Branching Out Blueprint

Grains, Legumes and Vegetables

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

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venture TARANAKI Te Puna Umanga

Ministry for Primary Industries Manatū Ahu Matua

Te Kaunihera-ā-Rohe o Ngāmotu New Plymouth District Council

Te Kaunihera ō Taranaki ki Te Tonga South Taranaki District Council

TE KAUNIHERA Ā ROHE O WHAKAAHURANGI STRATFORD DISTRICT COUNCIL

Cover Photo: Woodspan® PLT Panels

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UNTAPPED POTENTIAL

The soils and topography in Taranaki mean there are significant areas of land that are suitable for annual or perennial crop production, vegetable, cereal, legume, or bioenergy crops. The climate is also well suited with a fairly consistent monthly rainfall throughout the growing season.

Crops can be integrated into the existing farming system, grown in rotation with paddocks used for grazing or other uses, helping to restore soil, building resilience, sustainability and adding value and diversity to farming incomes.

Several crops have been considered for placement in a four-year crop rotation to provide a sustainable system where soil quality is maintained through restorative crops, inputs are minimised, and disease and pest risks minimised. Animal grazing in winter is an essential component of a viable crop system and legumes are represented in the winter crops.

Potential summer crops used within a four-year rotation include kūmara, garlic, wheat and sorghum with a range of winter crops. All winter crops involve grazing or forage production, but it may be possible to substitute with some winter vegetable crops. It may also be possible to interchange crops in the summer e.g., maize for wheat or sorghum, sweetcorn in place of wheat. Faba beans as a legume grain crop in place of sorghum or kūmara could fit effectively into a sustainable cropping system.

The summer crops could be used in a pasture renewal system (short rotation) as a crop before establishing new grass. The use of crops that are deep rooting and utilise nutrients from depth (below the pasture rooting zone) may be preferred in a pasture renewal system.

This preliminary market assessment indicates domestic and export opportunities for these crops.

WHY TARANAKI?

The regions climate, average rainfall and fertlie soils will support grain, legume and vegetable growth.

Grains, legumes and vegetables can be grown in rotation with paddocks used for grazing or for other crops, and therefore incorporated into existing farming systems.

Taranaki people have a readiness to take on new ventures and transfer their knowledge and skills to new industries.

WHO SHOULD BE INTERESTED?

Taranaki farmers and landowners looking to expand and diversify their income stream, restore pasture, build resilience and increase sustainability efforts.

Processors from other regions looking to reduce supply risks related to weather and disease.

Other service providers, such as food producers, wanting to grow their businesses or develop new products.

WHY NOW?

- There is growing interest in land uses that could contribute to a more sustainable farming system with greater resilience to climate change.
- Including crops as part of a rotation could also reduce the environmental impacts of a single farm system, ensure a greater local food supply and provide a wider range of farm income.
- Demand is growing for local market produce, recognition of provenance, food safety and security, and plant-based healthy food.
- Customer demand, product positioning and value addition lends to the potential for premium returns.

VALUE-ADDED OPPORTUNITIES

The preliminary market assessment indicates there could be both domestic and export opportunities for the crops. A key focus will be to understand the opportunity for local market produce, provenance, food safety or plant based healthy food and the ability to collect a premium for this product.

RISKS AND SENSITIVITIES

- The merits of individual crops should not be considered on their own - developing a sustainable crop system is essential.
- Final crop selection should ensure there is a clear market for the quality of product that can be grown and that there is the necessary infrastructure to store and handle the crop.
- Crops and land use options have been selected to minimise the freight of low value; high water content produce out of the region. Significant investment in infrastructure may be required. It may be possible to use infrastructure that exists for other crops within the region or in nearby regions. No estimate of the cost of infrastructure has been made as this will also depend on the scale of production.
- Labour requirements will vary in relation to land use, crop selection, rotation and mix. Labour used for some crops at a particular time of year may be used in the rotation to help fulfill demand for labour at other times of the year. There may well be increased demand for skilled labour.

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	4
Suitable land available at reasonable cost	4
Existing investment interest	3
Local development experience	3
Circular economy opportunities	4
Established local, domestic and international demand	4
Product Opportunity	
Large and growing demand for high quality gin botanicals	4
New Zealand gin botanicals and associated products differentiated in key markets	3
Contribution to health and wellness of the consumer (health product market)	3
Established sustainable/regenerative farming practices, including water usage	4
Reduced greenhouse gas emissions compared to existing landuses	4
Postharvest and Processing Opportunity	
Processing facilities available now in Taranaki	2
Opportunities for development of added value products, particularly from waste products	4

Suitability of growing conditions

CLIMATE[1]

Some key weather characteristics as they relate to vegetable, cereal or legume crops are:

- the frost-free days and dates of first and last frost,
- the date when the soil temperature reaches a particular minimum temperature (for germination),
- Growing Degree Days (GDD)[2]), and
- rainfall and humidity in the key harvest windows for combinable crops.

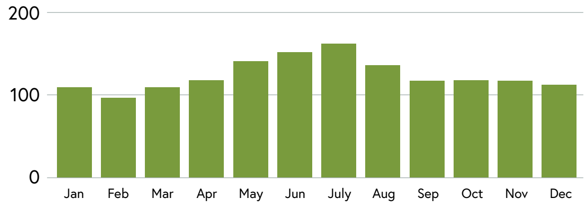
Ward et al. (2020) clearly shows that frost-free days and GDD's for Taranaki and the coastal regions may have suitability for a range of frost sensitive crops with longer GDD's.

Average rainfall for Taranaki indicates there is a fairly consistent monthly rainfall throughout the growing season for most crops, but annual variations mean access to irrigation may be required to ensure consistent crop production in years with lower rainfall.

The rainfall days per month and the relative humidity can have a large impact on the disease incidence, the ability to harvest crops and the crop quality. The high number of rainfall days and relative humidity in October, November and December means most grain and legume crops would be at a high risk of disease. The high humidity in January and February means careful consideration of harvest, grain quality and post-harvest handling (drying, aeration and cooling) is needed for grain cereal crops.

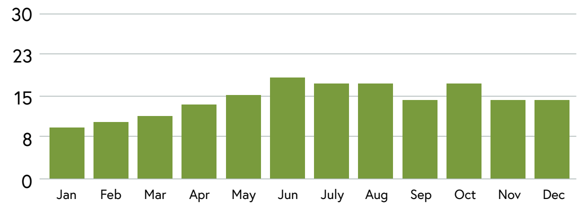
Monthly precipitation (mm)

The mean monthly precipitation over the year, including rain, snow, hail etc.



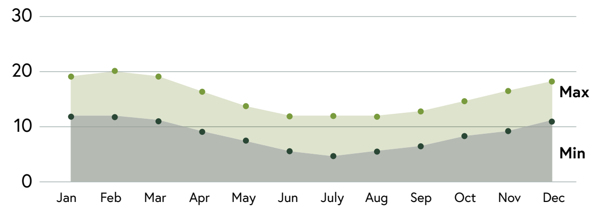
Monthly rainy days

The average number of days each month with rain, snow, hail etc.



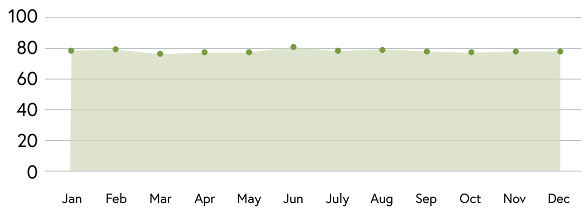
Average day and night temperature (°C)

The mean minimum and maximum temperatures over the year



Average humidity (%)

The mean monthly relative humidity over the year



1 *https://weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine,New-Plymouth,New-Zealand*

2 *GDDs is used to estimate the growth and development of plants during the growing season. The basic concept is that development will only occur if the temperature exceeds some minimum development threshold, or base temperature.*

CLIMATE CHANGE

In selecting crops for the Taranaki region, it is important to consider the potential impacts of climate change which is anticipated to be as follows:

- The temperature is projected to increase, which will increase the growing degree days. It is likely soil temperatures will increase earlier in the spring.
- By 2090, Taranaki is projected to have from 5 to 41 extra days per year where maximum temperatures exceed 25°C, which could put significant stress on many temperate species.
- Frosts are likely to become increasingly rare in Taranaki by 2090, thus enabling more frost sensitive species to be grown.
- Total rainfall is not expected to change markedly with potentially more winter rain, but the intensity of rain events is expected to increase meaning soil erosion risks and flooding may increase.
- The frequency and intensity of droughts may increase.

SOILS

The soils of Taranaki fall into five key groups:

- The volcanic soils of the easy, rolling and hilly country in the western part of the district,
- The steep hilly soils of the eastern part of the district, composed of papa and sandstone,
- The swampy soils in the Rahotu- Ōaonui, Pihama-Kapuni, and Tariki-Inglewood areas,
- The peaty loams at Ngarere, Stratford, and Ratapiko, and
- The recent soils of the river flats.

The volcanic soils are the soils of most interest in cropping as these yellow-brown loams are light in texture, free draining, and easily worked. However, they dry out fairly quickly so are at risk of drought.

Assessing cropping options and systems

In Taranaki there are four potential cropping systems:

- A long-term cropping system (rotation) which also involves animal grazing,
- Using crops in a pasture renewal system (short term crop rotation),
- A permanent perennial food crop, and
- Identifying areas of land that are suited to a different land use as currently they are uneconomic, or an environmental crop use may be desirable.

Growing the same crop or pasture in the same place for many seasons in a row gradually depletes the soil of certain nutrients and selects for a highly competitive pest and weed community. Without balancing nutrient use and diversifying pest and weed communities, the productivity of monocultures is highly dependent on external inputs.

Conversely, a long-term cropping system will use a range of crops with different attributes in a sustainable manner.

The system is designed to maximise land use with a range of summer and winter crops, often with some animal grazing.

These rotations reduce reliance on fertiliser nutrients, reduce pest, disease and weed pressure and the probability of developing agrichemical resistant pests and weeds. They are also critical to maintaining and improving soil structure, and possibly organic matter, through using crops with different rooting structures which reduce erosion and increase farm system resilience.

Using legume plants between crops provides a natural source of nitrogen which is required for plant growth, thus reducing the need for artificial sources of nitrogen. Animal grazing in rotations has the important function of removing weeds, pests and diseases from the system and returning nutrients to the soil. The reduction in agrichemicals from employing these types of farming practices increases the environmental credentials of the final product, which is more attractive to discerning consumers and can command a premium.

A long-term cropping system uses crop rotation, a practice of growing a series of different types of crops in the same area across a sequence of growing seasons. Crops need to be selected in relation to suitability to the climate and soils for a defined and viable market.

The pasture renewal system is a short-term cropping rotation where one or two crops are used as part of the pasture renewal process to utilise excess nutrients, often at depth, in the soil, to reduce weed seed burdens, reduce the survival of older cultivars and to improve the soil structure.

Using a crop on particular land areas because the current land use is uneconomic or to capture nutrients from run-off or leaching may utilise smaller or specific areas of the landscape and may be in permanent or annual crops. The crop may have value through the value of carbon e.g., native plantings or potentially as an energy crop.

In developing a suitable crop rotation, it is important to carefully consider meeting each crop's needs in the cropping sequence. For example, the late autumn harvest of maize grain may mean there is a very limited window to establish a viable crop option prior to the winter and in many areas, land remains ineffectively used over winter and increases the risk of environmental damage through soil or nutrient loss.

Crop selection

A number of broadacre crops have been considered for the Taranaki region. Assessment criteria included market potential, infrastructure, and aspects related to growing the crop and its impact on the environment.

The major determinants of what crops will grow successfully in Taranaki are the climate, the weather, and the soils. The temperate climate means that a wide range of temperate crops could be grown but the weather at particular times of the year may markedly influence planting windows and harvest opportunities, and the overall climate may markedly impact on productivity, weed, pest and disease impacts, and very importantly product, quality.

However, unless the crop has a suitable market, or a market can be developed, and it can be grown in a sustainable manner with the infrastructure to support its production, storage, and transport then it should not be considered as a potential crop in the region.

Based on the above criteria, a large number of broadacre crops were not considered further and this report therefore focuses on a short list of options with potential for the Taranaki region.

Pulse (legume) crops were considered but, apart from faba beans, are not discussed in detail as:

- While the climate suits crop growth, there is a high risk of crops becoming diseased and therefore crop failure e.g., lentils, chickpeas, and peas.
- There were no obvious market opportunities for processed or seed legumes, for example, processors for peas are in Hastings and transport to process would be difficult.
- Peas, although they fix nitrogen, do not have a substantive root system. While they could be valuable in a sustainable crop system, they are not essential.
- Soybeans would grow in the region but would be susceptible to insect damage and there is no processing capability for soybeans to feed in New Zealand. It may be possible to grow food soybeans for a relatively small domestic market.
- Fresh green beans could probably be grown but the distance from a large domestic market or an export hub may limit the potential for this crop.

Photo: Leftfield Innovation

The opportunity for Taranaki

- Capitalising on Taranaki's temperate climate and fertile soils, increasing market demand both domestically and internationally for fresh local produce and plant-based food, investment in grains, legumes and vegetables is an investment opportunity.
- Crops can be integrated into existing farming systems within the region, grown in rotation with paddocks used for grazing or other uses, and also help to restore soil, build resilience, sustainability and add value and diversity to farming incomes.
- Assessment of a long list of options has led to the following short list, having applied crop selection criteria discussed within this blueprint.
- The short-listed options include sorghum, food maize, grain cereals, faba beans, sweetcorn, kūmara, garlic and miscanthus. The food crops are all summer crops thus there is discussion which follows on winter crops to fit with a long-term crop rotation.
- All winter crops involve grazing or forage production, but it may be possible to substitute with some winter vegetable crops. It may be possible to interchange crops in the summer e.g., maize for wheat or sorghum, sweetcorn in place of wheat. Faba beans as a legume grain crop in place of sorghum or kūmara could fit effectively into a sustainable cropping system.
- The summer crops could be used in a pasture renewal system (short rotation) as a crop before establishing new grass. The use of crops that are deep rooting and utilise nutrients from depth (below the pasture rooting zone) may be preferred in a pasture renewal system.

The investment short list

- Sorghum
- Wheat
- Grain maize
- Faba beans
- Kūmara
- Sweet corn
- Garlic
- Miscanthus

Sorghum

Sorghum is a genus of flowering plants in the grass family and is an indigenous crop to Africa. Traditionally sorghum was used in drought prone areas to provide better food security than could beprovided by maize. The common grain sorghum is *Sorghum bicolor* (Lynn.).

This sorghum species is used as a food crop, animal feed, plus for alcoholic beverages and for biofuels. Growing sorghum for grain is possible, especially for early maturity cultivars, although the yields tend to be less than that likely to be achieved with maize grain, and an earlier harvest will enable winter feed crops (oats or annual ryegrass) to be established. Sorghum can also be used in rotation with other summer crops. Ryan (1975) assessed both maize and sorghum grains as being high-energy grain crops and potentially suited as stockfeeds for layer hens and broilers, as well as for pigs and stock. He noted that nutritionally maize and sorghum are similar, and he concluded that these were ideally suited for stockfeed, especially in the warmer parts of the North Island. Taylor et al. (1974) carried out trials with sorghum at three sites in Northland, and they presented results for grain production at two contrasting sites for five cultivars of sorghum with different maturity times. Yields on peaty soil (~7 t/ha exceeded those on sandy soil (~6 t/ha). Late season droughts also reduced the yields of late-season cultivars.

Sorghum has a number of specialised food uses and it also has the advantage of being harvested earlier than maize, allowing a winter crop (e.g. oats) or grass to establish prior to winter.

There is no reported commercial production of grain sorghum in New Zealand

MARKETS

- gluten free
- low GI
- good source of fibre
- animal feed

Sorghum flour is a popular gluten free choice for consumers. Other flours are required to be added, as on its own it tends to be dry and doesn't bind as well. Sorghum is used in a wide range of food products including flour, cakes, crackers, alcoholic beverages, and syrups.

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International

The global sorghum seed market is projected to grow at CAGR of 4.4% from 2020-2025. The largest producer of sorghum is North America (14 million MT), and the largest consumer is the Asia Pacific region. Sorghums main uses are human food, animal feed and biofuels. Australia grows approximately 1.6 million MT of sorghum with 95% of this being for animal feed. Very little is used for human consumption, but consumer trends are changing this, and awareness is increasing towards this being part of a gluten free or lowered gluten diet.

Production	
Growing season	Sow when 10cm soil temperature is over 16°C. Short season hybrids need over 1460 GDDs until end of grain fill which can only be fulfilled in some coastal areas. This may be around 180-200 days from sowing to harvest. Soil temperature is expected to reach 16°C in late October (Chappell 2014) thus harvest would be around mid-April. Further climate modelling may be needed to determine if there are years when there are insufficient GDD's to achieve harvest maturity.
Cultivation	Light. Could potentially direct drill or strip till.
Crop management	Slow to establish so may need some weed control. Low Nitrogen fertiliser requirement. Roots to around 600mm.
Climate tolerance	Drought tolerant once established. Susceptible to frost thus target coastal regions. Is susceptible to sprouting so will need to look for sprout tolerant hybrids if available. In exposed sites lodging may be a problem.
Labour input	Low. Machine planted and harvested.
Infrastructure	Specialist machinery for harvest, possibly drying and storage facilities.
Market	Food grade sorghum is used as a flour replacement for gluten intolerance, in a range of food products and can be used in brewing.
Environmental	Sorghum is a fairly benign crop in the system. Herbicide use is expected, and some insecticides may be required.

New Zealand

All sorghum food products that are listed on websites for sale are imported. Sorghum is imported into New Zealand for use as animal feed. Depending on price, sorghum is used as a substitute for other grains with imports in some years very low while in up years they may be as high as 175,000 tonnes. It is unlikely that sorghum grown for grain for animal feed in New Zealand will be competitive with other grains, but animal feed could provide an outlet for product which doesn't meet human food standards. Sorghum can be grown for forage.

Opportunities

Sorghum is used in a wide range of food products in New Zealand and is a mainstream cereal. In 2014, Weetbix launched its first gluten-free bix, predominantly made from sorghum. At a time when food allergies and intolerances were still a novelty, it seemed like an ambitious project for such a well-loved and known brand to embark on product innovation in this space. However, history shows that the launch would rank as one of the most successful product launches in Sanitarium's history.

There may be potential for the crop residue after a grain harvest to be used in producing bioenergy.

INFRASTRUCTURE

The infrastructure required for different end uses (flour, bran) changes only slightly. Field and harvest equipment are similar to maize; thus the key equipment may exist in the area. This includes cultivation, spraying and fertiliser application equipment. Sorghum seed is generally precision planted with a maize planter.

Harvest is readily carried out with a combine harvester with a suitable front and jockey bin, which may be best contracted as the time of harvest will not coincide with maize grain harvest so machinery should be readily available. Other equipment to handle, dry and store sorghum can be the same as for maize grain.

Sorghum processing to flour will need to be undertaken in a mill which does not handle wheat to ensure no gluten can contaminate the flour. A mill suitable for milling sorghum will vary markedly depending on the size and the mill will need to be in a food grade certified building with suitable packing and storing capability. Due to the large amount of tannins in the seed coat sorghum requires elaborate processing and thermal treatment before consumption. Additionally, the high fat content reduces the shelf life of sorghum flour significantly and impedes the milling process.

SUSTAINABILITY

Sorghum should fit in a sustainable farm system. Generally, the soil would be cultivated to a relatively fine seed bed which is at risk from erosion particularly on undulating land. The crop is slow to create ground cover and as such weeds are a potential problem and post emergence herbicides may be required. Harvest in early April means there is good opportunity to establish a winter crop or re-establish pasture which may be possible with minimal tillage or direct drill. The crop has a lower nitrogen demand so the risk of losses to leaching is reduced. Sorghum has a fibrous root system with approximately 90% of the roots in the top 50cm. When the crop is grown for bioenergy significant amounts to 3.1t dry matter/hectare of root biomass are produced. The crop may fit into a farm system for pasture renewal or into a crop system.

There is no information on costs of production for sorghum in New Zealand so returns per hectare are difficult to predict.

Wheat

Wheat is grown in a wide range of climates, soil types and for a wide range of end uses which may require specific management practices. Generally, the soil types in Taranaki will be suited to growing wheat as they are predominately free draining volcanic soils, however although wheat is fairly tolerant of dry conditions, in some years drought may limit yield. The climate may favour the development of a range of diseases and, even though the use of spring sown wheat will reduce disease exposure as compared to autumn sown crops, it is expected fungicides would need to be used to manage disease. Even with fungicide use there are risks of diseases, such as Fusarium, significantly reducing both grain yield and quality.

MARKETS

The market for wheat is expected to be a domestic market with two potential markets - milling or feed. Taranaki has very limited advantages over other wheat growing regions in relation to the market and there are a number of constraints currently in relation to the market, as discussed below.

Milling

While there are a number of bakers in the region there is no scale flour milling capability hence if a baker wished to capture the provenance of locally grown wheat the wheat would need to be shipped to a North Island flour mill for milling and the flour shipped back. Currently Yarrows mill their flour in Tirau.

In Taranaki there may be an opportunity for a small-scale flour mill (stone mill) to supply to boutique bakeries. There are a range of small-scale flour mills available from international manufacturers that could be purchased and used in a boutique growing, milling and baking context or slightly larger flour mills that could supply a few boutique bakers. An example of a small-scale flour milling enterprise is Minchins Milling in central Canterbury[3], who operate a seed to stone business growing grain to milling flour.

Wheat for milling needs to have a number of quality parameters some of which can be influenced by management, but some are largely determined by weather. Three key quality parameters which will influence milling, or the flour quality are: - the falling number, the black point score which are related to damp or high humidity weather, and grain size which can be markedly reduced by drought, disease or poor management.

3 https://minchinsmilling.co.nz/

Production	
Growing season	Wheat can be autumn or spring sown depending on cultivar but it is expected spring sowing would be better suited to Taranaki. Harvest would be in February/March.
Cultivation	Wheat can be established following a single cultivation pass or direct drilled depending on soil types and previous land use.
Crop management	Usually grown with an agrichemical programme for weed, pest and disease control. Synthetic nitrogen is usually required. Would need to source cultivars suited to the region. Roots to over 1m so is reasonably drought tolerant and can extract some nutrients from depth.
Climate tolerance	Wet weather favours a number of diseases and also can impact markedly on grain dry down and harvest. Grain quality close to harvest can be reduced with wet or humid conditions.
Labour input	Low. Machine planted and harvested.
Infrastructure	Specialist machinery is needed for harvest, drying, and storing of grain.
Market	Domestic, possibly through increasing demand for local grains for food uses and feed grains to the dairy industry.
Environmental	In most parts of the country has a moderate agrichemical use. Nitrogen use can be effectively managed to utilise soil reserves and apply in relation to plant needs. Wheat is a deep rooting crop which can utilise nitrogen reserves from the previous crop or pasture.

Feed

Wheat is used as a feed grain for many feed mixes. If a flour milling business of any scale is developed in Taranaki it will be essential to have a feed outlet for the wheat which is not milling grade. However, the feed outlet need not be within the region as feed grain is a commodity product and is unlikely to secure any extra value for provenance. The options for feed wheat are direct supply to a local animal production unit which has the ability to mill grain to feed to their animals or to supply to feed companies within Taranaki, Whanganui or further afield. Local supply to other farmers will require the development of storage and handling facilities. Examples of larger feed companies that utilise wheat are: - GrainCorp who have a site within Taranaki, and Seales Winslow who are based in Whanganui.

INFRASTRUCTURE

Cereal production will require some on-farm or contractor capability to drill, spray and harvest. It is expected that this equipment will exist in the region, although harvesting equipment may be limited, as harvest occurs outside of when combines will be used for maize grain harvest some availability may exist. Grain handling, storage and drying facilities will be required to ensure grain can be in a fit condition for long term storage as the average relative humidity is around 80% and there are around 10 rain days per month in the harvest period and grain is unlikely to be harvested in a condition fit for long term storage. Some grain handling facilities do exist within Taranaki and a number of companies undertake some feed formulation for the dairy industry but not necessarily using grain.

SUSTAINABILITY

To achieve both good yields and good quality wheat nitrogen is usually applied. The nitrogen requirements of wheat, both timing and quantity, are very well understood such that by understanding the nitrogen availability from the soil the quantity applied can be adjusted to minimise any risk of leaching loss. In fact, one of the strengths of understanding the nitrogen requirements is that wheat can be used to utilise excess nitrogen at depth in the soil after pasture and reduce the risk of leaching losses.

Wheat pricing and growing costs have changed markedly in the last six months such that a gross margin of around $2,000/ha may be expected.

Grain maize

Maize is one of the four plant species (maize, rice, wheat, potato) that provide 60% of the world's dietary energy intake. In New Zealand maize is grown for grain (190,000 tonnes) and silage with most of the grain production going to animal feed. Some maize grain is used in a range of human food uses.

Maize is widely grown in Taranaki (around 3500ha/year) but almost exclusively for silage. There has been a small area grown for grain producing around 700 tonnes. The climate is suitable for growing maize for silage, and it is harvested prior to the crop drying down - mostly in March and early April. Grain maize may be challenging to harvest with increased number of rain days and rainfall at harvest (May) and it may be difficult to establish another crop or pasture after maize prior to the onset of winter, thus soils may be exposed and at risk of erosion or nutrient leaching.

MARKETS

Dry milled

- Gluten free.
- Low GI.
- Good source of fibre.

Maize grain can be used in wide range of products. Grits are used in the manufacture of corn flakes and breakfast cereals and kibbled grits are also used in baking. Polenta is used in a range of snack foods, cereals, bread, and brewing grits. Semolina is used in the manufacture of extruded snack foods, breakfast cereals, bread, and brewing grits. Hominy is a high energy meal valued as an ingredient by manufacturers of pet foods and stock feeds. Popcorn is a further use of specialty hybrids. Maize Flour is used in pre-mix bakery products, batters and sauces, while whole grain flour is used for health focused products. Whole Maize is used in corn chips and tortillas. Corsons in Gisborne used approximately 20,000 tonnes of maize grain sourced from the Gisborne area to produce dry milled maize for food[4].

Wet milled

NZ Starch (South Auckland) produce a wide range of starch-based products which are used in everything from bioplastics to glues with by-products for animal feeds. NZ Starch source wet maize directly from harvest early in the season and dry maize grain as the season progresses. NZ Starch source maize predominantly from Northland, Waikato and the Bay of Plenty and use around 50,000 tonnes of maize grain[4].

Pioneer and Corson have a number of maize grain cultivars suitable for specific food uses.

Animal feed

Maize grain is widely used in animal feeds. While there is potential to supply the animal feed industry, and this could be an outlet for food grade maize that is outside of specification, Taranaki doesn't have advantages over other growing regions.

Approximately 150,000 tonnes of maize grain are imported to New Zealand each year.

4 *Booker 2009.*

Production	
Growing season	Sow when 10cm soil temperature is over 10°C around early to mid-September in Taranaki. Maize is very sensitive to frosts and as a result is planted in the spring when the risk of frosts has subsided. Maize requires 120-180 frost free days. Harvest maturity for grain would be expected from early May.
Cultivation	Light. Could potentially direct drill or strip till.
Crop management	Slow to get canopy closure so may need some post planting weed control. High Nitrogen fertiliser requirement. Roots to around 1,500mm.
Climate tolerance	Susceptible to drought. Susceptible to frost. In exposed sites lodging may be a problem. Grain harvest in May may be affected by wet weather.
Labour input	Low. Machine planted and harvested.
Infrastructure	Specialist machinery for harvest, grain drying and storage facilities.
Market	Food grade maize is used in a range of breakfast and other products.
Environmental	Can have a number of environmental impacts. High nitrogen requirements mean there is a risk of nitrogen leaching. Late autumn /early winter harvest means potential for soil damage at harvest or soil erosion losses through winter as the next crop will not be well established. Herbicide use is expected, and some insecticides may be required.
Yields	Grain yields from New Zealand grown maize crops typically average 11.5 tonnes/ha with around 17,500ha grown for grain.

INFRASTRUCTURE

The infrastructure required for different end uses (dry or wet milled) are very different[5].

Crop production requires cultivation, spraying and fertiliser application equipment. Maize seed is generally precision planted with a maize planter. Harvest is readily carried out with a combine harvester with a suitable front and jockey bin. This may be best contracted as the time of harvest will not coincide with other grain harvests so machinery should be readily available. Maize grain needs to be dried after harvest and then is generally stored in silos until use. Systems for harvesting and handling maize grain for food need to ensure separation from wheat to avoid any risk of gluten contamination.

SUSTAINABILITY

Maize grain is a difficult crop to fit in a sustainable farm system. Generally, the soil would be cultivated to a relatively fine seed bed which is at risk from erosion particularly on undulating land. The crop is slow to create ground cover and as such weeds are a potential problem and post emergence herbicides may be required. The crop has a high nitrogen demand so there are risks of losses to leaching. Harvest in May, and a large amount of crop residue and plant crown means cultivation is usually needed and there is little opportunity to establish a winter crop or re-establish pasture increasing the risk of soil erosion or nitrogen leaching through winter. Maize has a deeper rooting system so maybe useful to recover nutrients from depth.

Maize grain production costs have changed markedly over the last year. Using the Pioneer maize grain economic calculator https://www.pioneer.co.nz/maize-grain/tools/maize-grain-economics/ a gross margin per hectare of $4,000 - $5,000/ha could be readily achievable.

5 *Booker 2009.*

Faba beans

Faba beans are widely used for animal protein but also as a protein food source for humans. In New Zealand there have been numerous trials conducted looking at growing Faba beans for animal protein but, although New Zealand has produced very good yields and grain protein levels of around 28%, feed manufacturers have generally used imported soy as it is readily available and is usually a cost-effective source of protein. With increased concerns about biosecurity, costs of testing to ensure GE free and the opportunity for a local consistent supply of protein there may be value in revisiting Faba as an animal protein source, particularly for Taranaki where animal protein is often imported and trucked from Tauranga.

Faba beans have been used as a protein source at 20-25% in broiler hens and, for processed beans, up to 35% in ruminants[6].

Faba beans are widely used in human foods in North Africa, the Middle East and China as they are:

- A rich protein source – 27 -32%.
- A good source of fibre.
- Other non-nutrient compounds important for human health.

However, they do contain a number of antinutritional compounds such as tannins and saponins. These can be reduced by selecting low tannin varieties, dehulling to remove areas with high levels of these compounds, heating or soaking beans prior to consumption[7].

MARKETS

International

Australia is the largest exporter of Faba beans (more than 40% of world exports) and exports around 300,000 tonnes with most of this (90%) going to Egypt or the Middle East with a total value of $200mAU. UK and France are other major exporters, although China is the largest producing country.

Domestic market

The domestic market for Faba beans would primarily be as a protein feed for animals. Currently small quantities are used in feed mixes for cattle. Faba bean protein could be used in petfood products. In 2019 New Zealand imported $174 million of processed soybeans and $322 million of other protein oil cakes much of which is used for animal feeds. New Zealand also imported 1.9 million tonnes of palm kernel as a high protein animal feed. BHL Feeds (New Plymouth) truck over 5,000 tonnes of protein feeds into the Taranaki region each year and expressed some interest in Faba beans as a locally produced feed protein source.

Hamish Dunlop (NZ Quinoa Co.) has a food market demand for limited volumes of dried broad beans which is currently supplied from outside the region.

Faba beans can be cut while green during grain fill for silage with yields of over 15 tonnes/ha dry matter.

6 https://www.allaboutfeed.net/animal-feed/feed-additives/faba-beans-an-alternative-protein-source-for-animals/
7 (Multari et al. 2015)

Production	
FAR compiled a report on faba beans in New Zealand (FAR 2012) which provides comprehensive information on the results from a wide range of field trials.	
Growing season	Faba beans can be sown from autumn until spring. Yields have generally declined with later sowing dates. Both winter and spring faba bean cultivars are available but in New Zealand conditions spring cultivars can be sown throughout the whole planting season. Ben is the major cultivar grown in New Zealand, but newer cultivars are now available which may be more disease resistant and higher yielding. Harvest maturity for grain would be expected in February/March depending on sowing date.
Cultivation	Light. Can be direct drilled.
Crop management	Herbicides may be used both pre and post emergence. Some base fertiliser may be required but the beans fix nitrogen. Beans are susceptible to arrange of diseases and well-timed fungicide applications are generally required. The plant tap root can be down to 1m and the root system can improve soil structure.
Climate tolerance	Susceptible to drought. In exposed sites lodging may be a problem. Grain harvest may be delayed by wet weather and the pods may split and shed beans.
Labour input	Low. Machine planted and harvested.
Infrastructure	Specialist machinery for harvest, grain drying and storage facilities.
Market	Internationally used for human food either processed or whole. In New Zealand animal feed or pet food are the most likely markets.
Environmental	Can have a number of environmental benefits. The crop fixes nitrogen can improve soil quality and there is limited risk of soil erosion. Herbicide and fungicide use is expected.
Yields	Grain yields from New Zealand grown crops typically average 5.6 tonnes/ha but yields of over 9 tonnes/ha have been produced.

INFRASTRUCTURE

Crop production requires cultivation, spraying and fertiliser application equipment. Faba bean seed is a large seed and requires a good quality seed drill to minimise seed damage at planting. Harvest is readily carried out with a combine harvester with a suitable front and jockey bin. This may be best contracted as the time of harvest will not coincide with other grain harvests so machinery should be readily available. Faba bean harvest occurs in February/ March and grain generally doesn't need to be dried after harvest and is stored in silos at a safe moisture content and temperature until use.

Processing for feed use will generally require either dehulling or heating (extrusion or steaming) to reduce the anti-nutritional impacts although there are reports of unprocessed beans being fed to livestock. Faba bean dehullers are readily available and start in price around $8,000. Many of these dehullers can process a range of legume grains.

As an example of future uses for faba beans Beneo (Germany) has recently invested NZD$80 million in a plant to process faba bean to protein rich ingredients for human, animal and pet food uses[8].

SUSTAINABILITY

Faba beans are a good crop to fit in a sustainable farm system as they are sown in autumn or spring after either a summer or winter grazing crop. Generally, the soil requires limited cultivation or can be direct drilled minimising erosion risk. The crop has a low nutrient demand and fixes nitrogen. Harvest in mid to late summer means that other crops or pasture can be readily established (potentially direct drilled) post faba beans as there is limited crop residue. Faba beans have a tap root which is deeper rooting and may improve soil quality.

Grain production costs have changed markedly over the last year with significant increases to input costs and grain prices. A benefit of growing faba beans is they have a low fertiliser demand. The gross margin per hectare could be between $4,000 - $5,000/ha.

8 https://www.beneo.com/

Kūmara (sweet potato)

The benefits of eating Kūmara

- A great source of dietary fibre.
- One of the highest potassium-containing vegetables.
- One of the highest carbohydrates containing vegetables – so an excellent source of energy.
- Has a lower glycemic index (GI) compared with the standard potato.
- Colour of the skin and fruit provides a range of phytonutrients.
- Contains high levels of vitamins A and C.

MARKETS

International

The global sweet potato market is predicted to grow at 2.3% CAGR by 2025. This growth is largely driven by diet and nutritional preferences with consumers replacing foods like white potatoes with healthier alternatives.

Australia

The majority of the Australian sweet potato crop is consumed nationally with only a small volume being exported. However, these volumes are increasing. Key international markets are UAE (36%), Netherlands (24%) and Singapore (8%) with exports valued at AUD$3.7 million. Queensland accounts for 88% of all production and has an all year growing season.

New Zealand

The majority of kūmara is grown in Northland. Our research has led us to believe that New Zealand imports a considerable quantity of kūmara to meet domestic demand. Further research should be undertaken if kūmara be deemed to be a suitable crop for this region to quantify the demand. Seasonal climate impacts on imports, for example in 2017 weather conditions reduced the supply and opened up New Zealand to imported product while 2020 season was a good production year.

It would appear that China is New Zealand's main source of imported kūmara, accounting for 84% of all imported product, followed by the USA (11%) over the 2014-18 period. New Zealand exports primarily to Hong Kong (95%) and a number of our neighbouring Pacific Island Nations.

Opportunities

One of the food categories that has shown the greatest growth for sweet potato is the baby meals category. In 2019, baby food accounted for 14% of product launches worldwide and sweet potato also grew in other categories such as cake, pastries, vegetables, ready meals and confectionary alternatives.

Food and beverage formulators are using sweet potatoes lovely reddish colour as a natural food coloring. Traditionally food manufacturers use carmine as red colouring, however this is made from insects so can't be consumed by vegans, hence sweet potato is an attractive alternative over any synthetic colours.

Kūmara also offers opportunity for the food service industry, as it can be offered to customers at a higher price point. McCain's Sweet Potato Wedges food service brochure includes many examples of how kūmara can be marketed to clients.

Key selling points included:

- Consumers view sweet potato as 'different' and they're willing to pay premium for them, as it increases meal value which translates to average spend and client satisfaction.
- Allows the food service provider to charge a price premium per serve of fries (McCain Food Service Solutions 2019).
- Sweet potato wedges offer an appealing alternative to people who love the traditional wedge but are looking for something else.
- Provides a real point of difference either a permanent menu change or limited offer to drive additional sales.
- Consumers love the sweet potato alternative, in the last few years sales have doubled.
- 1 in 2 consumers would purchase sweet potato if available on the menu, with the key reasons being taste and a healthier alternative to traditional fries (McCain Food Service Solutions 2019).

INFRASTRUCTURE

Kūmara will require a significant amount of infrastructure both within the area and outside the area.

For kūmara there will be a need for cultivation, planting,

Production	
Growing season	Plant November when soil temperatures reach 15°C. Harvest March to April. 140-170 days depending on planting date. Around 1,100 growing degree days (GDDs).
Cultivation	Intensive. Cultivate, mound, hand plant in mounds and lift. There is potential damage to soil structure and risks of soil erosion due to heavy rains in spring and autumn.
Crop management	Crop rotation of 3 – 4 years to reduce disease risk. May need insecticides for black field cricket, greasy cutworm and black beetle control. Fertiliser (N) is usually applied. Herbicides are often used both pre and post planting. Rooting depth around 25cm. Irrigation may be required in some years.
Climate tolerance	Frost susceptible (frosts are unlikely after late September in coastal Taranaki), soil temperature needs to be over 15°C, ideal growing temperatures 20 - 25°C. Wet soils during tuber initiation can reduce yields. Not tolerant to drought thus irrigation may be needed in some years to secure reasonable yields.
Labour intensive	Producing cuttings for machine assisted hand planting and hand sorting at harvest.
Infrastructure	Specialist machinery for planting and harvest, storage facilities for curing and storing, specialist packing facilities. Need to cure and store in temperature and humidity-controlled stores – could use kiwifruit coolstores in nearby areas for three months until kiwifruit harvest starts.
Market	Domestic (fresh and processed), possibly export. Global demand for imports is increasing in Europe. Kūmara growers should consider targeting developed Asian markets with high population densities such as Singapore, Hong Kong, and urban areas in Malaysia, the Philippines, and Indonesia.
Environmental	Significant risk of soil erosion and damage to soil structure. Potential for nitrogen to be leached below the root zone. Some agrichemical use potentially with residual herbicides.

spraying, harvesting and packing equipment, transport systems to stores for both short-term curing and longer-term storage and then transport to either domestic or export market.

Firstly, production of tipu (kūmara plants) will require a specialist nursery area as it is critical tipu are produced within the region starting with high health material to minimise the risk of diseases and pests being introduced from other regions. The nursery will require beds and cloches, a good workspace for preparing and packing tipu for planting and ideally coolstore facilities to keep the tipu cool until machine assisted hand planting.

Field preparation generally requires significant cultivation to create a fine tilth to hand plant into and to create mounds in which to plant. Cultivation generally requires a rotary hoe or similar and a machine to create mounds/rows 75cm apart. This requires a tractor with reasonable horsepower. Planting is generally done using a machine which marks the position for each plant in the top of the mound and then the tipu are placed into the ground by hand often with planters seated on a trailed planter up to eight or ten rows at a time.

Equipment is also needed to spray and apply fertiliser during crop growth. At harvest the tops are usually rotary slashed with a mulching mower and then tubers are lifted with a potato lifter into bins suitable for kūmara.

Research on kūmara in East Cape has shown yields can be significantly increased (doubled) by planting into plastic mulches to increase soil temperature and reduce weed competition. Thus, investment in machinery to lay a biodegradable plastic mulch may be justified.

Shortly after harvest, kūmara need to be cured in a coolstore at 12-14˚C with high relative humidity (RH). This could be in a coolstore used for other purposes as kūmara are harvested prior to kiwifruit harvest commencing but ideally needs to be close to where the crop is harvested.

Packing facilities will require a water wash, sizing machine and hand sorting. From a product quality perspective, the less distance the product travels prior to packing the less damage will be done. Depending on the market, the packhouse may need to pack into a range of pack types and sizes. New technologies in how packaging increases product life should be considered if packing for export or long-term domestic markets. Kūmara can be stored in a coolstore after curing for a number of months prior to packing so a packhouse could employ labour for a number of months each year.

At some point in the value chain kūmara will need to be transported. Packing in Taranaki will reduce the freight as soil and reject kūmara will not be shipped. However, the product is bulky and heavy so transport will be a significant cost.

Further processing of poor quality or medium quality tubers may require collaborating or partnering with an existing processor (toll process) as opposed to a significant investment in processing capability. Processing and packing are probably best undertaken at a major hub to capitalise on the potential for processing other products in the same factory.

SUSTAINABILITY

There is significant cultivation and soil damage at planting and harvest when growing kūmara so it will be important to use other crops in rotation that improve soil structure. There is risk of soil erosion. Kūmara need to be fitted into a crop rotation to improve the sustainability.

Information on the economics of kūmara growing are not readily available.

Sweet corn

Sweetcorn is grown throughout New Zealand as a commercial crop or in home gardens. There are numerous references to sweetcorn in New Zealand but a useful resource in relation to growing the crop is the sweetcorn toolkit[9].

Sweetcorn is a good source of:

- carbohydrate and B group vitamins, fibre, folate and niacin, vitamins B6 and C, magnesium, phosphorous and zinc, and
- phytonutrients including carotenoids and zeaxanthin which is of value for eye health.

MARKETS

Internationally

The global market can be broken down into frozen, prepared or preserved. The global sweetcorn market is expected to grow at a CAGR of 5.3% from 2021-2026.

New Zealand

Sweetcorn supplies a domestic and export market with a fresh and processed product. Of the 110,000 tonnes produced, 41,400 tonnes of that is exported as processed corn. The majority of the processing is freezing, both for cobs and kernels, followed by canned whole kernel and creamed style corn, corn powder and cobs packed in pouches. The main export markets for frozen sweetcorn are, Australia $7.3m, Japan $6.2m and Kuwait $2.9m; dried sweet corn, Japan $7.7m and canned sweetcorn, Australia $4.4m.

Opportunities

There may be opportunities to supply to the New Zealand fresh market, particularly locally or outside of the main supply season.

In 2020 Australia ran out of locally grown sweet corn due to both historical drought and the pandemic panic buying, so processors were forced to import corn from Thailand. Opportunities may lie in backfilling the Australian corn supply during times of uncertainty. This would increase processing exports in New Zealand, where significant, but aged, investments in such processing facilities already exist.

It is possible crop residue could be used in bioenergy production.

9 https://www.vri.org.nz/research/new-research-document-page-30/

Production	
Growing season	Sow when soil temperature is over 16°C (November). Harvest 1,200-1,450 GDD above 5°C which is in the order of 130-145 days from sowing depending on variety. Use of biodegradable plastic mulches to increase the soil temperature may enable earlier sowing to target earlier harvests. In Taranaki it may be advantageous to utilise the long frost-free periods and target late season domestic markets as other parts of the North Island will have higher soil temperatures in spring.
Cultivation	Light. Could potentially strip till drill.
Crop management	Slow to get ground cover so may need some weed control. Has a significant demand for nitrogen, phosphate and potassium.
Climate tolerance	Susceptible to frost and drought.
Labour input	Machine planted, significant labour input to hand harvest but could be machine assisted or machine harvested if grown on scale.
Infrastructure	Specialist machinery used for planting, harvest and storage facilities.
Market	Fresh domestic and possibly export.
Environmental	Herbicide use is expected, and some insecticides may be required. A crop requires in the order of 300kg/ha of nitrogen (soil and applied) thus, unless managed effectively there is risk of nitrogen loss through leaching. Cultivation at crop establishment damages soil structure and may create a seed bed that is at risk of erosion.

INFRASTRUCTURE

Infrastructure required for growing of sweetcorn is similar to some other crops such as sorghum. However, to maintain quality through harvest, storage and transport requires some specialist equipment. Harvest could be done by hand or hand assisted with a moving gantry for high quality or smaller volumes otherwise a specialist harvester would be required. Sweet corn harvesters range from single row trailed machines (from around $70,000) to multi row self-propelled machines.

To target the early market, it may be justified to look at planting using biodegradable plastic mulches to raise the soil temperature. Mulches have significantly increased yields of sweetcorn and significantly advanced the harvest date and the quantity harvested in the early harvests. This may also reduce the need for weed control. However, specialist machinery will be required to lay the mulch.

Sweetcorn is highly perishable as it has a high rate of respiration, which can lead to the conversion of sugar into starch, thus reducing quality. Cob sweetness and tenderness can be lost very quickly. The respiration rate of sweetcorn is about eight times faster at field temperatures than at 0°C. Loss of sugar is about four times as rapid at 10°C as at 0°C.

To prevent loss of sweetness, it is important to cool sweetcorn quickly after harvest. If the corn is to be in bulk trucks or trailers for more than an hour, it should be kept from direct sunlight and cooled with water to remove the field heat. In warm weather, bulk lots of uncooled sweetcorn will rapidly overheat because of residual field heat and additional heat produced by respiration. There are several cooling methods available depending on operation size and transport time including: hydrocooling, package icing, vacuum cooling, and forced air cooling. Hydrocooling is the most common. Cooling using forced air and cool storage may be possible in some cool stores.

To maintain quality, sweetcorn should be cool stored immediately after postharvest cooling and for the shortest time possible, with a maximum of 2 weeks including transit time. Sweetcorn is not sensitive to chilling, and it should be stored as cool as possible (0 to 2°C) without freezing at a high relative humidity (95% to 98%) to reduce moisture loss and kernel denting. A cool chain should be used for transport from cool store to the customer.

SUSTAINABILITY

Sweetcorn can be a difficult crop to fit in a sustainable farm system. Generally, the soil would be cultivated to a relatively fine seed bed which is at risk from erosion particularly on undulating land. The crop is slow to create ground cover and as such weeds are a potential problem and post emergence herbicides may be required. Sweetcorn has a fairly high nitrogen demand and, although the nitrogen can be applied in response to plant demand, there is a risk of leaching particularly on light soils with heavy rainfall events. Post-harvest cultivation is usually used prior to the next crop or going back to pasture, but it may be possible to undersow sweetcorn with pasture or the next crop meaning there is no need for cultivation. The sweetcorn root system is not restorative in function thus overall, the crop would be likely to reduce soil quality. However, the crop may fit into a farm system for pasture renewal or into a crop system.

The gross margin for growing sweetcorn in Taranaki will depend on the potential market. Gross margins of between $2,000 and $6,000/ha could be achievable.

Garlic

New Zealand garlic has always been well received by chefs and home cooks but faced a new challenge with massive international production ramping up in the '90s. Exports from China to the world began on a massive scale, with more than five million individual garlic growers entering the global garlic market. This changed the face of the market completely. At the same time in Marlborough, New Zealand, farmers began focusing on the bourgeoning opportunities in the Marlborough wine industry, with many moving away from garlic and other crops. The availability of cheaper imported garlic around the world led to a massive drop in prices as garlic went from being considered a gourmet product to a commodity. New Zealand exports to Fiji were discontinued. Australia, which had previously been the biggest market for New Zealand garlic growers, also made a switch to cheaper options.

Benefits of eating garlic

Although garlic is readily associated with reducing colds etc there is no evidence to this effect. It does have some properties that destroy bacteria and causes minor reduction in blood pressure so may protect against heart disease. There is no evidence it has any effect to reduce cancer. A typical serving of garlic does not have any significant nutritional value.

MARKET OPPORTUNITIES

Internationally

A number of Pacific Region countries are large importers of garlic. For example, in 2020 the USA and Canada imported $450m, Malaysia $184m, Japan $76m of garlic probably mostly from China. In 2018 trade with the US from China in garlic dropped by nearly half and other countries have started to fill that gap. The USA increased imports of garlic from 88,000 tonnes in 2018 to 108,000 in 2021. The CAGR for garlic in the US is 1.6%. There may be international opportunities for black garlic.

Production	
Growing season	Garlic is winter planted from cloves and is harvested through mid-summer. The mid-summer harvest may create problems in establishing the next crop, particularly in dry summers.
Cultivation	Garlic prefers sandy loam soils that are free draining but have reasonable levels of organic matter. Significant cultivation and often the creation of beds is required to plant garlic and soil disturbance occurs at harvest.
Crop management	Usually grown with an agrichemical programme for weed, pest and disease control. Around 120kg nitrogen/ha applied regularly through the growing season is usually required. It is shallow rooting so is susceptible to drought.
Climate tolerance	Wet weather favours a number of diseases. As garlic is shallow rooting it may be susceptible to an early drought as the cloves fill late in the year.
Labour input	Hand or machine planted and machine harvested.
Infrastructure	Specialist machinery is needed for planting, harvest, drying and storing. Further processing to individual cloves would require further investment in breaking, peeling, cleaning, sorting and packing machinery[10].
Market	Domestic may provide limited opportunities, possibly through increasing demand for New Zealand product and displacing imported garlic. Export potential may exist to USA or Canada, but considerable market insight work will be needed.
Environmental	Garlic has a moderate agrichemical use for weed control as there is little plant competition from the crop through the crop cycle. Nitrogen use can be effectively managed to apply in relation to plant needs. As planting occurs into well cultivated soils which then have little plant organic matter there is risk of soil erosion through winter. The use of strip tillage could be explored to reduce the risk and also to reduce weed pressure through winter.
Yields	Yields vary markedly but a yield of 16-20t/ha should be achievable in Taranaki.

New Zealand

Domestic production of garlic is around 1,200 tonnes produced by approximately four-six growers on about 200ha. About 90% of the production is consumed in New Zealand with some exports of garlic and black garlic. China is the largest producer of garlic producing approximately 75% of the world supply at around 23 million tonnes. New Zealand imported approximately $10.3m of garlic in 2020 and exported approximately $640,000.

Longridge Garlic are based in Taranaki and currently source imported garlic which is peeled, washed and bagged and sold to the food service industry. Customers do ask for New Zealand produce and there is interest in sourcing local product. Longridge are aiming to grow their market share in New Zealand.

Opportunities

There is some potential for the local market through Longridge Garlic which would require small volumes of garlic. These small areas could be used as proof of concept from a production perspective to increase confidence to expand into export.

The opportunities to export garlic needs further research. Information is needed on the quality requirements, price, shipping and logistics and, as there is significant potential for insects to be present on garlic, the biosecurity requirements for each country. Some countries also specify no contaminant soil on garlic. Biosecurity risks could be reduced, and the value of the product increased by further processing garlic into peeled cloves prior to export

SUSTAINABILITY

Garlic is a difficult crop to grow sustainably thus needs to fit in a sustainable crop cycle. Soil cultivation can cause damage to soil structure and there are risks of soil erosion through the crop cycle as it is winter planted and there are significant areas of bare soil throughout the crop cycle. There is also use of herbicides to manage weeds. Research into strip tillage may be warranted as it could reduce damage to soil structure, erosion risk and the need for herbicides.

Garlic is currently retailing in New Zealand supermarkets for $38/kg.

Adapting a garlic growing budget based from the US with NZ costs, the US price per tonne from 2021 (USD$2,400/tonne), the gross margins in New Zealand for a yield of 14 t/ha could exceed $20,000/ha.

10 https://www.garlicprocess.com/

Miscanthus

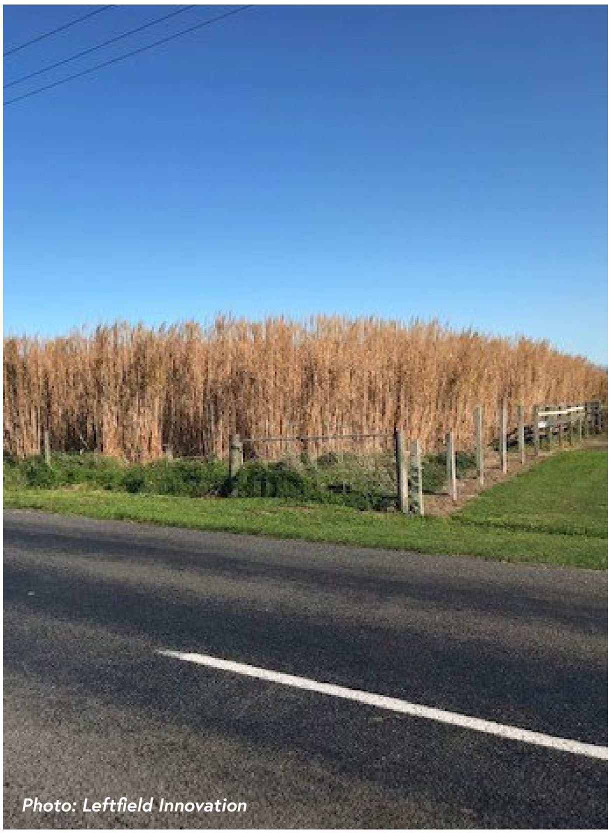
Photo: Leftfield Innovation

Miscanthus x giganteus is grown for biomass production and bedding uses. It is a perennial rhizomatous, sterile C4 grass that has the ability to grow to over two meters tall each year. It produces shoots in the spring which grow rapidly, and they dry down in late autumn winter allowing the biomass to be harvested in a dry form, without any leaves, and for the dry biomass to be baled or stored in bunkers until it is used for bedding or for bioenergy to generate electricity or to run boilers generating heat. The plant will regrow from the underground rhizomes each spring. Miscanthus and other bioenergy crops, such as Pennisetum or woody crops e.g. poplar are not developed on any scale in New Zealand.

There are very low GHG emissions from establishment, growing and harvesting of Miscanthus, it has been recognised internationally that Miscanthus stands increase the amount of sequestered soil carbon. As long as the crop continues to be grown and harvested, the amount of carbon stored in the underground rhizome system together with the amount of carbon stored in the continually increasing soil organic matter is quite significant – perhaps in the order of 2 tonnes of carbon per hectare per year in some soils.

There is a well established miscanthus planting at Normanby which is currently harvested for bedding uses and the grower is interested in expanding production.

MARKETS

Miscanthus is grown for bioenergy particularly in Europe where there are defined markets to electricity generating plants or to run boilers to create heat for manufacturing, greenhouses or even at a farm scale. There is potential for miscanthus to replace coal in coal fired boilers in New Zealand and Fonterra have had a trial at their Darfield site. Due to the bulk of the crop, the best use of it for bioenergy is to a local site and probably to sites in Taranaki that have significant use of heat, thus minimising transport costs. Overseas, significant work has been done looking at using miscanthus in the production of biofuels.

Miscanthus is widely used for animal bedding and the potential market for this is likely to increase in Taranaki due to an increase in the number of herds that are housed for part of the year. Further demand for bedding is also likely for calf rearing with increased demand for zero bobby calves in the future. Miscanthus has been used in the equine industry as a very effective bedding. The miscanthus grown in Taranaki is currently used for animal bedding.

Significant work will need to be done to develop markets for the crop and also to undertake financial analysis to ascertain the viability of the crop. At this stage, although it is a perennial crop, it is not eligible for carbon credits as the crop does not grow to 5m high.

Miscanthus can be grown on areas of marginal land due to soil type, size, shape, or slope that are high risk from and environmental perspective or are not economically viable to farm and as a riparian strip alongside waterways. As a harvested riparian planting Miscanthus has significant merit as each year nutrients are harvested and removed from the riparian zone, thus overcoming the risk with permanent riparian plantings which are only effective at reducing nutrient loss to waterways until they are saturated with nutrients. Miscanthus also has the benefit that the rhizomes hold the soil together reducing the risk of erosion and are harvested before the higher risk times of flooding in winter and spring allowing water to flow readily through a catchment. The summer growth means the plant can provide shelter and shade for animals at critical times of the year.

The chopped miscanthus has been shown to be a very effective mulch with a good ability to retain soil moisture.

The metabolisable energy and palatability of this plant mean it has very limited forage value.

PRODUCTION

Currently miscanthus is propagated from rhizomes and fully mechanised planting is generally not used. Paeroa Contracting in Taranaki have developed a mechanised system for lifting rhizomes and a mechanised planter with hand feeds of rhizomes for planting new areas. Work is underway in the UK to develop reproductive propagules which can be drilled (New Energy Farms pers. comm.). Some weed control may be required in the first year but apart from that miscanthus should be competitive to weeds. No or very little nutrient input is required after the establishment year.

After the establishment year, the management involves harvesting once a year in winter, once the leaves have dropped, with the likes of a maize chopper and leaving plants to send up new shoots in the spring. The crop should persist with minor inputs for many years.

The yields of miscanthus with the current variety are expected to be in the range of 15-20 tonnes/ha.

SUSTAINABILITY

Miscanthus, once established, requires almost no inputs. Grown in the right place for the right reason it can provide significant environmental benefits both during growing and in its end-use.

Miscanthus NZ[11] has some information on economics which suggest an Internal Rate of Return of between 4 and 20% depending on the scale of the planting and the end use. Witzel & Finger (2016) reviewed 51 miscanthus studies and concluded that the economic viability of Miscanthus depends on largely uncertain assumptions especially concerning yields (10 – 48t dry matter per ha) and prices ($80 – 220/tonne dry matter) but also the lifespan of the crop (10-20 years) and different cost items.

Photo: Leftfield Innovation

11 https://www.miscanthus.co.nz/the-plant/miscanthus-economics/

Adding supplementary winter feed crops to the mix

All of the crops outlined are summer crops. It is essential that summer crops have a winter crop or are sown to pasture which can establish before winter. There is significant demand for winter feed in Taranaki. Ideally the winter feed crop should be restorative and as such be a legume or have a root system which can improve soil structure.

A range of crops could be grown as winter crops depending on the harvest date of the summer crop.

- Faba beans can be sown from autumn to spring, are a legume and can improve soil structure. Sown mixed with oats can provide a valuable feed with high DM production. The deeper root system of oats can utilise nutrients which are below the root zone of some other crops.
- Forage rape can be sown from summer through into the autumn to provide winter feed. Brassicas provide a good break crop and the opportunity to control a range of weed species. A break of four or so years between brassica crops will help to prevent disease build up. In 2017 there were around 3500ha of forage brassicas in Taranaki.
- Annual / Italian ryegrass can be autumn sown and provide good dry matter production and feed quality through winter and spring. The root system of ryegrass can be restorative to soil structure. Ryegrass requires a good supply of nitrogen either within the soil from the previous crop or nitrogen fertiliser applied. Annual clovers (Crimson) may be able to be mixed with ryegrass to fix some nitrogen.
- Annual clovers – Arrowleaf (spring / summer active), Crimson (winter active) and Persian (winter active) clovers could all be autumn sown and grazed through winter and spring. As these are annual clovers, they will fix some nitrogen which could be available to the next crop and may allow some crops to be strip tilled into them thus minimising tillage and weed control.
- New pasture – Permanent pasture could be established out of a short or long-term cropping rotation in the autumn. A number of crops, wheat, sorghum, kūmara and garlic could provide a good entry point for new pasture.

Designing your crop rotation

The crops discussed could fit together to create a long-term crop rotation with certain crops contributing to the sustainability of the system.

An example of a possible crop rotation is shown in the table below.

This rotation aims to use the previous crop to benefit the next crop in the system. For example, following garlic the forage rape can be sown late summer to provide significant winter feed with wheat direct drilled in late winter and utilise any nitrogen from the winter grazing and at depth from the garlic crop. The annual clover and grass through winter will then fix some nitrogen and sorghum can be direct drilled into the grass / clover.

This crop rotation is an example of how the crops could be used. It would be possible to substitute summer crops for other summer crops. For example, maize could replace sorghum or sweetcorn could replace wheat or garlic. If faba beans were in the rotation, they could replace sorghum or kūmara and potentially increase the sustainability of the farm system. It could also be possible to look to grow winter vegetables at some points in the rotation if markets exist.

Land area	Year 1		Year 2		Year 3		Year 4	
	Summer	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**
25%	Sorghum	Beans & oats Grazed or silage	Kūmara	Grass Grazed	Garlic	Forage rape	Wheat	Annual clover Grass Grazed
25%	Wheat	Annual clover Grass Grazed	Sorghum	Beans & oats Grazed or silage	Kūmara	Grass Grazed	Garlic	Forage rape
25%	Garlic	Forage rape	Wheat	Annual clover Grass Grazed	Sorghum	Beans & oats Grazed or silage	Kūmara	Grass Grazed
25%	Kūmara	Grass Grazed	Garlic	Forage rape	Wheat	Annual clover Grass Grazed	Sorghum	Beans & oats Grazed or silage

Table: Potential long term crop rotation for Taranaki.

Next steps

YOUR SUPPORT TEAM IN TARANAKI

There is considerable professional and technical support available to those investigating the incorporation of Grains, Legumes and Vegetables into existing farming systems, and related infrastructure and markets. Getting good advice will reduce investment risk. Risk will also be reduced if relationships are developed with other growers and partners in other parts of the industry value chain.

- 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 buyers.
- Rural sector retailers to provide the equipment and supplies needed for hemp cropping (e.g., Farmlands).
- Transport companies to move product from farms to processors and beyond.

FUNDING OPPORTUNITIES

The source or sources of funding for development of a 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 is may be available through organisations such as Callaghan Innovation, Agri Investors and AGMARDT[12].
- 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.
- 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.

12 *The Agricultural and Marketing Research and Development Trust.*

CHECKLIST AND ACTION GUIDE FOR INTERESTED INVESTORS

If you are a:

- [ ] Taranaki landowner – who wants an additional low emissions revenue stream and a complementary crop for your farms.
- [ ] Grains, legume or vegetable contractor or processor – with an interest in diversifying in Taranaki
- [ ] Processors from other regions – looking to reduce supply risks dues weather-related and disease.
- [ ] Other service providers, such as food producers – wanting to grow your businesses or develop new products.
- [ ] Register your interest with Venture Taranaki.

REVIEW FURTHER INFORMATION

Information for this report was drawn from a wide range of sources. Where it was possible to directly attribute a source, the reference is provided below or as a link in the text.

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Expertise for this report: https://www.leftfieldinnovation.co.nz/

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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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