixed costs were incurred when using a wood fibre based substrate.

Effect of an increase in substrate price on gross margin % (compared to coir)

	Substrate price ($/unit)							
	$1.50	$2.00	$2.50	$3.00	$3.50	$4.00	$4.50	$5.00
Change to gross margin % compared coir	0%	0%	-1%	-1%	-2%	-2%	-2%	-3%

Effect of changing berry and substrate price on gross margin %

Berry price		Substrate price ($/unit)							
		$1.50	$2.00	$2.50	$3.00	$3.50	$4.00	$4.50	$5.00
Berry price ($ / punnet)	$3.00	-36%							-39%
	$3.50	-18%			Net loss (compared to coir)				-21%
	$4.00	0.3%							-3%
	$4.50	18%							15%
	$5.00	37%			Net gain (compared to coir)				34%
	$6.50	92%							88%

Effect of changing yield and substrate price on gross margin %

Yield		Substrate price ($/unit)							
		$1.50	$2.00	$2.50	$3.00	$3.50	$4.00	$4.50	$5.00
Yield (kg / ha)	8,000	-4.5%							-1.5%
	9,000	-3.7%			Net loss (compared to coir)				-0.6%
	10,000	-2.8%							0.3%
	11,000	-1.8%							1.3%
	12,706	-0.3%							2.9%
	13,000	0.01%			Net gain (compared to coir)				3.2%
	14,000	0.9%							4.1%

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Conclusions

The project findings demonstrate that wood fibre substrates most likely present a great opportunity for *Rubus* growers to diversify their substrate use. Further development and refinement of the substrates and their use as well as regional production options (circular economy) will be required, along with production, economic and emission assessment data collection and analysis.

RECOMMENDATIONS

- Conduct replicated trials (controlled, larger-scale, long-term) for identified alternative substrates, i.e. various wood fibre substrates, including:
  - different substrate mixes (e.g. 50:50, 75:25 ratios of coir or other organic substrate to wood fibre)
  - different geographic areas, differing methods of production (e.g. long-cane, different container sizes, etc.), different management practices.
- Conduct a feasibility assessment of setting up wood-fibre production facilities to supply substrate to *Rubus* producers in each production region; consider opportunities to supply other hydroponic crop producers and the nursery industry.
- Collect economic data as part of any trials.
- The costs of managing spent substrate (recovery, re-use, recycling) must be built into any future gross margin tools used to assess viable alternative substrates to coir. Emission impacts should also be considered.

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