Branching Out Blueprint

Hemp Fibre for Construction

THE OPPORTUNITY FOR TARANAKI, NEW ZEALAND

venture TARANAKI
Te Puna Umanga

A blueprint for the future of food and fibre

Branching Out is a project that has been initiated and led by Venture Taranaki. It is underpinned by funding from the Ministry for Primary Industries' Sustainable Food and Fibre Futures fund (SFFF). It is supported by local sponsors as well as the region's three district councils – New Plymouth District Council, South Taranaki District Council and Stratford District Council. The project has identified a number of innovative, commercially viable food and fibre value chain opportunities for Taranaki. This work supports the region's strategy and long-term vision for a resilient, high-value, and low-emissions economy built on inclusivity and sustainability, as articulated by Tapaue Roa and Taranaki 2050 – the guiding strategic documents for the region, co-created with the people of Taranaki.

Branching Out aims to strengthen and diversify the Taranaki economy and has taken input from a wide range of industry participants, from landowners to interested growers, manufacturers to food & fibre entrepreneurs and potential investors. Through a process of investigation, a shortlist of eleven feasible ventures have been selected. Crown Research Institutes and universities, including Massey and Lincoln, were engaged to provide robust research that underpins each venture selection. Work has also been undertaken with commercial partners to support the development of prototypes with significant market potential, and a core focus on sustainability and waste reduction.

The investigations, collaborations, and potential commercial pilot opportunities for the region that have been explored as part of this project are being presented as Venture Blueprints. These blueprints aim to build investor confidence and serve as an informative and inspirational roadmap to kick-start complementary land-based activities and associated value chain enterprises in Taranaki.

The blueprints focus on traditional methods of assessing value, determined by comparing inputs (land, animals, machinery, time) and outputs (milk, meat, wool, other products). However, consumer expectations and an increased awareness of environmental degradation mean that thought should also be given to how the natural environment can be protected and what value this action can add to a developing sector.

TE TAIAO

In 2020, the Primary Sector Council released their Food and Fibre Strategy, Fit for a Better World. This strategy adopted the Te Taiao framework, acknowledging that Te Taiao is all of the natural world that contains and surrounds us (land, water, air, and biological life). It is a uniquely New Zealand perspective that is underpinned by three guiding principles:

- Our land, water, air, and biological life must be able to thrive without over-use
- Any use is a privilege, not a right
- If something is not healthy or well, we must fix it.

Developing or participating in a new value chain is an opportunity to consider your business's relationship with Te Taiao. It is a chance to farm, produce and engage in a way that safeguards the mana and integrity of the natural world. If the whenua (land), and the entities that are connected to it, are to be nourished and thrive, then it must be cared for and protected. Each blueprint opportunity should be considered with Te Taiao in mind.

DISCLAIMER

This document, produced by Venture Taranaki, provides an overview of opportunity for commercial production and processing of hemp crops for construction in Taranaki, and an indication of potential returns. It does not constitute investment advice. Professional advice should be sought if you wish to explore this opportunity further. This blueprint is correct to our knowledge and based on the best information we could access as of June 2022. However, this work is ongoing, and we welcome new or emerging information about this opportunity. For more information or for input, please contact branchingout@venture.org.nz.

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venture TARANAKI Te Puna Umanga
Ministry for Primary Industries Manatū Ahu Matua
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Te Kaunihera ō Taranaki ki Te Tonga South Taranaki District Council
TE KAUNIHERA Ā ROHE O WHAKAAHURANGI STRATFORD DISTRICT COUNCIL

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Hemp fibre for construction: A snapshot

UNTAPPED POTENTIAL

- Hemp is a profitable low maintenance crop that absorbs a high amount of carbon (and can even be carbon negative).
- Construction is a booming industry in New Zealand with 49,773 new houses consented in the year ending February 2022, valued at more than $19 billion. If hemp materials were able to obtain a market share of 0.1% - 0.5% it could be worth $19 - $95 million.
- Around 300,000 New Zealand homes were noted by Child Poverty Action Group (2014) as being unsuitable due to being uninsulated, damp and cold – issues hemp building materials can also address.
- Hemp grown in New Zealand for construction could ameliorate over-reliance on imported building materials (in 2021, 90% of all construction products were imported).
- In addition to being used for construction purposes, an estimated 25,000 products can be made from hemp.
- Hemp can grow quickly, and sufficient supply to build a house can be grown in a 3-month period on just 1.2 hectares.

WHY NOW?

- Hemp is a niche crop currently on the resurgence due to its potential for a globally evolving bio-based economy.
- A construction boom, along with COVID-19 supply chain impacts, has led to shortages of materials for the construction industry.
- Hemp grown, processed, and manufactured into building materials in region could reduce the risk of supply chain constraints and contribute to emissions reductions, which are now urgent.
- The greenhouse emissions pricing schemes proposed for farms in the future mean that now is a good time for farmers to consider additional crops that could provide benefits in terms of carbon capture.
- There is growing demand from consumers for carbon neutral/ negative construction materials. The impetus for this has arisen from New Zealand's commitment to halve our net emissions by 2030.

SECTOR TURNOVER:

The current value of the New Zealand hemp industry as of 2020 was estimated at $3 - $5 million[1]

GROWTH TARGETS:

The hemp fibre sector value chain in New Zealand is expected to be worth between $25 – $317 million by 2030[2].

WHY TARANAKI?

Taranaki is an early adopter of using hemp construction materials and methods, and has the most hemp houses (four to date) of any region in New Zealand.

The region's mild climate, average rainfall, and fertile soils suit hemp growth well.

Taranaki region is well placed to be the home of a North Island processing facility. Our existing skills, knowledge and leadership in adjacent sectors, such as engineering, fibre and construction, would support the development of processing facilities.

Hemp can be grown in rotation with paddocks used for grazing or for other crops, and therefore be incorporated into existing farm systems.

There is already interest from people within the region to build with hemp (from producers, people within the construction sector, and consumers) and to also use hemp for many other purposes.

WHO SHOULD BE INTERESTED?

Taranaki farmers who want an additional low emissions revenue stream and a complementary crop for their farms.

Construction industry professionals looking to incorporate a low carbon, or carbon negative, material into existing products or construction methods – with potential to replace imported offerings.

Engineering firms who might see this as an opportunity to deliver new products and services. Processing technologies for fibre processing present an opportunity for innovation for a global market.

People wanting to build low carbon, or carbon negative houses, which offer other healthy home benefits.

Investors looking for opportunities.

1 *Sapere, Facilitation growth in the New Zealand Hemp Industry (MPI), 2021 - Sector turnover based on 1,200 hectares grown in 2020 with earnings of $3,000- $4,500 per hectare.*

2 *Sapere (MPI) indicates value of $25 million, NZ Hemp Industry predicts the hemp industry could be worth $3 billion by 2030, with $317 million of that coming from the fibre industry.*

VALUE-ADDED OPPORTUNITIES

Hemp hurd and bast fibre has many applications, especially in the construction industry, including[3]:

- Hempcrete
- Insulation materials
- Particle boards for dry walls or ceilings
- Other composite and biocomposite materials
- Acoustic panels
- Geotextiles
- Bioresins

Although not the focus of this blueprint, there are also various foods and oils that can be made from hemp seeds as well as other co-products from hemp plants.

RISKS AND SENSITIVITIES

- Existing stigmas around hemp and its relationship to marijuana.
- There are considerable establishment costs for setting up processing facilities and limited knowledge within New Zealand about processing technologies due to small number of existing growers.
- Currently there are few New Zealand building companies using hemp products as they are relatively unknown.
- Hemp builds can be more expensive than traditional materials but offer other benefits. Some economies of scale will need to be created to ensure competition with existing products.
- Early entrants in Taranaki may experience challenges accessing support services locally.
- Optimising crop selection and growing techniques, as well as processing and product manufacture may take some trial and error, as well as investment of time and money.

FARM FINANCIALS

Recommended Minimum Hectarage: 10 hectares

Minimum investment required: $2,000 per hectare + $511.11 yearly licence fee (per cultivar)

Estimated time to 100% yield: 3 – 4 months

Expected returns:

- Growing solely for fibre - $1,500 per hectare
- Growing solely for seed - $1,460 per hectare
- Growing for Fibre and Seed - $3,190 per hectare

POTENTIAL RETURNS FROM ONE SCENARIO OF HEMP FIBRE GROWTH AND PRODUCTION IN TARANAKI

If a farmer (or farmers) were to grow 100 hectares of hemp it could:

- Provide significant environmental benefits
- Be used to build approximately 149 houses
- Provide income for others involved in the value chain (approximately $2,500 - $4,000 per hectare of income would be spent on local supporting services)[4]

TARANAKI BRANCHING OUT SCORECARD

Opportunity rating
1 = low, 5 = high.

This scorecard is intended to act as a quick comparison between blueprint opportunities. These scores are subjective and based on information available at the time of publishing. Further professional investment advice should still be sought.

Development Opportunity	
Suitable growing conditions in Taranaki	**4**
Suitable land available at reasonable cost	**4**
Existing investment interest	**3**
Local development experience	**2**
Circular economy opportunities	**5**
Established local, domestic, and international demand	**3**
Product Opportunity	
Large and growing demand for New Zealand hemp construction materials	**3**
New Zealand hemp product differentiated in key markets	**2**
Contribution to health and wellness of the consumer	**4**
Established sustainable/ regenerative growing practices, including water usage	**3**
Reduced greenhouse gas emissions compared to existing land uses	**5**
Postharvest and Processing Opportunity	
Postharvest and processing facilities available now in Taranaki	**1**
Opportunities for development of added value products, particularly from waste products	**5**

3 *The value proposition of fibre in these various applications is dependent on fibre features such as fibre surface characteristics, fine-ness and tensile strength.*
4 *As indicated by data provided by AgFirst on Tupu.nz.*

What do we mean by hemp?

Hemp, a type of cannabis, is originally from central Asia and is grown in temperate zones across several continents as an annual crop, cultivated from seed for food, fibre, and medicinal uses. It grows to heights of between one and five metres and varieties grown for fibre are typically taller.

Archaeological findings and ancient records date cultivation of hemp back to at least 6,000 years ago. However, use of hemp in the 20th century declined due to the development of cheaper synthetic fibres, growing labour costs and legal restrictions.

Cultivation of hemp in New Zealand was enabled by the government in 2006 and further so in 2018. The number of licensees increased from 65 growing 259 hectares in 2018, to 260 growing 1,335 hectares in 2020. This levelled off in 2021 with 192 licensees growing 862 hectares.

This blueprint focuses on hemp fibre for construction, however recent technological advances have expanded the use of hemp fibre and hemp-derived nanocellulose for the production of geotextiles, carbon nanosheets, bioplastics, 3D-printer filaments, oil absorbent materials and construction concrete.

TYPES OF CANNABIS

There are three commonly recognised types of cannabis: *Cannabis indica, Cannabis ruderalis* and *Cannabis sativa*:

- *Cannabis indica* is known as marijuana. It has naturally high levels of the psychoactive compound THC (tetrahydrocannabinol) and poor strength in fibres. THC provides the euphoric effect, or 'high' sought by recreational drug users.
- *Cannabis ruderalis* is used for its flowers and is an uncommon cannabis plant.
- Cannabis sativa has naturally low THC levels (although some varieties have recently been bred to enhance THC levels), nutritional seeds, and extremely strong stems and is known as industrial hemp.

For the purposes of this Blueprint, the term 'hemp' is used to reference low-THC Cannabis sativa varieties of hemp, eligible for classification within New Zealand as industrial hemp as per the Misuse of Drugs Regulations (2006). This report focuses on construction and therefore on the use of the hemp stem for that industry. However, to maximize profits, some growers focus on cropping for both fibre and flower or seed harvest.

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Hemp for construction

Industrial hemp is one of the world's most fast growing, available, and widely produced fibres with high cellulose content. It is one of the strongest and stiffest of measured natural fibres, with hemp bast fibres having a specific stiffness comparable to that of glass fibres[5], giving it great potential for use as reinforcement in composite materials. There is growing interest in hemp fibres due to their inherent properties (e.g. low density, high specific strength and stiffness), as well as their potential to alleviate environmental impacts of construction and other industries, including manufacture of synthetic fibres.

HEMP FIBRE

Hemp stem is comprised of two main forms of fibre – approximately 25% bast fibres and 75% hurd fibres ('hurds' sometimes also being referred to as shivs or shives). Separating the hurd and bast fibres of the hemp stem is done via a process called 'retting', followed by a process called 'decortication'. The effectiveness of both retting and decortication steps play a major role in the determination of hemp fibre quality. New processes continue to be researched to counter some of the challenges around retting and decortication. Developing IP in these areas could be a business opportunity alongside growing hemp for fibre applications.

Development of hemp varieties that yield bast fibre with higher cellulose content, along with lower pectin and lignin cross-linkages, that can decrease retting requirements whilst improving fibre strength and quality is seen as one such opportunity[6].

USES OF HEMP FIBRE

Once decorticated, hemp can be used in construction in a variety of ways. Traditional use has been, and often still is, in the form of hempcrete - a biocomposite that is made when hemp hurd is mixed with hydrated/hydraulic lime (calcium hydroxide) and water (and sometimes sand; e.g. Australian Hemp Masonry Company's Lime Binder). This can then be sprayed or, more routinely, tamped into place within load bearing structures (typically timber or concrete), most often via use of a 'shuttering system'.

The benefits of using hempcrete are that it:

- can be carbon negative[7] from growing to construction,
- is non-flammable,

5 *Manaia et al., 2019*
6 *Schluttenhofer & Yuan, 2017*
7 *Long-term biogenic carbon storage can be achieved via the use of hemp hurds in hempcrete, and additional carbon storage can also be achieved via carbonation of the binder. Hempcrete produces low manufacturing emissions and a hempcrete build produces little or no waste. Approximately 50% of all NZ landfill is generated by the construction/demolition sector.*

- is breathable,
- is strong (although is not generally approved for load bearing applications),
- is lightweight (1/7th the weight of concrete),
- is highly insulative – offering high levels of thermal resistance and low levels of heat transfer,
- has anti-fungal and anti-bacterial properties,
- offers value as an acoustic Insulation material,
- is non-toxic, and
- is hygroscopic, meaning it is able to maintain its integrity in humid conditions.

Research into manufacture and performance testing of hempcrete 'bricks' is occurring, with this attracting government funding in the U.S. and Canada[8]. Bricks offer the benefit of being able to be made and dried offsite, hence saving build projects from the lengthy drying/curing times that are needed to dry hempcrete that is laid down in-situ when constructing a building.

Hemp fibre-reinforced composites or hemp boards are engineered wood products constructed from hemp fibres. To make these, the fibre (usually hurd fibre) is mixed with (ideally) non-formaldehyde binders to create fibre boards. HempWood® is an example of a product in market since late 2019 (marketed as 'deforestation-free hardwood lumber') with stability and strength noted as being comparable to, or better than, some other woods available for building applications[9]. HempWood® modelled their product on bamboo wood flooring manufacture and have developed a 'clean' non-formaldehyde soy-based glue as a binding agent. They anticipate production of 2,000m^3 per year in the near future.

Hemp fibres are also starting to be used to make insulation materials. Hurd can be used for this purpose, but bast fibre-made insulation materials are more flexible and can be made into 'batts'. Hemp insulation is viewed as an alternative to fibreglass and foam, and one that has less impact on the environment during manufacturing and when redundant[10].

Other composites made from finer hemp cellulose, or hemp nanocellulose, are already in use in a number of industries, including textiles, automotive, sporting goods, musical instruments and fibre-reinforced concrete (in which it has been found to decrease humidity variations in indoor settings and reduce energy consumption by 45%). The most researched and expanding application for hemp fibres (and natural fibres in general) is in the automotive industry, which is constantly searching for eco-friendly materials to use in its products, especially as end of life disposal is increasingly a consideration for manufacturers. In these applications, hemp fibre-reinforced composites are being used by manufacturers like Audi, BMW, Mercedes Benz and Volvo in a range of applications which benefit from their strength to weight ratio and greater flexibility on impact when compared to glass fibre-reinforced composites. Australian company EcoFibre is one company leading in terms of developing a range of innovative hemp fibre products[11].

The following serve as interesting examples of earlier industrial uses of hemp: Henry Ford's first car was made from hemp and could even run on hemp biofuel. The first pair of Levi jeans were also made from hemp, as were the ropes and sails on ships used by Captain Cook and Christopher Columbus. The Gutenburg Bible, The King James Bible and the first draft of the American Constitution were all written on hemp paper[12].

8 *Bennett, 2021*
9 *https://hempwood.com/*
10 *Innovative Building Materials website offers some helpful information and images regarding hemp as an insulation material: https://innovativebuildingmaterials.com/hemp-insulation/.*
11 *EcoFibre website*
12 *As referenced by Te Radar during interview with Dave and Anne Jordan https://hempnz.co.nz/about-us/*

New Zealand's hemp fibre industry

CONTEXT

As in other countries, industrial hemp has suffered from a social stigma in New Zealand due to the fact it is a cannabis plant, from the same family as cannabis known for being the basis of the drug 'marijuana'. This has stymied its development as a beneficial crop for production of fibre and other hemp products for at least 100 years.

In New Zealand, a number of hemp products businesses started to emerge from the early to mid 1990's and by 1997 there were at least 15 'purist' hemp companies registered in New Zealand. Today there are many more.

Hemp growing has increased in New Zealand since the Amendment of the Misuse of Drugs (Industrial Hemp) Regulations 2006 came into force in 2018. These regulations allowed hemp seed for human consumption. 65 licencees growing 259 hectares in 2018 rose to 260 licencees growing 1,335 hectares in 2020. This has levelled off in 2021, with 192 licencees growing 862 hectares. Based on the 2019-2020 growing season, the industry is estimated to be worth $3 - $5 million to growers[13].

However, stats from the 2021/2022 summer season expect to show growth again, with Canterbury fibre interests, Carrfields, expecting to grow around 1,000 hectares in support of their processing facility.

MAIN GROWING REGIONS

Of the 862 hectares grown in 2020, the largest areas in cultivation were Canterbury (447ha), South Canterbury (143ha), Hawkes Bay (89ha), 'Southern' (76ha) and Nelson-Marlborough (61ha).

Seven purchases of hemp general growing licences in 2021 were for Taranaki-based individuals/companies. With only 8.32 hectares notified as being in cultivation in Taranaki, the growing here is still largely experimental.

Soils and climate favour hemp cultivation in Taranaki over some other areas of New Zealand, however investments in local processing infrastructure and value-adding manufactures in region will be needed to ensure opportunities for scale and for competitive returns for farmers.

KEY HEMP VARIETIES

There are many different cultivars of hemp in New Zealand but only 20 are 'approved cultivars of industrial hemp' under the Misuse of Drugs (Industrial Hemp) Regulations 2006[14].

Hempseed Holdings Ltd are one company who have been developing cultivars within New Zealand, which are also now approved for sale and for growing by Ministry of Health/Medsafe. Two of these (*A1 Macmono*, and *Aotearoa 1*) are noted as being suitable for fibre.

The best economic returns are likely to be generated from acclimatised region-specific cultivars. Multiple sources note that cultivars need to be adapted over time to regional soils, climate and day length in order to develop the quality of output for a desired end use.

KEY OPERATORS AND ORGANISATIONS

NZ Natural Fibres

Hemp New Zealand is a Tauranga-based company at the forefront of the hemp fibre industry in New Zealand. They started in 2009, and now have, in conjunction with Carrfields (an end-to-end agri-services business), jointly ventured into a new natural fibres and materials business: NZ Natural Fibres Ltd (NZNF).

NZ Natural Fibres is aiming to be a pioneer in the global natural fibres revolution and have invested in an imported hemp processing plant (decorticator) which was installed in Christchurch in 2021. Following considerable amendments to the imported processing equipment, NZ Natural Fibres now expect they have capability to process around 12 tonnes of hemp a day (approximately 1,800 tonnes per year, working with one day shift only).

In late 2021 NZ Natural Fibres were successful in attracting co-investment of $1.34 million from MPI's Sustainable Food & Fibre Futures (SFFF) Fund towards a $3.2m, multi-pronged, five-year R&D programme. They are evaluating cultivars' suitability for fibre production, and trialing retting and other processing techniques that will allow them to produce (without use of chemicals) clean bast fibre suitable for hemp/wool blends or 100% hemp

13 *Sapere (MPI), 2021*
14 *Names of approved cultivars can be found on the Ministry of Health website*

textiles suited for apparel and other interior textiles, for which demand is increasing.

In Canterbury, Carrfields are engaging farmers in region as contract growers, offering a fixed purchase price at the outset (competitive with other arable spring land uses), and providing the end-to-end services and machinery needed for hemp cropping, including direct drilling, agronomy advice, contract harvesting and baling, and taking fibre away for storage.

In February 2020, NZ Natural Fibres CEO, Colin McKenzie, and Carrfields Senior Research Officer, Travis Ryan-Salter, outlined their prediction that the NZ hemp industry is to become a $1 billion industry[15].

NZ Hemp Industries Association (NZHIA)[16]

Formed in 1990, and incorporated as a society in 1997, the New Zealand Hemp Industries Association (NZHIA) have been working hard to provide information and advice for association members as well as the public since 1998. They have also organised events for those interested in the hemp industry and its viability in New Zealand, including Hemp Summits held in 2018 (Wellington), 2020 (virtual), and 2021 (Rotorua).

NZHIA facilitate the exchange of information between the industry and various stakeholders - from government to industry and the R&D community. Their members represent the entire industry - from seed growers and processors, through to suppliers and retail - and they continue to work on behalf of the industry to achieve a beneficial regulatory environment for industrial hemp, to stimulate and support R&D on behalf of the industry.

Hemp Building Association New Zealand[17]

The recently established association (HBANZ) has been voluntarily fulfilling a role of raising awareness of hempcrete construction benefits and are keen to support hempcrete-related activity in Taranaki. Their website includes useful information, videos and links relating to hemp's use in construction, both here and overseas. HBANZ is planning regional building workshops and are investigating the potential for micro-credentials for hempcrete building.

DEMAND IN THE CONSTRUCTION SECTOR

Currently demand for construction materials far exceeds supply, and COVID-19 impacts on supply chains are creating considerable issues for New Zealand's construction sector. The current 'gib-board crisis' is an example of this and is well documented[18]. 90% of all construction products sold in New Zealand were either imported or contained imported components not easily replaced by domestic supply[19]. Local production of hemp-derived construction products could serve to reduce emissions and ameliorate supply chain challenges, and potentially lead to new exportable products.

Various research institutions, such as Massey University, Waikato University, Ara Institute and University of Canterbury, have been experimenting and growing hemp for fibre and trialing and testing hempcrete and other fibre products to help address this demand.

Construction Industry Potential

There were 49,773 new houses consented in New Zealand in the year ending February 2022, valued at $19.242 billion. If hemp builds and building materials were able to obtain a 0.1% – 0.5% share of the national residential construction market, this could create an industry valued between $19 - $95 million.

A mid-point of 0.3% would be $57 million and would correspond to 149 new houses. With roughly 1.2 hectares of hemp required per house[20], only 179 hectares of hemp would be required to meet this demand. With hempcrete buildings able to sequester approximately 18 tonnes of CO_2, 149 hemp builds could have the potential to sequester nearly 2,700 tonnes of CO_2.[21]

15 *Sarah's Country, February 2020*
16 *New Zealand Hemp Industries Association (NZHIA)*
17 *Hemp Building Association New Zealand*
18 *Melanie Carroll (Stuff), Gib by the numbers: Why it's making people hoard, steal and beg, 9 June 2022*
19 *EBOSS Construction Supply Chain Report (2021)*
20 *New Zealand hemp Building Association*
21 *Jami and Kumar (2017)*

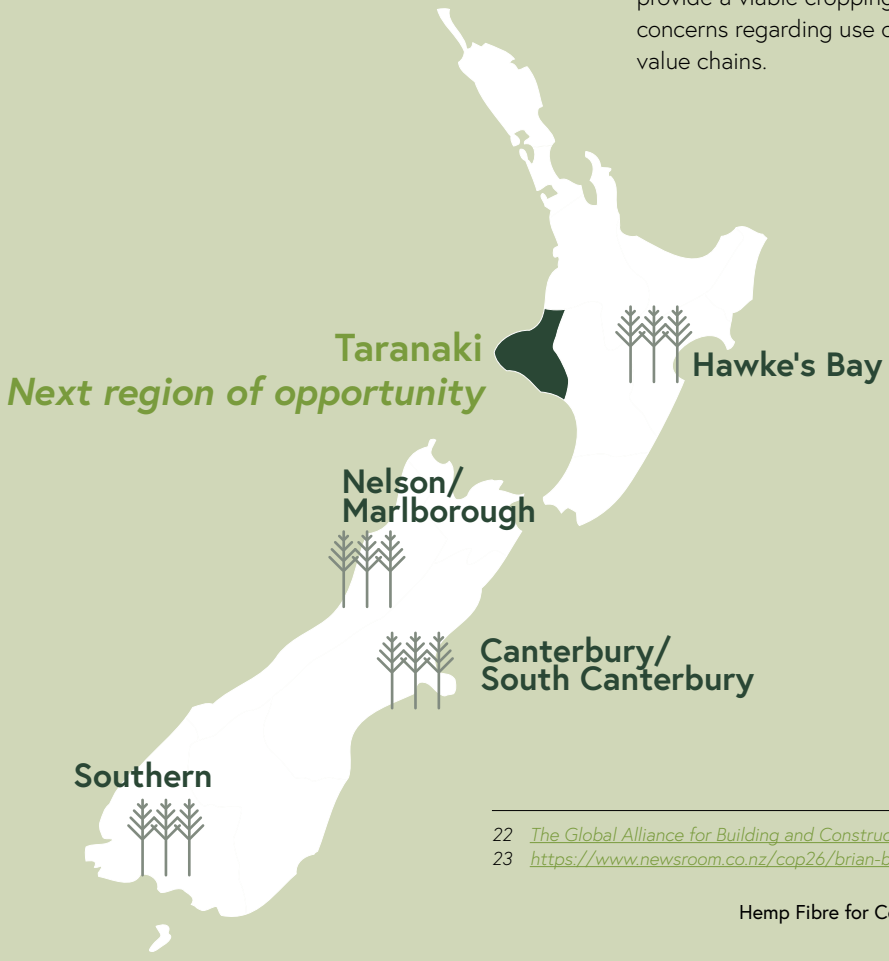
The opportunity for Taranaki

Hemp is suited to temperate climates, with reasonable rainfall (as hemp needs approximately 75-100mm for crop establishment). NZHIA's website notes that hotter, dryer climates are not as conducive for fibre production as are more mild and humid climates, which tend to produce stronger and more durable plant fibres, and less resin in hemp crops. They also note that a degree of wind can also contribute to improved fibre quality. As such, Taranaki's climate could well favour growing hemp for fibre production.

It has been estimated that buildings are directly and indirectly responsible for up to 20% of New Zealand's greenhouse gas emissions[22]. Reducing emissions in house builds (and via retrofitting, and insulating) through use of hempcrete and other hemp building products could allow Taranaki to respond to the government's 'Building for Climate Change' strategy and to commitments we have made at the Oct-Nov 2021 UN Climate Change Conference (COP26) to halve NZ's net emissions by 2030 and to being carbon zero by 2050[23].

Building houses or construction materials out of hemp aligns well with the Taranaki 2050 Roadmap. By using hemp to construct houses, we would be achieving progress towards goals we have set ourselves within our Food & Fibre, Energy, Innovation and R&D, and Health and Well-being Pathways to 2050. Taranaki has had the first, and the most houses to date, in New Zealand, constructed out of hemp – a total of four. With the significant existing engineering capability in Taranaki, the emerging hemp construction sector could provide a great opportunity for engineers to develop new technologies in relation to the processing of hemp and hemp buildings, as well as products.

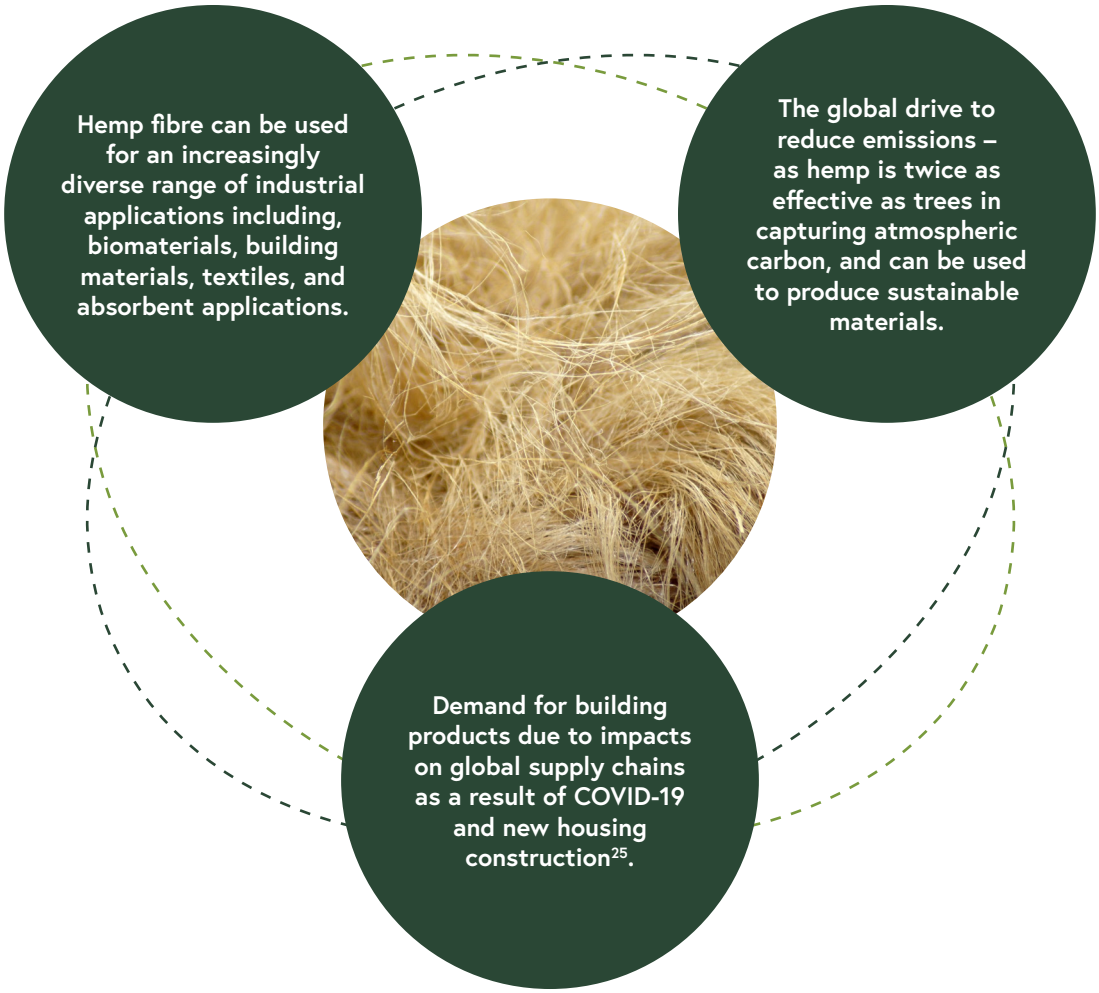
Taranaki's economy relies heavily on pastoral farming, so incorporating hemp into the existing pasture and fodder crop systems could provide farmers with a good rotation crop and alternative income. Hemp can improve soil quality as its long roots go deep into the ground, which can aerate and condition soils. Hemp produces biomass - matter which returns to the soil and decomposes, feeding nutrients back into the soil. It also offers potential as a bioremediation crop, for the absorption of pollutants or contaminants in soils or water. Experiments conducted by Massey University in 2015, growing hemp in soil from 'landfarms' in Taranaki, concluded that hemp grown for fibre could benefit from and enhance such soils and provide a viable cropping option that could alleviate concerns regarding use of these soils for crops for food value chains.



22 *The Global Alliance for Building and Construction puts this figure at more like 40%.*
23 *https://www.newsroom.co.nz/cop26/brian-berg-building-sector-must-decarbonise-now*

Drivers of growth

Interest in hemp and hemp products has been growing since the 1990's, and the removal of legal constraints to growing and manufacturing hemp has enabled a resurgence of hemp as a crop. The global hemp industry is projected to grow from USD$4.6b in 2019 to USD$64.8b in 2030, with the biggest share of that market being for CBD and other cannabinoid products, followed by seed food products. However, there will also be increasing demand for both low and high-tech fibre products[24]. The key drivers of this growth are:



When considered as part of the global hemp industry, New Zealand may have some comparative advantages such as[26]:

- A good existing ecosystem for plant and food related science and innovation,
- A good understanding of agronomic principles in certain regions (and in general, perhaps),
- New Zealand's clean green positioning – offering potential to match consumer preferences,
- Good availability of fresh water.

24 *NZ Hemp Industries Association's Investor Report (2020)*
25 *https://www.rnz.co.nz/news/business/460620/construction-material-shortages-price-hikes-plague-building-industry*
https://www.newsroom.co.nz/years-more-supply-chain-pain-for-construction
https://thespinoff.co.nz/business/18-01-2022/construction-and-tech-are-facing-unprecedented-shortages-why
26 *Sapere (MPI), 2021*

Entry requirements and current industry supply chain

LICENCES

To grow, trade in, or process industrial hemp as an agricultural crop in New Zealand, an individual, body corporate, or partnership needs to be licensed under the Misuse of Drugs (Industrial Hemp) Regulations 2006[27].

To be eligible for a licence, applicants must have a secure site, more than 5km away from a school, with the growing area not visible from the street. Two 'responsible people' must sign the application, and police checks are carried out on these 'responsible people'. A hemp licence is issued for a period of one year and is applied for via the Ministry of Health[28].

Every licence holder who is authorised to possess hemp seeds and cultivate them must keep a seed register, cultivation register and a harvest register. This must be provided to Medicines Control at the Ministry of Health upon request.

Growers also need to record sales and/or destruction of any hemp seeds and plant material, with acceptable methods for disposal including composting, mulching or burning.

TESTING

Each cultivar of hemp grown must be tested for its THC level. Environmental Science and Research Ltd (ESR) is one laboratory approved for testing hemp samples to ensure THC levels are below legislated requirements – i.e. below 0.35% in most cases[29]. Other laboratories also provide testing services, such as Hill Laboratories.

ACCESS TO SEED

Seed cannot be purchased until a growing licence has been issued. It is important to plan and to apply for a licence well ahead of time if intending to grow, as seed is often in limited supply and those late to the market may not be able to purchase.

Seedstocks for cultivars that have been approved for industrial hemp in New Zealand can be obtained from a licensed seedstock provider. Midlands, HempNZ, Hemp Connect and Canterbury Seeds often have seed available for sale, however, there may be others. NZHIA are able to provide updates to members regarding seed purchase options.

It is possible to also import whole seeds, however an import/export-controlled drug permit and compliance with all phytosanitary requirements is required if this is planned. Further details relating to Import Health Standards can be found on the MPI website.

From time to time, additional cultivars can be approved for research purposes (hence there are also Research and Breeding Licences). These can consequently become 'approved' by the Ministry of Health, providing testing validates they do not exceed allowable levels of THC for industrial hemp. This process usually takes around two years.

HARVESTING, PROCESSING, AND STORAGE

Considerable costs can be involved in terms of money, time and energy in setting up hemp processing facilities. Hence, investment in such facilities needs to be driven by high-value product propositions.

Experimentation with cultivars and crops (grown locally), harvesting and processing equipment and end use applications for fibre will be necessary steps if developing ventures using hemp for construction or other fibre applications. Variable and fluctuating qualities of hemp fibre are to be expected and optimising process and product may take some trial and error and investment of time and money.

Access to harvesters and decorticators are a key consideration when growing hemp for fibre, and access to processors has been observed to be driving industry viability. In Canada and the Netherlands, the most

27 *Currently a General Licence is $511.11 including GST. This allows for the cultivation, processing, possession, and supply of low-THC cannabis varieties approved by the Director-General of Health. A Research and Breeding licence is issued only if the applicant holds a general licence and is an additional $153.33 including GST. It allows for the cultivation and processing of approved and non-approved varieties.*

28 *More information and application forms are here: https://www.health.govt.nz/our-work/regulation-health-and-disability-system/medicines-control/industrial-hemp/industrial-hemp-licensing*

29 *ESR currently charge a fee of $575 including GST per cultivar tested.*

successful operators are vertically integrated businesses who are actively involved with both growing and processing of hemp.

There also needs to be storage facilities for hemp stalks before they are decorticated as well as for hurd/fibre after decortication and before it is further processed, or sold.

Timing for harvesting is dependent on end uses and harvesting within maturation and weather 'windows' can be critical for ensuring quality for planned end use(s).

Hemp is harvested prior to seeding for the strongest fibres, or when the seeds are mature in the case of a dual-purpose crop. The crop is hard on conventional farm machinery and modifications to machinery are often required due to the long stalk length and its toughness.

Various types of farm equipment are used for harvesting hemp, including straw walkers or combine harvesters, discbine and sickle mowers/reapers, side cutters and forage harvesters, often used in combination with tedder/rotor rakes and big square or round balers. Swathers or windrowers can also be used if volumes are not too great. Use of mower conditioners needs to be avoided if harvesting for hurd.

Equipment needs to be considered carefully if hemp is being grown to significant heights (as a result of cultivar choice and growing context). As cropping of hemp is developing worldwide, more appropriate modern machinery is being developed. For now, traditional machinery can do the job, if somewhat onerously.

If processing seed for foods such as hulled seeds, oil, protein powder or hemp flour, other processing equipment will also be needed, such as seed dryers, seed graders, colloid mills, cold press or other extraction processes[30].

TRANSPORT

It is generally prohibitive to transport bulky/heavy raw hemp materials for processing, and there is an industry 'rule of thumb' that having processing equipment within a 50km radius for growers helps make processing economical.

Unlike many other grains, including wheat and maize, hemp seed is harvested from a living green plant, which means the harvested crop is wet. In order to prevent quality of seed/seed oil being compromised, it needs to be delivered to drying and storage facilities within four hours of harvesting.

BUILDING AND BUILDING PRODUCT REGULATIONS

Currently, the consent authority (in Taranaki this is one of the New Plymouth, Stratford or South Taranaki District Councils) is required to issue a Code of Compliance for all the houses within its authority. The New Zealand Building Code permits a walling for a 3604 build to be used as long as it is able to be substantiated with supporting documentation that it will satisfy performance criteria, especially for weather tightness and durability. Hempcrete does this, and the use of a certified binder from Australia to date has facilitated this consent issuing and signing off process.

There are no ready-made compliance paths for designers to follow – hempcrete is considered an 'alternative method' currently. Designers and applicants for consent need to draw heavily on history of use and comparisons to other similar construction systems to convince building consent authorities of the worthiness of the consent application. All the home-owner builders who have built hempcrete homes so far in NZ have (usually in conjunction with their home designer) been able to provide the required hempcrete spec/performance documentation to their inspector, using existing data from either UK or Australian sources.

There are currently no established international standards for hemp hurd building. There are voluntary standards and these should be adopted in the interim[31], as building failures are the biggest risk to the hemp building industry.

For those who are keen to develop building products (composite boards, insulation materials etc.), initial work can be undertaken to develop and test prototype products. However, prior to being able to take these to market, designers and manufacturers need to provide confidence to potential buyers that products are fit for purpose and meet Building Code performance requirements.

R&D efforts should likely focus on environmental sustainability in materials used and on developing local supply chains for the construction market. Performance of construction materials in a range of New Zealand conditions, including thermal and humidity regulation will be needed. Assessing materials for building code compliance and fire retardancy is testing which BRANZ[32] can undertake.

30 *More information is available at Callaghan Innovation's Hemp Seed Capability Roadmap: https://www.callaghaninnovation.govt.nz/sites/all/files/Hemp-Seed-Roadmap_1.pdf*

31 *Stanwix and Sparrow, 2014*

32 *BRANZ Ltd is an independent research organization that works to improve the performance of New Zealand building systems. They offer product appraisal processes that provide a robust, in-depth and independent evaluation of a building product or system to assess whether it is fit for purpose and meets Building Code performance requirements.*

Other value chain opportunities

This report has focused on construction and on the use of hurd and bast fibre in the industry, however, to maximise profits the whole plant can also be used. In addition to construction applications, parts of the hemp plant can also be used for:

Fibre value-add products

Hemp fibre can be used for the production of textiles and geotextiles, animal bedding, oil absorbent materials, thermoset and thermoplastic composites, 3D printer filaments and carbon nanosheets. Due to increasing environmental imperatives, interest in its use in these applications is growing and research into hemp's utility for such applications is growing. Natural fibres are eco-friendly, being derived from renewable resources, and have low density but also high specific strength and stiffness.

Environmental value and carbon sequestration

Hemp produces biomass - matter which returns to the soil and decomposes, feeding nutrients back into the soil and stimulating microbial content (more if hemp is retted in the field, and if residuals are not entirely removed). It also offers potential as a bioremediation crop, for the absorption of pollutants or contaminants in soils or water.

Research also suggests hemp is one of the best CO_2 -to-biomass converters, capable of absorbing between 8 – 15 tonnes of CO_2 per hectare (across a 3 – 4 month growing season). Comparatively, forestry-based carbon capture typically captures between 2 – 6 tonnes of CO_2 per hectare (per year)[33].

When making a house out of hempcrete, the hempcrete also sequesters additional carbon. Hemp walls cure over time because of the lime reacting, turning the walls effectively into a limestone wall, and this process requires carbon. Once it is stone, the carbon is now locked in the house for the rest of its life (reportedly taking about 100 years).

R&D

Research into hemp genetics, agronomy and yields, alongside research into the properties of the resultant fibre, seeds and metabolites will grow understandings of hemp as both a crop and product feedstock.

Seed products

Hemp seeds are extremely nutrient dense, with 20-25% protein, 25-30% oil and 10-15% insoluble fibre, and with the oil containing >90% polyunsaturated fatty acids, which are a valuable addition to both human and animal diets[34]. They are gluten free and are an excellent nutrient source for products created for the growing flexitarian market.

Whole seeds that are capable of growing can only be sold to another licence holder, such as a processor, but as soon as seeds have been processed into a form that can't grow (e.g. seed hearts, meal, protein powder, or hemp seed oil), these can be sold to any customer.

Biofuel

Hemp is a rapidly growing plant that tolerates high planting density, producing biomass of hemp per hectare similar to other biofuels crops (such as miscanthus and poplar). Numerous bioenergy applications for industrial hemp exist and it is anticipated that the production of bioethanol and biodiesel from industrial hemp could have strong potential to reduce greenhouse gas emissions.

Metabolites

Hemp produces a diverse array of nonintoxicating phytocannabinoids, terpenes and phenolic compounds with potential pharmaceutical values as drugs or supplements. Of over 100 known cannabinoids found within hemp, most notably CBD, these are increasingly being used for, or being trialed for use for, a range of medical conditions, with more research ongoing so as to characterise specific compounds and understand how these impact biosynthesis of helpful compounds in the human (or animal) body.

33 Darshil Shah n.d., senior researcher at Cambridge University's Centre for National Material Innovation, cited in Bennett (2021).
34 Note that currently MPI regulations do not permit the inclusion of hemp seed or oil into animal feed for either production animals or companion animals.

What's the bottom line?

Financial modelling

The below table provides an indicative projection for three options of hemp production – for fibre only, for seed only, or for fibre and seed. The projections assume existing access to land and equipment needed to grow and process hemp crops and only considers ongoing operating expenses. While the info below is based on one hectare only, it is suggested that a minimum of ten hectares is required in order to have a profitable crop. These figures are provided to serve as an indication only, and are based on the best available data from 2019/2020.

	Fibre crop	Seed crop	Fibre & seed crop[35]
Hemp crop cycle	3 – 4 months	3 – 4 months	3 – 4 months
Estimated fibre yield per hectare	10 tonnes	-	9 tonnes[36]
Gross fibre value per tonne	$400	-	$400
Gross fibre income per hectare	$4,000	-	$3,600
Estimated seed yield per hectare	-	900kg	900kg
Gross seed value per tonne	-	$5,000	$5,000
Gross seed income per hectare	-	$4,500	$4,500
Operating expenses per hectare	$2,000	$2,540	$3,910
Transport costs per hectare	$500	$500	$1,000
Total net income per hectare	$1,500	$1,460	$3,190

ASSUMPTIONS

Future yields

While the yields indicated above have been advised as the current standard for New Zealand production, over time and with further research and breeding in the New Zealand context, it is possible that greater yields may be experienced by New Zealand growers.

Operating expenses

Costs for growing and harvesting a hemp crop can vary by region, depending on contractor costs and availability of equipment. Transport costs for seed and fibre depend very much on distance from buyers/processors. Transport for fibre is likely to be more expensive than it is for seed, due to its bulk. Without investment in equipment and processing plant based in Taranaki, costs of transporting raw product to processing centres elsewhere in New Zealand would add considerable costs to hemp ventures in region.

Operational costs used in this analysis were those proposed by AgFirst as 'average costs for seed/fibre crops in the 2019-2020 season' and were calculated to include: cultivation and planting, base fertiliser, seed, harvesting and transport to dryer, drying and cleaning. Farm costs, including fertiliser and fuel, continue to rise, meaning these operation figures will need to be revisited. These figures are based on calculations made by AgFirst which have been published on the Tupu.nz website with data gathered in 2019/2020 that relates to growing for seed only. Some conjecture was made by AgFirst in relation to fibre cropping figures, and we have further extrapolated what this might look like for a seed and fibre crop, which will have higher operating costs again. We have inserted a flat figure of $500 per hectare for transport costs in all scenarios, however, transport charges may also be variable.

Operational costs for growers have been increasing for growers, but it is likely that selling prices should also be increasing as more higher value markets are developed for hemp products.

The annual licensing cost of $511.11 per cultivation per year (GST included) has not been factored into the above figures.

35 *A fibre crop being late-harvested to allow for seed development may not allow for as high a quality or yield of fibre as a crop grown purely for fibre production.*

36 *Hemp New Zealand's Dave Jordan suggests that in a good year, from a multi-purpose crop, he might anticipate getting 6 tonnes of hurd and 3 tonnes of bast fibre, as well as 1 tonne of seed, from a hectare of hemp.*

Other hemp production considerations

Labour considerations

Hemp is a seasonal plant so there may be more labour around the farm during the spring-summer periods when the plants need to be planted, harvested, and retted. However, mechanised soil preparation, sowing and harvesting activities will generally not require too much additional labour. Farming at regional scale could generate additional employment for farm services contracting businesses. Depending on the amount of hemp grown, there is potential for new employment opportunities in relation to decortication and other post-harvest processes.

It is in the value-adding processing, product manufacture and marketing, logistics and distribution, and engineering innovation and R&D that new jobs could be created.

To build a house out of hempcrete is a very labour-intensive process, because of the shuttering process, and this could have potential also to generate more paid hours for newly skilled labourers/builders. Those who have been involved with hemp house building see opportunity for the engagement and development of individuals in the construction sector, who might otherwise not be attracted to this industry.

Regenerative approach

Growing hemp fits exceedingly well with regenerative approaches and has potential to play a significant role in reducing emissions and contributing to other environmental good. Hemp has many benefits for the soil it is grown on, as it can return an estimated 60-70% of nutrients it has taken up from the soil when it is retted in the field. It can also withdraw toxins from the ground, taking these out of the food cycle. Various studies have evaluated hemp positively for its cultivation on contaminated soils[37].

Marfell Community Garden pātaka kai, built from hempcrete by Venture Taranaki and volunteers in 2021.

37 - MultiHemp, 2017

Establishing a hemp crop

— what's required?

Cultivars

Attention to cultivar selection, and undertaking research and experimentation over time with cultivars in relation to local growing conditions, harvesting, and suitability for end use are pre-requisites for success.

Breeding programmes for the development of hemp best suited to context and purpose are recommended by researchers and the hemp industry alike. Currently the recency of the revival of this industry, plus the requirement to purchase seed of approved cultivars, limits to some extent how much this activity has been undertaken in New Zealand. However, there have been some locally developed cultivars added to the list of Approved Cultivars in recent years, and Natural Fibres NZ and others are working on such research.

For fibre end-uses it may make sense to select cultivars that produce less seed, flower and leaf biomass and to select based on stem biomass (i.e. cultivars with heavier and/or longer stems).

Best economic returns are likely to be generated from acclimatised region-specific cultivars. These need to be evolved over time. Well-designed breeding programmes start with a good understanding of positive traits that growers are interested in developing to bring in new plant varieties (i.e. hurd and/or bast quantities and qualities in this case). Breeding programmes should emphasise genetic stability and reproducibility. Breeding tools include crossing, quantitative selection for genetic gain and genomic selection. Data management and accurate record-keeping is important towards understanding relationships amongst plants (phenotypes and pedigrees), and tracking the usable crosses produced. Genetic software can help plant breeders manage this, and can incorporate crossing plans and measurement of key traits.

Consideration of how to achieve controlled breeding programmes for hemp needs to be cognisant that hemp is an 'anemophilous crop', in which the pollen can travel long distances (over 100km has been observed).

Location and climate

Hemp can be grown pretty much anywhere in New Zealand, and Taranaki, (terrain and licences permitting), providing there is water available at the right times, as well as:

- mild climate (it is best suited to temperate conditions of between 15°C and 27°C),
- fertile soils with good water holding/drainage capacity,
- 250-300 mls of available moisture, and potentially irrigation during the first month (New Plymouth will typically have around 400-500mls during the Dec-Mar period),
- pH levels of 5.8-6.0 (the standard pH level of soil in Taranaki is around 5.6 - 6.0), however, some hemp crops will tolerate up to 7.5pH,
- no-to-little risk of frosts (refer to further information below), and
- 1,900-2,000 Growing Degree Days 'GDD' for fibre crops, or 2,700-3,000 GDD for seed production[38].

Based on the average monthly temperatures in Taranaki, hemp meets the accumulated temperature requirements of 1,900 GDD from December to March (at 1,959 GDD), however it would be just short of Growing Degree Days if sown in November and harvested end of February (at 1,853 GDD).

In order to accumulate 1,900 GDD, hemp for fibre sown at the beginning of November will need to be a 124-day crop and will mature at the beginning of March. Hemp sown at the beginning of December will be a 119-day crop and will mature towards the end of March[39].

The optimal germination temperature for hemp is 24°C, though germination can occur at temperatures as low as 0°C. Optimum temperature during vegetation phase is 19-25°C[40], however, crops can survive at temperatures as low as -5°C for short periods of time, although this will severely reduce crop height[41]. It is relatively frost-sensitive, however seedlings have been known to survive a short period of frost exposure at temperatures of -8°C and -10°C, although these conditions are not ideal[42].

Wind exposure can be damaging to hemp crops, particularly in the early stages when the stalks are not strong. Hemp plants may try to recover from the damage, but potential yields may not be reached or will be delayed[43]. There is some research that suggests that exposure to mild winds can help strengthen hemp fibres.

Plot size

Ten hectares is envisaged as being able to provide a profitable crop. If fibre only is harvested and is onsold as a commodity, farmers should be able to net around $15,000 per ten hectares. If the crop is harvested for both seed and fibre, income could be around $31,900 from ten hectares.

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38 GDD is a weather-based indicator of the accumulated thermal time required for a crop to develop.
39 Kavas, 2015
40 Bouloc et al., 2012
41 Young, 2005
42 Lisson & Mendham, 2000
43 Mooleki, 2006

Ten hectares is also more ideal for contractors than a smaller sized plot. This is due to smaller paddocks being less efficient to harvest.

Preparation and fertilisation

Hemp needs to be planted into well-draining, fertile soil and is sensitive to soil compaction and waterlogged soil conditions. Heavy clays need to be avoided. Sandy soils can work with adequate moisture. Stony fields need to be avoided, as stones can cause issues and damage during harvest and decortication, including fire hazards.

Hemp fares best in non-saline environments with good surface and internal drainage.

Hemp has been noted as being highly sensitive to residual herbicides in soils, hence attention to field 'history' is important[44].

Hemp is considered to be a sustainable crop because it can grow well in areas that have accumulated too much nutrient due to run off from other cropping or from livestock farming.

However, before sowing hemp seed it is highly recommended to ensure sufficient nutrients in the soil. Fertiliser application and rates should be adapted to local soils and climate, with the objective of providing nutrition to meet the crop's growing needs.

Soil fertility suggestions vary, but have been proposed as 120kg Nitrogen/ha, 100kg Phosphorus/ha and 160kg Potassium/ha by British Columbia's Ministry of Agriculture and Food[45].

From research conducted across 20+ years, from 1977-2004, results indicating that in order to produce one tonne of dry matter (DM) from hemp, the vegetation process mobilises 18-24kg of Nitrogen (N), 5-10kg of Phosphorus (P2O5), 20-40kg of Potassium Oxide (P20), 30-40kg of Calcium oxide (CaO) and 8-10kg of Magnesium Oxide (MgO) [46].

For yields of ten tonnes per hectare, this research implies the need for plants to have access to some 180-240 kg/ha of Nitrogen, 50-100 kg of Phosphorus, 200-400kg of Potassium Oxide, 300-400kg of Calcium Oxide and 80-100kg of Magnesium Oxide.

Nitrogen is noted as the most critical nutrient for hemp fibre crops by various commentators. Insufficient nitrogen will cause yield losses, while excess nitrogen will reduce fibre quality[47]. Biomass tends to increase with increasing rates of nitrogen and phosphorus and can result in increased plant height[48].

Excess nitrogen can cause issues though, including stem weakness due to unusual stem elongation[49]. When excess nitrogen is applied, the nitrogen is used for leaf development rather than fibre, encouraging the leaves to stay greener for longer, which can also lead to difficulties in cutting and drying times as well as interfering with mechanical fibre separation[50]. Increased nitrogen rates also result in reduced density, as there is greater competition between plants during the vegetative period[51].

Photo: Anna Harding, via NZHIA

Potassium and phosphorus are also important, and uptake of both has been found to increase as the crop growth increases. Potassium fertilisation has been found to only affect hurd yield in particularly dry years, in which it can improve growth[52].

Fields are likely to need potassium added if retting of crops is not done in-field, or if residuals are taken off the field, as this prevents the return to soil of potassium from plant residuals.

Organic fertilisers are also capable of meeting the plant needs[53]. A recommended way to do this, especially in Taranaki, is to have had cows or winter crops in the field previously. In a 2017 episode of Rural Delivery, Hemp Farm New Zealand's Dave Jordan describes how he achieves this in an organic hemp farming operation, using chicken and/or fish manure and ploughing winter crop residuals into the soil[54].

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44 *MultiHemp, 2017*
45 *Industrial Hemp Factsheet, 1999*
46 *Bouloc et al. (2012)*
47 *Merfield, 1999*
48 *Vera et al., 2004*
49 *Bouloc et al., 2012*
50 *Legros et al, 2013, cited in MultiHemp, 2017*
51 *Bouloc et al., 2012*
52 *Bouloc et al., 2012*
53 *Bouloc et al., 2012*
54 *https://www.youtube.com/watch?v=DedRrEph9OA*

Sowing and sowing densities

Hemp seed should be planted when the soil temperatures reach at least 6 - 8°C, with some commentators recommending 8 - 10°C. The seedlings require 75-100 mm of rain or irrigation during their first month of growth.

Sowing times are influenced by environmental factors and vary from season to season. Some decreases in stem yields have been noted when sowing later in the spring. This is due to the shortening of the calendar and thermal time duration from sowing to flowering. This is attributed to delays in 'canopy closure' and thus a reduction in intercepted radiation. Earlier sowings can be limited by premature flowering in response to shorter day lengths, so in order to accomplish earlier sowings it is necessary to find a cultivar that is less sensitive to photoperiod[55].

Hemp will establish best when direct drilled into a fine tilth at around 12-20mm deep (and no deeper than 32mm). Direct drillers and/or air seeders (used at low fan speeds) can be used for seed sowing.

Sowing density is an influencing factor for fibre quantity and quality. For greater fibre yield, seeds should be sown at high densities to produce tall, quick growing straight stalks[56]. At high seed densities, the thinner stalks make fibre separation easier, as well as aiding in weed suppression[57]. Cross drilling seeds can help with this by filling the gaps between the rows of the plants which form when the sowing is only done in one direction.

Sowing densities will vary depending on cultivars, fertilisation and environmental conditions, but should be around 55-70kg of seed/ha in order to optimise fibre quality and quantity. Note that optimum seed volume/ weights will be impacted by seed size. Seeds can range from around 15gm – 21gm, and this has implications for calculating seed volumes for sowing densities.

A study conducted in Tasmania, Australia, found that the maximum stem yields were at a sowing density of about 110 plants/m2. Plant numbers can decline throughout the sowing period, especially where higher sowing rates have been applied, due to the self-thinning and the inter-plant competition for available resources.[58]

CROP MANAGEMENT AND PROCESSING

Water and irrigation

Seedlings require 75-100 mm of rain or irrigation during their first month of growth. The need for water reduces dramatically as the canopy and tap roots become established, however irrigation may be necessary in areas that are dry over the summer months (e.g. in other parts of New Zealand, like Hawke's Bay and Canterbury).

Weeds

Hemp will outgrow weeds when grown under ideal conditions. Its ability to smother weeds is weak in the early stages of growth, but strong once the crop establishes and the canopy covers the ground, hence it is important to sow hemp when conditions such as temperature are favourable, to enable quick crop establishment[59]. Planting in Nov-Dec should normally allow a crop to establish quickly and out-compete weeds.

Because hemp fibre crops are usually densely planted, weeding is not necessary, however crops with wide spacing may require (standard) weed control methods. Weeds can present issues when it comes to harvesting and processing, so optimising weed control methods is important. If weed pressure is a problem, Pendimethalin (post-plant pre-emergent commercially viable herbicide) has been known to be applied after planting and before germination, at a rate of 5L/ha.

Pests and diseases

Hemp is generally grown without the use of pesticides and using low input techniques, in keeping with regenerative aims of hemp growers. However, although hemp has relatively low susceptibility to pests and diseases, it does have over 300 pests and 100 diseases[60]. The majority don't cause damage, however 'damping off' and fungal diseases can kill or weaken seeds or seedlings before

55 *Lisson & Mendham, 2000*
56 *Young, 2005*
57 *Bouloc et al., 2012*
58 *Lisson & Mendham, 2000*
59 *Bouloc et al., 2012*
60 *McParland, 1996 – cited in Merfield, 1999)*

or after they germinate and are most prevalent in wet conditions. Fungal diseases like grey mould and hemp canker can threaten yields. Damping off and fungal diseases are most prevalent in wet conditions but can be controlled for by ensuring soils are free draining. Seed treatments and fungicides are also effective solutions in non-organic systems[61].

Birds can be problematic in large numbers; however, they are not a significant issue in crops for fibre production. Rabbits, slugs, springtails, possums, mice and pukeko are also pests and can reduce plant densities[62]. Harvest timing is important in order to reduce loss of seeds to birds.

Plant growth and maturation

Hemp is a short-day photoperiodic plant, i.e. decreasing day-lengths promote flowering. As is the case with other photoperiodic crops, it is essential to use cultivars appropriate for the latitude, climate and soils of the farm. Attempting to grow unsuitable cultivars is likely to result in an economic loss.

Hemp's growth can be divided into six stages:

1. Germination.
2. Slow growth, which lasts from the appearance of the first pair of true leaves to the fifth set of leaves.
3. Rapid growth, which lasts till the formation of flower buds.
4. From bud formation to first flower opening.
5. Flowering.
6. Seed production.

It is one of the fastest growing crop plants. In ideal conditions the tallest cultivars can grow up to 11cm a day and growth rates of 2cm a day, during the rapid growth stage, are common.

Harvesting

While hemp can produce a number of high-quality products, it is near impossible to produce high quality fibre as well as high-quality seed from the same crop. Farmers need to be clear on whether they want to harvest for just the stem and sell the bast fibre and hurd, or whether they want to harvest both stem and seeds.

Hemp takes approximately 120 days for it to reach full maturity, but needs to be harvested prior to seed formation (at full flowering, and as soon as pollen is starting to be shed) if growers are wanting to harvest for fibre to maximise fibre yield and fibre homogeneity.

To get the best quality, fibre should be harvested when one third of the anthers on the males are shedding pollen and when flowers first appear on the females. If harvested later than this, after pollination has occurred, fibre quality and yield are likely to be inferior.

Harvesting at the start of flowering means growers can avoid the bast fibres being excessively lignified, which occurs as the plant matures. Female plants have the highest levels of lignification. Stems from hemp grown for seed production are therefore not suitable for fabric manufacture, although they can be used for production of other hemp fibre products (e.g. particle board), where flexibility is not as great a requirement.

If growing for both seed and fibre, growers will need to harvest at around 120 days. Timing is critical for seed harvest. Seeds ripen from the bottom of the plant upwards. Growers will need to wait until a good proportion of the seeds are mature, but the longer the seed remains unharvested, the more that will be lost to birds and the greater the risk of seed shattering.

Harvesting seeds at 70% maturity is also one way of avoiding 'seed shattering' which hemp can be susceptible to. Further research to develop non-shattering cultivars is being recommended for the industry.

Retting

Retting harvested hemp stalks facilitates the separation of bast fibres from one another and from the woody core (hurd). Leaving plants in-field to ret (via dew or rain) is the most common approach, turning several times in order to ret evenly. This process has been noted in literature as taking up to anywhere from 7 days to up to 6-8 weeks. The process is influenced by climate conditions and microbial action, thus temperature and moisture are key factors. Harvesting of hemp stalks is likely to occur in March when temperatures in New Zealand are warm, and the microbial process is expected to take approximately 3 weeks. Stalks then may need to be dried and stored until they are ready to be delivered.

This is the field retting process, as opposed to tank retting, which can be done in large pools of fresh water. Chemical or enzymatic retting processes are also sometimes used, however chemical retting processes are less likely to support environmental credentials for hemp end product.

Depending on end use, growers might want to put retted stems in round bales, or chop them into 600-800 mm lengths and put them in square bales. Processors or customers should be able to advise as to how they want to receive the retted stems.

Growers will also need to record destruction of any hemp seeds and plant material, with acceptable methods including composting, mulching or burning (although burning is seen as detracting from hemp's carbon sequestration credentials). Biomass not processed can be directed to other value adding activities to minimise waste.

61 Merfield, 1999
62 Gibson, 2007

Decortication

Modern industrial hemp decortication is a method of using a mechanised process to separate the bast fibre and hurd fibre of the hemp stalk by breaking it. This method is made possible via a machine called a decorticator, which mechanically separates the inner hurd fibres from the outer bast fibre of the hemp stalks using a hammermill-like mechanism. Stems go into the decorticator and are crushed, broken and cycled through the process in order to separate the fibre and hurd.

A "scutching" process can also be used to separate more short fibre and the remaining hurd material from the long fibre, either manually or via the use of rotary blades.

There can be significant variability in hurd/shiv size achieved via decortication and related processing. This has implications for 'bindability' and thermal and acoustic properties of finished product. Required attributes for end product are important to consider in terms of process design.

Dust is a health and safety issue that needs to be managed, especially if using an indoor decorticator.

It is essential to confirm, in advance of growing, access to a processor with a decorticator who can process a fibre crop. While some decorticators can be transportable to the crop, these may not be appropriate.

It is worth considering need for decorticator(s) (fixed or mobile) and whether these can be shared or hired collectively by regional local hemp grower groups, or the potential for distributed decorticators to release and separate bast/hurd fibres, with bast fibres then being able to be transported to more centralised bast fibre processing facilities.

Crop rotation

Hemp has been found to be a very beneficial plant to be used within crop or pastoral grazing rotation systems (e.g. Tasmanian hemp crops are used in rotation with potato, grain and poppy crops and crops in the Netherlands are rotated with sugar beets and potatoes).

Crop production challenges

There can be issues and challenges for growers of hemp crops, including:

- Lack of appropriate cultivars adapted to regional soil, climate, and day length conditions.
- Agronomic information is still evolving in relation to industrial hemp (following the hiatus caused via the growing bans of most of the 20th century), and is even less readily available for dual purpose cropping.
- Poor stand establishment from seed, due to poor seed quality (e.g. dormant seed), insufficiently fertile soils or residual herbicide contamination, poor soil surface conditions (e.g. overly compact soils), and/or insufficient water available for seed germination and early growth.
- Lack of locally established best management practices for fertilisation.
- A lack of registered crop protection agents (e.g. chemical treatments) for appropriate pest management.
- 'Auto-flowering', wherein the hemp plants switch very quickly from vegetative to flowering states (in approximately 4 weeks).
- Feminized seeds (which mean that only female plants are produced).
- Photoperiodism issues (potentially from seeds of differing ages from seed sources).
- Limited information on harvest and post-harvest processing methods best suited to preserve the quality and value of the desired harvestable plant component(s) (i.e. fibre, grain and/or floral components).

Trials and monitoring

Trials of hemp cultivation are recommended to include monitoring of:

- Latitude.
- Elevation.
- Temperature.
- Humidity.
- Soil Types.
- Management practices – planting dates, planting density and fertiliser rates.
- Weed and pest presence.
- Flowering dates (in relation to the shortening of days).
- Yields (across several seasons, as a single season won't provide useful data).

Next steps

YOUR SUPPORT TEAM

Setting up and operating a hemp farm, providing infrastructure for the industry, or developing value added products using hemp requires a range of supporting services, such as:

- The support provided by NZ Hemp Industries Association (a membership organisation) and Hemp Building Association New Zealand.
- Horticultural advisors and consultants to assess opportunities and advise on crop establishment and operations (e.g. Farmlands cooperative).
- Financial advisors to support and/or package development projects.
- Seed suppliers.
- Contractors to help establish crops.
- Contractors to help with crop management/harvesting.
- Processors, processor retailers and hemp fibre buyers.
- Rural sector retailers to provide the equipment and supplies needed for hemp cropping (e.g. Farmlands Co-operative).
- Transport companies to move hemp from farms to processors and beyond.

Many of these services will initially be provided from other regions but as the industry grows, so too will the support industry in Taranaki.

FUNDING OPPORTUNITIES

The source or sources of funding for development of a hemp crop will depend on the circumstances of the party or parties carrying out the development and the structure of the proposed investment.

- Some Government funding is available through MPI's Sustainable Food and Fibre Futures Fund to subsidise research and development programmes.
- Other R&D and Agri Innovation funding or co-investment may be available through organisations such as Callaghan Innovation, Agri Investors and AGMARDT[63].
- Several New Zealand banks have teams with experience in assessing opportunities and providing loans for hemp developments.
- Some projects are funded by the landowner – perhaps using equity and cashflow from an existing farming operation that continues in conjunction with the hemp development.
- There are also developments part-funded by syndicators of hemp investment opportunities, where equity is provided from multiple investors.
- Other sources of funding may also be available for specific activities such as R&D. Venture Taranaki can advise on whether there are other such funding opportunities.

63 *The Agricultural and Marketing Research and Development Trust - https://agmardt.org.nz/.*

CHECKLIST AND ACTION GUIDE FOR INTERESTED INVESTORS

If you are a/an:

- [ ] Taranaki farmer who wants an additional low emissions revenue stream and a complementary crop for your farms.
- [ ] Construction industry professional looking to incorporate a low carbon, or carbon negative, material into existing products or construction methods – with potential to replace imported offerings.
- [ ] Engineering firm who might see this as an opportunity to deliver new products and services. Processing technologies for fibre processing present an opportunity for innovation for a global market.
- [ ] Person wanting to build low carbon, or carbon negative houses, which offer other healthy home benefits.
- [ ] Investor looking for opportunities.
- [ ] Register your interest with Venture Taranaki.

REVIEW FURTHER INFORMATION

- The report prepared by Sapere for the Ministry for Primary Industries about facilitating growth in the New Zealand Hemp industry - https://www.mpi.govt.nz/dmsdocument/48136-Facilitating-the-growth-in-the-New-Zealand-hemp-industry.
- Those wanting to learn how to build hempcrete houses have found good support from the hemp community, those who have previously designed/built, and now also have the resources and connections provided the Hemp Building Association New Zealand https://hba.nz/.
- Hemp Building Association NZ recommend reading *Building with Hemp* by Steve Allin, *The Hempcrete Book* by William Stanwix and Alix Sparrow, and *Hemp Lime Construction: A Guide to Building with Hemp Lime Composites* by Rachel Bevan for those interested in learning more about building with hemp and have links on their website for purchasing these publications, as well as some excellent videos https://hba.nz/building-basics/.
- *'Industrial Hemp Fibers: An Overview'*, by Manaia et al. (2019) provides excellent summary reading on this topic.

Get in touch, email branchingout@venture.org.nz

ABOUT VENTURE TARANAKI

Venture Taranaki is the regional development agency for Taranaki. The organisation is responsible for regional development strategy, enterprise and sector development, investment and people attraction, and major project initiatives which contribute to the inclusive and sustainable growth of the region. Venture Taranaki is a registered charitable trust and a New Plymouth District Council Controlled Organisation, supported by the three District Councils of the Taranaki region.

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