Industrial hemp in New Zealand – potential for cash cropping for a better environment in the Taranaki region

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Abstract
'Landfarming' in the Taranaki district in New Zealand (NZ) is the process of soil bio-remediation after spreading hydrocarbon-containing drilling wastes from the oil exploration and production industry onto land. This waste is incorporated into the soil and often these areas are re-sown with a pasture crop in order to facilitate the natural processes which biodegrade, transform and assimilate the waste. Currently landfarmed soils cannot be utilised for dairy as dairy processors stopped collecting milk from these land farms in response to major public concerns about potential health and safety issues. Massey University and Hemp Technologies Ltd are exploring together with the Taranaki Regional Council, Venture Taranaki, oil/gas explorers and affected farmers the application and benefits of growing industrial hemp (*Cannabis sativa* L) as a promising economic and environmental option for these Taranaki landfarms. This project will identify the pathways to grow industrial hemp as a non-food chain commercial end product (e.g. hemp fibre to make so-called 'HempCrete' to build homes), while at the same time improving the quality of landfarmed soils. Controlled glasshouse-based trials of selected cultivars of industrial hemp in landfarmed soils are being carried out to assess potential soil remediation properties and to evaluate crop quality aspects. Extension activities through regional workshop(s) to disseminate the information are planned. This paper will discuss the opportunities and potential for industrial hemp in NZ as promising new cash crop for the Taranaki region and beyond.

Key Words
Land use change, alternative crops, regional development, sustainable building

Introduction
Hemp (*Cannabis sativa* L) belongs to the Cannabaceae family. Hemp cultivars can be classified according to their attributes such as population type (wild or natural cultivars), plant use (fibre or seed cultivars), flowering time (early, mid or late ripening cultivars), gender (dioecious or monoecious cultivars) and geographic origin (Salentijn et al 2015). Industrial hemp is a sustainable and high yielding industrial crop which has been grown around the world for centuries for its fibre, seed or as a dual-purpose crop. There are an estimated 25,000 products made from hemp in the global market (Salentijn et al 2015). The product use are diverse and include a wide-range of (1) fibre/hurd (woody core)-applications from the hemp stalk such as textiles, paper, building materials, industrial products; and (2) nut/oil-applications from the hemp seed such as foods, personal care, biofuel and so on. The history of hemp in NZ is minor compared to indigenous flax (harakeke) (L.) which has been used by Māori as a high fibre plant for textiles use (McPartland et al 2004). Hemp seed was first imported in 1892 and the government trialled hemp in the central North Island in the 1940s but hemp never established as a crop. The Misuse of Drugs Act 1961 outlawed hemp cultivation (McIntosh et al 1998). A change in NZ government legislation in 2001 made it possible to grow industrial hemp under strict licensing laws (McPartland et al 2004). Almost all hemp varieties contain the narcotic compound delta-9-tetrahydrocannibinol (THC). Drug type (marijuana) varieties contain between 3-40% THC (Merfield 1999). Only industrial hemp cultivars on the NZ National Approved List that produce THC levels of <0.3% are permitted to be grown under licence (MoH 2015). Strict regulations regarding THC testing apply for crops grown commercially or for research-purposes, and so far only eight cultivars have been gazetted and approved for NZ (MoH 2015). There are currently 46 registered hemp cultivars in Europe (Salentijn et al 2015). Global interest in the potential of industrial hemp has continued to increase through research and investigations into the uses, sustainability and opportunities for hemp (Amaducci et al 2015). The financial viability of these products will influence whether there is potential for them in markets. Advancements in technology and hemp processing are becoming more widespread and there is an increasing demand for natural fibres in global markets (Bouloc et al 2012). Currently China, Europe and Canada are

the most important hemp producing regions in the world. The commercial production of industrial hemp in New Zealand is relatively new and has mainly focussed on the use of hemp seed oil in the Canterbury region (Townshend and Boleyn 2008).The hemp fibre market in NZ remains somewhat underdeveloped and lacking the processing facilities and farmer interest as seen in the seed oil value chain.

Agronomy

Hemp is an herbaceous annual with a deep tap-root and a single woody stem that can grow to a height of up to 5 metres depending on variety and growing conditions. Hemp plants are originally dioecious, but monoecious varieties also exist (Bouloc et al 2012). Industrial hemp grows well on a range of well-drained soil types and in a range of climates, but it is best suited to temperate conditions between 15°C and 27° (Cole and Zurbo 2008). Hemp requires 1,900-2000°C growth degree days (GDD) to reach fibre maturity and 2,700-3000°C GDD for seed production (Bouloc et al 2012). Hemp is a short-day plant and when grown for fibre production averages to be a 100-120 day crop in NZ where it is generally sown before mid-October and harvested between February and April (Merfield 1999; McPartland et al 2004). Hemp is frost sensitive, but has the ability to grow at low temperatures >1°C (Lisson and Mendham 2000). Plant densities range from 30-70 plants/m^2 (seed production) to 250 plants/m^2 (fibre production) (Van der Werf et al 1995; Cole and Zurbo 2008). Effects of nutrition on yield and quality of industrial fibre hemp is complex, but 120kg N/ha, 100kg P/ha and 160kg K/ha have been reported (Bouloc et al 2012; Cole and Zurbo 2008). Industrial hemp will outgrow weeds when grown under ideal conditions. Hemp fibre crops are densely planted and weed control is generally not necessary, but seed crops with wide spacing may require weed control methods (Bouloc et al 2012). Industrial hemp is known for being pest and disease resistant. Dry stem yields in Europe are reported to be between 8-15t/ha (Lisson and Mendham 2000), and 10-12 t/ha in NSW under irrigation equating to $2,450-2,940/ha with growing costs of $800-1,200/ha (Cole and Zurbo 2008). Since 2001, several oil hemp trials in NZ have been performed by both Midlands Seed Ltd and Plant Research Ltd to evaluate plant growth and yield of cultivars, site location, local climate and agronomic variables such as sowing dates, seed density and fertiliser regime (Townshend and Boleyn 2008).

Production & bioremediation potential for industrial hemp for the Taranaki region

A commissioned report by Venture Taranaki (2014) flagged industrial hemp as one the main opportunities for diversification of the agricultural activity for the Taranaki region (Figure 1), which is currently dominated by the dairy industry as the fourth largest dairy producing region. The growing conditions for industrial hemp in Taranaki are excellent due to ideal local soil and climatic conditions. A targeted level of production and processing of industrial hemp in the region of 1200 hectares is foreseen (Venture Taranaki 2014). Two Taranaki farms are currently licenced to produce industrial hemp. A processing facility is planned to handle the production from 250 hectares of industrial hemp, which will contracted by local growers. Initially only straw for the manufacturing of building material will be processed, but a seed pressing facility is intended as well (Venture Taranaki 2014). Hemp might be grown as a rotational crop with maize for dairy support and has the opportunity to provide a high-returning sustainable diversification option for Taranaki growers and to provide additional employment in the hemp processing sector (Venture Taranaki 2014). The oil and gas industry in Taranaki is another important signature industry, worth $2.8b to the NZ economy (Venture Taranaki 2015). As a result of this oil and gas drilling and exploration, the industry produces a hydrocarbon-containing waste which is disposed of by a practice called 'land farming'.

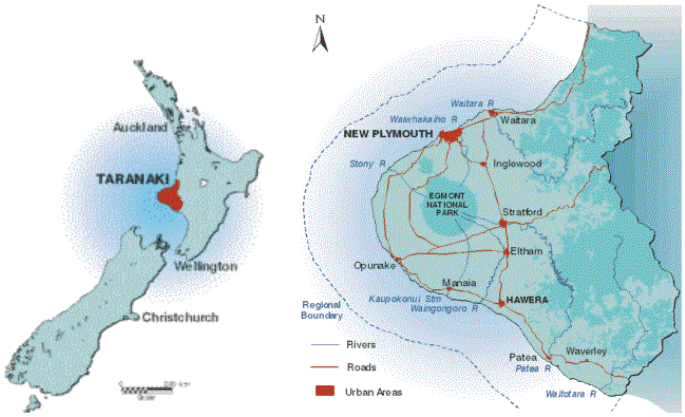

Figure 1. Taranaki region of New Zealand (source: www.safetaranaki.org.nz)

Land farming is a licenced activity of spreading drilling waste onto land and incorporating it into the soil (Proffitt 2013). This is followed by re-sowing the area with a pasture crop in order for the natural processes which stimulate the processes of biodegradation, transformation and assimilation of the waste. Landfarming often targets poor and sandy soils and potentially increases the agronomic value of the land (Edmeades 2013). However, landfarmed soils cannot be utilised for future dairy activities as dairy processors in 2014 stopped collecting milk from these retired land farms in response to major public concerns about potential health & safety issues of hydrocarbon contamination potentially entering the food chain. Phytoremediation is a process where a plant grows on soil, extracts the toxic substances which are accumulated in the upper plant and then can be harvested (Linger et al 2002). Plants grown for these purposes are often annual herbs which have little economic value, but high extraction potential (Linger et al 2002). Although hemp is not considered a hyper-accumulator, it has significant phytoremediation potential due to its high biomass production. Linger et al (2002) looked specifically into the fibre quality and phytoremediation potential of growing industrial hemp on heavy metal contaminated soil and found that the high quality of the fibres and hurds were not affected by heavy metal contamination and the fibre bundle fineness and strength were maintained. In addition to known environmental benefits of hemp to improve soil structure and soil organic matter and reduce erosion and nutrient loss (Merfield 1999), there is considerable potential for hemp production on land-farmed sites its phytoremediation properties due to higher absorbency properties (Linger et al 2002) and as a potential 'mop crop' (Cole and Zurbo 2008). Currently, in a MoH approved pot trial in the greenhouse under controlled conditions, we are assessing the phytoremediation properties of hemp (cv. Fasamo) in comparison with English rye (Lolium perenne L.) in soil extracted from a land-farming operation (Figure 2). Field trials of hemp are planned to assess yield potential and productivity on these land farms.

Figure 2. Controlled pot trial at the Plant Growth Unit of Massey University (Palmerston North) comparing the bioremediation properties of industrial hemp (*C. sativa* right) vs English rye (*L perenne* middle) grown on various soil combinations from a Taranaki land-farm. Control (no plants) left.

Global and local competition

The New Zealand hemp industry may encounter global competition which could affect the viability of domestic hemp production. Strong global competitors are those with a first mover advantage, pre-existing markets and/or those operating with price or scale advantages. Early adopters such as Canada, with established markets, have an advantage over infant hemp producing regions. In Canada fibre production is subsidised by the Hemp Food Industry. Canadian growers also receive a competitive crop income by growing seed for the North American health food market (Bouloc et al 2012). The remaining hemp hurds from the seed harvest can be purchased by processors at a relatively low price, contributing to global competition. The EU is one of the major producers of hemp fibre. Natural fibres such as flax and hemp are becoming more competitive; however they will be dependent on certain EU subsidies. Diversifying production systems in the Taranaki may be challenging due to the dairy domination in the region, however alternative horticultural systems may be more profitable, providing competition for land use (Proffitt 2013). There is a need for hemp fibre to enter product markets through alternative advantages and novel uses, driven by scale of production, yields, transportation costs and market demand (Merfield 1999). Novel uses include using hemp (hurd) mixed with lime ('hempcrete') as a sustainable building material and other applications like animal bedding (Figure 3). To date, the first two houses have been built using hempcrete, with another 20 homes planned within the Taranaki district (Greg Flavall, personal communication). Further investigation of potential product opportunities are critical and exciting options for hemp as key source for nano-cellulose

are currently being developed as spin-off from this initial pilot project. Sufficient local demand will be a key factor in determining the potential for the hemp industry in NZ to expand beyond importation of hemp fibre to local production and local value chain systems.

Figure 3. Hemp construction materials (left; Geiger, 2013) and hemp hurd for animal bedding (right).

Conclusion

There are considerable synergies for using industrial hemp for sustainable source of fibre (and oil) as a promising new cropping opportunity to diversify production systems for the Taranaki region in New Zealand. The potential of hemp as a bioremediation crop grown on local landfarms is currently being assessed and will create a sustainable non-food application which will supply an alternative and environmentally-friendly building material (fibre/hurd) for the district and beyond.

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