An information paper on industrial hemp (industrial cannabis)

Disclaimer

The information in this paper is provided for general interest only. It is recommended that decisions about investing in the industrial hemp industry be based on information specific to one's personal circumstances, including financial position, risk profile, and experience. On a case by case basis, prospective growers need to consider issues such as farm location, size, topography, vegetation cover, soil type(s), and availability/cost/need for/of irrigation water.

Participation in the industry in Western Australia

A person wishing to participate in the industrial hemp industry in Western Australia needs to apply for a licence usually valid for three years and will be scrutinised to ensure that they are suitable and eligible to participate in the industry. Applicants are required to pay an application fee. Details of the application process can be sourced from www.agric.wa.gov.au/agwest/plantlabs . Assistance can be obtained by telephoning Mark Holland or Mike Davies, at AGWEST Plant Laboratories, Department of Agriculture and Food Western Australia (DAFWA) on 08 9368 3721.

Acknowledgements

This paper was prepared by Dr Jason Olsen with the assistance of Suzanne Kelly and Barry Underhill Queensland Department of Primary Industry and Forestry. It has been customised for use in WA by Mark Holland (Department of Agriculture and Food Western Australia) with the permission of the original authors.

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1. Introduction

Industrial hemp (*Cannabis sativa* L.) is also known as 'Indian hemp', 'cannabis' or 'hemp'. The plant has a long history and has been used for its bast (phloem) fibre in the stem, the multi-purpose fixed oil in the seeds (achenes), and an intoxicating resin secreted by epidermal glands (Small and Marcus 2002). Items manufactured from it include food, textiles, paper, rope, fuel, oil, stockfeed, medicine, and spiritual and recreational products. It is thought that *C. sativa* was one of the first plants to be cultivated, and there is general agreement that the plant species originated in China, where the greatest diversity of germplasm is found. According to Schultes (1970), *C. sativa* thrived in the manured soils around early settlements, which quickly led to its domestication.

Early in the 20th century, industrial hemp was considered to be an important and beneficial crop throughout the Western World. However, as a result of the development of synthetics and its classification by the Western world as a drug in the 1920-30s, the production of industrial hemp was confined to India, Bangladesh and Eastern Europe.

Since the late 1980s there has been a resurgence of interest in fibre products, arguably driven by the green movement with a view to saving trees by growing renewable non-wood fibres in place of clearing forests for paper and building materials. This interest has gained momentum and credibility with Japan, for instance, setting a target date of 2010 to have 10% of its paper production sourced from non-wood fibre sources. Furthermore, the European Union (EU) has stipulated to its member countries that 95% of the components of each car produced by 2015 must be recyclable. The voluntary use by automotive manufacturers of natural fibres, including industrial hemp, suggests that demand for natural fibres will continue to increase. Market segmentation for ethically produced goods, and growing support for biodegradable and natural products has led to a wide range of new industrial hemp products being developed.

Whereas opportunities exist for industrial hemp, other fibre crops such as kenaf (*Hibiscus cannabinus* L.) may also play a significant role in meeting this demand. For a time, hemp was promoted as the ultimate crop requiring no pesticides, no fertiliser and no irrigation, as well as being a panacea for soil-borne disease. Clearly, however, these claims do not reflect reality and a far more pragmatic view of the crop is now emerging. Indeed, data from the FAO (2002) show that worldwide production of industrial hemp has steadily decreased since the 1970s.

The legalisation of growing industrial hemp in some Australian states in recent years is recognition by government and the general community that industrial hemp may make a useful contribution to the economy as an alternative agricultural crop and that the crop can be grown under conditions that do not compromise law and order. Because there is no national policy for the crop, only ad hoc experimental trials and small-scale production have ensued. Licensing systems to allow for the commercial production of industrial hemp were first developed in Tasmania from 1991/92 and later in Victoria from 1997. Interest in the crop has declined in these states in recent years due to uncertainties about financial returns, marketing, and regulation. In Queensland licensed production of industrial hemp crops was proclaimed in September 2002. In Western Australia, the Industrial Hemp Act was proclaimed in May 2004 to facilitate the commercial production of fibre and seed from industrial hemp crops. Field trials have been conducted in NSW each year since 1995 and changes to the legislation in that state are now being sought with the view to commercialisation of the industry. It appears that Governments in South Australia and the Northern Territory are not proceeding to legislate for the commercial development of the industry.

The objective of this paper is to provide information on a broad range of topics relating to the industrial hemp industry. Of particular interest are the issues that may affect the development of the industry in the Western Australia context. As stated by Fletcher *et al*. (1995), industrial hemp has a large casual or devotional following because of its 'green' image and its products seem to be almost self-promoting. The main difficulty is determining which information is factual and which information is of a promotional nature.

2. About the plant

2.1 Morphology and anatomy

C. sativa is a tall, herbaceous annual plant with a deep tap root which grows to a height of up to 5 metres, depending on variety and growing conditions. The basic morphological features of the plant are shown in **Fig. 1**. The stem is usually single and slender (4 to 20 mm diameter for mature plants) when grown at commercial crop densities (RIRDC 1995, p. 17). The stem tissues outside the vascular cambium are referred to as the bast (flexible inner phloem fibres of the bark) and contain the fibres useful for textiles (**Fig. 2**). The tissues inside the vascular cambium (inner woody core) contain the pith and the xylem vessels and are referred to as the hurd.

Fig. 1. Composite plate of *Cannabis sativa* by Elmer Smith. **1**. Flowering branch of male plant. **2**. Flowering branch of female plant. **3**. Seedling. **4**. Leaflet. **5**. Cluster of male flowers. **6**. Female flower, enclosed by perigonal bract. **7**. Mature fruit enclosed in perigonal bract. **8**. Seed (achene), showing wide face. **9**. Seed, showing narrow face. **10**. Stalked secretory gland. **11**. Top of sessile secretory gland. **12**. Long section of cystolith hair (note calcium carbonate concretion at base). (Source: Small and Marcus 2002).

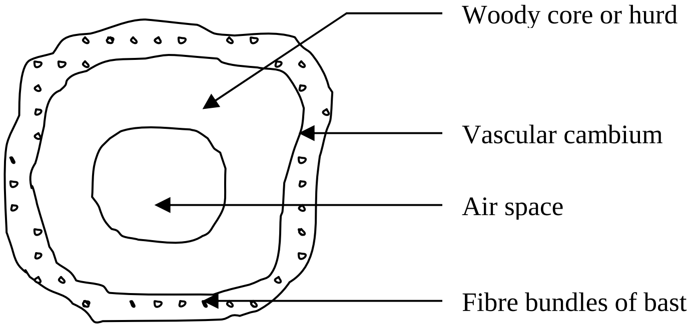

Fig. 2. Transverse section of the stem of a *Cannabis sativa* plant.

2.2 Dioecious versus monoecious

Industrial hemp is normally dioecious, meaning that the male and female flowers are borne on separate plants. Monoecious varieties, with separate male and female flowers on the same plant, have been bred and are widely cultivated throughout Europe. According to Wood (1997), monoecious varieties are reported to contain a proportion of dioecious plants, and also tend to have lower yields than do the dioecious varieties.

2.3 Difference between industrial hemp and marijuana – THC concentration

Tetrahydrocannabinol (THC) is the classified psycho-active (mind-altering) ingredient in *C. sativa* that is produced in specialised glands (glandular trichomes). These glands are found primarily in the flowers surrounding the seeds, and, to a lesser extent, on the leaf surface of the plant. No such glands are produced on or in the seeds. The difference between marijuana and industrial hemp is that the THC concentration is significantly lower in industrial hemp than it is in marijuana. However, since seed is borne in the flowers which have a large number of glandular trichomes, traces of THC can cling to the seed hulls through the flower head's sticky resin. The concentration of THC varies according to environmental influences (such as oxygen, light, moisture, and temperature) and genetic factors.

It is generally accepted that industrial hemp plants are those *C. sativa* plants with a concentration of THC less than 3%. The United States National Institute of Drug Abuse notes that most ordinary marijuana has an average THC concentration of 3%. Much of the illicit cultivated *C. sativa* has a much higher THC concentration than 3%. For example, sinsemal, also known as skunk, has a typical THC concentration range from 7.5 to 24%, although plants with a concentration higher than this range are also known to occur.

3. Products and markets

Traditionally, products made from industrial hemp fibre included rope and cordage, sailcloth, carpet backing, canvas, and apparel (such as the original Levi jeans made from hemp denim). Recent investigations have revealed that contemporary uses of industrial hemp may include reinforcing fibre for paper, fibre-reinforced plastics, fibreboards, geotextiles, textile fabrics (apparel and industrial), animal bedding, kitty litter, industrial absorbent products, and insulation. Many uses for the oil and seed have been developed or are under investigation, including animal stockfeed, soap, oil, paint and varnish, and cosmetics.

In the EU, cultivation of industrial hemp is more heavily weighted towards fibre than towards oilseed, with the production of about 27,000 tonnes of fibre versus only about 6,200 tonnes of seed in 1999 (Karus *et al*. 2000, cited Small and Marcus 2002). Conversely, the oilseed industry is the primary focus in Canada in recent years, with the breeding of new varieties and the development of improved technology for growing, harvesting and processing.

Some of the products into which industrial hemp plants can be or are being made are listed below, and, where appropriate, mention is made of present markets or future market possibilities.

3.1 Textiles

The history of textile production is rich and varied, with some 2,000 plant species having been processed into fibre at one time or other (Graham 1995). Today, based on world production of fibre in 1999, 54.5% was synthetic (of which 60% was polyester), 42.9% was plant-based (of which 79% was cotton), and 2.6% was wool (Karus 2000, cited Small and Marcus 2002). In terms of plant fibre production other than cotton, flax is the only significant plant fibre crop and held 2.7% of the world plant fibre market. Only 0.3% of the world plant fibre production was derived from industrial hemp in 1999

For industrial hemp, the most desirable long fibres for textiles are found in the stem near the phloem tissue in the bast. Unlike flax, industrial hemp long fibre requires retting for preparation of high quality spinnable fibres for the production of fine textiles. Steam explosion is a technology that has been experimentally applied to industrial hemp (Garcia-Jaldon *et al.* 1998). Using this technology, decorticated crude fibre is subjected to pressurised steam at high temperature to explode (separate) the fibres, resulting in hemp fibres that are thinner than those obtained from water retting. Small and Marcus (2002) viewed the refinement of equipment and new technologies as offering one possibility of making fine textile production from industrial hemp in developed countries, but noted that at present, China controls this market, and probably will remain dominant for the foreseeable future. Indeed, in the absence of the development of new technologies, Small and Marcus (2002) considered that the concentration of spinning facilities and extraction technology in China, in addition to cheap labour, were major impediments for the production of industrial hemp fabrics outside of that country.

3.2 Pulp and paper

The pulp and paper industry is currently based on wood fibre. Although industrial hemp fibre has been considered for use in pulp, it has only been used on an experimental basis (Small and Marcus 2002). Since virgin wood pulp is required for added strength in the recycling of paper, the long fibres of industrial hemp could make paper produced from hemp fibre at least two times more recyclable than paper produced from wood fibre.
Specialty pulp products made from industrial hemp, including cigarette paper, bank notes, technical filters, hygiene products, art paper, and tea bags, are believed to offer a highly stable, highly-priced niche market in Europe, where industrial hemp has an 87% market share of that sector (Karus *et al*. 2000, cited Small and Marcus 2002).

3.3 Plastic composites for the automobile and other manufacturing sectors

Fibres may be introduced into plastics to improve their physical properties, such as stiffness, impact resistance, bending and tensile strength (Bolton 1995). Although manufactured fibres of glass and carbon are most commonly used, plant fibres offer considerable cost savings along with comparable strength properties. In the EU, natural fibres are used in the moulded composites of automobiles to reinforce door panels, passenger rear decks, trunk linings, and pillars. In 1999, over 20,000 tonnes of natural fibre was used for these purposes in Europe, including about 2,000 tonnes of industrial hemp (Small and Marcus 2002). It has been estimated that 5 to 10 kg of natural fibres can be used in the moulded portions of an average automobile (excluding upholstery). According to Karus *et al*. (2000; cited Small and Marcus 2002), the demand for automobile applications of industrial hemp is expected to increase considerably, but is dependant on the development of new technologies.

3.4 Building construction products

Small and Marcus (2002) stated that the market for thermal insulation products in Europe is growing fast due to the high cost of heating fuels, ecological concerns about conservation of non-renewable resources, and political-strategic concerns about dependence on current sources of oil. According to Karus *et al.* (2000, cited Small and Marcus 2002), it has been predicted that tens of thousands of tonnes of thermal insulation products (composed of industrial hemp and flax) will be sold in the five year period from 2000 to 2005.

Industrial hemp fibres added to concrete increase tensile strength and reduce shrinkage and cracking. Fibre from industrial hemp is produced at a much higher cost than that from wood chips or straw from other crops. Given the greater strength of industrial hemp fibre than fibre from wood chips or straw, industrial hemp fibre may be more appropriately used in building materials requiring a high tensile strength.

3.5 Animal bedding/ industrial absorbent products

Animal bedding products made from the hurd (inner woody core of the stem) of industrial hemp plants can absorb up to five times their weight in moisture, do not produce dust, and are easily composted. The high absorbency of hemp hurd has also led to its occasional use as an absorbent for oil and waste spill cleanup. Small and Marcus (2002) attest that because hemp hurd is costly to produce (and animal bedding is a higher value use than industrial absorbent products), it is likely that animal bedding will remain the most important application of this product.

3.6 Geotextiles

Geotextiles include ground-retaining, biodegradable matting designed to prevent soil erosion, especially to stabilise new plantings while they develop root systems along steep highway banks to prevent soil slippage, or ground covers designed to reduce weeds in planting beds. The economic viability of using industrial hemp for geotextile applications is yet to be determined. However the relatively high cost structure would suggest that it may be difficult for industrial hemp to penetrate this market.

3.7 Stockfeed

Expression of oil from the seed of industrial hemp plants leaves behind a protein-rich, oil-poor seed cake, also referred to as ‘seed meal’. This seed meal has proven to be an excellent source of nutrition for animals (Mustafa *et al*. 1999), and does not contain THC, which is present in the leaves and flowering heads of industrial hemp plants.

Because THC is a fat-soluble compound and is known to occur in the milk of animals consuming feed that contains THC, there is the possibility that this compound may also reach the fat of stock which may be grazed on industrial hemp plants. In the absence of substantive information regarding residues in animals and animal products following consumption of industrial hemp the feeding of industrial hemp crops or crop residues and by-products to livestock should be avoided. Additionally, no animal or animal product should be permitted to leave a property where that animal has had access to the leaves, flowering heads or stems of industrial hemp plants.

3.8 Food in the human diet

Industrial hemp is not an approved food product in Australia. On 24 May 2002, the Australia New Zealand Food Standards Council (FSC) (Food Regulation Secretariat 2002) rejected an application for the inclusion of industrial hemp seed and oil in novel food. The FSC is comprised of health ministers from each Australian state and the heads of the Australian and New Zealand governments. The decision was taken despite the recommendation by Food Standards Australia New Zealand (FSANZ, formerly ANZFA) that the total prohibition on the use of *Cannabis* spp. in food be removed (FSANZ 2002). The rationale for the decision by the Ministers of FSC was that there were law enforcement issues, particularly from a policing perspective, where it was perceived that there would be difficulties in distinguishing between high THC and low THC products. The Ministers of FSC also believed that the use of industrial hemp in food may send a confused message to consumers about the acceptability and safety of *C. sativa*.

Despite the restriction in Australia, about half of the world market for oil extracted from industrial hemp seed is currently used for food and food supplements (de Guzman 2001). In North America, many of the products from the seed are incorporated into food preparations such as snack bars, bread, pretzels, biscuits, yoghurts, pancakes, porridge, ice cream, pasta, pizza, salad dressings, mayonnaise and beverages (Small and Marcus 2002). Such foods currently have a niche market, based particularly on natural food and specialty food outlets.

3.9 Personal care products

In the 1990s, European firms introduced lines of hemp oil-based personal care products, including soaps, shampoos, bubble baths, and perfumes. According to Small and Marcus (2002), hemp oil is now marketed throughout the world in a range of body care products, including creams, lotions, moisturisers, and lip balms. In Germany, laundry detergent manufactured entirely from hemp oil has been marketed. Hemp-based cosmetics and personal care products account for about one-half of the world market for hemp oil (de Guszman 2001). Of the approximate one billion US dollars in gross sales that is reported annually by The Body Shop, about 4% of sales in 2000 were hemp products.

4. Production trends

The information relating to the size of the international market for industrial hemp is not complete and in some cases is not reliable (Fletcher *et al*. 1995). Official data (FAO 2002) of worldwide area harvested (**Fig. 2**) and total production (**Fig. 3**) show that the industry has declined substantially over the past 30 years. Sources other than FAO indicate that areas of industrial hemp harvested are usually greater than those published by the FAO. This discrepancy illustrates the problems that confound any attempt to characterise the international market for those crops that are currently of lesser importance in western industrialised nations (Fletcher *et al*. 1995). Reliable and current information for such crops is often difficult to find. Nevertheless, the declining trend in world-wide production is unequivocal, regardless of the method used to determine it.

Currently, the counties growing the greatest areas of industrial hemp are India, China, the Russian Federation and North Korea. Countries with significant production (e.g. over 1,000 hectares) include Romania, France, Hungary, Yugoslavia, Poland, the Ukraine, Chile, and Pakistan (Fletcher *et al*. 1995).

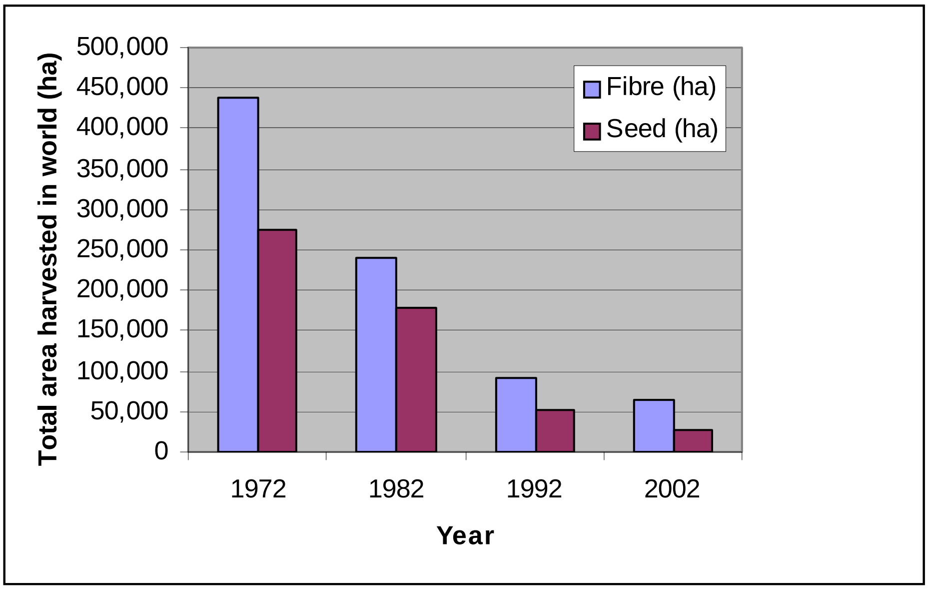

Fig. 2. Total worldwide area of industrial hemp harvested for fibre and for seed since 1972 (FAO 2002).

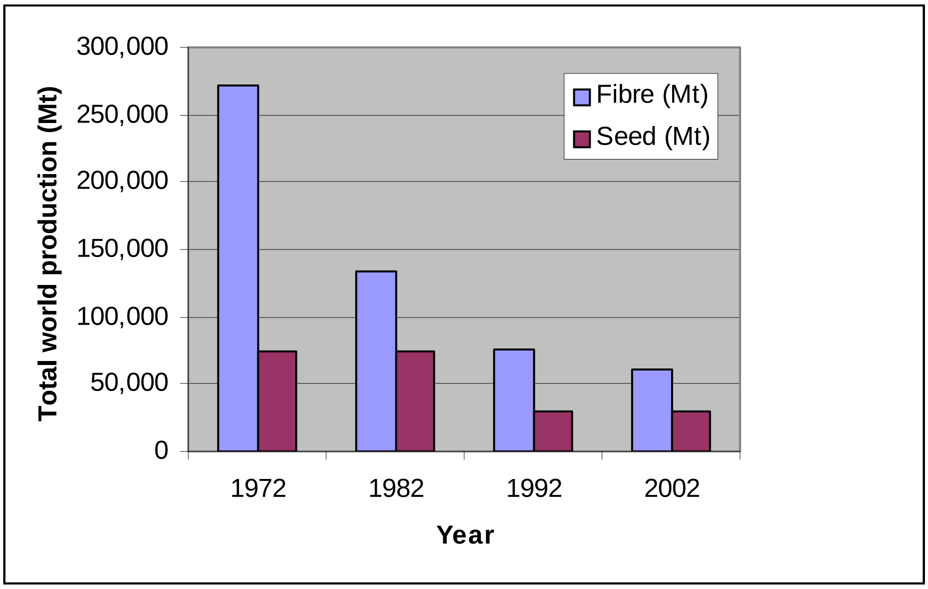

Fig. 3. Total worldwide production of fibre and seed harvested from industrial hemp crops since 1972 (FAO 2002).

5. Issues

Several authors have noted many of the issues confronting the industrial hemp industry in Australia (e.g. RIRDC 1995; Fitzgerald 1995; Wood 1997; Spurway and Trounce 2003). In general, these issues include the need for more research, financial/ economic considerations, a lack of processing infrastructure, a requirement to better assess market demand, and better access to markets.

5.1 Research

Research to develop varieties with low photoperiod sensitivity, reduced THC concentration, and a high yield of fine fibre is seen as a critical priority for the industrial hemp industry in Australia. Furthermore, research into optimum sowing times and densities, nutrient application rates, photoperiod response, susceptibility to pests and disease, the impacts of wind and extremes in soil moisture, the ability of the crop to act as a weed suppressant, yield and quality of fibre produced, crop rotations and the opportunity cost of planting compared with other crops have also been seen as important. Many of these issues are being addressed in research programs conducted in Western Australia and elsewhere.

5.2 Financial/ economic

There are numerous issues that have been raised that would impact on the economic viability of the industrial hemp industry in Australia and enable it to be competitive on world markets. A major concern is competition from the EU and China, the major world producers of the crop. The EU has heavily subsidised production, and labour costs in China are only a fraction of those in Australia. Furthermore, products from other bast fibre species such as flax and kenaf suitable for the paper pulp and textile industries can compete with those from industrial hemp without the need for costly monitoring and inspection services.

5.3 Processing infrastructure

Many of the end uses of industrial hemp require separation of the bast and hurd fibres or the extraction of oil from seed. Separation of fibres or extraction of oil are primary stage processes that would require milling facilities to be located close to production areas to minimise the cost of transportation of the bulk material.

5.4 Market demand

Industrial hemp products have found a place in niche markets in the developed world and there is speculation of more opportunities in the future, with some industry proponents estimating the international market for bast fibre to increase from 100,000 tonnes in 1999 to over 20 million tonnes by 2050. The degree to which industrial hemp will fill this assumed market demand will depend on demonstrable proof that its products are of equal or superior quality to its competitors, at equal or reduced costs in adequate and consistently available amounts.

5.5 Access to markets

It has been estimated that approximately half of the world market for industrial hemp oil is currently for food and food supplements. The comparatively higher profitability of producing seed and oil for this market than of producing plant products for other markets has been suggested. Current prohibition in Australia and New Zealand of industrial hemp seed and oil in novel food denies access to this potentially lucrative market.

6. Gross margins/ likely profitability/ financial risk

Industrial hemp plants have been widely reported to produce high yields and to have a strong resistance to pest incursion. Such claims, if substantiated, augur positively for keeping costs down and profitability up. However, most gross margin analyses for industrial hemp include little or no consideration of the cost of necessary monitoring and inspection by regulatory staff, which, in Western Australia, can exceed $600 per crop annually under some circumstances. Furthermore, processing requires substantial capital investment that is usually not factored into analyses of industry profitability.

One of the major determinants of profitability is market price, or more important to the grower, the farm-gate price. Hitherto, such prices are not well defined, largely because markets are still being developed. Nevertheless, gross margin assessments have been made, and the reader needs to be cognisant of the estimates that are used, the assumptions made, and the data that are or are not included.

Several authors have highlighted the dearth of key information on the potential returns from industrial hemp production. For example, Fitzgerald (1995) expressed frustration with this fact, and stated that data on market prices, market size, and production costs were especially difficult to obtain. He stated that the industry in Australia had come about by a combination of ignorance and uncertainty, since the market demand was difficult to ascertain, more agronomic assessment was required, primary processing technologies were expensive and not suitable for anything other than a niche industry in Australia, current market prices were ‘spot prices’ which could not be used to determine economic rates of return for an expanded industry in the future, and any resurgence of industrial hemp production in Australia might alter significantly the world pricing structure and therefore have a substantial impact on returns.

The gross margin for the production of decorticated material for the dry geotextile market for feedstock for the paper pulp market was estimated by Graham (1995) to range from -$60/ hectare for a yield of 1 tonne dry stem/ hectare to $452/ hectare for a yield of 12 tonne dry stem/ hectare. The analysis assumed a fibre value of $300/ tonne, and did not include the cost of irrigation or inspection fees. For a straw price of $130/ tonne and input costs (excluding irrigation and inspection fees) of $360/ hectare, RIRDC (1995, p. 16) estimated a break-even yield of 2.8 tonne dry straw/ hectare.

Graham (1995) stated that it was clear that industrial hemp did not provide a gross margin comparable with many current crops within potential growing regions. It was assumed that market penetration would be difficult for all paper pulp types with the exception of those suited to specialty papers. For both the paper pulp and textile markets, Graham (1995) concluded that production of high quality bast fibre was an expensive and difficult process and would not be feasible unless by-product markets were secured.

A study by Australian Hemp Resource and Manufacture (1997), now called Ecofibre Industries Limited (EIL) provided a far more favourable assessment of the potential returns from growing industrial hemp. Using variable costs for producing dryland sorghum in Central Queensland as well as information from trials conducted in southern Australia and overseas, these authors estimated gross margins for industrial hemp for northern NSW and Queensland of $1,164 to $3,354/ hectare.

RIRDC (1995, p. 5) concluded that textile products offered the highest potential for value-adding to industrial hemp, but warned that suitable processing facilities for hemp textile production were not available in Australia. Because the domestic market for natural fibres was small and mostly supplied by the cotton and wool industries, both of which export the majority of production, it was believed that a viable industrial hemp industry would also need to export the majority of production. Furthermore, RIRDC (1995, p. 5) called into question the cost of processing industrial hemp compared with competing fibres, since the yield of high value fibre from harvested stems was relatively small at less than 1% by weight.

Using a competitive advantage method for identifying and valuing key features and issues for investment opportunities by institutions (the McKinsey Multifactor Matrix), Fitzgerald (1995) determined that the industrial hemp industry was high risk. However, some opportunities for specialist paper fabric and board production were identified.

Wood (1997) presented a SWOT (strengths, weaknesses, opportunities, threats) analysis of the commercial prospects for the development of an industrial hemp industry in Australia. He concluded that although there was considerable interest and public support for the development of a hemp industry in Australia, the demand for fibre was almost entirely from potential producers or conservationists, rather than from those involved in the processing or marketing.

In a review of the potential of industrial hemp products for industrial and commercial applications, Johnson (1999) concluded that seed and oil crops would produce the most economically viable products. Furthermore, she stated that the residual stems and fibres of the harvested crop could be utilised for a range of products, including paper, building materials, or biomass fuel. The current prohibition of industrial hemp seed and oil in novel food by the FSC (Food Regulation Secretariat 2002), despite a recommendation by FSANZ that the total prohibition on the use of low THC *C. sativa* in food be removed (FSANZ 2002), denies the industry access to this potentially lucrative market.

Assessments of the profitability of growing industrial hemp give widely varying accounts of likely financial performance. Opportunities in specific niche industries such as specialist paper fabric and board production have been identified. However, a lack of information and a view by some that the industry is high risk are issues that need to be considered carefully in the business plan of any potential participant.

7. Legislative frameworks/ industry development in Australia

Enthusiasm for an industrial hemp industry has grown in Australia in recent years. Legislative frameworks developed by some State Governments have given the industry the opportunity for broad-scale commercial production and/or for the development of research programs. Although there has been small-scale experimental production of industrial hemp under a permit system in most States in the last several years, no nation-wide policy has been developed for the crop. This lack of a coordinated national approach has led to a large number of ad hoc trials being conducted for a range of purposes, including variety assessment, machinery development, and the determination of better agronomic practices. One exception was a comparative trial in 2001/02 that was run concurrently at five sites (extending from Rockhampton to Hobart) to test the effects of latitude on six selected varieties (Spurway and Trounce 2003). Although methodology, such as the fact that dry matter production was determined during the various phases of the growth of the plants by progressive sampling, the results of the trial were not reported (Spurway and Trounce 2003).

7.1 Western Australia

7.1.1 A brief history of legislation

In December 2003, the Industrial Hemp Act 2003 was passed by Parliament, which allowed for the commercialisation of industrial hemp fibre and grain. Proclamation of the Act and publishing of Regulations occurred on 19 May 2004.

The legislation now allows for the research, production, processing, marketing, and trade of processed industrial cannabis fibre and seed products in Western Australia, with the exception of those products that could be smoked, administered or consumed.

7.1.2 An outline of legislative requirements

Only licensed or authorised persons are able to deal with *C. sativa* without committing an offence under the Misuse of Drugs Act in relation to trafficking in, supplying, producing, publishing or possessing instructions for producing and possessing *C. sativa.*

Industrial hemp inspectors are appointed under the Act to monitor the compliance of licensees with their licence. Inspectors have wide powers of entry.

A *licence*, among other things, enables a person to possess industrial cannabis plants and seed and to produce industrial cannabis plants from certified cannabis seed. An 'industrial cannabis plant' has been defined to mean a cannabis plant with a THC concentration in its leaves and flowering heads of not more than 0.35%. Industrial cannabis seed has been defined to mean cannabis seed harvested from an industrial cannabis plant or certified cannabis seed. 'Certified cannabis seed' has been defined to mean seed certified, in the way prescribed under a regulation that will produce cannabis plants with a THC concentration in their leaves and flowering heads of not more than 0.35%.

7.1.3 Eligibility to hold a licence

To be eligible to hold a grower licence, an applicant (if a corporation, its executive officers), must not have been convicted of a serious offence in the preceding 10 years and not be affected by bankruptcy action. A serious offence is defined in the legislation. The Registrar of the Industrial Hemp Act also has the power to determine the suitability of an applicant having regard to their character, honesty and integrity and the character of their close associates, their criminal history and whether they are capable of satisfactorily performing the activities of a licensee. Applicants for a licence are required to be assessed by the Western Australian Police Service.

7.1.4 Costs associated with licences, inspection, and monitoring

As set by regulation, an application for a licence must be accompanied by an application fee of \$300. For corporations, criminal history checks are required for each executive officer. After three years, a licensee has the option of renewing their licence for a further three-year period at a cost of \$120.

Participation in the industrial hemp industry is based on a user-pays principle. The legislation requires the licence-holder to pay the reasonable costs of compliance monitoring activities performed under the licence, including inspection and plant sampling fees and any laboratory analysis necessary to determine the concentration of THC in the leaves and flowering heads of cannabis plants in the possession of the licence holder. Licence-holders should expect to have their crops analysed for THC concentration. Where more than one variety of industrial hemp is grown, license-holders should expect to have each variety analysed for THC concentration. The cost of inspections is based on the time taken to conduct the inspection, as well as the travelling time of the inspector. Where repeat inspections are necessary due to non-compliant behaviour, the licensee is required to pay the full cost of these additional checks.

7.1.5 Enquiries about making application for a licence in Western Australia

In Western Australia, the AGWEST Plant Laboratories (APL) business unit of the Department of Agriculture is charged with the responsibility for administering the licensing scheme and for compliance monitoring inspection services. The Industrial Hemp Registrar within APL coordinates these activities. Information and advice about making application for a licence can be sourced by contacting the Registrar on 9368 3721.

7.2 Other states or territories

7.2.1 Victoria

Full commercialisation of the industrial hemp industry in Victoria has been possible since 1997, when the *Drugs, Poisons and Controlled Substances Act 1981* was amended to allow the production of low-THC cannabis for non-therapeutic use. The Act, administered by Victoria's Minister for Health and the Department of Human Services, allows for the possession, cultivation and selling of industrial hemp by authorised persons who meet strict criteria and undergo a police records check. Three-year-authorisations are issued by the Department of Primary Industries Victoria, and the Secretary of that department must be notified of changes in ownership of management of the business of the person. Authorisations are also subject to various terms, conditions, limitations and restrictions. Significant fees and charges apply.

Most of the permits that have been issued since 1997 were for less than one hectare, although one authorisation was approved for 30 hectares. According to Nowland (2002), the total area of industrial hemp planted in Victoria was less than 100 hectares per year. Various trials have been conducted – for example, field assessments conducted at five sites in 1996/97 showed a weight of stems (dried in the field) of cultivar Futura 77 of 5.3 to 12 tonnes/ hectare (Spurway and Trounce 2003). Interest in the industrial hemp industry in Victoria has declined significantly in recent years, with only two authorisations current for 2003/04 (pers. comm. Gary Darcy, DPI Victoria).

7.2.2 New South Wales

The Hemp Industry Bill 2008 passed through Parliament in late June 2008. The allowable upper limit for THC in commercial crops is set at 0.5%, with a tolerance to 1.0%. It is expected that a licensing system will be in place to allow commercial production by November 2008.

NSW Department of Primary Industry will administer and processes applications for hemp licences. Applicants meet all costs associated with commercial production. Trials conducted over the past 12 years have allowed the development of varieties particularly suited to the NSW environment and have produced crops which are yielding around 12 tonnes dry stems/ hectare. Highest yield have occurred in high rainfall areas in the north of the state and under irrigation in the MIA. Most of NSW is deemed to have insufficient summer rain for a dry-land crop to be an option.

The development of infrastructure and processing plant in NSW will begin after November, however it may take some time before NSW can be competitive in the national and international market place.

7.2.3 Tasmania

The Tasmanian Hemp Company based in southern Tasmania, was first licensed in 1991/92 to cultivate industrial hemp for commercial research purposes. Australian Hemp Research and Manufacture (AHRM), based in Queensland, commenced trials in Tasmania in the mid-1990s and was later joined by a newly formed group called the Tasmanian Hemp Growers' Cooperative. AHRM has now changed its name to Ecofibre Industries Limited (EIL).

Licences are granted by the Department of Health and Human Services in cooperation with Tasmania Police and the Department of Justice and Industrial Relations, in accordance with the provisions of the *Poisons Act 1971*, which is presently under review. There is provision for the licensing of processors, however, no large commercial processing facility exists in Tasmania to date. Cottage industry size manufacturing of specialty stationery products does occur.

Areas sown to industrial hemp between 1997 and 2002 have fluctuated from 2 to 40 hectares. For 2003/04, only 0.2 hectares was sown (pers. comm. Joe Horak, DPIWE Tasmania). Yields in Tasmania have been approximately 5 to 6 tonnes fibre/ hectare or 800 kg seed/ hectare (Nowland 2002).

Confidence in the Tasmanian industry has fluctuated dramatically over the years. This fluctuation appears to be dependent upon financial, marketing and regulatory variability, particularly due to recent decisions regarding hemp for food (pers. comm. Joe Horak, DPIWE Tasmania). DPIWE continues to process inquiries regarding the production of industrial hemp, although it is expected that a lack of processing facilities will continue to stymie development of the industry in the short term

7.2.4 Queensland

On 8 August 2002, the *Drugs Misuse Amendment Bill* was passed by Parliament, which allowed for the commercialisation of industrial hemp fibre and grain. Proclamation of the amendments to both the *Drugs Misuse Act 1986* and the *Drugs Misuse Regulation 1987* occurred on 27 September 2002.

The legislation now allows for the research, production, processing, marketing, and trade of processed industrial cannabis fibre and seed products in Queensland, with the exception of those products that could be smoked, administered or consumed.

Amendments to the *Drugs Misuse Act 1986* in 1998 provided for a trial period for controlled field trials and plant breeding research of fibre varieties, and 38 growers and three non-DPI&F researchers participated. Following proclamation of the amendments to both the Act and the Regulation in September 2002 which provided for commercialisation of the industry, approximately 60 hectares of industrial hemp were planted in the ensuing 2002/03 season. At the time of publishing this information paper, there are 38 growers licensed under the Act to produce industrial hemp plants, including two licensed researchers. These licensees are located at a number of districts throughout Queensland including the Wide Bay, Darling Downs, Atherton Tableland, Central Burnett, Mackay district, Cairns/ Innisfail districts, Moreton South, and Brisbane.

7.2.5 South Australia

Three trials to assess the growth of industrial hemp were licensed by the South Australian Government in the mid-1990’s (Nowland 2002). Irrigation trials conducted in the south east of the State in late spring demonstrated sufficient yield to promise a commercial potential, with subsequent testing required. Attempts to grow industrial hemp as a dryland winter sown crop on Yorke Peninsula and the Lower North failed. Spurway and Trounce (2003) subsequently reported that the trial program has recently been wound down due to low trial yields. While the current legislation in SA is restricted to allowing only research trials, Nowland (2002) reported that the South Australian Government sees little point in changing the law to make it easier to grow commercial crops until real commercial prospects can be demonstrated.

7.2.6 Northern Territory

At the present time, the Northern Territory Government is reported to have no intention of licensing any industrial hemp trials as it sees short day lengths as a major problem during the growing season (Nowland 2002). It was reported that kenaf is considered to be a better option than industrial hemp and a commercial proposition was encouraged from a South East Asian company to grow this rival crop for use in the paper industry. However, due to a lack of interested growers, the kenaf project is now on hold.

8. Yield

8.1 Fibre

Yields of dry stems harvested in trials at Biloela, Queensland, have typically ranged from 8 to 11 tonne/ hectare. The dry weight of stems of industrial hemp plants grown during the 2003 season in trials in the Mackay district ranged from 7.5 to 9.1 tonnes/ hectare, depending on variety and locality (pers. comm. Raylene Hansen, DPI&F). It is hoped that higher yields than these will be attained through breeding and biotechnology. Gaining access to germplasm from around the world will be essential to maintain a competitive edge and enhance new product development. An average crop of industrial hemp grown in France was reported by Fitzgerald (1995) to produce 6 to 8 tonnes stem (16% moisture)/ hectare. This yield would equate to a bast fibre yield of 2.1 to 2.8 tonnes/ hectare, assuming an average 35 to 40% bast in each stem. According to Nowland (2002), 40 trials of industrial hemp in NSW produced an average yield of 5 tonnes dry stems/ hectare, although a yield of 12 tonnes dry stems/ hectare was reported for irrigated plants grown in trials in the central west of that State (Spurway and Trounce 2003).

8.2 Oil seed

Ideally, the yield of industrial hemp seed per unit area should be based on the air dry weight of the seed, which is usually about 12% moisture. Exaggeration of up to 50% of the yield of industrial hemp is sometimes the result of measuring the fresh weight of harvested seed rather than recording the weight of dry seed. According to Small and Marcus (2002), a yield of 1 tonne/ hectare is usually considered good in the EU, whereas in Canada, where considerable effort has been given to develop the oilseed industry, yields of up to 1.5 tonne/ hectare have been achieved. In 1999, the average yield of seed from industrial hemp crops grown in Canada was 0.9 tonne/ hectare (Small and Marcus 2002).

9. Agronomy – farming the crop

It may be that to achieve a viable gross margin, the production of industrial hemp in Australia will need to be undertaken on a broadacre basis. If this assumption is correct, the size of industrial hemp farming operations would need to be comparable with other broadacre crops such as cotton, wheat or barley. Furthermore, planting, cultivation and harvesting equipment would need to be of sufficient capacity to handle large scale operations.

Information on growing industrial hemp is more focussed on fibre crops than on oilseed crops. The following information on the cultivation of industrial hemp is not sufficient to address all of the practical difficulties that may emerge and should be treated as a general guide only.

9.1 Soil

Industrial hemp plants grow well on a fertile, neutral to slightly alkaline, well-drained clay loam or silt loam soil (Reichert 1994). The requirement for a well-drained site is necessary as industrial hemp plants are particularly sensitive to wet, flooded, or waterlogged soil. This susceptibility has been noted from plantings conducted in Tasmania (Lisson 1995) and in Queensland (pers. comm. Tanya Jobling, Ecofibre Industries Ltd).

9.2 Temperature, photoperiod

For most commercial varieties, industrial hemp is a short day plant, meaning that flowering occurs when the daily period of light is shorter than some critical length (e.g. 13 hours). Flowering is also accelerated by high temperatures (Van der Werf *et al.* 1994). Some varieties of industrial hemp that have been bred in high-latitude countries with comparatively long photoperiods have critical day lengths which are close to those of the maximum day length experienced in Queensland (summer solstice). Growing such varieties in Queensland results in premature flowering and a low fibre yield due to a shift of photosynthetic assimilates away from vegetative growth to reproductive growth.

9.3 Varieties

Although there are over 400 varieties of *C. sativa* known to exist, only a small number of these have low concentrations of THC (RIRDC 1995, p.4). Finding varieties with low THC concentration and suited to Queensland conditions is an important step in developing a successful industry. Whereas varieties currently grown in the EU may be suited to the growing latitudes of Tasmania, Victoria or southern Western Australia, they would not necessarily be adapted to Western Australia. It is possible that varieties from Pakistan, India, China, and South America may be appropriate for Western Australia, although such lines are renowned for having an unstable THC concentration and little is known of their commercial potential in terms of the proportion and quality of fibre in stems when using full mechanisation.

Evaluation of varieties suited to Western Australia is being conducted. Recent trials have shown that these programs are delivering lines upon which a viable Western Australia industry can be based.

9.4 Sowing

A well-prepared seedbed that is fine, level and firm is best for uniform germination. Analysis of the soil prior to sowing is recommended to assist in determining the rates of fertiliser application. Seeds are usually sown at a depth of 10 to 20 mm. According to Lisson (1994), the seeding rate for industrial hemp has been widely researched in a number of centres and recommendations include 40 to 150 kg seed/ hectare for fibre production and 1 to 24 kg seed/ hectare for seed production. Small and Marcus (2002) stated that fibre strains are typically sown at a minimum rate of 250 seeds per square metre (approximately 45 kg/ hectare), and up to three times that density is sometimes recommended. Seeding rates for grain production vary widely, from 10 to 45 kg/ hectare. The use of a roller at sowing may assist germination by facilitating good contact between the seed and the soil. Seeds are normally sown in rows spaced from 70 to 200 mm apart.

The optimal rate of sowing at any one location will depend on a number of factors such as the variety selected, local environmental conditions including radiation and water supply, and the end product required. The seeding rate influences strongly the yield and quality of fibre produced by the crop. For example, Van der Werf *et al.* (1995) found that the proportion of stem in the total dry matter increased with increasing plant density. RIRDC (1995) reported that plant densities between 80 and 400 plants per square metre have been found to have little effect on stem dry matter yield.

9.5 Irrigation

Until germination has occurred (usually 3 days after sowing), it is recommended that irrigation be applied to keep the surface soil moist. Industrial hemp is sensitive to drought and needs ample water, especially during the first six weeks of its growth (Reichert 1994). Without rain, a crop may require 2 to 6 ML of irrigation water/ hectare.

9.6 Pests and disease
Industrial hemp has a reputation for being resistant to pests and disease, although the degree of resistance has been greatly exaggerated, with the crop playing host to several insects and fungal pathogens. Grey mould, caused by the fungus *Botrytis cinerea*, is one of the most significant diseases associated with industrial hemp, and there are nearly 300 pests worldwide, the most serious of which are the European core borer (*Ostrinia nubilalis*) and the hemp borer (*Grapholita delineana*).

Green vegetable bug (*Nezara viridula* Linnaeus), heliothis moth (*Helicoverpa* spp), and monolepta beetle (*Monolepta australis* Jacoby) have been found in crops of industrial hemp grown for fibre in Queensland, but appear not to have had a significant impact on yield, possibly because the rapid growth of the crop tends to minimise the effects of pest damage. However, damage to the terminal buds of plants, particularly from heliothis moth, may require strategic pest control intervention. Monolepta beetle was reported to have defoliated a large proportion of the industrial hemp plants grown in a trial conducted in the Hunter Valley of NSW (Spurway and Trounce 2003). A useful guide to the potential pests and diseases of industrial hemp is presented in McPartland *et al*. (2000).

Under optimal growing conditions, such as a well-prepared seed bed, adequate soil moisture, rapid germination, and a high plane of nutrition, canopy closure normally occurs 5 to 7 weeks after sowing. This competitive ability of industrial hemp plants against weeds usually obviates the need for herbicide application during the life of the crop. However, sound agronomic practices for weed management prior to planting need to be followed to reduce the competitive effect from the weed population early in the life of the crop.

9.7 Use of pesticides
There are no pesticides registered or available for use under off-label permit in industrial hemp in Australia. Therefore, no pesticide may be legally applied to the crop. Should the use of a particular pesticide be required, it would be necessary for the industry to make application for an off-label permit to the Australian Pesticides and Veterinary Medicines Authority (APVMA). Information on applying for an off-label permit may be obtained from the APVMA website (www.apvma.gov.au) by selecting the ‘permits and minor uses’ link.

9.8 Harvesting
For fibre production, industrial hemp plants are normally cut in the early flowering stage or while pollen is being shed, well before seeds are set. Mediavilla *et al*. (2001) showed that stem, bark and fibre yield of industrial hemp plants reached their maximum at the time of flowering of the male plants, a stage of development that was called ‘technical maturity’. However, a study by Keller *et al*. (2001) showed that a later harvest time at the beginning of seed maturity led to easier decortication without any effect on the tensile strength of the bast. A stem diameter of 4 to 7 mm is considered ideal for fibre production, and most hemp billets are chopped to a length of 40 to 60 cm.

Consideration of mechanical harvesting technology suitable for industrial hemp has only recently begun to take place in developed countries such as Australia where the high cost of labour makes it a necessity to harvest mechanically.

9.9 Retting
The traditional and still major first step in fibre extraction is to ret (rot) away the softer parts of the plant, by exposing the cut stems to microbial decay in the field (dew retting) or by submerging them in water (water retting). The result of retting is the sloughing off of the outer parts of the stem and to loosen the hurd from the phloem fibres.

For dew retting, harvested industrial hemp is placed into windrows and left to desiccate until fungal organisms can complete the retting process in the stems (RIRDC 1995, p. 28). The length of time for the retting process will depend entirely on the weather, but typically requires one to 2 weeks. Windrows would normally be turned once or twice, and if not turned, the stems close to the ground remain green while the top ones are retted and turn brown (Small and Marcus 2002). Determining when the stalks have become sufficiently retted requires experience – the fibres should turn golden or greyish in colour, and should separate easily from the interior hurd. Stalks should have less than 15% moisture when baled, and should be allowed to dry to about 10% in storage out of the weather.

Water retting has been largely abandoned in countries where labour is expensive or where environmental regulations exist. Water retting, typically by soaking the stalks in ditches, can lead to a high level of pollution. Most hemp fibre used in textiles today is water retted in China and Hungary (Small and Marcus 2002).

The development of improved processes such as by the use of micro-organisms or enzymes in water or by industrial ultrasonic retting could augment or replace traditional methodology. However, such techniques are still being researched or have been carried out in semi-commercial situations for other crops such as flax (RIRDC 1995, p. 29). Graham (1995) reported that pilot projects have shown the energy, water, and chemical cost of enzyme or ultrasonic breakdown processes to be approximately \$1.95/ kg (\$1950/ tonne) of treated fibre, without including the costs of infrastructure, finance or labour. On this basis, therefore, only dew retting would be considered economically viable for Australian conditions at this time.

10. Conclusions

The strong world demand for renewable and recyclable fibre products and the decline and demise of some established agricultural industries in recent years has created an interest in industrial hemp and an opportunity for diversification into other crops. The legalisation of growing industrial hemp in some Australian states in recent years is recognition by government and the general community that industrial hemp may be a viable alternative crop and that it can be grown under conditions that do not compromise law and order.

Although it has been argued by some that industrial hemp is low risk from an agronomic perspective, that it has the requirement for low chemical input and that it makes an excellent rotation crop, the question is whether or not the industry will be profitable for growers and other participants. As for most new crops, the incidence of pests and disease is lower than that of established crops that provide an available food source and the opportunity to develop resistance to various control strategies. However, not often disclosed is the fact that should they be needed, pesticides are not registered or available for use under off-label permit in industrial hemp crops in Australia, and applying these formulations could lead to prosecution. By submitting an application to the APVMA for an off-label permit, access to use a specific pesticide can be obtained on a temporary basis.

The occurrence of failed industrial hemp crops in eastern states may go some way to emphasise the need for employing good crop husbandry and management practices. Whereas the poor adaptation of varieties originating from regions in the northern hemisphere with long daylengths may be a possible explanation for the result in NSW, poor agronomic practice was almost certainly a contributing factor in Queensland. Breeding programs by EIL and Crop Tech Research Pty Ltd may address the first of these issues in the future.

Although the majority of industrial hemp in the world is grown or processed using low mechanisation and high labour inputs at minimal cost, in Australia the industry is likely to be broadacre, mechanised and capital intensive to achieve viable gross margins.

Assessments of the profitability of the industrial hemp industry give widely varying accounts of likely financial performance. Opportunities in specific niche industries such as specialist paper fabric and board production have been identified. One view is that if the industry is to develop and prosper in Western Australia, it will be through the development of markets for innovative new products rather than through the more traditional uses such as paper and cloth. However, a lack of information and a view by some that the industry is high risk are issues that need to be considered carefully in the business plan of any potential participant. From a broader economic perspective, the success of the industry in Australia depends on competition from other countries, such as the EU which has subsidised production, and China which has low labour costs. Moreover, other bast fibre crops such as flax and kenaf will also compete with industrial hemp, without the need for monitoring and inspection fees and charges.

It has been concluded that the seed and oil from industrial hemp crops could produce the most economically viable products, while utilising the stems and fibres as a residual agricultural product. Despite the fact that about half of the world market for industrial hemp oil is currently for food and food supplements, the prohibition in Australia and New Zealand of industrial hemp seed and oil in novel food denies access to this potentially lucrative market.

Particularly for fibre and perhaps for oil, processing infrastructure needs to be located within close proximity to growing areas to minimise the cost of transport of the bulk material. Such facilities, which require a large capital outlay, are not yet available at the required scale in Australia.

Speculation of a future burgeoning market for bast fibre products is a positive sign for the industrial hemp industry in Western Australia. However, the degree to which industrial hemp can share in this assumed market demand will depend on its products being comparable or of equal quality to its competitors, at equal or reduced costs in adequate and consistently available quantities. It can be argued that the industry is in a ‘Catch 22’ – until the market is well defined and the magnitude of demand is known, a lack of investment in capital intensive processing infrastructure will be an impediment. Conversely, however, until there is supply, demand will not be crystallised.

Industrial hemp plants can now be grown commercially in Western Australia, Queensland, Tasmania and Victoria. Changes to the legislation in NSW are being sought with the view to commercialise the industry. Although industrial hemp has been grown commercially in Tasmania and in Victoria since the early and mid 1990s, respectively, the industry has not expanded significantly in those States.

Further research and development initiatives need to include plant breeding to improve THC stability in heat tolerant varieties, to increase stalk and fibre yield, and to widen the adaptability of the varieties that are available. Additionally, identifying suitable growing locations and streamlining farming and processing systems would also be useful initiatives for development of the industry.

11. Further information

General enquiries on industrial hemp may be directed to AGWEST Plant Laboratories on 9368 3721. Further information may be sourced from the internet. Some useful websites are listed below:

www.hort.purdue.edu/newcrop/ncnu02/v5-284.html
http://www.ecofibre.com.au/
http://www.croptech.com.au/
http://www.agrifibre.com.au/

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