Can fibre crops add value to the Australian sugar industry?

A report for

By Joseph Muscat

2013 Nuffield Scholar

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Executive Summary

The Australian sugar industry is an ageing industry that has relied on excellent research and great technologies which have reinforced its reputation as a world-renowned sugar producer. As we move forward our industry must embrace the challenges that agriculture provides for its farmers and associated processing and marketing systems. The Australian sugar producers have been heavily reliant on the world export market for sugar in the past and currently this market has been very volatile, increasing the need to manage the sugar business well.

Vertical integration and diversification of the sugar business will be an ongoing process and must be well researched and implemented to provide for a sustainable agribusiness enterprise. However, for the last century the Australian sugar industry, at the production and processing level, has been predominately a crystal sugar producer. In addition, most sugar mills generate electricity, with a few now exporting into the electricity grid.

This report provides some insights into opportunities for greater vertical integration and diversification, including an option to add fibre crops to the Australian sugar industry. There are strong synergies between sugar cane and fibre crops such as industrial hemp (*Cannabis sativa*), kenaf (*Cannabis hibiscus*) and sunn hemp (*Crotalaria juncea*) which can deliver value to all sectors of the sugar industry, providing better utilisation of its invested capital. The multitude of product options that can be produced from fibre crops is impressive, products such as building materials, automotive and aviation components, body armoury, paper, bio-fuels (ethanol), pharmaceutical products, textile and geo-textile products. These are only a few of the options. The Australian sugar industry needs to evaluate the direction of its future development and determine if crystal sugar alone can deliver those objectives.

Table of Contents

Table of Figures

Foreword

As a sugar producer of 35 plus years, my concerns are that while we produce a single commodity (crystal sugar), we are vulnerable to a volatile world sugar price. This volatility creates management and planning issues within the farming business, so my Nuffield journey was about investigating the ability to add value to all sectors of the sugar industry with the cropping option of fibre crops.

While we have produced fibre crops in rotation with sugar cane at Oakenden, 30 kilometres southwest of Mackay Qld, the challenge is to efficiently process and market these crops and to develop the pathways to commercialisation. The processing system is about separating the bast (outer skin) from the hurd (inner core) and then separating the single fibre strands to be utilised in the end product.

Australia is rapidly earning a reputation for its inability to manufacture or process any products in a cost-effective way. An opportunity to turn this around lies within the factories of the Australian sugar industry. Here, rather than starting from scratch, the challenge is to adapt / modify current processing equipment to process other crops such as Fibre that provide materials and products to meet emerging market requirements.

Fibre crops have the ability to add value to all stakeholders in the sugar industry, including growers, harvesting contractors and the milling groups. The synergies between a sugar cane plant and a fibre plant are great, which in-turn means that current harvesting and hauling equipment, mill transport systems can all be utilised.

The Australian sugar industry is a single commodity producer which is adding huge pressure for the industry to be sustainable into the future. While diversification is not always easy to accomplish, it is imperative that the sugar agribusiness steps up its approach to diversification: one such option is fibre cropping and processing that will produce end products.

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Abbreviations

CBD	Cannabidiol
Dm	Dry Matter
EIHA	European Industrial Hemp Association
FAOSTAT	Food and Agriculture Organisation of the United Nations
FIDEC	Fibre and Composite Centre
GGIP	Grower Group Innovation Program
	(Sugar Research and Development Corporation, no longer in operation)
GO	South Goias State Brazil
Ha	Hectares (measure of area)
MSL	Mackay Sugar Limited
NSW	New South Wales
NTKB	National Tabaco and Kenaf Board (Malaysia)
QLD	Queensland
SME	Small and Medium Enterprises
SP	Sao Paulo state Brazil
SRA	Sugar Research Australia (Newly formed research arm of the Australian sugar industry)
TCH	Tonnes of cane per hectare
THC	Delta-9-tetrahydrocannabinol
TSH	Tons of sugar per hectare
UNICA	Brazilian Sugarcane Industry Association
USDA	United States Department of Agriculture
WA	Western Australia

Objectives

The objectives of the research for this report were to discover:

- Is there a sense of urgency to add-value to the Australian sugar industry?
- Can current world markets sustain a fibre industry and a pathway to commercialisation for Australia?
- Are there synergies between sugar cane and fibre crops?
- What are limiting factors that impede the processing of fibre crops?

Chapter 1: Introduction

The Australian sugar industry produces 30 -36 million tonnes of sugar annually (Figure 1) and is an industry which is highly mechanised, making it a very reliable producer of sugar. The industry is predominately located in Qld with a production of 28 million tons of cane and one million tons are produced in NSW. Western Australia (WA) no longer has a sugar industry.

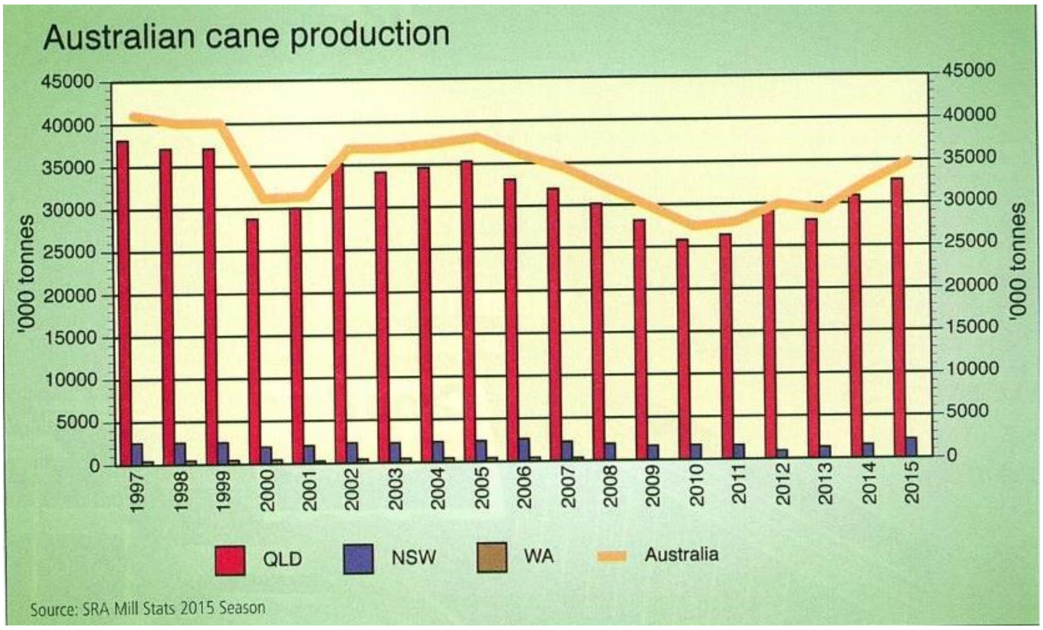

Figure 1: Australian sugarcane production results showing tons of sugar cane produced by year

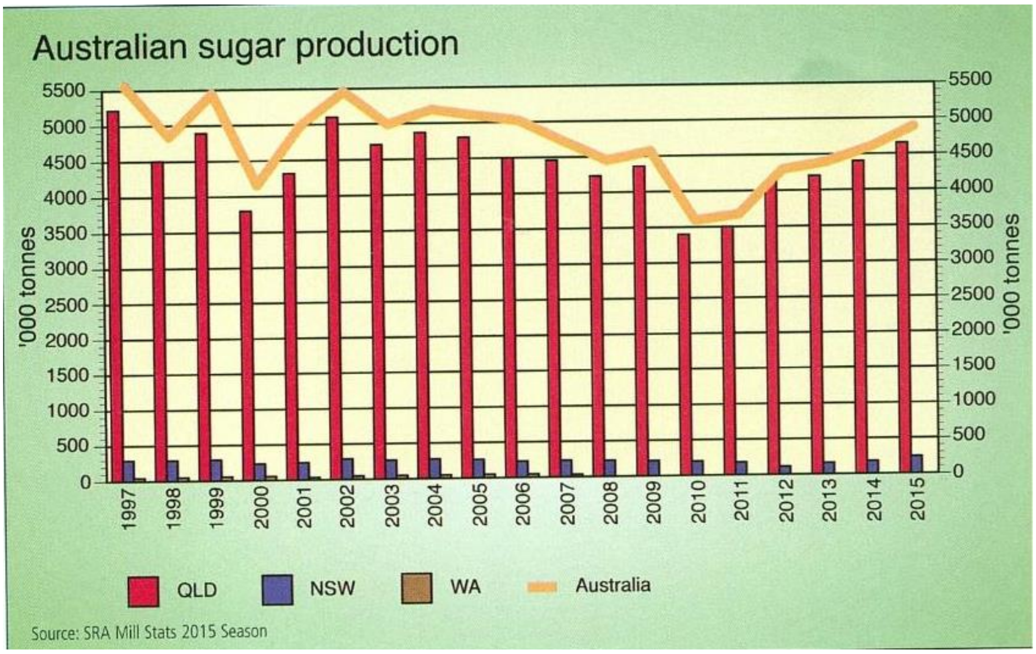

Figure 2: Australian raw sugar production results

Figure 2 illustrates that sugar production exceeded five million tonnes in 2015, which is the best result for a decade, however both cane and sugar production are volatile this adds to the pressure of maintaining positive business results.

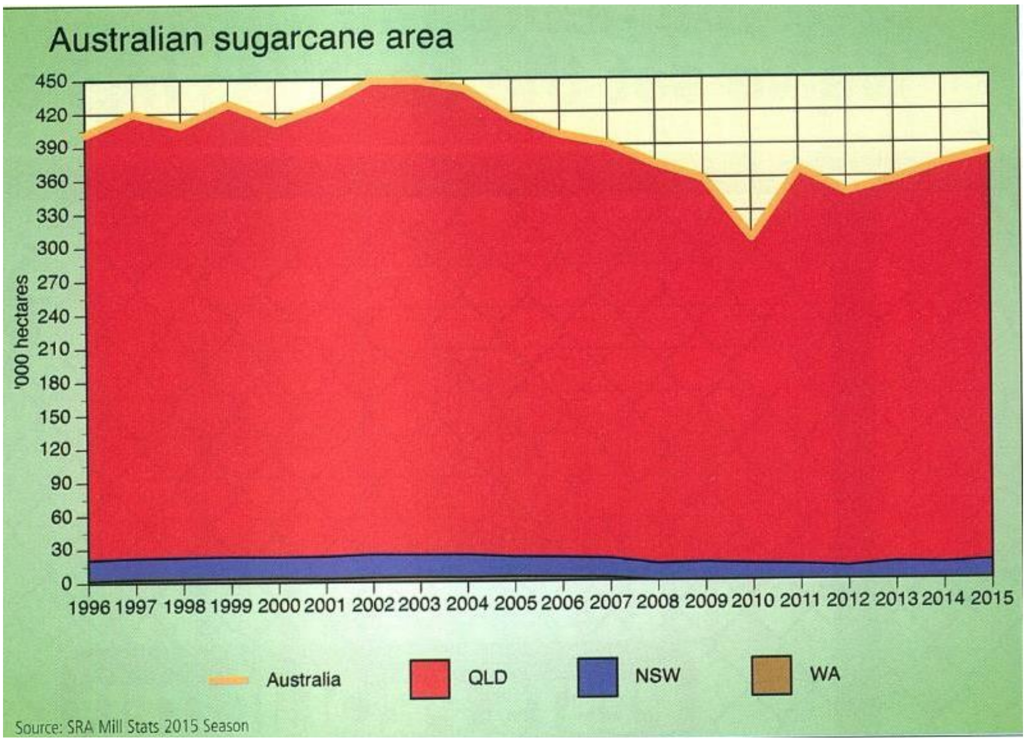

Figure 3: Area under cultivation in the Australian sugar industry

Figure 3 shows that, while in 2015 some area has been brought back into production, the overall trend in area under production has declined.

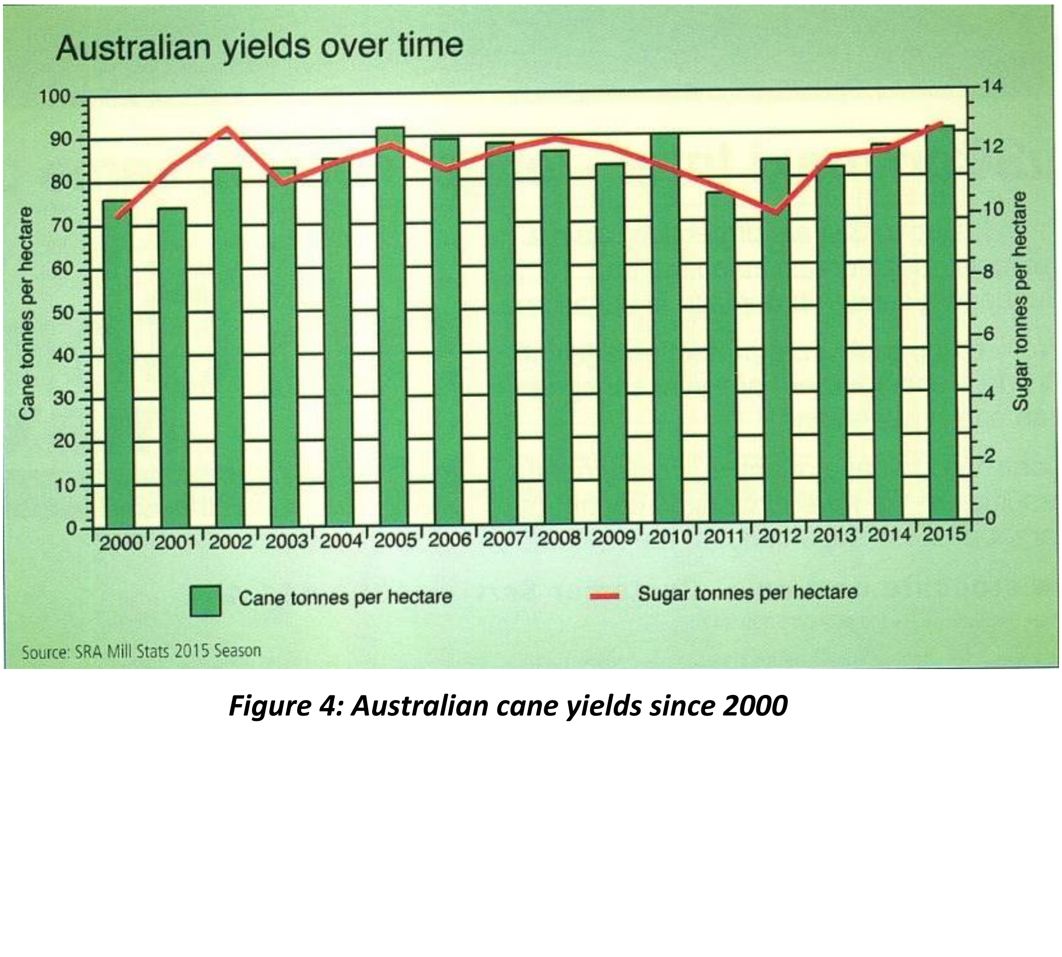

Figure 4: Australian cane yields since 2000

Figure 4 Demonstrates that yields have been static since 2000.

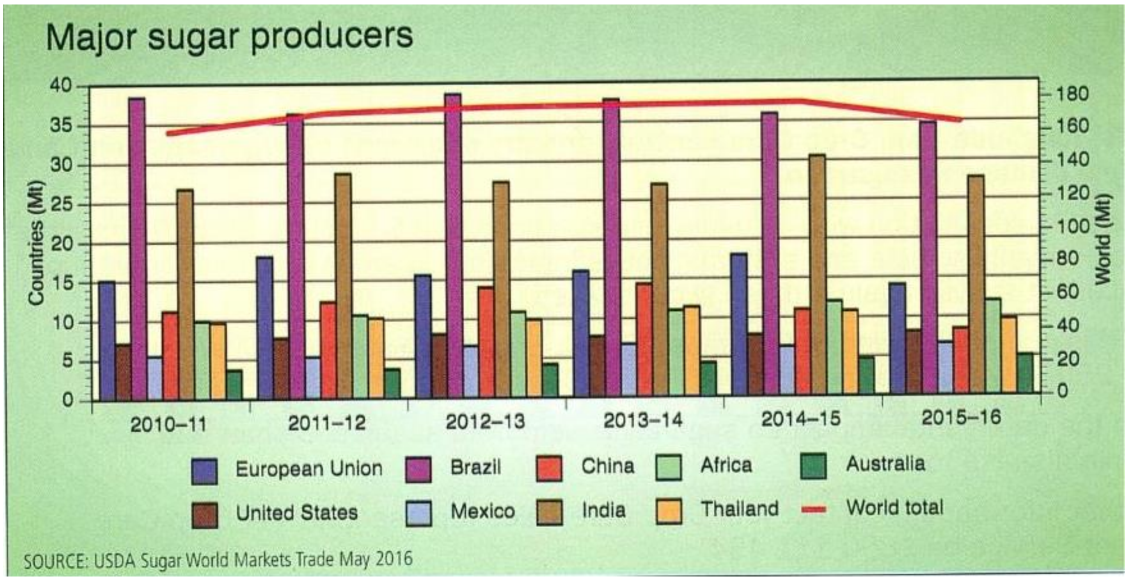

Figure 5: Sugar production by country

Figure 5 shows that Australia now ranks the ninth largest sugar producer in the world; note the dominance of Brazil and India. China is also a country which has expanded its dominance on the world stage in the last five years. Australia moved from the fifth largest sugar producer to the ninth within the last ten years.

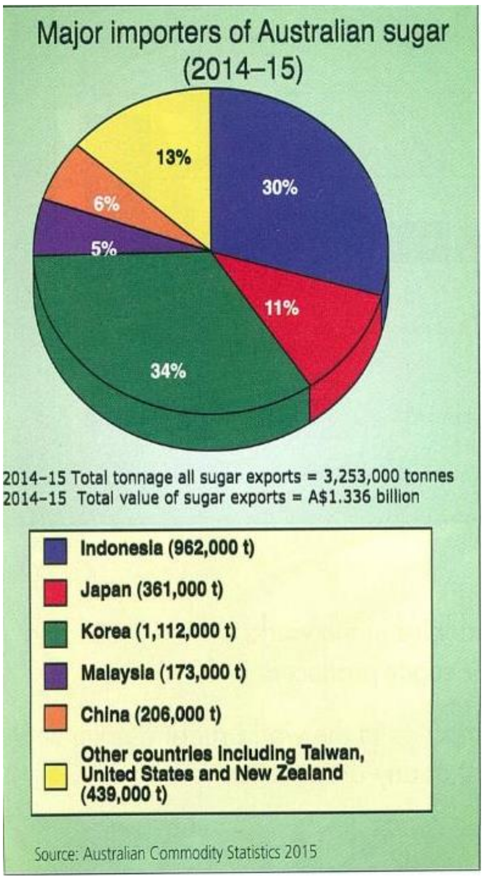

Figure 6: Major importers of Australian sugar

Figure 6 demonstrates sugar importers of Australian sugar by country. It also demonstrates that more than 70% of sugar produced in 2015 was exported; this exposes Australian farmers to the impacts of a volatile world sugar price.

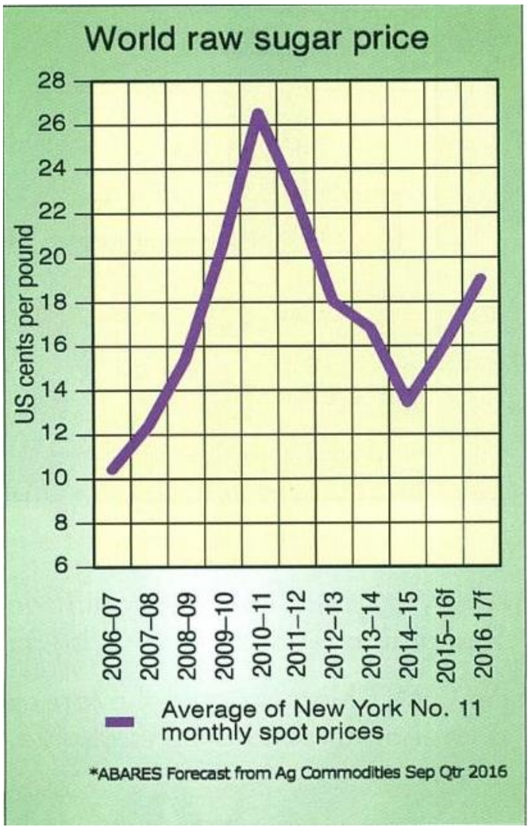

Figure 7: World raw sugar price

The world sugar price, as illustrated in Figure 7, demonstrates the volatility over a ten-year period. This gives rise to many challengers for both producers and processors in relation to managing margins within those businesses.

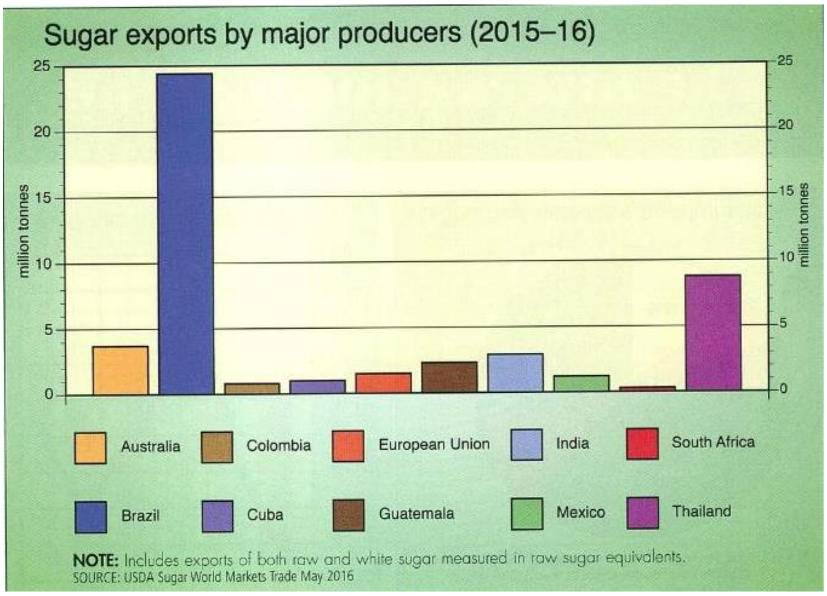

Figure 8: Australia's competitors on the world sugar market

Brazil is the largest sugar exporter in the world (Figure 8) and Australia is the third largest exporter. However, to put this in context, Brazil is exporting just over 65% of the sugar that it produces, while Australia exports more than 80% of its production of sugar, making Australia more reliant on the world price of sugar.

A feature of the Australian sugar industry is that it has a production system that has flat-lined and is declining, while countries like Brazil, India, China, Africa, Indonesia and Mexico are increasing their production keeping pace with the increase in world consumption, on the other hand the Australian industry is not keeping pace with the rest of the sugar producing world. Ten years ago, Australia was the fifth largest sugar producer, now it is the ninth largest.

The majority of the Australian sugar industry produces raw sugar. This is of great concern while we look at the long-term viability of the industry. The industry must add value where ever it can and because of the demographics of the industry, the challenge will be to support all sectors of the industry.

One of the outstanding learnings throughout the study was being exposed to all facets of agriculture and to understand how some agri-businesses had vertically integrated operations, providing real sustainability. Value adding and diversification were the keys to successful agribusiness, however thorough investigation and implementation were imperative to deliver successful outcomes.

Background, Fibre Crops

Since 2002, the author has been investigating fibre crops such as Industrial Hemp, Kenaf and Sunn Hemp, gaining experience with the crops, their agronomic requirements, their growing characteristics and the impact on the following cane crops. These crops have provided positive results to the following cane crops, improved soil health by reducing *Packametra* root rot (a root borne disease in sugar cane), reducing root knot nematodes, breaking compacted layers from the tap root of these plants and introducing large amounts of organic matter; all these factors improve aspects of the following cane crops.

Fibre crops such as the industrial hemp in figure 9 measured 5 metres in length which is an exceptional result.

Figure 9: Industrial Hemp ('cannabis sativa')

Industrial Hemp produced in the central region Qld (Mackay) at 24 tonnes of dry matter/ha.

Figure 10: Kenaf ('Cannabis hibiscus')

Figure 10 shows Kenaf produced in central Qld at 22 tonne dry matter/ ha.

Figure 11: Sunn Hemp ('crotalaria juncea')

Figure 11 Sunn Hemp produced in central Qld at 22 tonne of dry matter/ ha.

Fibre crops are exceptional and are produced in 120-150 days. All fibre crops are rapid accumulators of bio-mass. Growth rates measured up to 66mm growth in 24 hours. This growth can be maintained while good moisture, a well-matched nutrition program and sunlight are available to the plants.

A grower group project conducted in the SRDC (Sugar Research and Development Corporation), **Grower Group Innovation Program (GGIP)** (Project GGP024, title, '*Validation of fibre cropping in rotation with sugar cane*') has documented an agronomic assessment of the production cycle for these three fibre crops.

Another GGIP project has investigated the use of Kenaf and Sunn Hemp as a fuel for the Mackay Sugar Limited co-generation project, (project GGP063 '*Investigating renewable feedstock's such as (Hibiscus canabinues – Kenaf and Crotalaria juncea – Sunn Hemp) for co-generation at Mackay Sugar Limited'*). This project has prepared a business case for utilising fibre crops such as Kenaf or Sunn Hemp as feedstocks (fuel) to generate electricity at the Mackay Sugar factory at the racecourse site, when bagasse has been exhausted and there is a need to utilise coal (black energy) Sunn Hemp (renewable green energy)could be used as alternative fuel. In summary, Kenaf residues could have an adverse corrosive effect on the new high-pressure boiler; however, Sunn Hemp did meet all the requirements as an alternative fuel source.

More than a decade of testing and producing fibre crops in rotation with sugar cane has certainly confirmed that these crops grow at world standards in the Australian region and provide better cane crops on land that has had fibre crops grown on them. With this understanding and knowledge the gap to full commercialisation for these crops is providing the challenge, hence the study undertaken as part of this Nuffield project is to investigate pathways to commercialisation for fibre products, understanding the gaps that will hinder the process will also be very important. The question that needs answering is this: *"Can fibre crops such as Industrial Hemp, Kenaf and Sunn Hemp add value to the Australian sugar industry?"*

Chapter 2: Brazil

The research objective in Brazil was to investigate the sugar industry and more importantly the demographics of their industry. Brazilian sugar and the ethanol industry were observed.

According to the Brazilian Sugarcane Industry Association (UNICA), in 2012/2013 Brazil crushed 588.5 million tons of sugarcane, producing 38.2 million tons of sugar and 23.2 million cubic metres of ethanol. About two thirds of the total sugar produced in Brazil, approximately 27.0 million tonnes, was sold on the international market. Sugarcane cultivation accounts for 2.2 percent of Brazil's total fertile land, or approximately 7.8 million hectares.

The majority of Brazilian sugarcane is cultivated in two regions, the Centre-South and the North-North East regions. The Centre-South region takes in the South, South-east and Centre-West regions covering the states of Paraná, São Paulo, Minas Gerais, Rio de Janeiro, Espírito Santo, Mato Grosso do Sul and Goiás. The North-North East region encompasses the states of Alagoas, Pernambuco, Paraíba, Sergipe, Rio Grande do Norte and Bahia. The two regions have separate harvesting periods.

In the Centre-South region, the harvesting period runs from March to October (as of the commencement of the 2006/2007 harvest, whereas prior harvests ran from April to November of each year). In the North-Northeast region, harvest runs from September to March.

Brazil's vast territory and favourable climate provides a large supply of available land for sugarcane production. These conditions permit sugarcane to be harvested five to six times before requiring re-planting, compared to other countries, such as India, where, on average, sugarcane needs to be re-planted every two to three harvests. The planting and harvesting of sugarcane is significantly less costly than planting and harvesting sugar beet, which has one annual crop, needs to be re-planted every year and requires crop rotations every three to five years.

Case Study 1: Sao Martinho

According to a study conducted by UNICA, the São Martinho Group is one of the largest producers of sugar and ethanol in Brazil. They purchase, cultivate, harvest and crush sugarcane - the main raw material used in its sugar and ethanol operations. The harvest results achieved in 2013/2014:

- Net income of R$ 135.0 million; (AUD $56.7 million)
- Crushing of more than 15.6 million tons of sugarcane.

During the 2013/2014 crop year, São Martinho Group accounted for approximately 2.5% of the total amount of ethanol produced in Brazil, and 2.9% of domestic sugar production.

The company operates through four mills: São Martinho, localised in Pradópolis (SP), Iracema, in Iracemápolis (SP), Santa Cruz, in Américo Braziliense (SP) and Boa Vista, in Quirinópolis (GO), the latter being part of Nova Fronteira Bioenergia, company formed in June 2010 through a joint venture between São Martinho Group and Petrobrás Biocombunstível.

The São Martinho, Iracema and Santa Cruz Mills produce sugar and ethanol while the Boa Vista Mill is dedicated exclusively to the production of ethanol. They all generate electricity from the burning of bagasse, ensuring self-sufficiency and sale of surplus electricity (except the Iracema mill). In addition, the subsidiary company Omtek is a manufacturer of yeast derivatives through advanced biotechnological processes that cater primarily markets for food and animal feed.

Sao Martinho has a well-diversified agri-business; it produces 970,000 metric tonnes of crystal sugar 452,000 cubic metres of ethanol, and it export 177,000 megawatts of electricity from its co-generation plant.

The mill produces 324 metric tonnes of RNA (ribonuleic acid as the sodium salt) for the pharmaceutical and food industry. Sao Martinho also produces yeast and vanasse which are by-products from the sugar and ethanol process.

Recent History

In April 2010, São Martinho S.A. announced a definitive agreement with the U.S. company Amyris Bio-technologies Inc. and its Brazilian subsidiary Amyris Brazil S.A. This agreement defines the construction of a chemical plant in the Usina São Martinho unit which will begin producing farnesene, which is used as a feedstock for chemical products. The term farnesene refers to a set of six closely related chemical compounds which all are sesquiterpenes. α-Farnesene and β-farnesene are isomers, differing by the location of one double bond. Amyris'trans-β-farneserne is produced through fermentation of sugars by yeast. Target genes are selected to change the yeast's metabolism, converting the yeast from an ethanol-producing organism into an organism producing more complex hydro-carbons.

In June 2010, São Martinho S.A. and Petrobras Bio-combustível S.A. (PBio) – Petróleo Brazileiro S.A. (Petrobrás) subsidiary - announced a strategic partnership to increase ethanol production in Goiás state through the São Martinho S.A. subsidiaries "Usina Boa Vista S.A." and "SMBJ Agroindustrial S.A.".

A new company will be incorporated under the name 'Nova Fronteira Bioenergia S.A.' which will control Usina Boa Vista S.A. and SMBJ Agroindustria lS.A. PBio will control 49% of the new company and São Martinho S.A. will control 51%. Currently, Boa Vista mill has a crushing capacity of 3.4 million tons of sugarcane per year. With the new investments, production is expected to reach a crushing capacity of 8.0 million tons per year by 2016/2017.

In August 2010, São Martinho announced the first phase of the cogeneration project at São Martinho Mill. The initial investment was R$ 173 million (AUD $72.66 million). The forecast is to have a surplus of 244,000 MWh to be sold by 2013/2014.

In October 2011, São Martinho announced the acquisition of 32.18% of Santa Cruz - Açúcar e Álcool (Santa Cruz Mill) and 17.97% of Agropecuária Boa Vista S.A. The synergy between São Martinho´s and Santa Cruz´s agricultural area was relevant to this transaction, which should generate gains of scale and reduce the logistics costs these are neighbouring sugar mills with interconnecting production systems.

In 2014, São Martinho concluded the acquisition of 59.95% additional stake in Santa Cruz, reaching the participation of 92.14%. Then, at the AGM held on 31 October 2014, São Martinho held the incorporation of USC. (Source; Sao Martinho, 2012/2013 Annual and Sustainability report)

São Martinho – Consolidated production	**2011/2012**	**2012/2013**
Processed sugarcane (‘000 metric tons)	10,590	12,915
Own (‘000 metric tons)	6,886	8,236
Third-party (‘000 metric tons)	3,704	4,679
Harvest mechanization (%)	85.7%	87.3%
Production		
Sugar (‘000 metric tons)	774	970
Anhydrous ethanol (‘000 m³)	191	275
Hydrous ethanol (‘000 m³)	188	177
RNA – ribonucleic acid sodium salt (metric tons)	226	324
Energy exported (‘000 MWh)	140	177

Sa Martinho Products

Sugar: The groups mills produce several types of raw sugar. In recent years, the main product has been WHP, a standard sugar category traded on the international market.

Ethanol: The Sao Martinho Group produces hydrous ethanol, used in the tanks of ethanol-driven vehicles; anhydrous ethanol, which is added to gasoline used by gasoline-driven vehicles; and industrial ethanol, which is mainly used in the production of paint, cosmetics and alcoholic beverages.

Electricity: Sugarcane bagasse, a by-product from the sugar and ethanol production process, is fully reused. The electricity produced from burning the bagasse powers the mills and the surplus is sold to the energy market, a clean process that avoids the use of fossil fuels.

RNA: Another product manufactured by the Sao Martinho Group, through its subsidiary Omtek located in Iracemapolis, is ribonucleic acid (RNA) sodium salt, which is used in the pharmaceutical and food industries as a raw material and flavour enhancer.

By-products: As by-products of the sugar and ethanol production processes, the Sao Martinho Group manufactures and markets yeast, which is used in animal feed; fusel oil, also a solvent and used in the manufacture of explosives, and pure amyl alcohol.

Outside of these products that are produced, the by-product of the ethanol production system is vanasse, (known as bio-dunder in Australia) a rich source of potassium, vanasse is pumped to the farms surrounding the sugar mill in a 50km radius and sprayed onto cane crops, providing its complete requirement of potassium for the crop cycle. Approximately 32,000 hectares of the production has vanasse applied each year; 35 percent of the area is applied by truck and has nitrogen added to it making a one-shot blend, while the remainder is pumped directly to the farm. The Sao Martinho sugar mill by-product of filter cake or mill mud and mill ash, (the residue that remains after burning bagasse that powers the steam boilers), is utilised with the addition of chicken manure to produce a rich compost. Chicken manure is bought in from nearby chicken houses and is a valuable feedstock in the compost produced. Lime and gypsum are added to the compost blends. Where soil tests indicate a deficiency, soil testing is carried out at block level and is analysed at the mill laboratory. 360,000 tons of compost is produced each year, which is sub-surface applied to 24,000 hectares; this is referred to as planting compost. This operation has been in practice since 2006 and has been progressively increased to the current day requirement with the majority of the fallow land treated.

Sao Martinho Farming Observations

It was evident at the time of inspection that this sugarcane producing region was performing very efficiently. There were many factors that support this observation. The demographics of the Sao Martinho sugar contributed to its ability to perform at this high standard. The milling group owned one-third of the production area, they leased or rented another one-third of the production area providing two-thirds control by the sugar milling group. The milling group controlled 100% of the harvest, which encompassed late-model machinery and 24-hour harvesting. The other third of the production system was privately owned by some very large operations with one of the farms visited having a productive area of 6,600 hectares producing 500,000 tons of sugar cane.

While the Sao Martinho group is one of the leading sugar and ethanol producers in Brazil, the Australian sugar industry must understand it status as a competitive producer of sugar in the world sugar market. The strengths of Sao Martinho noted in this report provide a clear understanding that it is not only a strong competitor for the Australian sugar industry; it has the potential to dominate the world sugar market.

The Australian sugar industry exports 80-85% of sugar produced, Sao Martinho and the Brazilian sugar industry provide a real threat to the long-term viability of the Australian industry. The demographics of the Australian industry, such as the unit size of the farms, in most cases with different ownership of the processing and harvesting sectors are providing real challenges to maintain completeness in the world stage. There is a sense of urgency for the Australian sugar industry to add value across all sectors of the industry as soon as possible.

Sao Marinho sugar has control of 66% of its production system (total production area 120,000 Ha) through ownership or rental. This allows for fast adoption of best practice and new technologies. The total control of the harvest allows the full quality control; targeted harvester outputs, haul out and transport are matched, creating efficiencies that support harvester productivity. Large scale farming enterprises allow for efficient farm operations making the Brazilian sugar industry a low-cost producer.

Soil is certainly one of Sao Martinho's strong points with organic carbon ranging from 1.6% to 2.6%, the milling operation manufactures prescription compost to satisfy block requirements, and all compost is sub-surface applied. A focus on legume rotations also provides support to improving soil health. Its climate is generally reliable with less than three percent irrigation required.

Case Study 2: CFM Cana Ltda

This property is located at Pitangueiras, Sao Paulo state Brazil. The property has a British owner and managed by a Brasilian (Juliano Viscardi) who was able to take me through his operation providing the relevant details of this large-scale farming operation.

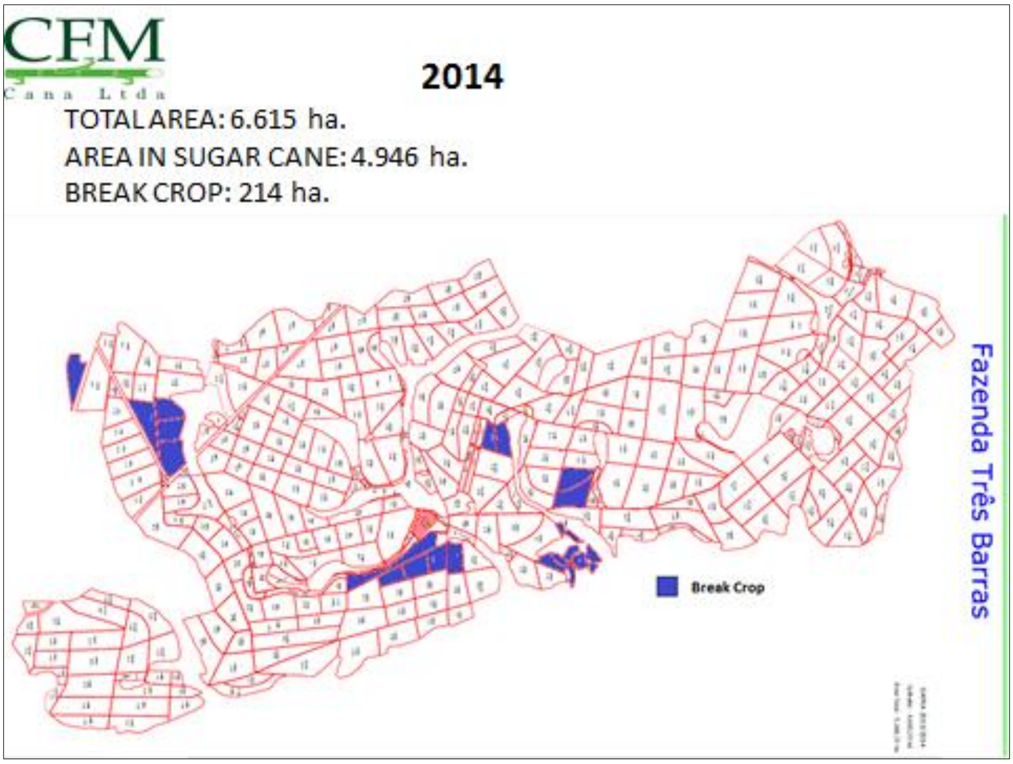

Figure 12: Farm map of CFM Cana Ltda

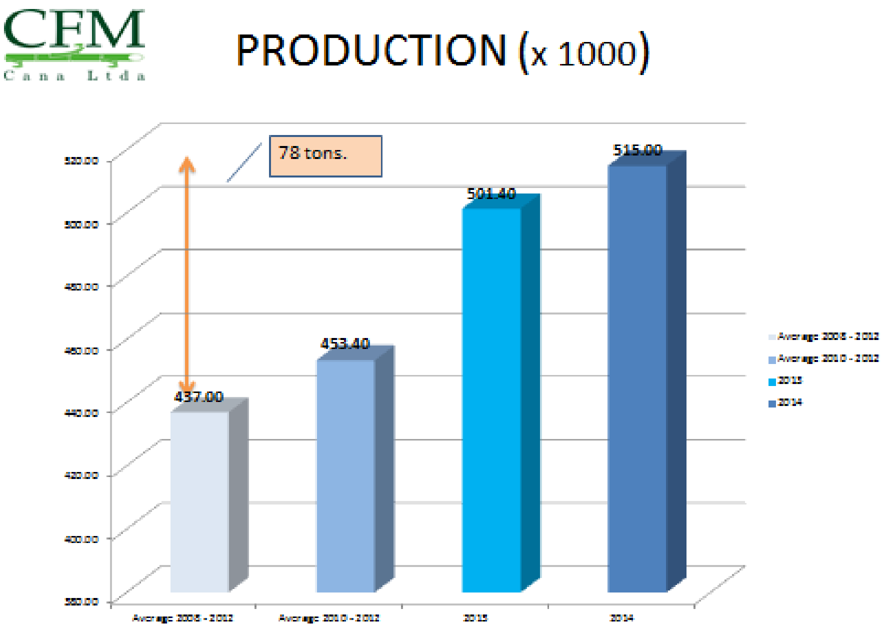

Figure 13: Tons of sugar cane produced at CFM Cana Ltda

CFM
Cana Ltda

DESCRIPTION	REAL 2012	REAL 2013	BUDGET 2014
NUMBER OF EMPLOYEES	81	79	78
VINHASSE AREA	3.900	4.700	4.700
IRRIGATION AREA	433	648	1.700
MUD AREA	312	810	1.000
HARVEST AREA	4.627	4.612	4.935
PRODUCTION (MILL)	496.455	501.455	515.000
PRODUCTIVITY	109	111	104
AVERAGE CUTS	4,1	4,4	4,8
ATR	133,9	138,52	140

Figure 14: CFM Cana Ltda business overview

The CFM Cana Ltda operation was impressive due to the scale of the business. It has limited irrigation but its production results were outstanding. The 2014 results were estimated in Figure 14. In further discussions with the manager, Juliano Viscardi, he reported that the production result was 84 TCH (tons of cane per hectare); this result was an all-time low and was a result of 60% less rainfall. Another outstanding result in this production system was its ability to maintain plant cane through to ninth ratoons, maintaining more than 100 t/ha.

Case Study 3: Agmusa" Cane Planting System with Legume Rotations

The first farm visited in Brazil was a 500ha sugar cane farm in the Pitangueiras region in Sao Paulo state, owned by Ismael Perina Junior. This system produces an average of 105 TCH (tons of cane per hectare) and was the author's first exposure to the Agmusa planting system, a system unique to the Sao Martinho sugar producing area. This planting system boasts an increase in plant cane productivity of 10-15%, which is an incredible result. The fundamentals of this planting system can be summarised as:

- Harvest the cane block from April to July.
- Prepare the block for planting, using selected legume and one eye sets/ tissue culture (cultivation).
- Plant compost utilising GPS guidance at 15ton/ha across the whole paddock. (subsurface applied compost, prescription compost prepared for block requirement).
- Plant cane in two rows leaving the next six or eight rows fallow; the plant source is either one eye sets or tissue culture. (Clean plant source).

- Plant a legume in the six or eight rows (legume selection is relative to the organic carbon level of the field; with high organic carbon levels (greater than 2%) select peanuts, less than 2% select soybeans, less than 1.6% select Sunn Hemp.
- All fields would be managed for weeds/insecticides, and peanuts or soybeans would be taken through to harvest as a cash crop. If Sunn hemp was selected it would be incorporated for its bio-mass and the nitrogen value (yielding 300kgs N/ha or more).
- The inter-rows (six or eight rows) would be prepared for planting in the March/April period the following year. The two rows planted with the one eye sets or tissue culture seedlings would then be used as the plant source for the six or eight rows where the legumes had been planted, (illustrated by Figure 17). The plant source – two rows of one eye sets or tissue culture – would be put straight into the planter, eliminating any extra handling causing damage to the plant source. The majority of the planting is billet planting using a two-row planter.

Figure 15: Agmusa planting system (soybeans planted in the six or eight rows)

Figure 16: Billet planter planting two 1.5m rows (GPS controlled)

Figure 17: Agmusa planting system (two plant rows utilised for the plant source for the six or eight row gap)

The Agmusa planting system has been commercial for a number of years; initial research was conducted on this system more than five years ago. Nobody interviewed in the Australian sugar industry was aware that this planting system existed.

Figure 18: Soybean planted as a cash crop (legume break crop)

Figure 19: Mumosa (legume break crop)

Case Study 4: Agronomic Institute of Campinas (IAC) Research Facility

The IAC facility in Ribeirao Preto is government owned and operated. It conducts a range of agronomic research, and also through its laboratory, undertakes work on genetic markers in sugar cane, Ratoon Stunting Disease (RSD) screening, herbicide phytotoxicity testing and conducts tissue culture preparation. Information is extended through a range of activities utilising Syngenta and Bayer, private operators and the Sao Martinho sugar mill.

IAC also has an extensive sugar cane plant breeding program which boasts a 1.4% genetic gain per annum and has identified yield potential in sugar cane of 234.5 tonnes of cane per hectare (X*avier, 2016*) which is an impressive target. The plant breeding program sources sugarcane cultivars from wild canes globally; wild canes are sought after for the different characteristics they offer to the breeding program. Generally, they are collected from remote areas all around the world (Figure 21).

The research facility also operates an extensive one eye set program. This is propagation process for increasing new variety uptake as a clean plant source (disease free and highly vigorous) for the transition into a commercial production system (Figure 22).

Figure 20: IAC facility Wild cane section

Figure 21: One eye sets ready for commercial release

Brazil summary

Sao Marinho sugar has control of 66 percent of its production system (total production area 120,000 Ha) through ownership or rental of land. This allows for fast adoption of best practice and new technologies. It also controls one hundred percent of the harvest thus maintaining a quality job, targeted harvester outputs, haul out and transport are matched creating efficiencies that support harvester productivity. Large scale farming enterprises allow for efficient farm operations making the Sao Martinho sugar industry a low-cost producer.

Sao Martinho also has a well-diversified agri-business; it produces 970,000 metric tonnes of crystal sugar, 452,000 cubic metres of ethanol, and it exported 177,000 megawatts of electricity from its co-generation plant. The mill produces 324 metric tonnes of RNA (ribonuleic acid as the sodium salt) for the pharmaceutical and food industry. Sao Martinho also produces yeast and vanasse which are by-products from the sugar and ethanol process.

The Australian sugar industry exports 80 – 85 percent of sugar produced, Sao Martinho and the Brazilian sugar industry provide a real threat to the long-term viability of the Australian industry. The demographics of the Australian industry, such as the unit size of the farms, in most cases with different ownership of the processing and harvesting sectors are providing real challenges to maintain completeness in the world stage. There is a sense of urgency for the Australian sugar industry to add value across all sectors of the industry as soon as possible.

Chapter 3: Fibre production and processing in Germany

German technology for processing fibre crops is second to none; its technology is the best in the world and currently can process at five tonnes per hour. This is a dry processing system. Several major fibre producers were visited, and these will be discussed as case studies.

Processing Fibre Crops *(Source: USDA)*

Harvesting and fibre processing differ depending on the product being produced, whether it is a high-quality textile market or an industrial requirement, the harvesting and processing is aligned to the end market. Fibre length is also important to the market it is being produced for. Harvesting equipment must be adjusted for the particular fibre length required. Harvesting fibre crops is generally conducted utilising a forage harvester with a Kemper front and machines are modified relative to the fibre length required. If 600mm fibre length is required the forage harvester would be configured to cut stalks to this length and place the cut stalks on the ground. In a dry separation process the 600mm billets would require field retting which starts the separation process.

Retting

If hemp fibres are to be used in textiles and other high-quality applications, the bast fibres must be separated from the rest of the stalk. Retting is the microbial process that breaks the chemical bonds that hold the stem together and allows separation of bast fibres from the woody core. There are a number of different processes to ret fibre stalk: field retting, water retting and chemical retting. These processes need to be conducted by experienced people because damage can be easily done to the fibres resulting in poor quality fibres.

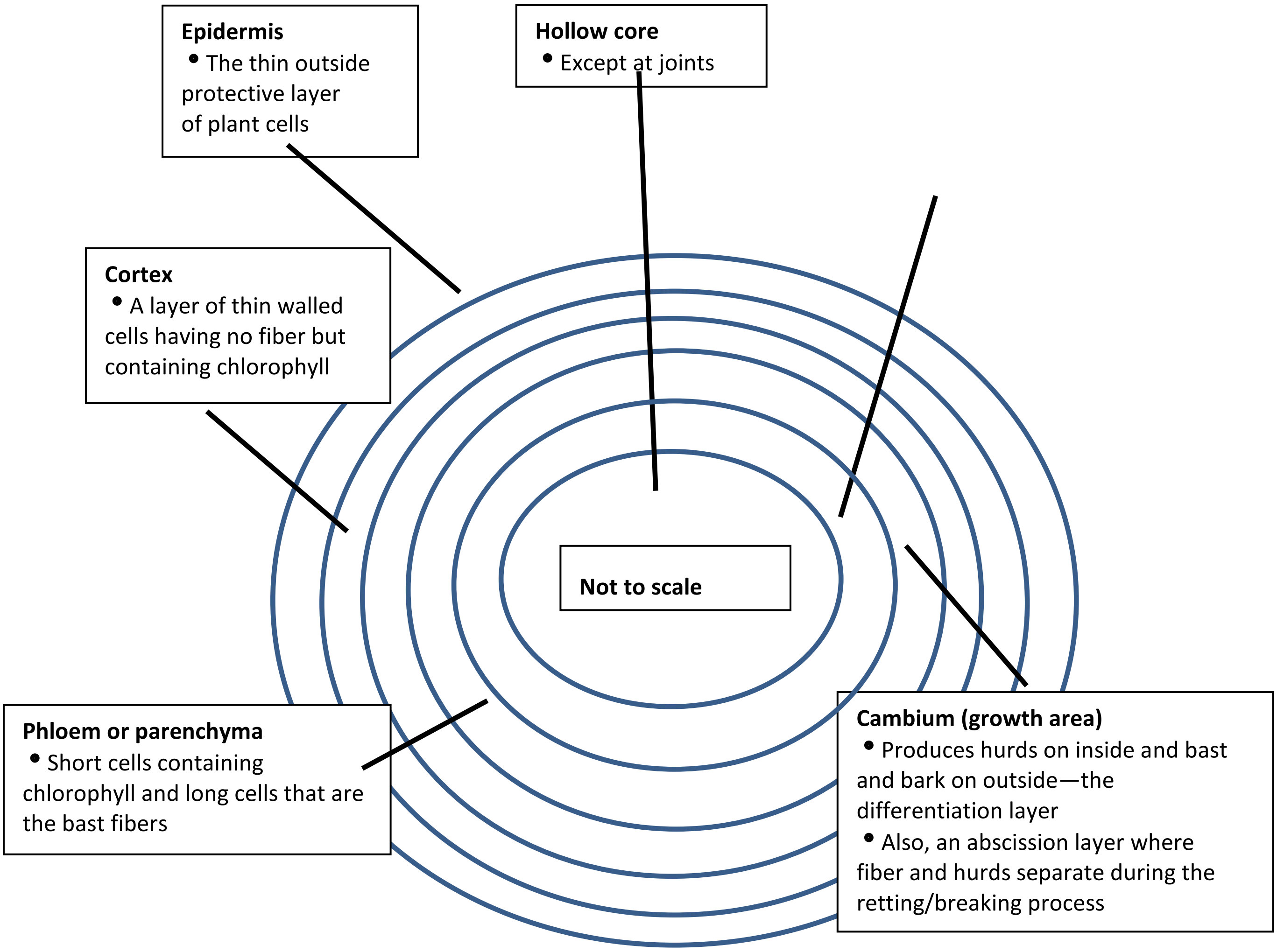

Figure 22: Cross section of a hemp stem

Bast fibres are composed of primary bast fibres, which are long and low in lignin, secondary bast fibres, which are intermediate in length and higher in lignin (Source: Oliver and Joynt)

Fibre Separation

Once stalks are retted, dried and baled, they are brought to a central location for processing. With mechanical separation, in a process called breaking, stalks are passed between fluted rollers to crush and break the woody core into short pieces (called hurds), separating some of it from the bast fibre. The remaining hurds and fibre are separated in a process called scotching. Fibre bundles are gripped between rubber belts or chains and carried past revolving drums with projecting bars that beat the fibre bundles, separating the hurds and broken or short fibres (called tow) from the remaining long fibre (called line fibre). Fibre and hurds also can be separated with one machine called a decorticator (Kerr,1998).

Research in Europe has sought methods for separating bast fibre that by-pass traditional retting and scotching. Steam explosion and ultrasound are under investigation in Germany, but the processes produce only short fibre. Neither technology has moved beyond laboratory or pilot scale trials.

End products produced from fibre crops such as building materials, high quality printing paper, automotive components, geo-textiles and the many other products. Production of these products is limited by the commercial supply of separated fibre and core and a processing system capable of matching the commercial quantities required to sustain the production of the end products.

For Hemp to be a viable crop in any area around the world, modern harvesting and processing methods would need to be developed.

Cannabinoid (CBD)

By introducing new possible applications, hemp can become more interesting. During the 11th annual International Conference of the European Industrial Hemp Association (EIHA) new applications were presented. One of the new applications was the following medicinal use; next to THC, hemp contains another interesting by-product, Cannabinoid (CBD). This cannabinoid does not, in any dose, induce psychotropic or other side effects. Concentrations of CBD in hemp range from 0.5 to 2 percent and can be extracted from the upper part of the plant in the flowers, leaves and stem. CBD can be obtained from industrially cultivated hemp plants, 3kg of CBD can be collected per hectare. CBD is a promising treatment for numerous diseases, including epilepsy, diabetes, cancer, skin cancer, skin diseases, some anxiety disorders and more.

The price for CBD as a pharmaceutical, ranges from $AUD27,900 to $AUD41,800 per kg. In the USA, a large number of products with CBD are already available, which include dyes, oils, and chewing gum. (source: The future of Industrial Hemp in the Netherlands. E.van Vliet)

Case study 1: The Leibniz Institute for Agricultural Engineering at Potsdam

The Leibniz Institute for Agricultural Engineering at Potsdam-Bornim is a European centre of agricultural engineering research at the nexus between biological and technical systems. Their research targets a knowledge-based bio-economy. They are developing highly innovative and efficient technologies for the use of natural resources in agricultural production systems. They thus contribute to the nutrition of humans and animals, to a sustainable use of biomass, and to protect the climate and environment

Case study 2: The Pahren Agricultural Cooperative (Germany)

This German cooperative demonstrated strong pathways to commercialisation of industrial hemp. It encompassed the production system and processing (the separation process) providing separated fibre to a manufacturer which went on to produce car components mainly and other product lines.

Figure 23: Pahren Agricultural Cooperative (Germany)

The co-operative manages 2,500 ha of land of which 500 is grassland which supports 900 cattle. They have a production system which produces corn, canola, peas, beans, industrial hemp and linseed.

The co-operative has a strong focus on environmental issues applying a wide range of crop rotations to improve crop outcomes. It aims to produce a high income to secure its existence, which has a flow-on effect to create jobs and develop new perspectives for their region.

A SWOT analysis of Germany's competitive position in fibre processing

Strengths;

- A government supported research program leading the world in the fibre separation process.
- Strong knowledge base at the production, processing and manufacturing systems.
- A strong focus to improve market options for fibre end use.
- Demonstration of clear pathways to commercialisation.
- A renewable feedstock source that meets German environmental standards.
- Collaboration with other countries to improve the fibre industry and also as a supplier of separation equipment.
- A world leader in the dry separation process.

Weaknesses;

- Competition from higher value crops for available cropping land.
- Maintaining cost competitiveness at the market place.

Opportunities;

- A clear focus to increase market penetration.
- Investigating different processing systems that will decrease processing costs and improve product competitiveness.
- Can source raw material from alternate sources (import)

Threats;

- Competitive nature of food production verses fibre production.
- Maintaining and securing processed fibre feedstocks.
- Lack of machinery to mechanise the harvesting and product handling systems.

Chapter 4: Malaysia

Strategic Development Plan

Malaysia demonstrated a very well organised plan which encompassed a seed to market concept.

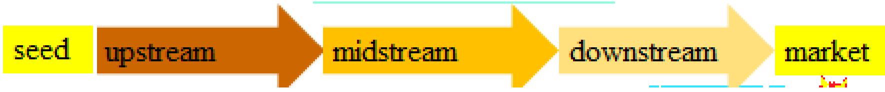

Figure 24: Flow chart demonstrating kenaf industry strategy for Malaysia

This flowchart outlines a comprehensive approach to a successful industry.

Upstream processes include seed production; seed storage; seed distribution; production system and mechanisation.

Mid-Stream processes are harvesting, post harvesting, storage, processing centre, fibre and core grading.

Downstream; Product development and manufacturing, promotion and marketing, market penetration and expansion

Malaysia's National Kenaf and Tobacco Board (NTKB) has a strategic plan with six key objectives:

1. Enhance kenaf productivity.
2. Accelerate Research, Development and Commercialisation (RDC) activities.
3. Encourage commercial kenaf production.
4. Enhance the development of the downstream industry.
5. Promotion of kenaf usage and products.
6. Promote human capital development.

The driver for Malaysia was to transition its tobacco farmers into a kenaf (fibre) industry. The Malaysian government was certainly providing support for this transition to be successful. The government also demonstrated that it supported a holistic approach from research that delivered solutions aimed at developing pathways to high end value products.

While conducting this research it was recognised that without strong government support and incentives, the pathway forward is slowed dramatically this appeared to be true, no matter which country was visited.

Processing

The author's visit to Malaysia provided an opportunity to meet with some processors which provided an insight into how processing is being conducted in Malaysia. Processors in Malaysia indicated that the separation process operated at approximately two tonnes per hour; this rate demonstrated low performance and was a limiting factor in the supply chain. Some separation processors utilised a chemical retting process; this type of process can easily damage fibre strands if not managed well. The low separation rate also contributed to higher processing costs.

With the high demand for quality fibre, many products being produced in Malaysia struggle to access enough fibre to meet the commercial demand. While Malaysia has demonstrated excellent market lines, with a wide range of high value products, one of the limiting factors was the lack of continuous supply of separated fibres and a production system that had scope for improvement.

Product development to commercialisation

Malaysia demonstrated an excellent and well organised pathway to commercialisation. This process was backed by excellent research and development. A clear focus was to supply high value products to the aviation sector and the defence force. This demonstrates a good understanding of the customer’s needs. The Malaysian government also set strategic direction through its Centre of Excellence which played a coordination role, understanding the customer’s requirements and tasking the universities to solve those particular issues.

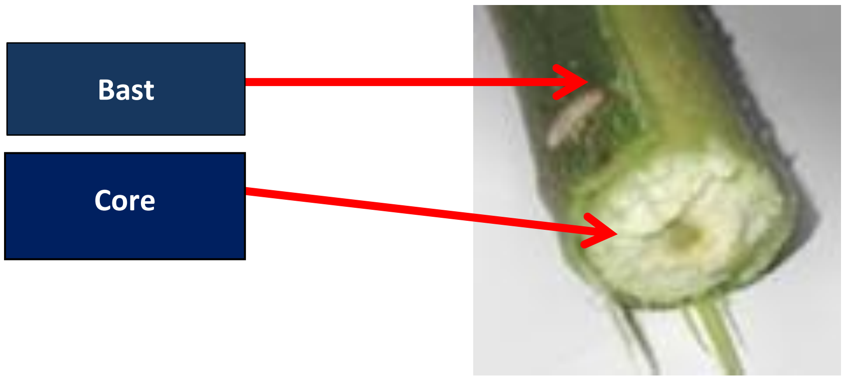

Figure 25: Industrial Hemp stalk

Primary processing is separating the bast from the core, further processing of the fibre to short, long and pulverised improves product applications. Malaysia leads the world in the marketing of fibre into high value products. This strategy has and will keep providing a pathway forward for Kenaf fibre.

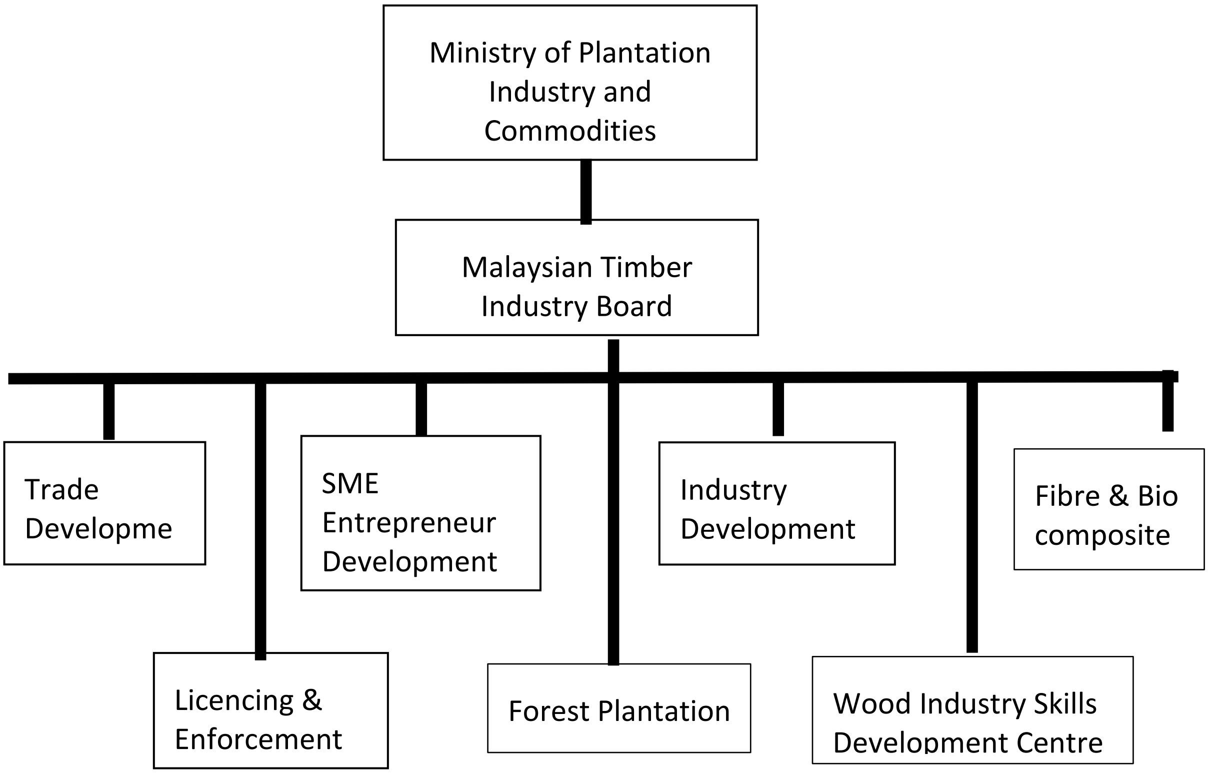

Figure 26: Malaysian Government structure with respect to hemp production

Source: Fibre & Bio-composite Centre (FIDEC)

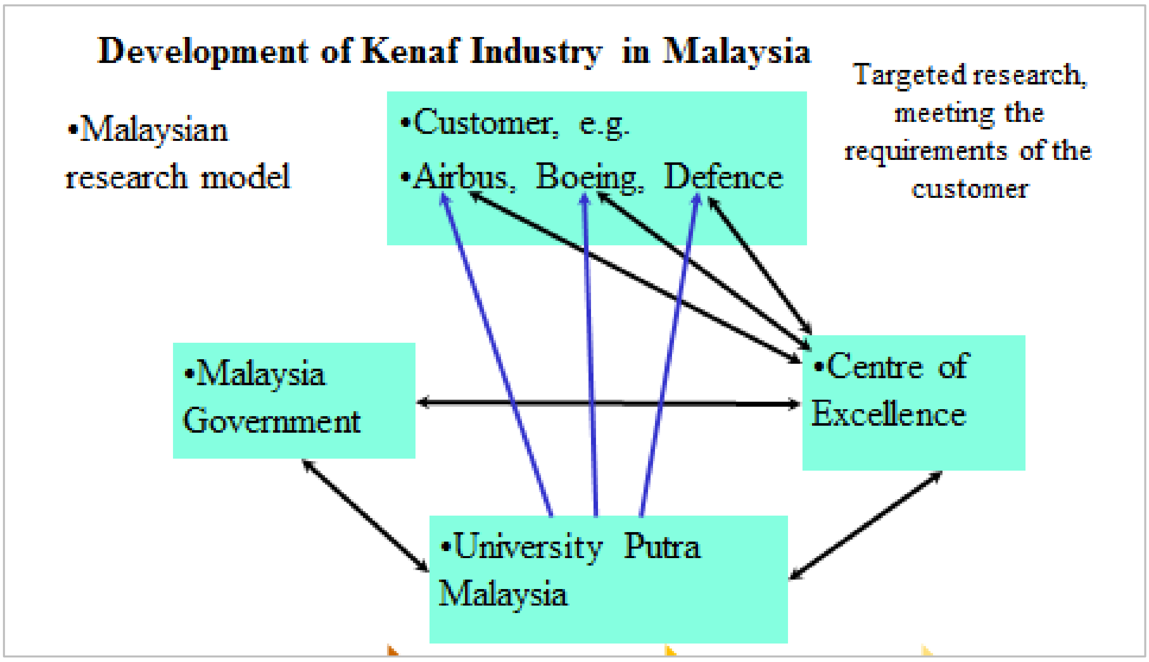

Figure 27: Schematic of Malaysia research model

Source: Fibre and Bio-composite Centre (FIDEC)

Research model

Malaysian research model aims to promote targeted research providing solutions for the end user (customer).

The Centre of Excellence, based in Kuala Lumpur Malaysia, has the following research priorities:

- To stimulate interest in and to enhance the utilisation of fibre and bio-composite materials in the country.
- To facilitate pre-commercialisation of fibre and bio-composite materials.
- To establish vital linkages and smart partnerships with universities, research institutions and the industry towards commercialization of R&D findings related to fibre and bio-composites.
- To coordinate the overall development of the fibre and bio-composite industry in Malaysia
- To work closely with the end user (customer).

A good example of this research model working has been the identification of two customer requirements which are the aviation industry and defence department of Malaysia. Airbus and Boeing identified the need for a bomb-proof cargo barrier, while the defence force required light weight bullet-proof vests and other body armoury. The bomb-proof cargo barrier is still being developed while the light weight bullet proof vest produced from kenaf fibre has been developed and is being utilised by the Malaysian defence force.

At the core of the successful utilisation of fibre in Malaysia is the close co-operation between the Malaysian government and the University Putra Malaysia. This involves Malaysian government ministries setting policy directions and providing the financial support to the Group of Excellence and University Putra Malaysia.

- University Putra Malaysia, through its designated facility on natural fibres, developing and problem-solving issues highlighted by the group of excellence for the customer.
- Delivering to the customer needs.

This targeted research model can be adapted to any research provider in any situation, delivering solutions and providing a pathway forward.

The research model above is the key to achieving targeted research results; for the research agency it provides an understanding and incorporating the costumer's needs and gaps within the business they operate to deliver and drive solutions.

The FIDEC was established to spearhead the development of the fibre and bio-composite industry in Malaysia. The FIDEC was established in September 2006, as the focal point for information on pre-commercialisation activities, and to coordinate Research & Development exclusively for the bio-composite industry in Malaysia.

The Centre promotes collaboration between government and private sectors in the commercialisation of fibre and bio-composite products, through development of infrastructure, funding, technologies and product.

Malaysian Summary

The strengths include:

- A well strategized and targeted researched plan, which is providing pathways to high value products utilised for the aviation and defence force markets.
- Strong government and university support at the research level that supports a new fibre industry.
- An understanding of components of the value chain which need direct support mechanisms to improve outcomes.
- A strong collaboration of other countries that improve pathways to a successful fibre industry.
- A strong focus that supports a new industry from the production system to the end products.

Weaknesses include:

- Current production levels of fibre crops are below sustainable standards.
- Lack of scale at the production level is contributing to the high cost of production.
- Lack of mechanisation is contributing to the high cost of production.

Opportunities include:

- The fibre industry needs to mechanise the production, product handling and processing systems.
- Investigate opportunities that would guarantee separated fibre feedstock supplies that support high end value production.
- Malaysia has a central location to export end products to other Asian countries.

Threats include:

- Need to improve agronomic results to support the Malaysian high-end value products developed.
- Inability to produce viable planting seed due to climate limitations.
- Low productivity results of fibre crops need to be addressed.

Conclusion

It is important to understand the focus different countries set to develop new opportunities in agriculture and the flow-on effects of this to the processing and manufacture of products. Countries like Brazil and specifically its sugar industry demonstrates a desire to diversify and add value where possible.

The Brazilian government is committed to the long-term sustainability of this industry. 25 years ago, the Brazilian sugar industry was smaller than the Australian sugar industry; today, the Brazilian sugar industry is 32 times the size of the Australian sugar industry.

Government intervention that incentivises progress towards specific targets does provide pathways to commercialisation. Without this vision and understanding, governments like the Australian government, are missing opportunities that agriculture can provide. The limiting factor for any nation is the availability of land; Australia has an abundance of land.

Food security seems to be the challenge moving towards 2050, and a forecasted nine billion people to feed. A number of Nuffield Scholars believe this could be achieved through innovation, improved farming methods and technology.

The Brazilian sugar industry, especially in the Sao Martinho mill region, are utilising best-practice farming methods, and have a well-diversified agribusiness approach which provides real threats to Australia as a competitor, when compared to the Australian sugar industry and especially Mackay Sugar. Lower costs of production and many more product lines will provide real sustainability for the Brazilian industry. This situation should encourage Australian producers to urgently improve their industry performance and level of management.

While fibre crops have the ability to add value to the Australian sugar industry, and provide new opportunities, research needs to be undertaken to understand the limiting factors. The processing system for fibre is one of the limiting factors; current separation processes are utilising a dry separation process. This process, at world best, is separating five tonnes per hour. In a commercial operation separated fibres are the feed-stock for a large number of products. However, maintaining a good supply of separated fibres becomes the limiting factor. The challenge of maintaining production of fibre crops to meet current markets is also a limiting factor, as competition with higher value crops for land normally overrides the production of fibre crops, which tend to show low margins.

If the Australian sugar industry embraced fibre crops in a cropping system in rotation with sugar cane, then the competition for land could be reduced significantly. Fibre crop's cropping cycle fits extremely well with sugar cane. This fit enables current infrastructure to be utilised more efficiently (such as sugar milling equipment, cane transport systems and cane harvesting equipment). The utilisation of current infrastructure provides a huge benefit when introducing a new cropping option such as fibre crops and the efficiencies required making it successful.

While legumes are also an excellent rotation crop for sugarcane they will not add-value to all sectors of the sugar industry; growing, harvesting and milling sectors all benefit from the introduction of fibre crops. Engagement of all sectors could provide a real competitive strength for the Australian sugar industry. Figure 29 below shows that fibre crops could be grown in periods separate from sugar production, and so could utilise the same infrastructure, also shown in Figures 30-32.

<table>
<tr><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>June</th><th>July</th><th>Aug</th><th>Sept</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td colspan="3"></td><td colspan="2">Fibre Harvest</td><td colspan="7">Sugar Cane harvest</td></tr>
<tr><td colspan="2"></td><td colspan="6">Sugar cane planting</td><td colspan="3">Fibre Planting</td><td></td></tr>
<tr><td colspan="3">Wet Season</td><td colspan="7"></td><td colspan="2">Wet season</td></tr>
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Figure 28: Synergies between sugar cane and Fibre crops

Figure 29: Current cane harvesting equipment harvesting Kenaf

Figure 30: Cane rail transport system could be utilised to transport harvested fibre crops to sugar mills

Figure 31: Permanent bed controlled-traffic farming system allows for transition from sugar cane to fibre in a rotation. (Sunn Hemp and Kenaf)

The Australian sugar industry is shrinking and must not be complacent when it comes to understand why this contraction is happening. In summary, the important drivers of this contraction are:

- Productivity is down by 9% in the last five years (Central region). Australia is ranked nine as a world producer of sugar.
- Available land is down by 7% in the last ten years (Central region).
- The industry is a single commodity producer (crystal sugar) with a volatile world price. It needs to target more diversity in its products. Enterprise scale is limited – there are too many small farms.
- Industry demographics – the production system is divided into multiple sectors, such as growing, harvesting and milling, which are difficult to co-ordinate.
- There is a lack of targeted research.

The points show our industry has many challenges which need to be overcome if we are to prosper and be sustainable into the future. While our industry exports 85 percent of the commodity that it produces, its mainstream income relies on a volatile world price, fluctuating currency and the whims of supply and demand markets.

The Australian sugar industry is a high-cost producer, with little support from the Australian government in maintaining inputs such as water and electricity and is a target of increased levels of red tape. Foreign ownership of more than 75% of the sugar milling in Australia also adds another layer of complexity which must be addressed.

One of the many strengths of the Australian sugar industry is that it is highly mechanised and has engineering excellence in whatever the industry puts its mind to. The sugar industry is renowned for developing efficient mechanical solutions in the growing, harvesting, and milling sectors.

Adding value from a waste stream e.g. the co-generation of electricity from bagasse (the fibrous material left after the crushing process), is an excellent diversification.

The strategy the sugar industry must adopt is to control the whole value chain, by taking a paddock to plate approach to forward planning.

Diversifications like ethanol, paper and alcohol are real opportunities and must be researched thoroughly before moving forward. However, if these products are produced in Australia and consumed in Australia then these diversifications have a high chance of being successful. Some of the waste streams of these products also have opportunities; an example of this is the waste from an ethanol process, dunder, which is a potassium source. Potassium is an important macro nutrient in the production of sugar cane. As with the Brazilian industry, the Australian industry must develop the flexibility to move from crystal sugar to fuel (ethanol) in response to product price. This flexibility is a huge strength and will protect the industry's bottom line.

Fibre crops can add value to the Australian sugar industry; one of the unique opportunities being that they can add value to all three sectors of the industry. It is widely believed that fibre crops will compete with sugar cane; on the contrary fibre crops can improve sugar cane production.

Sunn Hemp is a legume which can fix large amounts of organic nitrogen (300kg/ha), is root knot nematode resistant, its tap roots can break compacted soil layers, it produces large amounts of bio-mass (22tonnes DM /ha), , is an excellent germinator and can perform in a dry profile. All these aspects improve soil health, which then addresses cane productivity.

Fibre is a feedstock for many applications; its high tensile strength and light weight material makes it an attractive alternative to fossil based non-renewable materials.

The availability of fibre as a feedstock in commercial quantities is a limiting factor all around the world. A real opportunity exists if large amounts of separated fibre can be reliably produced and supplied to manufacturers.

The current dry separation process is also a limiting factor to producing commercial quantities of industrial fibres. A recommendation is for research to investigate sugar mill components to separate fibre in a wet separation process.

The sugar industry has the potential to utilise current infrastructure in the growing, harvesting and transport sectors. The adoption of targeted research to investigate high rates of fibre separation in the milling operation could provide solutions that would revolutionise one of the main limiting factors to a sustainable fibre industry.

Recommendations

- A supply chain issue for the fibre industry is its current processing system. Dry separation of bast and hurd has limitations for maintaining high volumes of industrial quality fibre and core. Germany demonstrated a separation capacity of five tonnes per hour, which is insufficient to provide commercial quantities of separated fibres and core.

- A recommendation from this report is to investigate the opportunity of a wet separation process, which means that the fibre crop is harvested fresh, the separation of bast and hurd being conducted in this raw state. The author believes that this process is the way forward and has the opportunity to address the supply chain issue meeting commercial requirements needed to be sustainable.

- Sugar cane is processed at better than 600 tons per hour, where the objective is to extract the juice from the sugar cane billets. Stages of this process have been tested to separate bast from hurd in the fibre plant. The challenge is to research the feasibility of this concept for this process and then develop the concept into a pilot mill which will enable testing fibre quality and separation capacity.

- While investigating markets of fibre products and understanding market forces of supply and demand, one considerable factor which has a significant impact on marketability and direction are government incentives.

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NKTB: National Kenaf and Tobacco Board (Malaysia)

Plain English Compendium Summary

Project Title:	Can Fibre crops add value to the Australian sugar Industry?
Nuffield Australia Project No.:	1305
Scholar:	Joseph Muscat
Organisation:	Sugar Research and Development Corporation, now Sugar Research Australia. 50 Meiers Road, Indooroopilly Qld 4068
Phone:	0429 377 162
Email:	josephm@jcsenterprises.com.au
Objectives	• *Is there a sense of urgency to add value to the Australian sugar industry?* • *Can current world markets sustain a fibre industry and a pathway to commercialisation for Australia?* • *Are the synergies between sugar cane and fibre crops complementary to each other?* • *What are limiting factors that impede on the processing of fibre crop?*
Background	More than a decade of researching fibre crops in rotation with sugar cane has demonstrated the ability to produce these crops to world standards. However, while the production system is impressive, the pathways taking these fibre products to commercialisation are non-existent.
Research	There are many product lines that can be produced utilising fibre crops. High end value products for the aviation industry, defence force, automotive industry and pharmaceutical requirements are being developed, creating great interest all around the world. Fibre crops are a renewable resource which meets an environmentally sustainable cropping option. Understanding the limiting factors that could impede the pathway to commercialisation, such as a dry separation process needs further investigation, research and development.
Outcomes	This paper demonstrates the endless list of products that are derived from fibre plants; it also identifies the limiting factors that impede the commercialisation pathways required to be sustainable. It also provides an insight into the current situation of the sugar industry and identifies concerns that effect the future viability of the sugar industry. It is imperative that as an industry we identify ways that will add value; a fibre cropping option is one that certainly has the potential to significantly add value.
Implications	The sugar industry first needs to strategically recognise the need to add value to provide long term sustainability for its stakeholders. Agri-business success revolves around taking the raw commodity, understanding all aspects of the value chain for that commodity, and then identifying where value can be added. Once identified, the concepts need to be well researched and modelled before being implemented.
Publications	Nuffield conference (Tasmania) Soil health symposium (Mackay), Reef Catchments forum (Townsville) Next Gen conference (Cairns), ABARES Outlook Conference (Rockhampton).