Alternative Hay Crops for the Australian Hay Industry

Thinking outside the square

A report for

by BRYCE RIDDELL

2012 Nuffield Scholar

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Executive Summary

According to the United Nations, the world's population is estimated to increase to 9.6 billion by the year 2050. With this population increase and subsequent growth in demand, Australia's agricultural production and exports are sure to increase. One sector that is set to grow is the export hay industry, as all ruminant animals require grass or hay for digestion, and in most cases the most cost effective form is hay. This is the case of many Asian countries and Middle Eastern countries with large populations, with sizeable dairy or feedlot industries. Domestic consumption of fodder can be greater than local supply; therefore the balance of the fodder requirements needs to be imported.

In Northern Victorian cropping areas, the common crops grown for hay are oaten hay, lucerne hay, vetch hay and pasture hay. These types of hay all have specific places in which they fit into in order to help fill the feed gap of livestock and dairy producers, as well as equine and export markets. In the 2011/2012 Australian hay season, over 605,000 tonnes of hay, and 75,000 tonnes of wheat straw were exported from Australia, with the majority coming from Victoria, South Australia and Western Australia (Australian Fodder Industry Association, 2013). The major destinations for this hay and straw are Japan, South Korea, Taiwan and now also China.

This report aims to inform hay producers and other farmers of the size and potential of the hay industry, where new and existing markets lie, and what alternative crops could be produced to access these markets.

Contents

Foreword

The hay and fodder industry is a multimillion-dollar sector for Australian agriculture. It has in the past been viewed as part of either a cropping program, or as part of a grazing enterprise, and rarely as its own stand-alone industry. This though, is a common misconception, as it has and does have the potential and flexibility to achieve both.

Our family first started growing hay in the late 1980's, approximately 50km's north east of the Melbourne central business district (CBD), in a town called Yarra Glen. It was here that we produced mainly two-tie small bales and round bales. From there, we progressed into hay densification with the purchase of a mobile hay cuber. However, with paddock or field produced cubes, quality is dictated largely by the weather conditions on the day, and therefore consistent quality was difficult to maintain. This then led to us building a stationary cubing plant, where baled hay would be stockpiled at the plant to be processed into cubes. This was the direction that cubing was moving towards in the United States of America (US), as conventional large square hay balers had a far greater field through put than a mobile cuber.

With our stationary cubing plant now having a greater capacity than the amount of quality hay that could be produced and sourced in the area, we moved our operation to the Northern Victorian town of Yarrawonga, as the area was known as a safe crop growing region, coupled with having well established irrigation networks for producing lucerne hay throughout the summer period. We continue to farm hay and run cattle in Yarrawonga, as well as operate our cubing plant, which now supplies both the domestic Australian market and export markets overseas.

As the southern Australian hay industry has grown and achieved much with oaten hay, lucerne (alfalfa) hay, vetch hay and pasture hay (predominantly consisting of rye grass and clover), I feel with the addition of new crops will come new opportunities, both with niche markets and also high volume export and domestic markets. Furthermore, alternative crops would have the ability to spread the potential weather risk during harvest season, with different maturing times/dates, so that we are all not looking at the sky at the same time!

This Nuffield report is aimed at investigating these opportunities, as well as highlighting some of the best management practices for alternative crops that may possibly be produced in southern Australia, where these new crops may fit into current farming programs, as well as what market demand there is for them; both domestically and overseas.

My Nuffield journey has taken me further than I could have possibly imagined, with my research taking me to the U.S., Canada, Mexico, the United Arab Emirates, Saudi Arabia, Japan, China, the Philippines, Singapore, England, Ireland, France, Belgium and the Netherlands. None of this would have been possible without the support and generous sponsorship of Rural Finance Corporation and Nuffield Australia.

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Abbreviations

AFIA	Australian Fodder Industry Association
AUD$	Australian Dollar
ADF	Acid Detergent Fibre
A.R.G.T	Annual Ryegrass toxicity
D.A.F.F	Australian Government Department of Agriculture, Fisheries and Forestry
GCC	Gulf Cooperation Council
MAFF	Japanese Government Ministry of Agriculture, Forestry and Fisheries
MRL	Maximum Residue Limit
NDF	Neutral Detergent Fibre
NHA	National Hay Association (U.S)
P.N.W	Pacific North West, United States
P.S.W.	Pacific South West, United States
U.A.E	The United Arab Emirates
U.S	The United States of America
USD$	United States Dollars
TMR	Total Mixed Ration
SAA	Spotted Alfalfa Aphid
BGA	Blue Green Aphid

Technical terms

Lucerne Alfalfa

Objectives

The Australian hay and fodder industry can be separated into two industries; one supplying domestic demand, and the other supplying export market needs. Both markets though have the ability to overlap with supply and also demand. The situation in winter 2013 for southern Australia was that hay which was produced for export markets being released back onto the domestic market, due to the previous summer being abnormally dry which set the scene for a domestic shortfall in southern areas. However, in alternative years, surplus domestic tonnages can then flow over to the export markets.

This report aims to achieve the following outcomes by researching:

- What markets there are for hay currently produced in Australia?
- Who are the main hay exporting countries in the world?
- What are the hay crops that are exported from other countries?
- Is there potential to grow these crops in Australia?
- Where is all this hay going, and why?
- Is there a potential perennial crop that could fit into existing cropping programs for hay production?

To gain an understanding of these objectives, I toured the U.S and Canada, as well as Japan, Saudi Arabia and the U.A.E. During these overseas trips, I met with fellow farmers, researchers and importer/exporters.

This report is aimed at aiding hay, cropping and livestock operation in northern Victoria and southern Australia.

Introduction

World markets

The Australian hay and fodder industry produces over 4.5 million tonnes of hay annually (AFIA, 2013) (Figure 1). The domestic dairy industry accounts for just over 60% of the hay demand within Australia, with exported hay and straw making up over another 10% of this demand (AFIA, 2013). Australia's geographical location places it in prime position to supply international customers throughout Asia in the North American off-season.

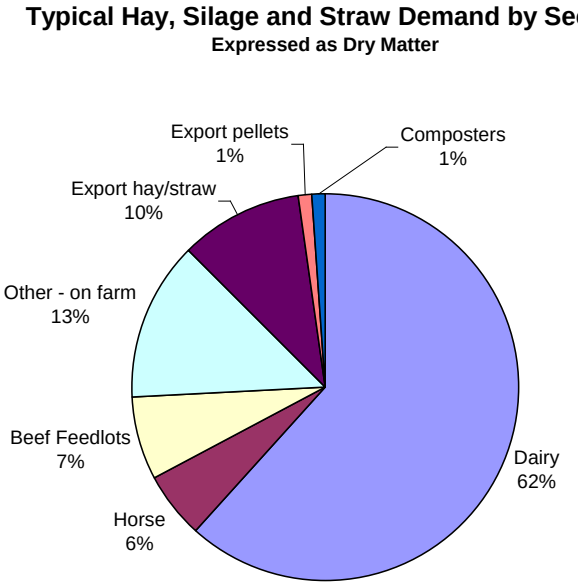

Figure 1. Australian fodder demand by industry 2013 (Source AFIA, 2013)

Since the early 1990's, the major crop grown in Australia for export has been oats (Avena sativa) or oaten hay, with over 60% of the 600,000+ tonnes of oaten hay produced annually for the export market destined for the Japanese market (Figure 2). Although smaller, South Korea and Taiwan are strong markets also.

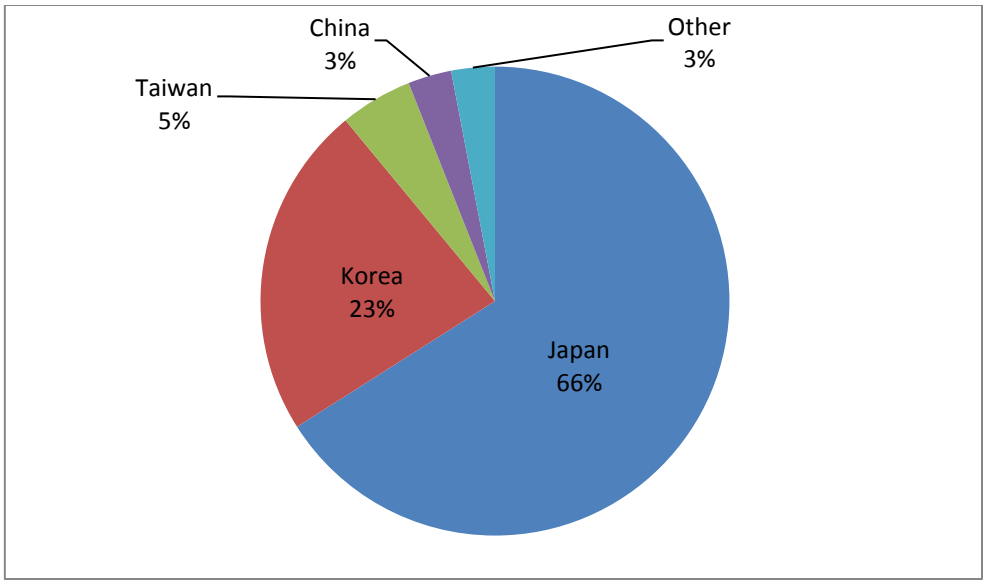

Figure 2. Australian export oaten hay market share by country 2013 (Source AFIA. 2013)

The international market for Australian oaten hay has a strong correlation to Sudan hay crop from the U.S, which starts in early June in the Imperial Valley in California, and continues all the way through September. Other major crops also supplying export demand are alfalfa and timothy.

The hay industry, like all other agricultural industries, has risks associated with it as well. In the hay season of 2011/2012, the majority of oaten hay crops in northern Victoria sustained such severe rain damage that, for some crops, it was more cost effective to burn the windrows rather than baling. Therefore, if there were alternative dryland crops to oaten hay, both annual and/or perennial and with different maturing dates, this would enable a larger harvest window and enable a greater spread of production risk.

As with any new crop, there are hurdles that must be met and overcome such as the use of on-label chemicals for these crops; if a new crop is adaptive to regional climatic conditions, if the

crop can be grown under dry land conditions, or if irrigation is essential to grow or finish the crop. The growing conditions for these crops in other countries will be researched in this report.

In order to gain an appreciation and understanding of alternative crops that can be produced, the west coast of the United States were studied - both the Pacific North West (PNW) and Pacific South West (PSW) regions - including California, Utah, Nevada, Oregon, Washington State, Idaho and Arizona.

Of these Western states, the major hay growing areas were studied and visited, and locally produced crops were assessed. These crops include, but are not limited to, Timothy Grass (Phleum pretense L.), Sudan Grass (Sorghum bicolor L.), Klein Grass (Panicum coloratum L.), Bermuda Grass (Cynodon dactylon L.), Orchard grass (Dactylis glomerata L.), Teff Grass (Eragrostis tef), and also alfalfa, even though it is widely cultivated in Australia as lucerne.

Although some of the above listed species are already used in Australia, varieties that are suitable for hay may not be commonly grown.

Utilizing the advantages of alternative crops in some farming operations is a way that weather risks can be reduced, as most of these plants have slightly different maturing times, and this maturing date flexibility has the advantage to better spread the use of hay harvesting equipment.

The list of crops that were studied have been tried and proven in haying operations in the PNW and PSW, or are currently in the process of being trialled. These crops are intended as only an

alternative option for farmers in southern Australian areas, as trialled research is required for Australian adaption.

Current Australian hay markets

In Australia there are three markets for hay:

- Dairy.
- Beef and Lamb, other livestock.
- Equine.

Dairy

The Australian Dairy industry is the largest market for hay in southern Australia, with over 6,770 registered dairy farms milking in excess of 1,630,000 head of cows (Dairy Australia, 2013). Although the majority of Australian dairies are built on a pasture-based feed system, supplementary feeding of fodder (hay or silage) is common practice to fill seasonal feed gaps when pastures are dormant, out of season or over-stocked.

There are five main feeding systems with in the Australian dairy industry. These are made up of:

1. Pasture + other forages + low grain/concentrate feeding in bail.

(Grazed pasture + other forages + up to 1.0 tonne grain/concentrates fed in bail).

2. Pasture + other forages +moderate to high grain/concentrate feeding in bail.

(Grazed pasture + other forages +more than 1.0 tonne grain/concentrates fed in bail).

3. Pasture + partial mixed ration ± grain/concentrate feeding in bail.

(Pasture grazed for most or all of year + partial mixed ration on feed pad ± grain/concentrates fed in bail).

4. Hybrid system.

(Pasture grazed for less than nine months per year + partial mixed ration on feed pad ±

grain/concentrates fed in bail).

5. *Total Mixed Ration system.*

(Zero grazing. Cows housed and fed at all times.)

(Dairy Australia, 2010)

The stage of lactation a dairy herd is in will greatly influence what type of hay is used in the building of a ration.

Beef

Australia's national cattle herd stands at 28.5 million head (MLA, 2013). The demand by the beef industry is cyclic, and closely motivated by seasonal conditions. As the majority of cattle produced in Australia are pasture fed, price is a large factor when purchasing hay, with producers often opting to quit cattle when feed prices outweigh gains that will be achieved. Cattle producers mainly opt for large square bales and round bales.

Equine

There are estimated to be around 1.2 million horses in Australia with the majority of hay being consumed by horses being small square bales, as small square bales allow for ease of transport (RIRDC, 2006). There is also demand for larger bales, both round and square, where handling equipment is available.

Current Major Australian Hay Crops

The current crops that are used to produce hay in Southern Australia are;

Southern regions.

- Oaten hay, Export/ Domestic
- Lucerne hay, Export/ Domestic
- Vetch hay, Domestic
- Pasture hay, Domestic

The areas that these crops are predominantly grown in are those that are also used to produce wheat crops. With oaten hay now being a valuable rotation crop in many cropping programs.

Figure 3. Australian major export oaten hay production areas (Bryce Riddell, 2014)

Northern regions.

- Lab Lab, Domestic
- Rhodes grass, Domestic/ Export potential
- Cavalcade, Domestic

Common hay varieties in Southern Australia

Oats

Common Name: Oats

Scientific Name: Avena sativa

Growth regions: Oats will grow in rainfall zones of above 400mm;

Are adaptable to most soil types as long as they are well drained;

Commonly grown as a winter cereal for grain, hay, silage, or grazing.

Oats for oaten hay are now the major hay crop that is grown in southern Australia, with a large percentage going to export markets. The three largest states for export hay in Australia are Western Australia, South Australia and Victoria.

Oaten hay is now largely grown as a rotation within many cropping programs. When used in a cropping program, oaten hay can be a useful tool in combating glyphosate resistant ryegrass, as a large percentage of the seed bank is cut away in the haying process.

With the size of this export industry growing immensely over the last two decades, much research has gone into breeding oats. This has been in conjunction with the hay exporters Australian Exporters Company (AEXCO) and the National Oat-Breeding program. Much research and development has gone into breeding oat varieties that are extremely well suited to producing hay. These new varieties have been bred to meet certain characteristics for the export oaten hay market; this includes a finer stem diameter, more desirable digestibility with lower Acid Detergent Fibre (ADF), lower Neutral Detergent Fibre (NDF), and higher Digestible Dry

Matter (DDM). New varieties that are currently being bred have higher disease resistance as well.

When producing oats for hay, cutting time is critical to ensure a high quality product and cutting should take place at the watery ripe stage. When the oat plant is in this stage of growth, there is an excellent spread of nutrition throughout the entire crop. Also when growing oats for hay or export, care is needed to be taken on chemicals that are used, as importing countries such as Japan have strict chemical residue level tolerances, and use of some chemicals may hinder this. The visual appearance and palatability of a crop is just as important as the feed test analysis (RIRDC, 2006).

Lucerne

Common Name: Lucerne or alfalfa in North America

Scientific Name: Medicago sativa

Growth region: Lucerne is grown in all states of Australia and requires rainfall of above 250mm, with higher precipitation allowing for greater yields.

Lucerne is a perennial legume, grown widely across Southern Australia either for grazing, seed or hay production. Irrigation is most suited for hay production, as the plant is highly active in summer and multiple cuttings can be achieved with favourable conditions. It is highly adaptable to irrigation, with up to five cuttings of hay being achieved over the summer months in Northern Victoria.

In 1977, the majority of Australia's lucerne acres were greatly affected by pests known as Blue Green Aphid (BGA) and the Spotted Alfalfa Aphid (SAA) (Lattimore, 2008). Up until then, the main variety of lucerne being grown was the Hunter River variety, which had little resistance to the pest. This widespread damage to the industry was the main catalyst to the breeding of new varieties with better resistance.

When growing lucerne with irrigation, a more desirable plant can be grown for hay. Many customers will look for a high ratio of leaf to stem when purchasing lucerne hay - hay with finer stems, high leaf content and bright green colour being regarded as a higher grade. Colour is also a large determinant of hay grade, and the largest factor of reducing lucerne's colour in a windrow is moisture and sunlight. Heavy dew on cut hay can have a large affect on the overall colour. Reducing the number of days that cut hay is cured remains one of the largest challenges that hay producers face.

Vetch

Common Name: Vetch

Scientific Name: Vicia sativa

Growth regions: Vetch will grow well in rainfall zones above 300mm. It will grow in a range of soil types from sandy loams through to heavier clays of moderate fertility.

Vetch is an annual legume, which is grown in cropping rotations as an excellent break crop. In rotation practices it helps with managing cereal diseases and grass weeds. Vetch also has the

benefit of fixing atmospheric nitrogen back to the soil. As vetch seed has the ability to flow through most common seeding equipment, no additional machinery purchases are required.

Vetch crops that are harvested for hay have the ability to be high in protein and high in metabolisable energy, if conditions are conducive.

Also, vetch is well suited to being sown with a companion cereal crop such as oats. This combination has the potential to have extremely high dry matter yields, which are highly palatable and have a relatively high feed test. Vetch hay has become a favoured hay of the Australian dairy industry.

Pasture hay

Common names: Perennial ryegrass.

Annual ryegrass.

Variety of clovers.

Growth regions: Ryegrass will grow in rainfalls above 400mm. It is the most commonly grown pasture in temperate Australia.

There are two ryegrass plant types, tetraploids and diploids.Tetraploids have larger cells, leaves and seeds. They have good seedling vigour and establish quickly, producing early feed. They have slightly higher plant sugars and are more palatable than diploid types. They produce well under high input management systems. Diploids tiller well, have finer leaves and still yield well if conditions are unfavourable (DPI 2012).

Pasture mixes offer flexibility with both haying and grazing options.

Pasture hay is a sort-after feed in the equine industry, with a preference for small square bales.

Common hay varieties in Northern Australia

Rhodes grass

Common Name: Rhodes Grass

Scientific name: Chloris Gayana

Growth regions: Rhodes grass is highly adapted to areas receiving more than 500mm of rain per year, it spreads via runners and is highly drought tolerant. It has a high salt tolerance and also has the ability to be grazed heavily. It is highly responsive to nitrogen fertilizer.

Rhodes grass is grown widely in the Northern Territory and Queensland, with the majority of production coming from the areas with coastal weather patterns.

This hay has developed a market in the feeding and pre-feeding of live export cattle, as well as demand from stations.

Rhodes grass is also widely grown throughout the Middle East.

Lab Lab

Common Name: Lab Lab

Scientific name: Lablab purpureus

Lablab is grown in Northern areas of Australia that have an annual rainfall of 600 – 2500mm, with this mainly falling in the summer months. It has the potential to be a very high yielding crop.

Chapter 2: North American hay exporting countries

United States

The United States is the largest hay exporting country in the world, accounting for over half of all the hay and fodder tonnages imported into Japan, the largest hay importing country, as shown in the table below.

Fodder Item	CY2006	CY2007	CY2008	CY2009	CY2010	CY2011	CY2012	CY2013 (1-6)
US Alfalfa Hay	456,968	422,178	429,289	435,162	455,673	454,656	432,456	218,550
US Timothy	222,744	233,015	243,686	268,677	311,227	308,512	437,257	198,202
Can Timothy	289,831	271,538	191,841	155,469	121,489	97,163	156,857	78,522
Aus Oaten Hay	538,300	364,867	426,945	468,140	483,561	434,574	384,451	192,306
US Sudan Hay	309,477	356,315	347,825	287,825	293,186	311,765	330,818	166,708
US Rye Grass Straw	281,081	214,370	181,967	194,771	167,479	213,929	206,478	99,503
US Fescue Straw	106,303	90,405	80,918	82,552	76,321	89,284	73,060	31,185
US Bermuda Hay & Straw	106,927	138,569	95,146	70,126	81,987	93,788	69,543	41,282
Chinese Rice Straw	1,010	23,748	161,562	199,060	172,538	213,549	200,922	35,418
Others	123,384	142,439	121,203	99,995	95,353	105,545	110,100	60,006
Total	2,436,025	2,257,444	2,280,382	2,261,777	2,258,814	2,322,765	2,401,942	1,121,682

Table 1: Japanese yearly forage import volumes (Source Balco 2013)

The largest two hay types being alfalfa (lucerne) and timothy grass hay and the third largest export hay being Sudan grass hay.

The majority of all export hay out of the U.S originates from the west coast states of the Pacific Northwest (PNW) and the Pacific Southwest (PSW), with the PNW consisting of Washington (WA), Oregon (OR), and Idaho (ID). The PSW consists of California (CA), Nevada (NV), Utah (UT) and Arizona (AZ). These areas are shown in Figures 4 and 5 below.

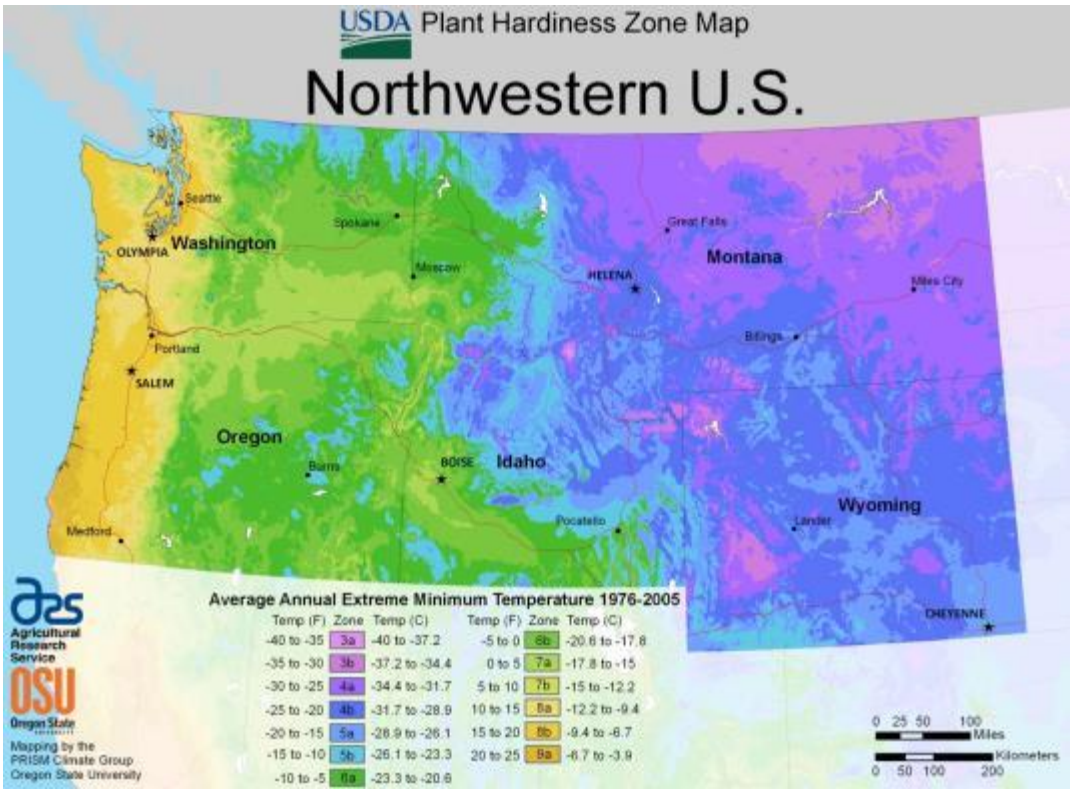

Figure 4, Pacific North West, United States (Source USDA 2005)

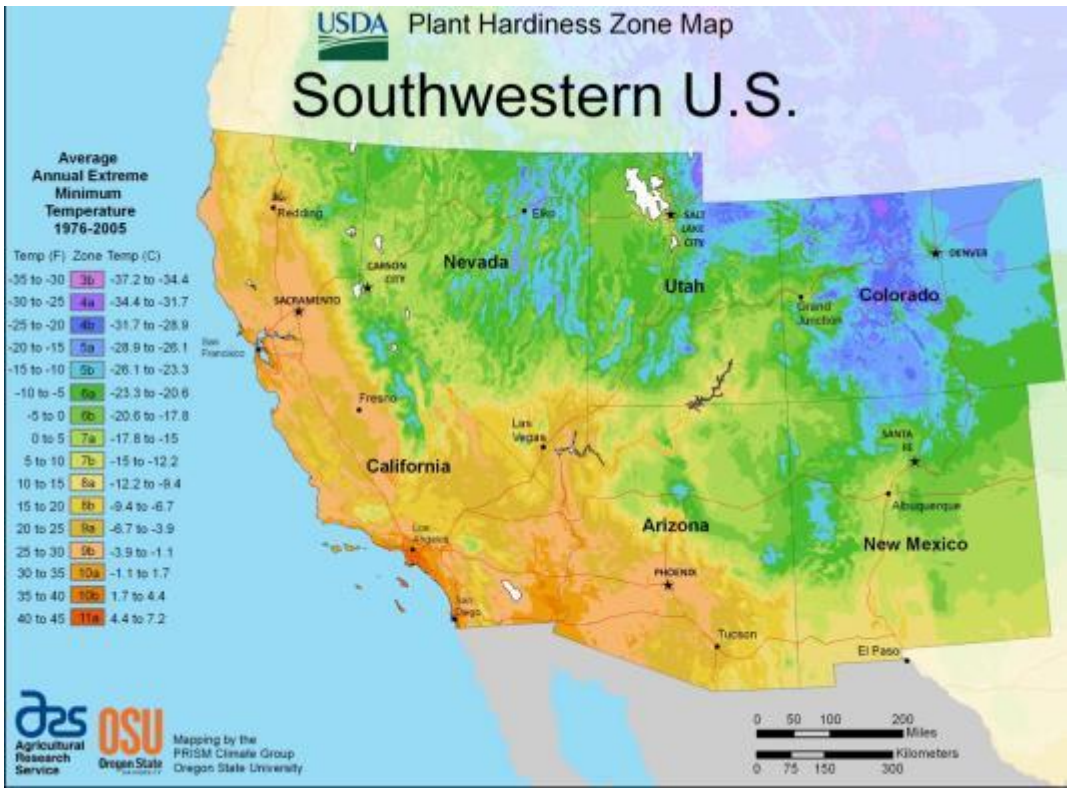

Figure 5, Pacific South West, United States (Source USDA 2005)

In order to have a successful export hay industry, there are several important factors that are required:

- Proximity to port
- Surplus-shipping containers
- Presence of a hay industry
- Ability to compress/densify hay by either cubing, double compressing or pelletising
- Ability to adhere to quarantine protocols
- Suitable climate
- Ability to transport finished product/shipping container efficiently and cost effectively
- A purchasing market.

Since the start of the export hay industry in the 1970's, most hay exporting processors, both hay double compressors and hay cubers, have been based in rural hay growing areas. (The history of the export hay industry will be explored in greater detail in following chapters).

As the majority of processors have evolved from being hay growers themselves or hay traders, many of the facilities that were built have been on farm or in rural industrial areas, with processed hay then being transported to ports already compressed and packed in shipping containers. However, in recent years with the rapid expansion of the export industry, there have been a number of hay processing facilities established inside major cities, such as Los Angeles.

By working with hay growers, and customising bale sizes to fit into dry-van semi trailers, back loads have enabled hay to be transported with no weather risk and reduced costs in transporting hay back to the city areas for processing.

Inside the Los Angeles port zone, there are now four major hay processors operating within the ports heavy zone, with this number destined to increase. California can be divided into four main hay-growing areas, figure 6

- Northern.
- Central.
- San Joaquin.
- Southern.

Figure 6: Californian agricultural regions (Source: California Irrigation Management Information Systems, 2014)

The Imperial Valley in the Southern zone is the largest export hay producing area in California. It is renowned for its hot desert climate and abundant irrigation water, provided by the All American Canal. The Imperial Valley's hot days and drying winds produce an optimal environment for growing and also curing hay. The bright, almost fluorescent colour of hay produced in the area was observed, and this was in part due to the climate for reducing the number of days that were required to cure hay to baling moisture levels.

The major crops of the Imperial Valley comprise of alfalfa hay and Sudan grass production, as well as other hay crops such as Bermuda grass and Klein grass. In 2011, over 1,736 million tonnes of hay was produced in the region (Imperial County Farm Bureau, 2011). The Imperial Valley has a total of the 537,098 irrigated agricultural acres (217,448 ha) in the Imperial Irrigation District,

- 28.9% or 155,355 acres (62,896 ha) are used for growing alfalfa hay,
- 12.0% or 64,457 acres (26,095 ha) for growing Sudan grass,
- 9.7% or 52,114 acres (21,098 ha) for growing Bermuda grass,
- 2.8% or 14,778 acres (5,982 ha) for growing Klein grass,

(Imperial Irrigation District 2012)

It is not uncommon for producers in the Imperial Valley to achieve 8-9 cuttings of alfalfa throughout a season. This accounts for approximately 17% of California's total alfalfa production with a large percentage of this hay going to local export hay processors as well as to Californian dairies (Putnam, Summers & Orloff, 2007).

Imperial Valley Hay Harvest Schedule

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Alfalfa hay										
Sudan grass hay										
Klein grass hay										
Bermuda grass hay										

Table 2. Imperial Valley hay harvest schedule

****Shaded areas represent harvest periods. (Bryce Riddell, 2014)***

Figure 7: Alfalfa hay Imperial Valley, CA (Bryce Riddell. 2012.)

The Willamette Valley of Northern Oregon is one of the largest producers of export grass straw. This has evolved as a complimentary industry from residue of the grass seed industry in the Valley. The Willamette Valley's grass seed industry is estimated to be worth $228 million per year (Oregon State University, 2010). The Willamette Valley is where the majority of the 200,000+ tonnes of exported U.S grass straw originates.

Oregon Hay Harvest schedule

	May	June	July	Aug	Sept	Oct
Alfalfa hay						
Timothy hay						
Oaten hay						
Sudan hay						

Table 3 The harvest season in Oregon: *Shaded areas represent harvest periods (Bryce Riddell, 2013)

Figure 8. Rye grass straw bales, Salem, Oregon (Bryce Riddell, 2012)

Figure 9. Grass seed harvest, Salem, Oregon (Bryce Riddell, 2012)

The Columbia Basin and the Kittitas Valley in Washington State are two of the many hay-growing areas in the state. They are known as some of the finest hay producing areas in the

U.S., with the Kittitas Valley being regarded as the finest quality timothy hay due to their elevation and cool summers, and drying wind from the near-by Cascade Mountains.

Figure 10. Timothy grass seed heads, Ellensburg, Washington State (Bryce Riddell. 2012)

Figure 11. Timothy grass field, Ellensburg, WA. Timothy grass (Bryce Riddell, 2012)

Timothy grass has been heavily grown in the Kittitas Valley since the establishment of the export hay industry in the 1970's.

The Columbia Basin accounts for 30.5% of all hay grown in Washington State, with the major hay crops being produced including alfalfa, timothy grass, orchard grass, oaten hay, and more recently teff grass (Washington State Hay Growers Association, 2006). The seaports that service the hay exports out of Washington State are the ports of Seattle and Tacoma.

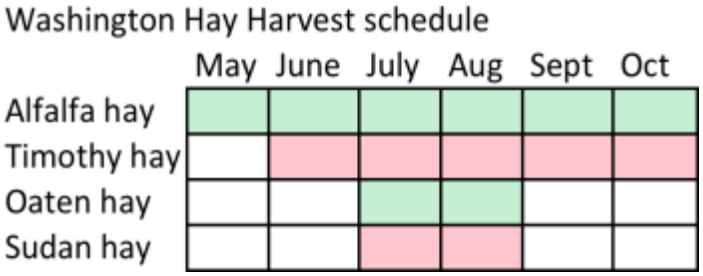

Table 4. Washington State hay harvest schedule * Shaded area represents harvest period (Bryce Riddell 2013)

Common hay crops grown in the PNW and PSW:

Sudan grass

Scientific name Sorghum bicolour (L.)

Sudan grass is a tall growing annual, warm season grass. It is largely grown in the Imperial Valley of southern California. sudan grass is a large competitor of Australian grown oaten hay in supplying Asian dairy and lot-feeders rations.

The desired characteristics of a first grade sudan grass hay are to be bright green in colour, with fine stem size, soft in feel and a high leaf to stem ratio. Precautions need to be taken when producing Sudan hay, as lethal levels of prussic acid can be present if the plant has been stressed, or suffered frost damage. Sudan grass has a large demand for water when it is grown in the Imperial Valley, and has been examined to perform better with flood irrigation, as opposed to spray irrigation.

Figure 12. Sudan grass hay. Imperial Valley (Bryce Riddell, 2012)

Alfalfa, also called Lucerne in Australia

Scientific name Medicago sativa

Often called “the Queen of forage crops”. Alfalfa is the third most valuable crop grown in the U.S, after corn and soy beans (University of California Alfalfa and Forages, 2005). Due to Alfalfa's potential for high yields and also its high energy feed values, it is the single most important plant grown for hay.

Alfalfa is grown widely throughout the PNW and PSW, with the largest market being the domestic dairy industry, followed by lot-feeders, exporters and the equine industry. It is most common that pure stands of Alfalfa will be planted when irrigation is available.

Figure 13. Raking Alfalfa hay, Imperial Valley, CA (Bryce Riddell, 2012)

Figure 14: Alfalfa field, Blyth, California. (Bryce Riddell. 2012)

Timothy grass

Scientific name *Phleum pretense*

"It's the Cadillac of hay"

"There is no hay that you can grow for the same bang for buck"

(Hay Processor, personal communication, 28 July, 2012)

Timothy grass hay is the most desired exported hay crop on the market, whether its demand from Asian dairies, through to the most affluent racing horse and camel racing stables from Asia to the Middle east. It is the second largest exported hay variety after Alfalfa.

Timothy is a cool season perennial grass that produces high quality forage, known to be one of the most highly palatable and digestible hays for horses. Timothy grass produces long cylindrical seed heads. These long seed heads indicate to Japanese hay purchasers that the hay has had a good growing season. When hay is being sold to exporters, long seed heads are highly sought after.

As Timothy grass requires long cool days to achieve substantial yields, it is often found growing in higher elevation areas of the PNW, such as Ellensburg, the Columbia Basin and Spokane areas of Washington State, refer to maps above (figure 4). Also, the inter-mountainous areas of Oregon.

It is also widely grown throughout Canada, with a large export industry operating in Alberta. It has been grown for many decades, and since the 1970's for the export trade.

Figure 15 & 16. Timothy grass, Eureka, NV and Ellensburg, WA (Bryce Riddell, 2012.)

Klein grass

Scientific name Panicum coloratum

Klein grass is now a major forage crop grown in the Imperial Valley of Southern California. It is known as a relatively easy crop to grow and will thrive under moist soil conditions. Klein grass has now established a market with export dairy and feedlot rations, as well as a market for domestic feedlots for lower grades of hay.

When grading Klein hay, a deep green colour and soft texture are desired, with no weed contamination. Klein grass has, however, been known to be toxic to sheep and also horses, due to levels of saponins.

Bermuda grass

Scientific name *Cynodon dactylon*

Bermuda grass hay is also another now common crop in the Imperial Valley, and California more widely. It was originally grown in the Imperial Valley for seed, with hay and straw only being produced when seed was not conducive. Bermuda hay has now become a favourite in the

domestic equine industry, which has greatly influenced the size bale it is commonly produced in - a small 3 tie bale, ranging in weight from 35 – 45 kg per bale.

Figure 17. Bermuda grass, Blyth, CA (Bryce Riddell, 2012)

Figure 18. Bermuda grass, Blyth, CA (Bryce Riddell, 2012)

Teff grass

Scientific name *Eragrostis tef*

Teff grass is a new forage crop to the PNW and the PSW, and to a lesser extent Australia. Teff is a highly summer active grass, that can tolerate mild moisture stress. It has a very fine but

hardy seed. Currently, it does not have a substantial export market. However, it has found a niche as a palatable hay for horses, with similar feed quality as second cut Timothy grass.

Teff is known to be highly digestible, due to its common lower water-soluble carbohydrates, makes Teff hay suitable for horses suffering laminitis. It is known to respond well to nitrogen fertilizer.

Figure 19: Newly planted Teff grass, Pasco, WA (Bryce Riddell, 2012)

Potential for cultivation in Australia

Potential to grow the above listed crops in Australia requires careful consideration of climate, both minimum and maximum temperature, frost risks, both first and last frost of the season. Further considerations are whether rainfall will be sufficient, or if application of irrigation is required.

Careful consideration must be taken in to respect the viability to produce the aforementioned crops, as it was observed that most crops that were grown in a region had been tried and had adapted to the conditions, which is why some crops are present in one area and not in another. Can they be economically and competitively produced in our environment?

Case studies trialling the use of these hay species in Australia

Case study: Teff grass

Teff grass was trialled at Mulwala, NSW, in the summer of 2012 by Bryce Riddell and Lochie Donald. It was sown into warm soils, as it was sown late in November. No nitrogen was applied as the paddock had previously been sown to Lucerne. The Teff produced two cuttings of hay, with some being sold to dairy farmers, and some for the equine industry.

Figure 20. Mulwala, NSW. Teff grass (Bryce Riddell, 2012)

The growing of Teff grass was successful. However as there was very limited understanding of this new hay type by customers, this imposed limitations to the marketing of the hay. This limitation may only be a short lived deterrent, as if production had continued into second and possibly third years, a greater understanding may have been achieved by customers, thus increasing demand.

Chapter 3: Foreign export hay markets

Currently Australia exports over 600,000 metric tonnes of hay per year (AFIA, 2013). The U.S exported over 3 million tonnes of hay worldwide in 2013 (University of California, 2013). The countries that purchase this hay use it for both dairy and livestock production, as well as for the equine and also camel industries. Japan has long been the largest purchaser of exported hay, with South Korea positioned as the second largest market, as well as new markets emerging such as the U.A.E and China.

These markets will be researched more in depth below.

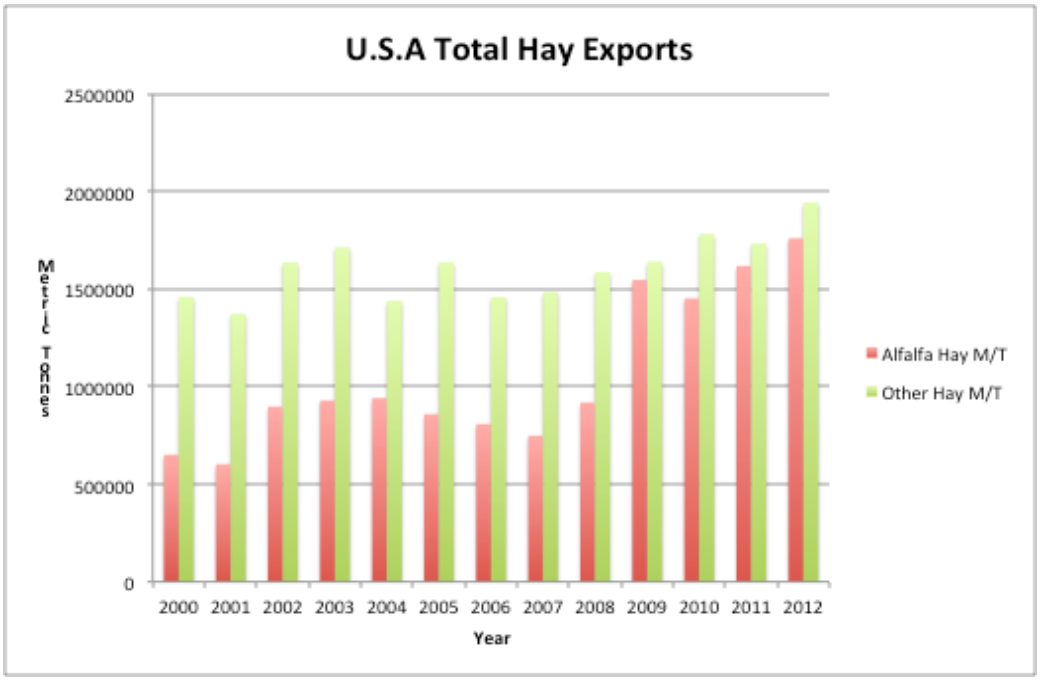

Figure 21. United States export hay volumes (Source Anderson Hay and Grain, US Census Bureau, Foreign Trade. 2012)

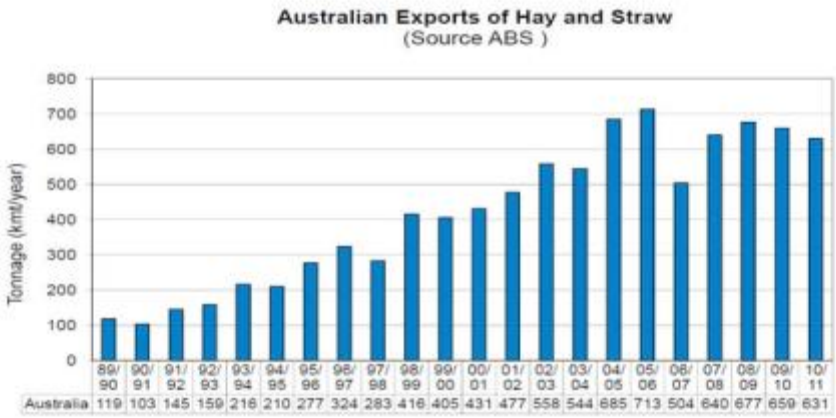

Figure 22. Australian export hay volumes (Source AFIA., 2013)

The increases and decreases in yearly export tonnages can be influenced by such events as currency exchange rates, drought or seasonal influences in the production season, also trade restrictions due to seasonal quarantine risks.

Japan

Japan was the first market to emerge as an export hay destination in the early 1970's, first with the importing of Alfalfa hay cubes for the growing dairy industry, then with the importing of double compressed Timothy for racehorses, which then progressed to also being supplied to the dairy and beef industries. Now, much of the imported feed is in the form of double compressed bales, with cubes now making up a smaller percentage of the 2.4 million tonnes of imported fodder. A large percentage of imported hay and cubes goes to feed mills to produce Total Mixed Rations (TMRs), as well as long stem hays going to dairies for direct feeding. The north island of Japan, Hokkaido, is the largest producer of dairy in Japan, and accounts for 51.9% of milk production (Japan Dairy Council, 2012).

A high percentage of dairy farms in Japan are family run, with the average number of cows per farm in 2012 being 70 (Japan Dairy Council 2012).

Japanese dairy farmers have a preference for Timothy hay, as it has been grown in Japan throughout the main island Honshu and also Hokkaido. It is therefore considered a safe feed in many farmers' eyes.

Figure 23 & 24. Japanese dairy farm (Bryce Riddell, 2012)

South Korea

South Korea is the second largest market for exported hay. This industry has grown rapidly since hay first began being shipped in the 1980's, when only 1% of forage used was from imported hay, and in 2007 22% of forage was imported (USDA, 2013). Korea imports large quantities of Alfalfa hay, as well as Sudan grass and Australian Oaten hay.

China

China has emerged as a very significant hay importer of Australian oaten hay since early 2012. The establishment of many large-scale corporate mega dairies has driven this increase in hay imports. It is forecast that this growth will continue, as the government School Milk of China Programme continues, along with more education of the importance of dairy products.

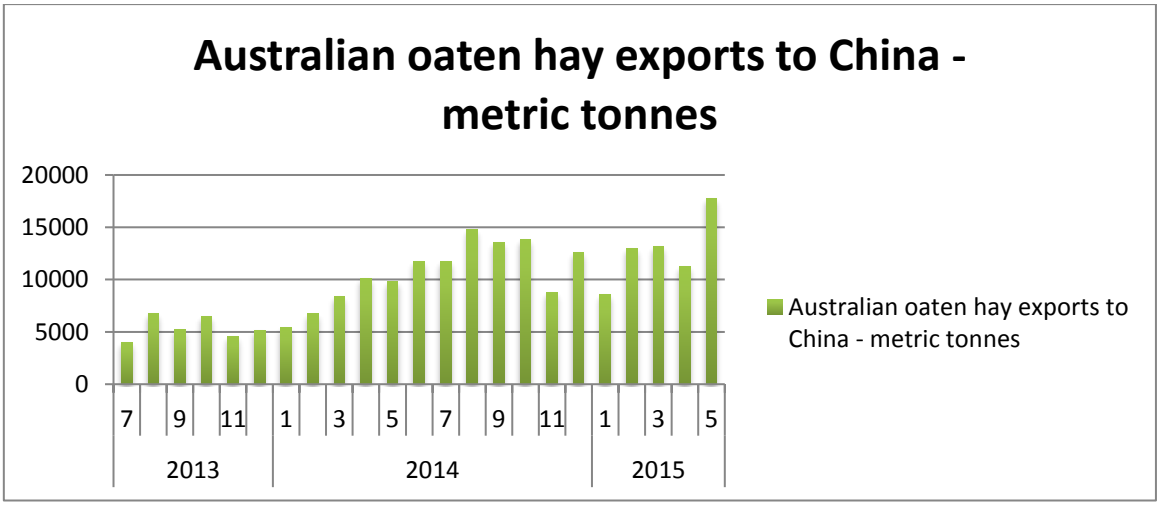

Figure 25, Australian oaten hay exports to China (Source AFIA, 2015)

United Arab Emirates (U.A.E)

The U.A.E has emerged as a major hay importing country since the early 2000's. Much of this increase can be attributed to the growing number of large-scale dairies for domestic food security. Many of these large-scale farms have an average heard number of 1000 cows. Hay and forage is also imported for use in local farms.

As there are limited amounts of irrigation for agriculture, and also government policies in place to further reduce water use in agriculture, the U.A.E is set to continue growing as a major hay importing country.

Figure 26. Equine facility, U.A.E (Bryce Riddell, 2013)

Figure 27. Hay distribution centre, U.A.E (Bryce Riddell, 2012)

Chapter 4: Methods of compressing hay

There are two main methods of compressing hay that maintain a high fibre level; the first being cubing, and the second being double compressing. Double compressing is now the main method that is used for export hay. The first shipment of hay to be double compressed was from Ellensburg, in Washington State, in the early 1970's. This first shipment of hay that was compressed was Timothy hay from Anderson Hay and Grain (Morris, 2010).

The first quantities of compressed hay were destined for the Japanese horse racing industry. This came about as Anderson Hay and Grain and had been shipping premium Kittitas Valley Timothy grass to Lexington, Kentucky, for racehorses. It was there that a group of Japanese racehorse owners first saw the quality of the hay that was being sent to Kentucky. It was not long before this hay had been traced back to Anderson Hay and Grain, where an order for 200 tonnes was placed for delivery to Japan. This would have required 16 or 17 forty-foot shipping containers to accommodate the order, with the cost of 17 containers to Japan for that amount of hay it would have been very cost-prohibitive.

However, AHG had been working with an Oregon based engineering company to develop a method of compressing hay to ship to Alaska and Hawaii. This was the method that was used in reducing the number of shipping containers required for the first shipment. (Morris, 2010. Since then, many advances have been made to compressing equipment, both in the speed at which the hay can be processed and also to the level of compression that can be achieved, with many modern double compressors having capacity to process over 20 tonnes of hay per hour, and also compress to a ratio of approximately 1:3 of the original volume of hay.

The standard size of a double compressed bale is approximately 25-30 kgs, and now also with a trend of bales that exceed 500kg. These larger size bales are accommodating the needs of larger farms in importing countries.

Figure 28. Compressed bales, Imperial Valley (Bryce Riddell, 2012)

Figure 29. Cubing plant, Yarrawonga, Victoria (Bryce Riddell, 2013)

Figure 30. Hay compress facility, Salem, OR. (Bryce Riddell, 2013)

Figure 31. Compressed bales, Imperial Valley (Bryce Riddell, 2012)

Conclusion

Although not all the crops that are exported worldwide are grown in Australia, careful consideration must be given to why they are not grown.

In relation to new crop opportunities such as Teff grass, limited registered chemicals are available for use. This has a great limitation on its ability to be grown and managed as a weed and pest free crop.

Also in regards to export markets, there is resistance to import new hay varieties, as they may not be covered by the importing governments subsidy scheme (Saudi Arabia). Therefore preference will be given to hay varieties that are cost subsidised. In relation to China, only varieties of hay listed on the approved for import list, are allowed from certain countries, currently Australia only has approval to export oaten hay to China, with the United States also being restricted to only GMO free alfalfa. However, with current negotiations with free trade agreements, Australia may receive greater access to the Chinese market.

Many factors have to be negotiated when growing and producing new crop varieties, whether they are grass, legume or cereal species. For example, many timothy grass varieties require cool spring and summer conditions; for our warmer region this could be a critical issue, as without the right climate, the plant will become stressed extremely quickly.

Rhodes grass became a crop of great interest, as it is moderately salt tolerant, is a perennial grass, newly developed varieties are frost tolerant and it is also very responsive to any summer

rain fall. It is also a hay variety that many Middle Eastern countries are familiar with. Countries such as the U.A.E have cut back subsidies to grow local Rhodes grass hay, and, therefore, have created a void in the market, which could be filled if export quality Rhodes grass hay could be adapted, and then grown and produced on a commercial scale.

Recommendations

If Australia is to capture future world demand for our hay, a focus on quality needs to be maintained, along with an effort to establish alternative crops that can help extend the seasonal harvest window.

If alternative crops can be established, it would not only aid in the flexibility or cropping rotations, it would also have the ability to gain better usage of the equipment needed to produce quality hay.

It is also necessary to work with government and relevant association bodies to lobby for greater market access into developing markets, such as the acceptance of other cereal hays, straw and grass hays into markets such as China.

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Plain English Compendium Summary

Project Title:	Alternative hay crops for the Australian hay industry

Nuffield Australia Project No.:	1212
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Objectives

To investigate and research the domestic and export hay industries in Australia.

To realise the opportunities to produce alternative to hay crops to those that are currently produced in Australia.

Background

The export hay industry in Australia was established in the 1980's.

Hay is often thought of as a locally produced and consumed commodity, however, the global export hay industry at large is responsible for feeding millions of dairy cows, along with other livestock throughout Asia and the Middle East.

Research

Research used for this report includes the Nuffield Global Focus Program, along with research in China, Japan, the United States, Mexico and Canada.

Hay producers, exporters, researchers and importers were visited.

Outcomes

Upon reading this report, a greater knowledge and understanding of the global hay industry will be acquired, including which are the major export and importing countries of hay in the world, along with major crops that are cultivated for hay.

Also, what opportunity's lie in the development of alternative hay crops, for Southern Australian farmers.

Implications

There are many steps and processes that are involved in making an export transaction successful, with many of the companies involved having decades of experience, which has led to the development of strict quality control measures, both on the exporting side and the importing side.