# Advancing a Sustainable Scottish Supply Chain for Industrial Hemp and Co-Products

**Commissioned by:**

**Scottish Enterprise**

**The Industrial Biotechnology Innovation Centre**


**Authors**

**Iain Riddell (Iain.Riddell@sac.co.uk) SAC Consulting**

**Mark Bowsher-Gibbs (mark.bowsher-gibbs@sac.co.uk) SAC Consulting**



**Published Date: 28th February 2025**

**Contents** **Page**



Cover photo, from left to right: Iain Fullarton (farmer/grower), Mark Bowsher-Gibbs, Iain Riddell.

Location: Netherlands

## **1.Objective of Study**

The objective of this study is to investigate the feasibility and steps required to set up a sustainable Scottish supply chain for industrial hemp and its co-products. The work has been undertaken by SAC Consulting Ltd, part of SRUC, supported by the Scottish Agricultural Organisation Society (SAOS) and has been funded by the Industrial Biotechnology Innovation Centre (IBioIC) and Scottish Enterprise. Work was undertaken from April 2024 to December 2024.

Components of the study

The main components are as follows:

- Study tours to the Netherlands and Yorkshire to learn from other industrial hemp supply chains.
- Industrial Hemp growing trials at three locations in eastern Scotland to assess how the crop performs under Scottish conditions.
- A review of hemp agronomy, harvesting and processing and the market prospects for the crop.
- Comparison of hemp growing margins with other crops and its place in crop rotations.
- A detailed costing of the feasibility of setting up a Grower Co-op and a Decortication Plant to grow and process product for sale to manufacturers.
- An investigation into the business structure options, involving a Grower Co-op, a farmer providing facilities for an on-farm decortication (processing) plant, and a Decortication Company selling product to Manufacturing Companies.
- Prospects for commercial applications of industrial hemp fibre/shiv.
- Market constraints to growth across sectors and actions required to accelerate uptake and incentivise investment.

## 2.Executive summary

Industrial hemp is widely cultivated globally; in the region of 35,000 hectares are under cultivation in the E.U. alone and expansion of industrial hemp in Scotland could potentially offer a valuable solution for enhancing cropping diversification. Globally, industrial hemp is used across sectors such as agriculture, automotives, bioenergy, construction, food and beverages, furniture, paper, personal care, recycling, and textiles. Its cultivation is expanding, and the world hemp market is projected to quadruple by 2030, reaching £13 billion in value. The crop offers immense promise in food security, sustainable housing products, eco-friendly textiles, urban development and carbon sequestration.

Fibre crops were once widely grown in Scotland, but current production is small scale with niche enterprises mainly harvesting seeds for health and food markets. This study seeks to establish a co-op to grow industrial hemp at large scale (circa 2,000ha) producing hemp fibre and shiv, largely for the building market. An industrial fibre manufacturing business operates in Jedburgh in the Scottish Borders, which continues to expand its output and range, having initially focussed on building insulation and soundproofing products. To date there has been no meaningful farm industrial hemp production save for a few trial fields. In the UK, there are few other industrial hemp groups, and these operate at a smaller scale than our planned operation.

Hemp is a fast-growing, spring-sown crop which is typically harvested 90 -110 days from sowing. Nitrogen requirements are low to modest depending on soil fertility and plant protection requirements are not necessary, making it a strong alternative or addition to existing break crops like oilseed rape, or legumes in the rotation. Its deep tap root helps improve soil structure for following crops and contributes to greater carbon sequestration below ground.

Evidence suggests that the hemp crop should be well suited to southeast Scottish conditions. The main requirement is to sow into warm soil, preferably above 10°C, from late April to mid-May. Growers should focus on areas with adequate rainfall, sandy or silty loams, and adjust sowing depth appropriately to ensure the developing seedling has adequate moisture. Areas with excessive rainfall, poorly drained soils and fields prone to compaction should be avoided. There is nothing unusually challenging about hemp agronomy when compared to other arable crops. A non-selective herbicide can be applied pre-sowing to help lessen weed competition, but a rapidly growing crop will out-compete weeds. Thereafter it does not require any inputs, other than fertiliser requirements aligned to existing soil fertility.

Two crucial decisions are when to cut and then when to bale the retted industrial hemp crop as this has a major impact on processing speed, product quality and value. The crop must be cut when it starts to flower, normally around early August. It then relies on retting, a 4–6-week process that requires proximity to the soil and moisture for soil microbes to break up lignin in the fibre, helped by turning the swath in the same way one might cure a hay crop. The swath is then rowed up and baled when the crop is dry (less than 17 percent moisture content) and fibres have begun to separate from the shiv element of the stems.

Square baling is essential as this shape stacks more efficiently for transport and feeds best into decortication equipment (2.4 x1.2 x 0.9m bales recommended). It is essential to protect the industrial hemp from moisture after baling and ideally all buildings need to be watertight with walls on 3 sides and all faces enclosed if filled to capacity. The same rule applies to transport with curtain sided lorries recommended for haulage. In most cases industrial hemp bales will need intermediate storage on farm until they are transported to the decortication plant.

Replicated plot trials carried out as part of the project used 3 varieties; Futura 75, Santhica 27 and USO 31 and looked at the yield response of each variety to varying application rates of artificial nitrogen ranging from 0kgN/ha to 120kg/Nha. Additionally, trials were carried out so see how yield at those different nitrogen rates responded to varying seed rates, ranging between 40-60kg/ha. Futura 75 recorded the highest yield whilst Santhica 27 and USO 31 exhibited diminished yield response at higher nitrogen rates. Deciding on seed rates must take in to account the soils inherent fertility and the intended application rate of nitrogen. The trials demonstrated that too high a seed rate will negatively impact yield where nitrogen application is not sufficient to support those higher plant populations.

Farmers are attracted to a crop if it can provide a consistent, competitive financial net margin compared to current crops in their arable rotation. However, they need to be convinced that the new crop will perform consistently well and fit their farming system and labour availability. They are dissatisfied at being price takers, at the mercy of fluctuations in supply and demand on world markets and would welcome the opportunity to be part of a co-operative that added value to their farm finances. A 6.0 tonne/hectare crop, valued at £270/tonne, would provide a net margin (after operational costs) of £764 per hectare, which is in the top quartile of arable crop performance, but only marginally ahead of winter oats and spring barley and behind winter oilseed rape and 1st wheats, based on 2024 crop and input values.

Case study visits to East Yorkshire Hemp and Harrison Spinks in Yorkshire and Hempflax in the Netherlands provided an invaluable insight into the practicalities of growing and harvesting industrial hemp, and the equipment and processes involved. Our visit to Stevens in the Netherlands provided a great insight into the contracting machinery required for cutting, tedding and baling operations. The main take home messages were that quality starts in the field, and good results require cutting and baling at the correct stage with the correct decortication/cleaning equipment to match your customers specification.

Crop processing.

Industrial hemp decortication is the process of removing the ‘bast’ fibres from the plant's woody core known as ‘shiv’ or ‘hurd’. The bast fibres are separated into bales of short, fine fibre for a variety of uses, primarily insulation products. The shiv is separated and milled into material that can be used for insulation boards, hempcrete or animal bedding. Dust and any remaining shiv or bits of fibre can be compressed into briquettes for use in wood burning stoves. The decortication, cleaning and packing process involves passing hemp bales through a long line of fixed machinery consisting of bale openers, hammer mills, shakers and separators with an air filtration system to remove dust.

Quotes were obtained from companies specialising in industrial hemp processing equipment. Processing around 2000ha or 12,000 tonnes of crop is likely to require a system that can process 4 tonnes per hour, which will cost around £4.5 million plus shipping and installation costs, a substantial capital outlay. It is possible to buy and re-engineer second hand textile equipment for some processes, however if the line is to work 16 hours per day for many years the core machinery is best purchased new.

Co-op and business structures.

This proposal involves several groups – farmers who will grow the crop, a farmer providing shed facilities for the decortication plant, a decortication/processing company and manufacturers purchasing the decortication plants products. There would be clear benefits to setting up a

Grower Co-op that could encourage farmer membership, manage hemp production up to bale storage on farm. It would be advantageous for a grower co-op to be involved in part-funding and the running of the decortication plant, and in so doing retain a greater share of processed value. It is likely however, that substantial investment may also be required from other investors.

Grower co-op costs are likely to include a dedicated manager undertaking both office and field work functions backed up by administrative and accountancy support. It is debatable whether the co-op would own any machinery, or whether this would be the role of contractors. Either way costs will be charged back to the farmers at estimated rates of £37.50 per hectare for co-op staff and £32 per hectare for annual machinery costs.

A 10 Year Discounted Cash Flow has been prepared to assess the profitability of the decortication part of the process. Modelling different scenarios has shown that the most important factors for success are rapid build-up of crop hectarage and plant throughput and maintaining product prices close to budgeted levels with hemp fibre at £725/t and shiv at £430/t. The largest costs are the purchase price of industrial hemp bales ex-farm, electricity charges and factory labour costs.

Capital costs form the largest barrier to setting up a decortication plant, which are estimated to be in the region of £4.5m to £5.0m. This money will need to be raised from investors, preferably including farmers, loans and sources of grant funding.

The Decortication Company budget shows a negative net cash flow until Year Five, net surplus exceeding £230k from Year Six and reaching £331k by Year Ten. Surpluses may be used for Decortication Company reserves and investor payback from Year Six. Cumulative cashflow is negative until Year Eight, turns positive in Year Nine and reaches £368k in Year Ten. This scenario requires the peak hectarage of 2,000ha to be reached by Year 5.

Barriers to development of industrial hemp supply chains to date include:

- Negative connotations of cannabis and restrictive licensing requirements for growing hemp.
- Limited construction industry demand for biobased products that replace products derived from fossil fuel, and a lack of government incentives to make this change.
- Hemp processing equipment and facilities come at relatively high capital cost requiring significant investment involving risk and reward decisions.
- Lack of incentives or support to pump prime the development of growing co-ops or processing groups.

Actions required to ameliorate market constraints, accelerate uptake, and incentivise investment:

- Facilitate a bio-fibre steering committee for Scotland with Parliamentary support and backing.
- Reform the Proceeds of Crime Act to attract investment and allow farmers to scale up production.
- Support farmers and manufacturers with clear policy framework and industry incentives around bio-based material use.
- Create a government backed carbon credit platform to reward hemp's potential contribution to the circular economy.

## 3.Background to the hemp crop and uses

Industrial hemp has a centuries-long history of diverse uses as a uniquely versatile crop. However, over the past seventy years, cultivation has been hindered by regulatory challenges stemming from its association with cannabis. These restrictions, combined with socio-economic misconceptions have limited hemp's potential particularly within the United Kingdom.

Globally, industrial hemp is used across sectors such as agriculture, automotives, bioenergy, construction, food and beverages, furniture, paper, personal care, recycling, and textiles. Its cultivation is however expanding despite the issues previously mentioned and the world hemp market is projected to quadruple by 2030, reaching £13 billion. The crop also offers immense promise in food security, sustainable housing products, eco-friendly textiles, urban development and carbon sequestration.

Indeed, industrial hemp also plays a critical role in advancing the circular economy toward climate goals. Its applications in textiles, construction, and packaging provide opportunities for regional transformation, helping meet climate targets while creating economic prospects for farmers, businesses, and municipalities. Legislative shifts in Germany, the U.S. and other nations, combined with growing global interest in sustainability, are driving innovation in hemp-based solutions. Leading market players in construction, packaging, textiles, energy, and automotive industries are actively exploring and realising new developments.

Whilst Environmental, Social, and Corporate Governance are central to corporate and public strategies, ensuring companies address stakeholder needs while fostering equitable value creation and sustainable development, industrial hemp is becoming increasingly valued within relevant pathways to deliver on these criteria.

Industrial hemp has a long-standing history with human use, dating back to before the advent of agriculture. In temperate climates, it was primarily cultivated for fibre, and ancient varieties contained only trace amounts of THC (less than 0.3%). In contrast, biotypes in southern Asia developed higher THC levels and were increasingly cultivated for drug-type cannabis. Widespread concerns over the psychoactive variant of cannabis led to legislative bans on cultivation across the Western world in the early 20th century. During this period, non-psychoactive hemp, used for seed and fibre, lost ground to competing fibre crops like cotton. Despite this, industrial hemp has become naturalized in a variety of climates worldwide, from alpine to tropical regions. Legislative restrictions on industrial hemp are now being relaxed across the Western world, driving an increase in global production.

Industrial hemp was grown extensively across the U.K, including Scotland, where it was primarily used for manufacturing marine ropes and sails. The decline in this natural fibre crop was influenced by the shift from sailing vessels to steamships and the emergence of polypropylene ropes as a replacement to natural twines. Over recent decades the hemp plant is once again becoming increasingly valued for its end-use processing capabilities (Fig 1).

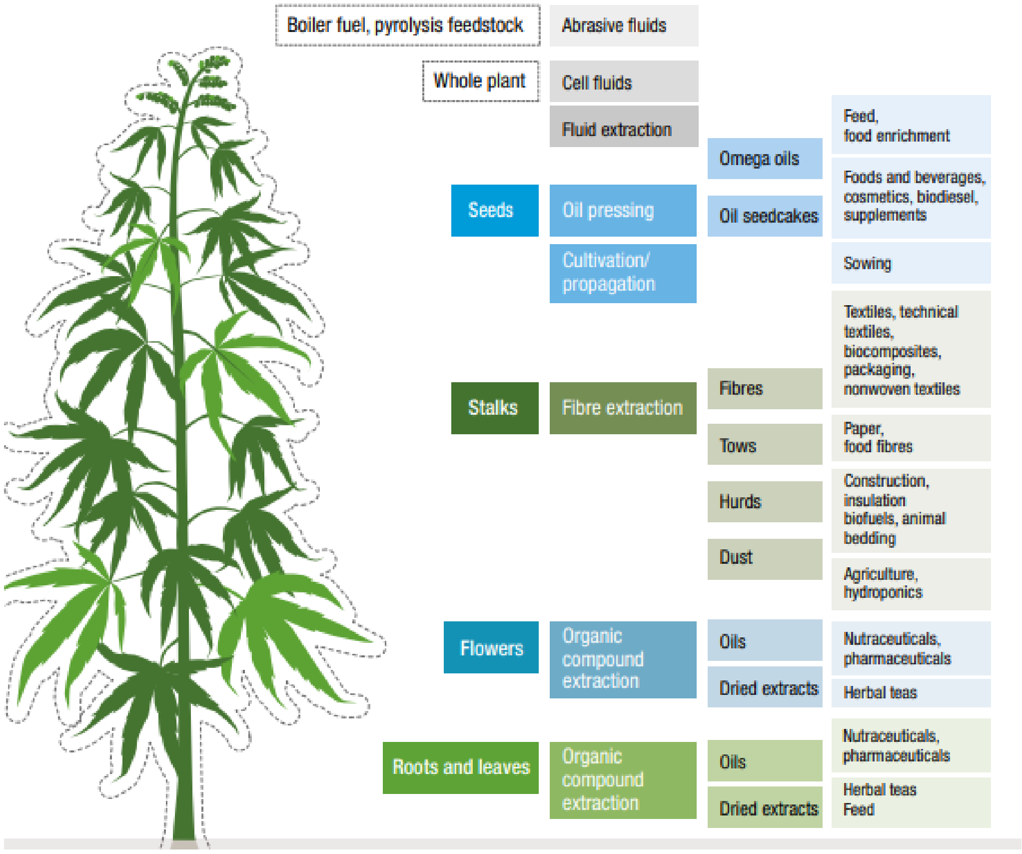



FIG 1 Source UNCTAD

**4. Technical and economic aspects of crop production**

Hemp production potential for Scotland

Industrial hemp is widely cultivated globally; in the region of 35,000 hectares are under cultivation in the E.U. alone and expansion of industrial hemp in Scotland could potentially offer a valuable solution for enhancing cropping diversification. Because U.K. regulations restrict the use of cannabis leaves and flowers prohibiting the processing of hemp flowers and buds for novel foods or medicinal products, only industrial hemp varieties grown for fibre or seed can currently be grown. Even then, current legislation dictates that industrial hemp, classified as a phenotype III, (fibre-type, with very low THC content) must adhere to strict THC limits of less than 0.2%.

In 2025, the UK government is implementing changes to the industrial hemp licensing process to support regulated farmers and encourage investment in the hemp industry. Additionally, the government has sought advice from the Advisory Council on the Misuse of Drugs regarding a potential increase in the permissible THC threshold for industrial hemp from 0.2% to 0.3%, aligning with standards in countries like the United States.

Crop suitability for Scottish arable regions

The observations recorded in this report draw on knowledge gained from:

- industrial hemp variety trials in 2024, located in Mid-Lothian and Angus

- working with farmers in Scotland growing commercial crops in 2024 (Iain Fullarton and Martin Cessford)
- visits to and discussions with Nick Voase of East Yorkshire Hemp and the team at Harrison Spinks
- a study tour to the Netherlands (June 2024)
- attendance at the 2024 EIHA Conference in Prague

### 4.1 Place in rotation

Industrial hemp is a fast-growing, spring-sown crop which is typically harvested 90-110 days from sowing. Nitrogen requirements are low to modest depending on soil fertility and pesticide requirements are not required, making it a strong alternative or addition to existing break crops like oilseed rape, peas, and beans in the rotation.

Scottish agriculture does not adhere to a specific crop rotation system. Instead, growers of crops like potatoes, vegetables (such as cabbages, carrots, onions, and brussels sprouts) and oilseed rape, typically ensure a 5–7-year gap before planting these crops again in the same fields. This practice helps to prevent the buildup of pests and diseases. During the intervening years, fields are mostly planted with cereal crops like wheat, barley, and oats. Some farmers may also grow vining or dry peas and beans or establish temporary grassland for 4–5 years. Wheat that follows a break crop like vegetables or oilseed rape is referred to as "1st wheat," which generally yields higher than 2nd or continuous wheats, making it more profitable. As a result, farmers often aim to maximize the area devoted to 1st wheats. Industrial hemp would serve as a break crop too, with the expectation that a following wheat crop would benefit from increased yields of 15-20% (pers.com N.Voase 2024).

An additional appealing feature of industrial hemp is that it can also be grown consecutively in the same field without negative impacts from pests or diseases, offering a simplified farming approach for some growers. Its dense cover suppresses weeds effectively, reducing the need for herbicides whilst improving soil health and reducing soil acidity. Studies have demonstrated hemp's allelopathic properties, which involve releasing chemicals into the environment that inhibit the germination or growth of certain competitive plant species. Additionally, hemp has been noted to have phytoremediation properties and a nematocidal effect, reducing pest nematode populations and benefiting subsequent crops like potatoes and maize that are susceptible to nematode infestations.

Ultimately farmers will be attracted to growing industrial hemp where:

A) the net margin can compete with other spring sown crops
B) it confers some advantage to the rotation e.g. spreading labour and machinery operational timings, improves soil structure and soil drainage
C) it de-risks the rotation by introducing a crop that requires less working capital (seed, fertiliser, sprays) to be invested ahead of crop sales
D) it provides a means to diversify away from food commodity markets, reliant on fossil fuel derived inputs
E) businesses see merit or incentive in reducing net Greenhouse Gas Emissions

### 4.2 Suitable soil types and improving soil health

Hemp thrives in a variety of soil types but performs best in deeper, well-aerated soils with a pH between 6 and 7.5, having good moisture and nutrient retention. Poorly drained soils are undesirable as exceptionally high rainfall events can lead to seedbed capping causing poor plant establishment. Rolling seedbeds after drilling is therefore discouraged to avoid surface capping. This was evidenced first hand in 2024 at two of the three trial sites (Edinburgh and Kelso) where immediately post drilling, 60mm of rain fell and capped the soil causing the loss of one site and the need to re-drill the other.

One major factor potentially limiting hemp yield is soil compaction which leads to waterlogged roots. It's crucial to address soil compaction well before planting. However, industrial hemp itself can contribute to soil improvement once established. Its developing taproot, which can extend up to 150 cm in length, helps break up compacted layers and enhances soil structure. This root system also allows hemp to access nutrients beyond the reach of most plants and reduce nutrient loss from leaching into groundwaters. Additionally, industrial hemp generates substantial below-ground organic matter that decomposes and enriches the soil, supporting carbon sequestration and building healthy soil. Furthermore, hemp's thick leaf canopy, established early in growth, helps prevent soil erosion and minimises water loss. Due to its efficiency in ecological restoration, hemp is also valuable for land reclamation, gradually removing contaminants from deep soil layers as its roots grow. This phytoremediation capacity has been documented in various studies, highlighting hemp's role in environmental recovery.

### 4.3 Climatic requirements

Studies indicate that optimal moisture levels for industrial hemp are 250–300 mm during the vegetative stage and a growing seasons total of 500–700 mm for maximum yield, although this can vary based on soil and climate. Rainfall in June and July is particularly influential on yield. Scotland's maritime climate, characterized by a northerly latitude, generally experiences less drought than other European regions. However, in recent years, the East of Scotland has seen drier, cooler springs followed by increased mid-summer rainfall, which could benefit industrial hemp if sufficient soil moisture is available at sowing.

Industrial hemp can germinate at relatively low soil temperatures, but the optimal soil temperature is 10°C or higher. N.Voase from East Yorkshire Hemp recommends sowing in warm, moist soil above 10°C, typically in mid to late May. Overall, industrial hemp appears frost-tolerant (N.Voase also noted that his crops endured air temperatures as low as -4°C) but planting into warm soil is essential for uniform and rapid germination, early growth and early ground cover for better weed suppression.

According to N. Voase, aside from soil temperature, the key to successful industrial hemp growth is sowing deep enough to access adequate moisture for germination. He has cultivated hemp in Yorkshire for 17 years without irrigation. Given that soil moisture conditions in Scotland are comparable to those where N.Voase farms in Yorkshire, water availability should not be a significant limiting factor. For example, MET Office data from 1991–2020 shows Charterhall near Duns in the Borders receives an average annual rainfall of 746 mm, with 360 mm from April to September. In comparison, Leconfield in the East Riding of Yorkshire averages 661 mm annually, with 328 mm from April to September. Rainfall around harvest time in September is similar, at 58 mm and 60 mm, respectively. Seasonal variations occur, and N.Voase mentioned only one year out of 17 where wet conditions prevented harvesting.

Considering changing climate variability, it may be useful to not concentrate industrial hemp farms too close together but spread out over regions to de-risk potential for crop or retting yield reductions due to unusual adverse weather events.

4.4 Land suitability in Southeastern Scottish arable regions

Soils mapped for Land Use Capability and avoidance of poor or impeded drainage would suggest that industrial hemp should be grown on fields of Land Classes 3.1, 2 and 1. Class 1 is the best land coloured brown on the maps, class 2 is very good land, coloured yellow, and class 3.1 good arable, land coloured green. These are soils suitable for a wide range of arable production and tend to grow the best crop yields. Some class 3.2, which has some limitations such as imperfect drainage may be suitable for hemp depending on the soil series and annual rainfall. The Land Classification Assessment system was developed by the Macaulay Institute for Soil Research (now the James Hutton Institute) and is the output of extensive field surveys conducted over many years.

Figures 2, 3 and 4 map the availability of suitable soil at distances of 25, 50, 75 and 100 miles from three potential central processing locations – Jedburgh in the Scottish Borders, Haddington in East Lothian, and Cupar in Fife, to represent three of the main arable cropping areas in Southeast Scotland. Hectarages are shown in the table below for all available land, and a sixth of the available land if farmers grow hemp one year in 6. It is clear from these figures that there is a large amount of suitable land in the area. By way of example, for a processing site requiring 2,200 hectares of industrial hemp, that area would represent 20% of rotational land within 25 miles of Jedburgh or 13% of rotational land within 25 miles of Haddington or 9.5% of rotational land within 25 miles of Cupar.

| **Processing Sites** | **LCA 3.1 + ABOVE** | | | |
|---|---|---|---|---|
| | **Within 25 miles** | **Within 50 miles** | **Within 75 miles** | **Within 100 miles** |
| | **All available land - hectares** | | | |
| Jedburgh | 65,260 | 151,084 | 252,357 | 358,934 |
| Haddington | 99,270 | 286,380 | 344,747 | 395,182 |
| Cupar | 139,742 | 271,456 | 363,405 | 514,627 |
| | **Hemp grown 1 year in 6 - hectares** | | | |
| Jedburgh | 10,877 | 25,181 | 42,060 | 59,822 |
| Haddington | 16,545 | 47,730 | 57,458 | 65,864 |
| Cupar | 23,290 | 45,243 | 60,568 | 85,771 |

Fig 1 – Available land within radial distances of three locations

There are some caveats to these figures:

- distances are measured radially "as the crow flies" and actual travel distances will be greater, particularly when estuaries and terrain must be circumnavigated.
- Industrial hemp will be a new crop and might not appeal to a sizeable percentage of farmers.
- farmers are already growing other crops, and hemp will have to offer better financial returns or long-term price security to compete for inclusion in a rotation.

Maps showing land available at radial distances from potential processing sites:

Figure 2 Jedburgh

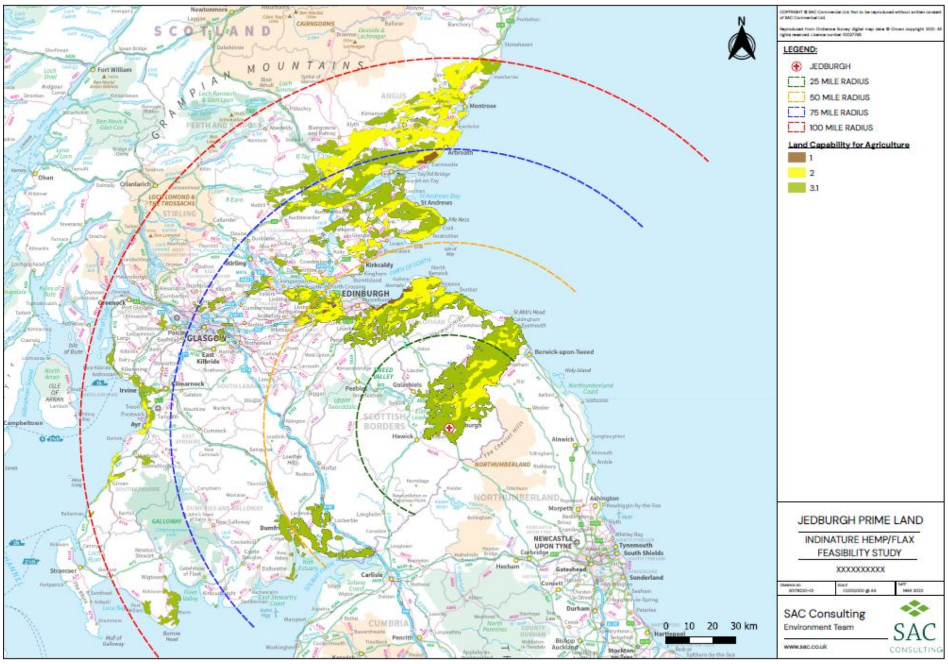



Figure 3 Haddington

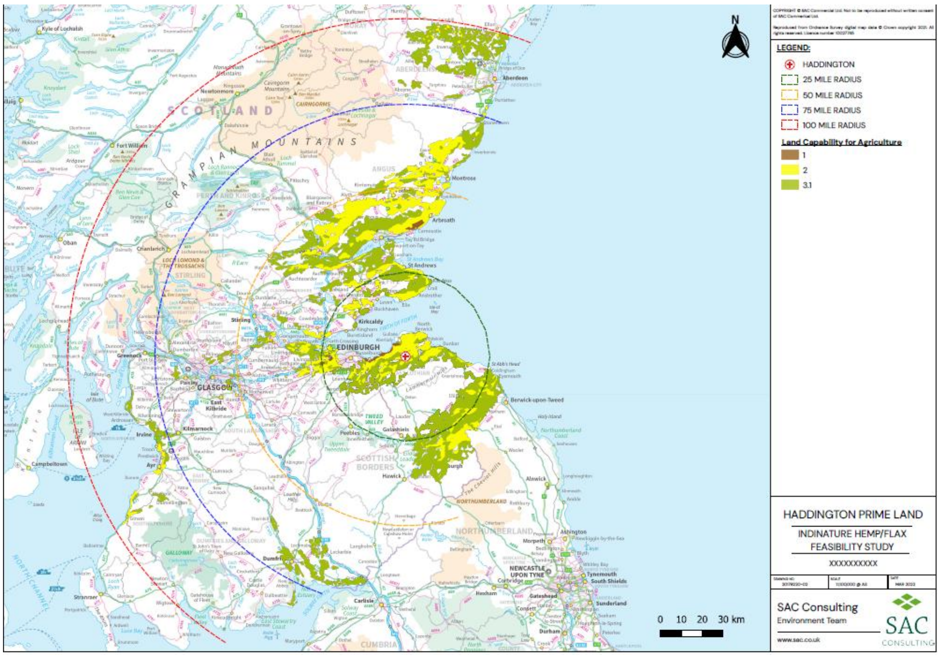
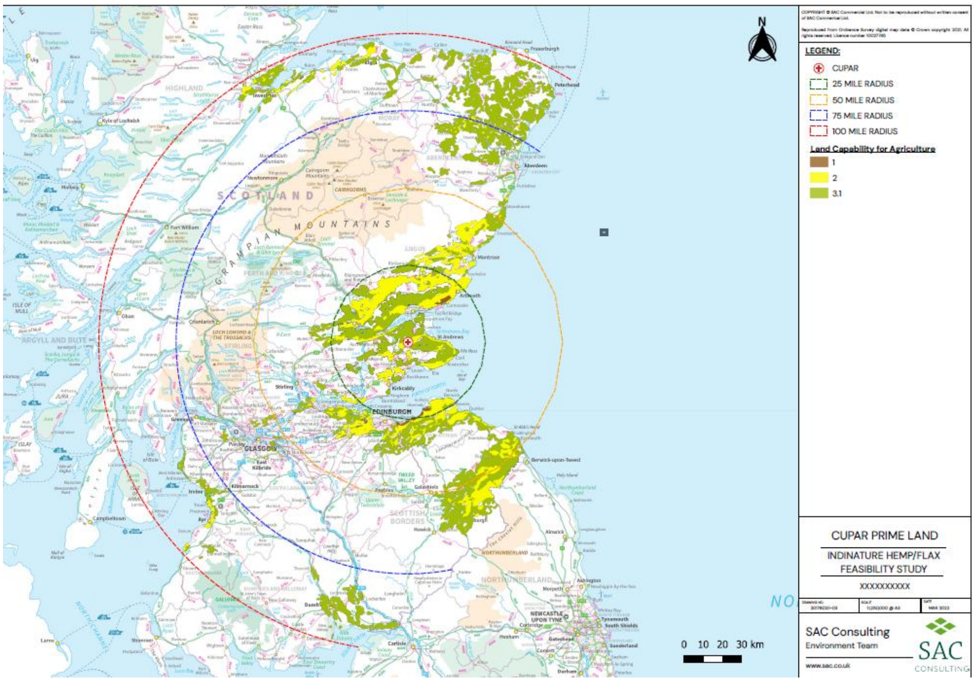



Figure 4 Cupar




4.5 Hemp agronomy characteristics

Seed and Sowing the crop

Variety selection for industrial hemp cultivation in the UK is limited to those approved after undergoing two years of trials. These varieties must be licensed by the Secretary of State, DEFRA, and APHA and can only be grown for their fibre and/or seed, as these are classified as "non-controlled" plant parts. The use of leaves and flowers remains prohibited, as they are designated "controlled" by the Home Office. Growers must declare a defined commercial end use (either fibre and/or seed) and are only permitted to cultivate approved varieties listed in the Common Catalogue with a THC content not exceeding 0.2%. Industrial hemp is defined as having a THC content of 0.2% or lower.

Given the early stage of UK industrial hemp cultivation, growers are encouraged to rely on peer knowledge to determine suitable varieties. Futura 75 is the most widely grown variety for fibre production and in our trials Futura 75 was compared to USO 31 and Santhica 27. While all three are preferred for fibre production, they differ in maturity dates.

As mentioned previously correct soil temperature is critical for successful seedling establishment. The soil should be fine, dry, and have warmed to at least 10°C. Sowing should align with 5–6 days of mild and dry weather to prevent soil capping from heavy rain. A disc seed drill with press rollers (max depth 2 cm) ensures good seed-to-soil contact. Emergence is also influenced by temperature, typically occurring between a T-sum of 80 and 100°C. Under warm conditions, hemp seedlings emerge within six days of sowing and should be visible in rows shortly thereafter.

Fig 5 13th May -10 days post drilling

Fig 6 24 days post drilling

Seed and fertiliser rates

Edinburgh crop trial

On our trial site at Boghall farm we took a single variety, Santhica 27, sown at 40, 50 and 60kg/ha and compared yields obtained at each of the seed rates under four different nitrogen regimes: 0kg/haN, 40kg/haN, 80kg/haN and 120kg/haN. Plots were replicated three times for each scenario and the results averaged across the three replicates (Fig 9). The trial site has a high basal soil N status (2780 mg/kg soil dry matter) arising from routine historical applications of FYM and was evidenced by the high yields obtained even where no artificial Nitrogen was applied. (Full soil analysis is provided in the Appendices)

Fig 7 trial plot samples laid out for retting

Fig 8 Recording plot yields

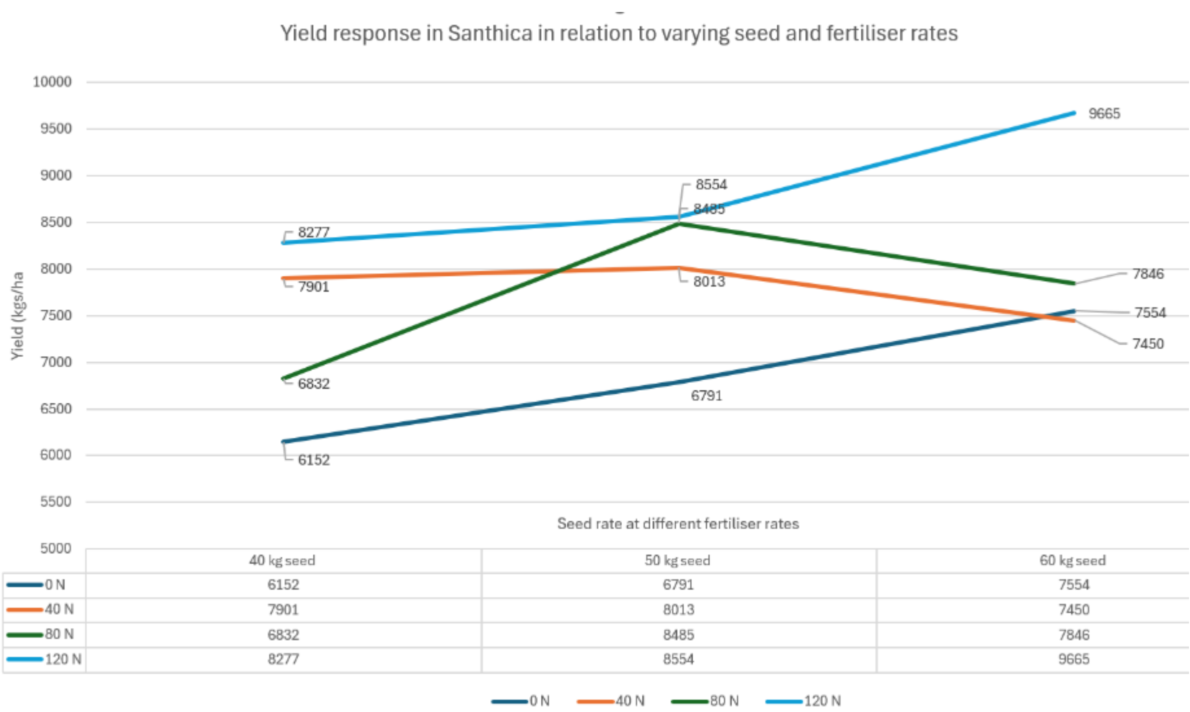



Fig 9. Yield response of Santhica 27 to varying nitrogen and seed rates

Conclusions

In a high fertility situation on a 'no Nitrogen' regime, increasing the seed rate from 40kg/ha to 60kg increased yields incrementally.

In a high fertility situation, mid-range applications of N (40-80kgs) at higher seed rates demonstrated a detrimental effect on yield achieved. This is likely due to the higher ratio of seed to fertiliser resulting in greater competition for light and nutrients resulting in smaller diameter stems and hence less overall biomass yield.

In a high fertility situation, increasing seed rates to 60kg/ha must be supported by higher N application (120kg/ha) and in trial this combination resulted in the highest plot yield (9.665t/ha).

At 0 kg N the highest yield came from 60kg/ha seed.

At 40kg N the highest yield came from 50kg/ha seed.

At 80kg N the highest yield came from 50kg/seed.

At 120kg N the highest yield came from 60kg/ha seed.

Under none of the fertiliser regimes did a 40kg/ha seed rate produce the highest yield.

Montrose trial

At our 2nd trial site at Montrose, we looked at the response to increasing fertiliser rates using 3 different varieties all of which were sown at the same seed rate of 50kg/ha. The varieties were Futura 75, Santhica 27 and USO 31. Three replicates for each scenario were grown and yields averaged before comparing the results.

This site was less fertile, measuring 1680mg N/kg soil dry matter and indeed the yield range observed was much more responsive to artificial N from a considerably lower baseline compared to the Edinburgh site.

Futura 75 showed both the most positive response curve to increasing fertiliser application and yielded the highest, recording 7929kg/ha at 120kgN. USO 31 and Santhica 27 yielded less at the 120kg/ha application rate: 7,110kg/ha and 6013kg/ha, respectively. The response curve for USO 31 was less marked beyond the 40kg/ha N level, whilst the Santhica 27 yield, peaked at 80kg/ha N and showed no further increase in yield at the 120kg/ha N level.

Additional yield attained applying 120kgN/ha over and above the yield attained at 0kgN/ha:

| | |
|---|---|
| Futura 75 | 6,416 kg/ha |
| USO 1 | 5,444 kg/ha |
| Santhica 27 | 3,639 kg/ha |

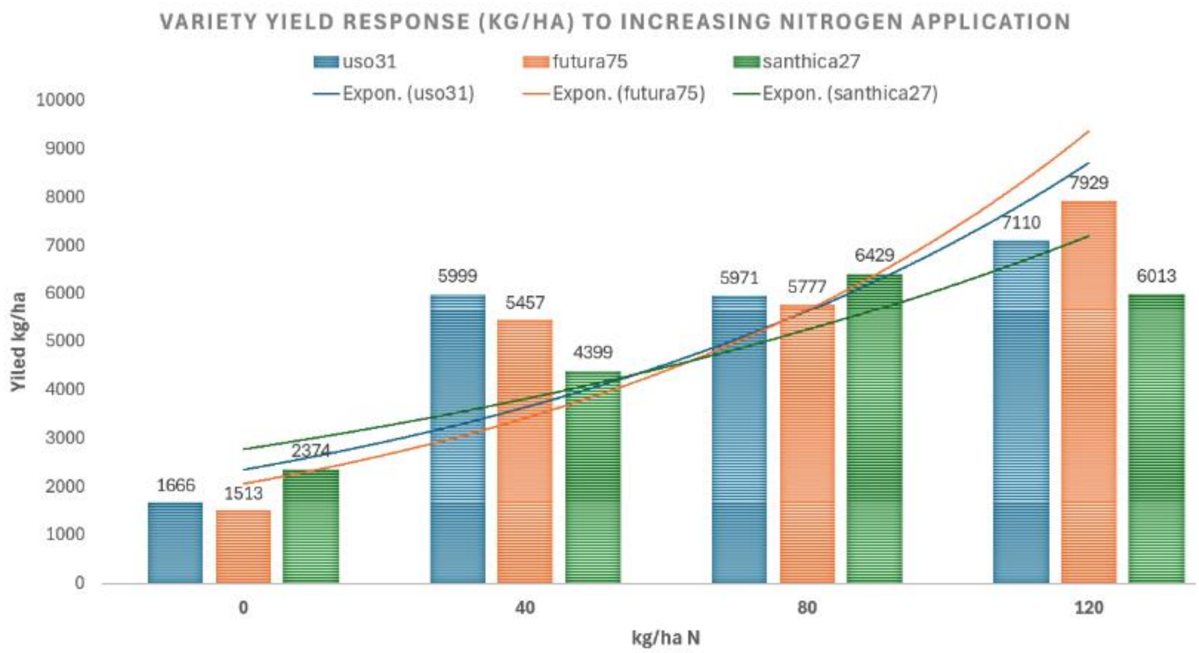



Fig 10. Varietal response to increasing nitrogen levels

Crop heights were measured at the time of harvest (Fig 11) and reflect the yield data recorded, as illustrated in Fig 10.

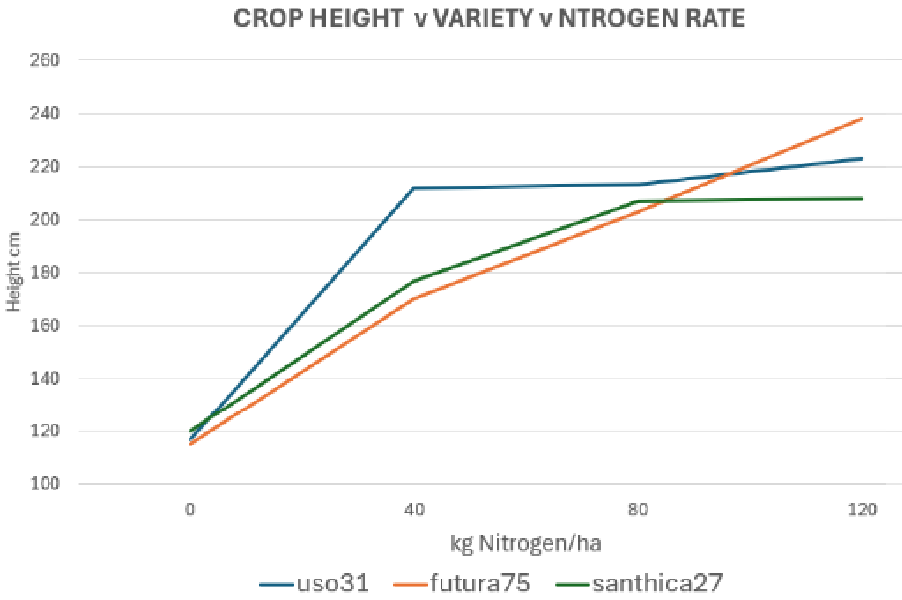



Fig 11 Crop height by variety under differing nitrogen regimes

Pests and diseases

There are currently no pesticides permitted for use on industrial hemp in the UK. Since Brexit, the UK oversees the approval of pesticide product use and until such times as manufacturers see a viable market to sell a pesticide into, they will not incur the regulatory costs of seeking that approval. This does not however prejudice against growing the crop in the UK commercially as industrial hemp out-competes weeds and is not susceptible to insect damage. Industrial hemp is potentially susceptible to sclerotinia (stem rot), a pathogenic fungus resulting in white mould (soil tests can mitigate site risk should successive crops of hemp be considered in the same field). Infection to sclerotinia was not evidenced across the trials in 2024.

Weed control

Optimum sowing dates, usually in May, allow plenty of time to control weeds with a non-selective weed killer before the crop of industrial hemp is planted. This will be an attractive benefit of growing industrial hemp on farms where late spring weed control is advantageous for pernicious weeds, such as blackgrass. Industrial hemp once established rapidly achieves ground and an unimpeded crop will out complete weeds for nutrients and light (Fig 12).

Fig.12 Seven weeks post drilling, crop height 80cm

4.6 Harvesting, storage and transporting the crop

There is nothing unusually challenging about the agronomy of industrial hemp when compared to other arable crops.  However, decisions on cutting and baling must be well timed to ensure efficient processing and a good fibre yield.

The most crucial decisions are when to cut and when to bale the retted hemp crop. From Tatham guidelines - "The yield of fibre depends on both the stalk yield per acre and fibre content of the stalk.  For textile applications it is important to realise that the hemp plant should be cut prior to the early flowering stage (or while pollen is being shed) and before the seed sets.  Fibre that is cut after seed harvest will have lignified considerably and is only suitable for some non-woven fibre applications."

These decisions can be overseen by the co-op to ensure consistency with a dedicated agronomist on hand to guide the complete process, particularly key cutting and baling decisions. N.Voase provides this service for the other growers in East Yorkshire Hemp as these decisions have a huge bearing on crop quality. The crop must be cut when it starts to flower. In his experience one 3 bar cutter (Fig 13 ) 3 metres wide, can handle around 1000 acres (400ha) of crop in a season.  In Yorkshire, cutting normally starts in the first week of August. As an alternative to the horizontal cutter bar, during our visit to the Netherlands we witnessed the adaptation required to a self-propelled forager cutter drum to facilitate cutting the crop and windrowing the swath behind the machine (Fig 14).

Fig 13 Laumetris 4 bar cutter

Fig 14 Cutting using adapted cutter head

Retting (Fig 15) involves a tedder to spread out the crop over the stubble. It should be turned once and if needs be, a 2nd time, before rowing it up prior to baling. The retting process requires contact with the soil and moisture to allow soil microbes to break up lignin in the fibre.


Fig 15. The stages of retting

In Yorkshire, baling takes place 4-6 weeks after cutting in early to mid-September. Each crop needs a field assessment to determine when it is ready to bale. The crop must not be baled at over 17% moisture content, and the drier it is the better. Insufficient retting reduces crop value and increases the amount of processing required. Crop losses can occur if baled damp. For N.Voase, square baling is essential as they stack more efficiently for transport and more importantly feed in better to his decortication equipment (Figs 16/17).

Fig 16. Fully retted hemp rowed up for baling. Fig 17. Baled on 18th September after 4 weeks retting

Storage

This element of the supply chain should not be underestimated in its importance, both in terms of on-farm availability and the cost implication of providing alternative storage. In most cases hemp grown on farm will need intermediate storage on farm until such time as the bales are picked up and transported to the decortication line. It is not an unusual practice for cereal straw to be temporarily stacked on field headlands uncovered, until such time as it is loaded out to supply the buyer. This option is not advised for hemp given the requirement to keep the bales dry.

Discussion with N.Voase highlighted that it is essential to protect the hemp or flax bales from moisture and ideally all buildings need to be watertight with walls on all 4 sides. Many farm straw storage sheds are open on at least one side and an assessment needs to be undertaken of potential storage on farms, or modifications required on these sheds.

The predominance of existing barn storage is associated with livestock farms or arable/livestock units where capacity is closely linked usually to the feeding and bedding needs of the livestock. As the livestock sector is so prevalent in Scotland nearly all cereal straws are baled. Resulting in more competition for covered barn storage space than say for an operation based in southern England where arable predominates.

Farmers growing the crop and storing undercover on farm would not necessarily expect a storage payment in the way one might pay a commercial rent. Moreover, we would anticipate that the pricing model rewards those suppliers who store for longer. It is usually a nominal amount and by comparison, grain contracts usually operate a £1-2/ton/month 'carry' premium through the season.

It is essential that the hemp/flax bales are stored dry in watertight sheds. With harvest in September, and processing spanning much of the following 12 months, a large storage capacity is required. 2,000ha or 12,000 tonnes of hemp bales at 1.1 tonnes per square metre require 10,909 square metres of storage space. It is hoped that most of this can be accommodated on farms, with seven days supply stored at the Decortication Company site. If there are insufficient fully enclosed sheds, alternative ways of storing hemp/flax bales in existing farm sheds that are partly open sided should be investigated. Could the hemp/flax bales be protected by an outer layer of straw bales in open sided buildings to protect them from the elements to increase farm capacity? This is a critical issue, and it is recommended that a study of potential on farm storage and alternative storage methods is undertaken when forming a Grower Co-op.

4.7 Haulage

Hemp bales must be kept dry during haulage requiring curtain sided vehicles for road haulage. It is possible that a proportion of the crop could be delivered by tractor and trailer within a 10-mile radius of the processing plant. A 40ft tautliner has a load capacity of 32 rectangular bales; a payload of 15.5tons at 485kg/bale. Quotations for curtain sided lorry haulage up to 30, 60 and 90 miles have been calculated at £11/tonne, £14/tonne, and £19/tonne, respectively. If all crop was sourced from Lothians and Borders, the up to 60-mile option, the annual haulage charge would be around £180k.

Haulage costs would be minimised by growing most crop close to the processing plant in Jedburgh.

4.8 Crop performance in relation to other crops grown in Scotland

If industrial hemp is to be considered as a rotational crop to be grown in Scotland it is important to compare its likely profitability with other crops currently established. The analysis conducted as part of this report used indicative crop market values associated with the 2024 harvest and the associated growing and operational costs of each crop. Industrial hemp performance was compared with autumn sown crops of 1st and 2nd wheat, oilseed rape, feed barley and feed oats and with spring sown crops of beans, oats and barley. Specific data relating to industrial hemp is illustrated in Fig 18. Gross margin results (sales less variable costs) were compared, as were net margin results (gross margin less field operational costs*). Results are shown in Fig 19. (Full data tables are given in Appendices)

*Based on typical farmers cost of field operations

Fig 18. Industrial hemp Gross and Net Margin

| | |
|---|---|
| Output | |
| Straw sold | 6.00t/ha |
| Straw price | £270/ton |
| Straw income | £1620 |
| **Income** | **£1620** |
| | |
| Variable costs | £/ha |
| Seed | 350 |
| Fertiliser/ trace elements | 204 |
| Sprays | 10 |
| Agronomy fees | |
| Levies | |
| Sundries | 10 |
| Total variable costs | 574 |
| **Gross Margin £/ha** | **1046** |
| | |
| Operational cost | £/ha |
| Plough | 58 |
| Seedbed preparation /drill | 60 |
| | |

| | |
|---|---|
| Roll | 0 |
| Fertilise @£10/pass | 10 |
| Spray @£12/pass | 12 |
| Combine /mow | 26 |
| Tedder x2 | 30 |
| Row | 15 |
| Bale contractor £5.50/bale | 60 |
| Cart corn/ bales | 11 |
| | |
| Total operational cost | 282 |
| **Net Margin £/ha** | **764** |

Fig 19. Net Margins per ha for autumn and spring sown combinable crops compared to industrial hemp at 3 yield levels

| 2024 harvest | | 1st winter wheat | 2nd winter wheat | winter barley | winter feed oats | winter oilseed rape | spring barley | spring milling oats | spring beans | Hemp low yield 4.5t/ha | Hemp medium /low yield 5.0t/ha | Hemp medium /high yield 6t/ha | Hemp high yield 7t/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Income | £/ha | 1632 | 1359 | 1198 | 1227 | 1468 | 1224 | 1129 | 1083 | 1215 | 1350 | 1620 | 1890 |
| Total variable costs | £/ha | 302 | 420 | 267 | 148 | 265 | 189 | 142 | 325 | 574 | 574 | 574 | 574 |
| Gross Margin | £/ha | 1330 | 939 | 931 | 1079 | 1203 | 1035 | 987 | 758 | 641 | 776 | 1046 | 1316 |
| Field operational cost | £/ha | 344 | 344 | 320 | 320 | 344 | 296 | 296 | 288 | 269 | 276 | 282 | 294 |
| **Net Margin £/ha** | **£/ha** | **986** | **595** | **611** | **759** | **859** | **739** | **691** | **470** | **372** | **500** | **764** | **1022** |

At a 'medium-high' yield of 6t/ha and at a value of £270/ton, industrial hemp produces a gross margin of £1046/ha and a net margin of £764/ha. Both these values are in the top quartile for all crop margins measured. Fig 20. ranks the crop net margins in ascending order (top to bottom)

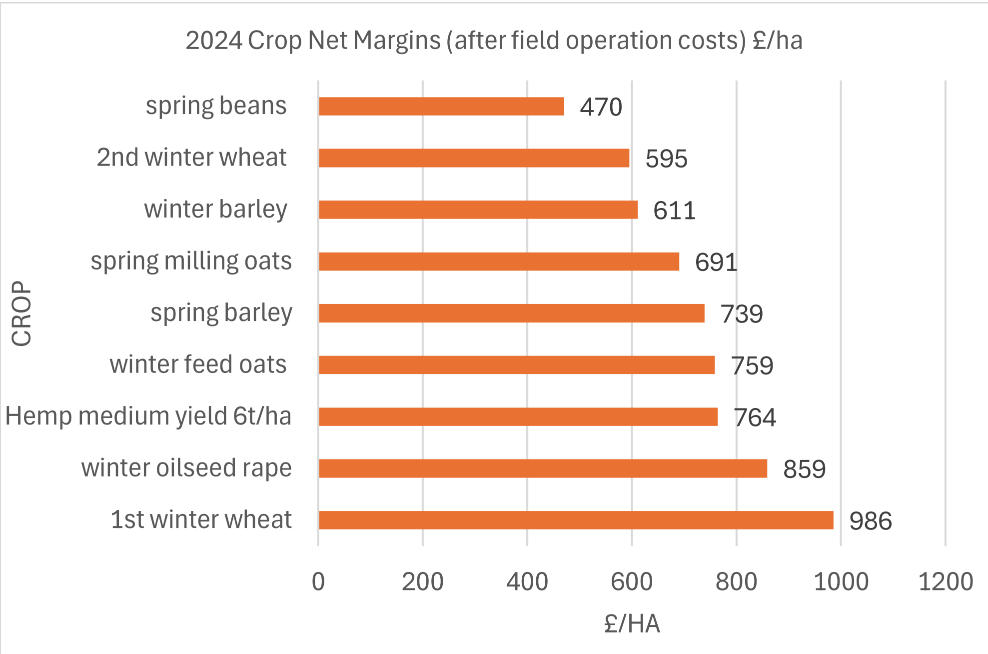



Fig 20.2024 crop net margins ranked according to return

Large increases in farm input costs and uncertainty on crop margins, following Covid and the war in Ukraine, may have hardened farmers attitude to risk, but conversely the industrial hemp supply chain might be attractive as a stable longer term income stream when compared to fluctuating cereal commodity prices.

4.9 Economics of production for the grower

Feedback from farmers indicate they will be attracted to a crop if it can provide a competitive net margin compared to current crops in their arable rotation. They are risk adverse and need to be convinced that the new crop will perform consistently well and fit their farming system and labour availability. They are dissatisfied at being price takers, at the mercy of fluctuations in supply and demand on world markets for crops such as cereals and would welcome the opportunity to be part of a co-operative that added value to their crop. A co-operative arrangement would allow them to share in onward processing successes. On the other hand, most agricultural co-operatives have involved adding value to crops they already grow e.g. potato marketing and pea vining co-ops, and they will need strong evidence and incentives to invest in a completely new crop venture. Contractual details will be key to minimising risk and a guaranteed minimum price with top ups, pooled pricing and production quality incentives need to be considered.

## **5.Case study visits**

5.1 Case study – The Netherlands – HempFlax, Stevens and CANN

Our Netherlands trip was hosted by Gerard Hosper, then Business Development Manager for HempFlax, who explained the Hempflax processing and manufacturing business at Oude Pekela and took us on a visit to the farming and contracting business of Alric Stevens in the Groningen area in the Northeast of the Netherlands.

HempFlax was founded in 1993 by Ben Dronkers with the aim of restoring the age-old crop to its former glory. It is now one of the worlds leading industrial hemp companies, with bases in the Netherlands, Germany and Romania and around 75 full time employees. The German operation is a joint venture with Kingspan the majority partner. HempFlax is also the majority shareholder in CANN Crop Solutions, a joint venture with John Deere, engineering new farm or contractor equipment for hemp production.

HempFlax takes hemp from the field to manufacture an impressive range of products:

- Construction – insulation and hempcrete products
- Industrial applications – composite items such as internal car parts, furniture and reusable cups.
- Animal care – bedding products for horses and pets
- Nutraceuticals – food and dietary supplements
- Horticulture – seed and plant growing mediums
- Genetics – hemp seeds and advice

The range of uses for industrial hemp is constantly being expanded with examples of non-woven mats for car door panels for an automative group, and 3D manufactured parts. Insulation products are composed of entirely natural materials which is an important consideration for recycling. A sports car company uses hemp fibres for car panels - they don't need natural fibres to sell a sports car but use hemp fibres as they are the strongest lightest material available. They also manufacture chairs moulded from non-wovens in a biobased binder.

Gerard reiterated the mantra – "quality starts in the field" and "harvest cheap process dear" leaving us in no doubt about the importance of using the correct equipment from the very start of a new hemp business. A hemp crop is easiest to process with correct stem length and retting stage. Also "Know your quality and the type of uses each grade is suitable for."

The Oude Pekela factory houses a 7 tonne per hour decortication system that currently works 15-16 hours per day, utilising two worker shifts. It used to work through the night too but located near housing got complaints about noise. The company have taken steps to reduce noise impacts on neighbours by relocating their air filtration fan unit below ground level. Double work shifts are essential to maximise daily hemp throughput and minimise processing costs per tonne when operating at this scale. The factory handles in excess of 2000ha of Netherlands crop with larger yields than experienced in the UK.

Electricity is a major cost for the factory and to reduce energy costs the company has installed 6000 solar panels on the factory roof with a plan to be "fossil free by 2025."

The future for hemp in the Netherlands seems bright as thirty percent of houses will need to have thirty percent natural fibre (insulation) by 2030.

Website - Home - HempFlax - Solutions from nature!

5.2 Alric Stevens, Farmer and Contractor

Stevens are a large-scale farming and contracting business, based in the Groningen area, who undertake all HempFlax contracting in the Netherlands. They grow and undertake contract work on approximately 2000ha of hemp, which represents a similar scale to our proposed Scottish operation. Our visit, facilitated by Gerard Hosper of HempFlax and hosted by Alric Stevens, covered the hemp growing process, harvesting practice and a tour of the machinery shed to view equipment. Stevens started growing hemp in 1995, HempFlax having been formed the previous year.

Alric Stevens grows sugar beet, potatoes and vegetables as his highest margin crops and regards hemp and surprisingly, winter wheat as break crops. A typical rotation is Potatoes – Sugar Beet – Hemp – Potatoes – Sugar Beet – Winter Wheat. They grow hemp in a 1 in 3 or 1 in 4 years rotation. Aside from crop returns Alric highlighted the large although unquantified benefits of the hemp crop to soil structure through its deep rooting, and a reduction in cultivations for following crops.

Fig 21 Claas forage harvester with Kemper header for cutting hemp crop

HempFlax growers can use their own drills to sow crops, typically from the middle of April to early May. They can also spray weeds and spread fertiliser prior to sowing. Then the crop is untouched from sowing through to cutting around 100 days later.

Stevens provide all services thereafter, machinery requirement for 2000ha of hemp consisting of 2 self-propelled forage harvesters, 5 tedders – 2 small 9m, 3 large 18m, and 8 big square balers.

Hemp is generally ready to cut on 1st August with retted hemp in baled by 10th September. A balance needs to be struck between optimum fibre quality and maximum yield. Stevens motto is “better to start harvest early than lose crop later.” Crop height doesn’t matter, the taller the better. It was strongly recommended that we mark all field obstacles on GPS as these will not be visible when cutting a tall hemp crop!

Self-propelled forage harvesters are used for cutting, the two we saw being a Claas Jaguar 870 and John Deere 9600i. John Deere and HempFlax have formed a company called CAAN to design and retail specialist hemp harvesting equipment and Alric Stevens test runs the prototypes before release. This includes a modified forage harvester single knife on the forager intake drum, as opposed to multiple knives for grass silage. This single knife must turn at a slower speed to chop the crop at an average 60cm length, which is ideal for processing. 4.5m headers are used on the foragers - we viewed a Kemper header in the machinery shed. Forward operating speed is around 10-12km/hour, cutting 3-4ha/hour, with a 15cm stubble is left to hold up the swath. These foragers can cope well with leaning crops.

Retting, tedding and baling. Stevens managed to ret many crops in just 2 weeks between 2010 and 2015, although have sometimes needed more in recent years. The sequence is – crop left in swath at back of forager – turn it twice with a tedder – row up for baling.

Fig 22 Alric Stevens owner of farming and contracting business in front of hemp crop, early July

Fig 23 Tour of Stevens workshop

The tedders have teeth removed to allow swaths to be turned rather than having hemp scattered out across the field.  The 9 metre tedder works two swaths and the 18 metre model four swaths. Two tedder passes may suffice in a good season but they can need up to four in more challenging seasons.

The crop is ready to bale when it is brown with no green or yellow material visible in the swath and has a moisture content of 15-17%. A tedder rows up the crop into a one metre swath for baling. The hydraulically operated baler pick up must turn slowly, to avoid crop losses at this stage. HempFlax favour a big square baler producing – 2.4 x 1.2 x 0.9m bales (approx. 8 x 4 x 3 feet) - which is most effective for stacking and transporting.

Most bales go straight to the HempFlax factory after baling, a job done by contractors. More distant crops are stored on the growers farm before transport.

Hemp yields are impressive averaging around 6-8 t/ha. These are exceptional yields from top quality soil, a long growing season and experienced operators, whereas the Yorkshire experience suggests we should target closer to 6t/ha in Scotland.

This impressive visit gave us confidence in the type of equipment we should utilise. We have had discussions with a Borders contractor who currently uses John Deere self-propelled foragers for grass and whole crop silage, who may be interested in hemp contracting work.

5.3 CANN, Netherlands

CANN is a HempFlax spin out company developing new machinery in house with John Deere. Stevens trials prototypes of new machines, which become commercially available after a year of testing. Stevens is also a partner in this business. Examples are a single knife intake drum on JD foragers that modify flow of hemp. They also engineer double cut headers for hemp combines, with a combine table upper cut, and a lower header for stems and leaves.

## Yorkshire Case Studies – East Yorkshire Hemp and Harrison Spinks

### 5.4 East Yorkshire Hemp, near Driffield, Yorkshire

Nick Voase is a pioneer of growing in the UK having grown it since 2002 and processed it on farm through a decortication plant since 2007. He currently grows around 115ha of hemp with contracted farms growing an additional 100ha, and processes hemp bales for others.

Fig 24

Nick has alternated hemp with wheat crops in the rotation and grown hemp two years in succession but now favours a rotation with a gap of two other crops between hemp to better combat blackgrass infestation. Crops are drilled in early May into a fine seedbed at 40kg/ha, followed by 90kg/ha of nitrogen or organic manure plus 50-70kg/ha of nitrogen. Weed control needs to be done before drilling due to a lack of suitable herbicides. Pest control and diseases are not major issues as cannabinoids act as a natural repellent. Average yields are 5.5 tonnes per hectare yielding between 25 and 28 percent hemp fibre. Nick is clear on the issue of growing dual-purpose crops for seed and fibre, it has to be one or the other, as a good fibre yield and fibre quality would be compromised by seed harvest in October.

Nick has built his own hemp cutter with three levels of knives cutting the crop in approximately 1m lengths – at 12cm off the ground then 75cm higher and 75cm higher. The ideal crop is 2.5m tall with small stems. Cutting takes place at the start of flowering usually in early August. Missing this timing results in a crop with a higher shiv content. The hemp is then left to rett on the ground with moisture and soil bacteria playing their part. Cut hemp is generally rowed up twice before baling when the crop begins to turn from golden to brown, generally 5-6 weeks after cutting.

The baling decision is critical to producing a crop that will be easy to process, and Nick will personally visit each crop to make the baling decision. Ideally the crop should be processed between 15-17 percent moisture content, preferably at the lower end of the range, as a rough guide when fibres begin to separate when twisting the stems by hand. Baling generally takes place in early to mid-September and large square bales of 8x4x3 feet tend to weigh around 500kg. Bales must be transported dry from the field to the sheds which are enclosed on four sides with passive ventilation. It is imperative that the crop is transported and stored dry and curtain sider lorries can be used for transport of more distant crops.

Fig 25 Hemp bales from farms pre decortication

Fig 26 Decortication equipment at East Yorkshire Hemp

Nick's processing line has evolved over time. Some of the equipment was sourced new from Tatham of Bradford and other machines have been purchased second hand from the textile industry. The line occupies two sheds and processes two tonnes of hemp bales per hour. It is a combination of preparation (bale opening), crushing separating and cleaning and baling.

Products

- Hemp fibre - produce the 10cm hemp fibre length required by his main customer in 350-400kg bales. Hemp fibre has to date been used in mattresses, upholstery products and for building insulation.
- Shiv – the woody core of the stem, is hammer milled and screened to make Hempbedz – a horse bedding product, and finer shiv is used to make Hempcrete to construct house walls or as a substrate for mushroom farming. Nick incorporated hempcrete into the walls of a house he built on farm.
- Shiv and dust are compressed to make Hemp briquettes (Hemplogz) for burning in domestic stoves.
- Remaining dust is spread back on fields to build organic matter in sandy areas.

Potential for hemp.
Nick believes that there is good potential to expand hemp production as it is currently in short supply in Europe. France and some other countries now include a set percentage of natural fibres in their insulation products. Limitations are a shortage of seed production and not enough decortication plants producing hemp fibre to allow manufacturing to flourish.

Fig 27 Nick Voase with hemp briquettes for log burning stoves

5.5 Harrison Spinks, Hornington Manor, near York

Harrison Spinks is a renowned manufacturer and retailer of beds and mattresses based in Yorkshire. The family-owned company employs 600 staff to operate their mattress factory in Leeds and their farming and event operations at Hornington Manor at Bolton Percy near York.

The following is an extract from their website. "At the heart of our approach is knowing that natural healthy sleep can only be achieved in a bed that's handcrafted from natural, healthy materials. British wool, natural hemp fibres, flax, linen and more. With acres of homegrown natural hemp fibres, linen flax and our flock of sheep, it's here, on 300 acres of prime Yorkshire land, where our story begins."

Fig 28 Harrison Spinks processing site

We visited Hornington Manor to view the Harrison Spinks decortication plant and tour the recently sown farm crops of hemp and flax and talk hemp with our hosts - Matthew Butler, Textile Manager; John Horsfield, Decortication Plant Manager; and Liam McPartland, Farm Manager.

Why do Harrison Spinks use hemp and other natural fibres in their mattresses?

Wool provides springiness whilst hemp is strong and doesn't stretch. Natural fibres are being used to replace nylon and polyester foam in beds as they provide strength, comfort and moisture control. Harrison Spinks sales of high-end mattresses have increased at a time when competitors are struggling, and they believe that inclusion of natural fibres has played a part. Their aim is to maximise inclusion of natural fibres in mattresses.

The carbon sequestration angle

According to Harrison Spinks staff, hemp is good at capturing and locking up carbon – 43% of a fibre bale is atmospheric carbon, a 1:1.6 ratio. One tonne of hemp sequesters 1.6 tonnes of carbon. The carbon cycle for hemp is 12 months (with only four months of growth) compared to trees at 30-50 years. Hemp sequesters four times more $CO^2$ per hectare than the same area of woodland every year. This highlights a need to factor ownership of carbon capture into our Scottish production and manufacturing model.

Crops and products

Hemp and flax are grown at Hornington Manor. The decortication plant is based on farm producing hemp and flax fibre bales, bagged shiv and dust/shiv briquettes.


Fig 29 Bagged shiv for animal bedding

Crops are drilled at end April to early May. They have had some frosts after sowing but this has not been an issue in ten years of production to date. All the arable land, 185 acres, is in a 50:50 hemp: flax rotation. Liam indicated that on their best soils yields well above 5 tonnes per hectare can be achieved, rising to 10 t/ha. Up and coming varieties include Mukka 75 and Fibra 79, whose fibres could potentially be easier to separate during decortication. Three other contract growers produce additional hemp and flax, with farmers cultivating, sowing and baling while Harrison Spinks cut the crop and decide when to bale.

The future for hemp

According to the staff, there are very few proper hemp growers and even fewer processors out there. Harrison Spinks' Linkedin enquiries about fibres have rocketed over the past year. They reckon that now is the time to invest in hemp production as there are big advantages to getting established earlier than others. There is a huge opportunity to use natural fibres to replace chemicals that are more harmful to the environment particularly in the building industry. In Europe, large construction suppliers are now buying up natural fibre producing companies indicating the direction of travel. The problem is that there are few processors and manufacturers out there. The UK will need dozens of processing plants, and we need to speak to government to help make this happen.

European countries are introducing legislation dictating an increasing minimum inclusion of natural fibres in insulation products and it is likely that this inclusion percentage will increase. Global events have recently disrupted the hemp supply, notably the supply of hemp from Ukraine to countries like Belgium.

Decortication and Production lines

These have been built up and adapted over a ten year timescale. There is a mix of "off the shelf" new equipment and repurposed second hand textile equipment with adaptations by local engineers. All energy needs are currently from the electricity grid with plans to instal solar panels to help reduce cost.

Fig 30 Processing line at Harrison Spinks

It is hard to open a bale of hemp, as it requires a lot of pulling, stretching and crushing to extract fine fibres. A basic description of the process is shown below.

1. Strong drum roller with hardened steel teeth. Single roller avoids complications with blockages. Fed from top of vertical shaft and bale pressed against rollers.
2. Dust extracted at three stages, and all pulled via flumes into an outside extraction system. Dust is blown or augered back into briquette machine that compresses dust and some shiv into blocks.
3. Line with two shakers working off one motor. Shakers are old MF combine straw walkers that shake and separate out the shiv and fibre, adapted by local engineers.
4. Rag pulling line – a single drum big, spiked roller. Fibre almost made by this stage.
5. Shirley wheel separator, Suction pulling fibres through.
6. Machine that cleans cotton. Slatted conveyor pulls shiv out.
7. Hemp fibre baler.
8. Shiv conveyor.

Labour requirement is typically four people per shift due to the layout of the machine through different sheds. One loading, two checking machine is running properly and dealing with blockages, and one person at bagging off points.

## 6. Crop processing

This section looks at the primary processing phase, taking the baled hemp product and passing it through a decortication and cleaning plant.

### 6.1 Decortication and cleaning

Hemp decortication is the process of removing the bast fibres from the plant's woody core known as shiv or hurd. It involves passing a hemp bale through a long line of fixed machinery.

Lines vary but as a general description: conveyors load the bales into a bale opener, the material passes through hammer mills to begin separation of fibres and shiv, it is then further refined over a series of shakers and separators. The fine fibres are blown towards a bale press to produce hemp fibre bales usually with a specification of e.g. 95% or above purity, and the required hemp fibre length e.g. 50-70mm. Heavier shiv is extracted in the refining process and hammer milled to the required size depending on end use. A powerful air filtration system removes dust through a network of ducts.

Products of the decortication stage

1. Hemp fibre suitable for making a variety of products including non-woven insulation batts and boards, soundproofing and other materials.
2. Coarse shiv hammer milled that can be sold on for inclusion in insulating boards, structural boards and hempcrete. Other items can be made from this including compression moulded car door acoustic panels and furniture.
3. Coarse shiv that can be hammer milled and bagged to make a product suitable for horse or pet bedding.
4. Fine shiv and short fibres can be compressed into briquettes suitable for using on wood burning stoves.

5. Dust that has no current value but may be applied on agricultural land.
6. The above is not an exclusive list and our Case Studies indicate that this range of uses will increase as more buyers demand natural, low carbon products.

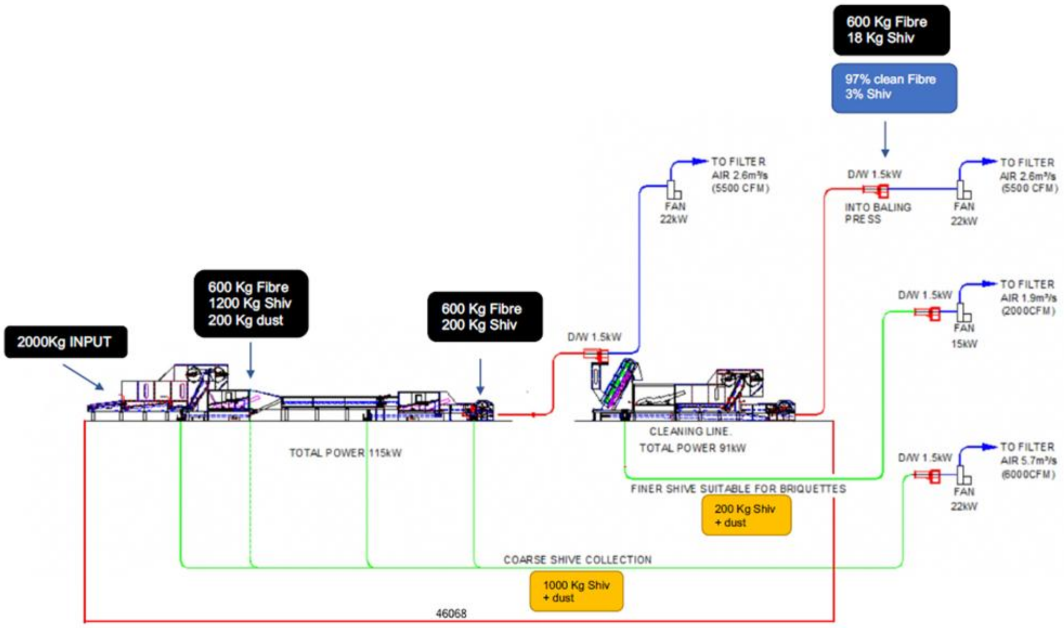
Fig 31 Demonstration of shiv used for shuttered hempcrete walling at Harrison Spinks

Fig 32 Processed hemp fibre bales at Harrison Spinks

6.2 Equipment

Processing line design

Below is a diagram of the main components of a 4 tonnes per hour hemp processing line and the product output at each stage. (Fig 33)



6.3 Plant throughput

Cash flow calculations show that the minimum number of hectares for a viable plant is around 2000ha, and given average yields of 6.0 tonnes per hectare, production of 12,000 tonnes of baled hemp. Commercially available decortication lines processing this volume of baled hemp have throughputs of either 4t tonnes per hour (tph), 5 tph or 7 tph. There are also models that process 2.0-2.5 tph, which are too small for the intended throughput.

For our study a 4 tph line is better value for money than the 7 tph line, particularly if it can be used for two shifts per day, as the latter is significantly more expensive in terms of capital outlay and requires more shed space.

One manufacturer provided an approximate quote for full decortication line options without going into a detailed specification.

- For a non-expandable 4 tph line a budget of around £3.4m.
- For a 4 tph expandable line they suggested a budget of £4.25m, with around £2.5m for the expansion – a total of £6.75m.
- For a 7 tph line around £6.4m.

Note that these are solely equipment purchase costs and do not include shipping and construction on site. They are summer/autumn 2024 costs and will rise with inflation.

They recommended the 4 tph expandable version as better for a start-up business, as it reduces initial capital cost and keeps options open for expansion.

An alternative for later expansion might involve setting up a second decortication facility, rather than expanding an existing line, particularly if sourcing additional hemp from more distant areas. In practice, economies of scale and a concentration of expertise, suggests that expansion is the preferable option for a new start enterprise.

Actual processing throughput tends to be less than the manufacturers stated value, due to breakdowns and cleaning time, and a manufacturer recommended that we assume 85% working time, which converts a theoretical 4 tph to an actual 3.4 tph. All going well it will take 3882 hours to process our example established year 13,200 tonne crop at 3.4 tph.

Fig 34. Processing throughput and worker shifts required

| | |
|---|---|
| Hectares grown | 2000 |
| Yield t/ha | 6.0 |
| Total tonnes | 12000 |
| Throughput t/hour | 3.4 |
| Total hours required | 3529 |
| Hours per shift | 8 |
| Weeks worked/year | 48 |
| Days worked/week | 5 |
| Total hours per shift | 1920 |
| Shifts required | 1.8 |

Above are assumptions used for our cashflow. With 3529 hours required to process 12,000 tonnes and 1920 hours per worker or team on a single 8 hour per day shift, full production requires 1.8 shifts or 16 hours worked per day.

## 6.4 Equipment costs

### Bespoke line specifications

We approached equipment manufacturers to provide quotes for a bespoke 4 tph decortication line. Industrial hemp is a relatively young industry and demand for equipment remains low, hence there are only a small number of manufacturers. For reasons of confidentiality neither company names, line design or pricing detail are quoted in this report – approximate figures have been used.

Quotes for bespoke lines need to be tailored to the specific requirements of farm production and buyers requirements. Some of the variables here are:

- The length of hemp fibre required by the buyer e.g. 50-70mm.
- The tolerance of other material within the hemp fibre bales. E.g. 95% hemp fibre.
- Whether bales are square or round – square bales are easier to open.
- Chop length in the field e.g. 60cm or 100cm.
- Requirement for bagging lines for by-products – shiv and briquettes.

Fig 35. Approximate costs for a decortication line producing baled hemp fibre and processed shiv.

| | £ |
|---|---:|
| Intake and decortication | 1,100,000 |
| Fibre cleaning | 550,000 |
| Fibre baling | 375,000 |
| Shiv handling | 300,000 |
| Filtration system | 350,000 |
| Byproduct packing system | 625,000 |
| Electrical system | 700,000 |
| Total | 4,000,000 |

These do not include the cost of a compressor and ducting for the air filtration system.

Prices of engineered equipment have risen substantially in the past 3 years. In addition to this £4m equipment cost another approx. £100k needs to be added for transportation and approx. £150k for installation of the equipment on the premises. Installation costs include the cost of specialist company engineers for a 4-6 week period helped by local labour and electricians.

### Location

This studies objective is to investigate the feasibility of locating a decortication processing plant on a farm site, within the area of production to reduce haulage costs. Central to this will be finding a farmer with suitable shed facilities who is enthusiastic to site the plant on his farm.

Hemp processing plants are quite power hungry using 550 – 650 kw of electricity per hour and a suitable electricity supply will be essential.

There may be the possibility of augmenting the power supply and reducing its cost by utilising farm generated renewable power such from a wind turbine or solar panels, although there will be periods when these do not generate power.

Storage space is less of an issue if the farm is reasonably close to other growers of hemp and bales can be delivered on a regular basis. There will be a reliance on farmer growers being able to store their hemp bales on their own farm before delivery to the processing farm, and this storage capacity will need to be investigated when a farmer group and co-op is set up. Likewise, an assessment of the processing farms available shed space and potential to build new sheds needs to be assessed.

The main Scottish hemp insulation manufacturer is based in Jedburgh; a Scottish Borders location would be advantageous in reducing haulage costs.

## 7. Ownership models for the growing and processing operations

Collaborative Hemp Supply Structure and Finance Options by Hamish Walls, SAOS

The co-operative business model is highly flexible, and structures are developed to suit the needs of members and individual business circumstances. They range from small low-cost models which provide services to members such as group purchasing up to large fully integrated business conglomerates operating on a multinational basis. The aim is always the same, to provide benefits to members.

SAOS have been asked to provide some examples of co-operative business models which might be applicable for hemp growing and processing.

### 7.1 Option one – a co-op to organise farm production

The key purpose of this option would be to organise the farm production of hemp and flax and supply a new Hemp Processing Company with baled material suitable for further processing (decortication).

The strengths of this model include opportunities to:

- Introduce one point of contact for the Processing Company when dealing with farmers
- Provide a centre of administration to deliver business transactions, contracts, and payments between farmers and the Processing Company
- Undertake the necessary liaison with the relevant Government Department to licence the production of hemp for farmers – take the hassle away
- Pool the purchase of inputs and equipment to grow hemp, most particularly the seed and harvesting chopper (hemp is a low input crop)
- Pool growing expertise over time and benchmark across the group to increase productivity
- Plan overall production, harvesting and storage
- Manage quality and develop expertise and control over the retting process
- Stage farmer delivery of hemp and thus cashflow equitably amongst the group

- Outsource the delivery functions of the co-op to external contractors, e.g. a machinery ring or to use the services of an existing co-op looking to diversify – this may avoid the need to employ a fulltime individual if that is not required
- Diversify risk on farm by growing a non-food crop (a different asset class)
- Maintain low costs
- Manage risk for the farmers (see also below)

One limitation of this model is there will be no access to the added value processing margins further up the supply chain.

Risk

With any new venture, there is always risk. From the farmer perspective, there are two obvious risks:

- The potential for a poor crop, crop failure or inadequate quality
- The failure of the Processing Company to implement their commercial strategy and the loss of this customer

On the first risk, the losses will relate to the costs of the growing crop and the opportunity forgone of growing another arable crop. On the latter risk, it is possible that if demand for hemp grows, there may be other buyers entering the market – for example for clothing and other textiles, rope, hempcrete, structural boards, compression moulded products or animal bedding. Provided the baled product is stored correctly, its value can be retained while accepting that delayed cashflow may be an issue as new buyers are sought.

Baled hemp can retain its quality over a period of a period of several years. Nick Voase in Yorkshire advised that he has stored harvested hemp and hemp fibre bales for up to 5 years without any issues provided that it is kept dry. However long-term storage (beyond 12 months) means that the grower will not be paid until such time as it is processed.

Costs

Input and capital costs will include pooled purchase of hemp seed and possibly equipment costs, although it is likely that these will be provided by a contractor and charged to individual farmers as a hectarage contracting charge.

Operational costs will include management time to deliver the functions required by the business. Some level of up-front capital will be necessary until hemp sale revenues are generated. Thereafter, the costs of the co-op could be deducted on a fixed fee basis based on throughput. A discussion with an existing Co-op should provide some indication of the sale and cost of the services required. Thereafter, an investment proposal can be developed which quantifies the scale and structuring of the funds.

The investment required can be financed in several ways as detailed in the co-op finance section.

Structure and registration

A co-operative business requires to be registered with the Financial Conduct Authority (FCA). The constitution highlights the rules of governance. This will include the key objectives of the business, in this case to grow, harvest, store and service the needs of a decortication enterprise.

A supporting members' agreement will quantify the obligations of the farmers (to grow and produce hemp) and the co-op (to organise the supply). Registration with the FCA involves completing an application form and submitting a signed copy of the rules for inspection. SAOS retains a set of registered model rules which can be amended as required. The FCA inspection of the rules is to make sure they comply with the Co-operative and Community Benefit and Societies Act 2014.

**7.2 Option two – a co-op to organise farm production and further processing**

The key purpose of this option is to organise the farm production of hemp and to further process (decorticate) it to supply hemp fibre and shiv to Hemp Product Manufacturers.

In addition to most of the strengths highlighted in option one, this includes opportunities for farmers to:

- Manage control of the decortication process and access added value margins
- Seek to obtain rates exemption for the decortication stage in a similar way to how some other co-ops obtain the same for added value processing, e.g. potato packing, grain drying and storage, etc
- Share the risk of the new venture on a pooled and equitable basis
- Obtain a transparent overview of the costs and margins over a larger part of the supply chain
- Over time, obtain a greater understanding of how retting and crop quality impacts on decortication efficiency and thus what can be done to improve yields
- Access support from schemes such as the Enterprise Investment Scheme (the project would not be eligible for the FPMC grant unless the rules are changed).

In addition to the risks in option one, others include:

- Increased investment costs
- Higher levels of risk encompassing both the growing but also the processing of a new crop

Both risks can be mitigated if the demand for hemp and hemp products increases. Other potential buyers may enter the market providing alternative selling options if Hemp Manufacturing Customers fail to develop their commercial strategies.

Costs and finance

In addition to the growing and harvesting costs outlined in option one, additional investment will be necessary to fund the purchase of decortication equipment and rent buildings

As in option one, operational costs will include management time to deliver the functions required by the business. Some level of up-front capital will be necessary until decorticated hemp sale revenues are generated. Thereafter, the costs of the co-op could be deducted on a fixed fee basis based on throughput. An investment proposal can be developed which quantifies the scale and structuring of the funds.

The investment required can be financed in several ways as detailed in the co-op finance section.

Structure

A co-operative business can be registered with the Financial Conduct Authority (FCA). The constitution highlights the rules of governance. This will include the key objectives of the business, in this case to grow, harvest, store, decorticate and service the needs of Hemp Manufacturers and shiv customers.

A supporting members' agreement will quantify the obligations of the farmers (to grow and produce hemp) and the co-op (to organise the supply and decorticate hemp). The co-op registration process has been outlined.

**7.3 Option three** – a joint venture between a co-op and a Hemp Manufacturer to organise farm production and further processing

The key purpose of this option is no different to option two, i.e., to organise the farm production of hemp and flax and to further process (decorticate) it to supply hemp and flax fibre and shiv to Hemp Manufacturer and to other wider customers. A structure can be developed to accommodate a joint venture between a farmer co-operative and a Hemp Manufacturer. This can be achieved by forming a company where the farmer co-operative and a Hemp Manufacturer jointly own the business. For example, the farmer co-operative might hold 80% of the shares leaving 20% for a Hemp Manufacturer and other private investors. The proportion of the shares would require to reflect the scale of the investment from each stakeholder and their corresponding appetite for risk. Board positions would similarly reflect the scale of the shareholding. Control would be vested with the largest shareholder. This kind of structure is used by the Orkney Cheese Company Ltd where a farmer co-operative (Orkney Milk Ltd) owns 70% of the creamery and the remaining shares are owned by Lactalis (a large French multinational cheese maker with 20% of the shares) and the Local Council (with 10% of the shares). The farmers retain most of the Board positions while Lactalis and the Council both retain seats.

In addition to the strengths already highlighted, this option delivers a more transparent method of conducting business and a structure which shares the risk between the farmers and Hemp Manufacturer. The extent of the risk sharing will depend upon the scale of the individual shareholdings. One issue to manage will be the conflicting desires of the shareholders where the farmers will wish to maximise their returns from hemp and flax and a Hemp Manufacturer will hope to purchase at least cost. Prior agreement of a fair method of revenue allocation can be used to manage the commercial status quo.

Co-op finance – members

Commonly used sources of member finance for co-operatives include:

- Member share capital
- Member loans
- Grant funding – if any is available
- External loans/lease
- Creditor finance

Once the business is up and running there is an on-going requirement to re-invest in new and more efficient assets, finance working capital and maintain an appropriate level of reserves within the co-op in proportion to the risks involved. The most appropriate capital structure for the co-op will depend on the type of business the co-op is involved in, the level of capital required and the risk appetite of members. The simplest method is where the members of the co-op provide the entire capital requirement, investing in proportion to the use they make of the co-op's services.

Often, the greater the level of capital required, the more likely the members will be unable to provide all the capital, thus requiring external sources to be found. Sources of finance include:

Shares

Members are required to purchase a minimum level of shares upon joining a co-op, although these may be paid over a period of time. The Rules determine the circumstances in which shares may or may not be withdrawn ('sold' back to the co-op) or transferred (to another member). The Rules of the co-op also set out the value of each share and this is fixed for the life of the investment.

Co-op legislation imposes a maximum withdrawable shareholding of £100,000 for any individual co-op member. This can be restrictive when trying to raise additional capital from members.

Unlike a company, voting is not in proportion to capital shareholding but by one member one vote. Share capital in a co-op can be rewarded through the payment of interest. This is paid at a rate decided by the Board, which should be in line with the market rate at that time, and within the limits stated by the co-op's rules.

Loans

Loans from members are often the most significant source of capital for a co-op as there are no limits to the value of loans that can be made. Loans may be fixed term or repayable after giving a fixed period of notice and may or may not be interest bearing. Loans in the form of compulsory "qualification loans" may be required from members and would be in proportion to their committed throughput with the Society.

Capital levy

Capital retentions may be levied by way of a charge on members' throughput. These are usually applied at a rate per tonne, e.g., £2 per tonne. These are then credited to an individual members' capital or loan account. It would be normal for an Agreement to be in place between the member and their co-op for the capital account and the Agreement to include repayment or transfer terms.

Bonds

Bonds may be issued by the co-op to individual members who provide capital for a fixed period at an agreed rate of interest. Bonds are repaid to the member upon a set notice period or at the end of the period agreed at the date of issue of the bond.

Retained profits

There are several ways in which retained profits can be allocated and used as capital for the co-op. Annual surplus /profits can be allocated to general reserves so that the capital is allocated to the co-op as a whole and not to a specific member. This can be a cost-effective source of capital as it is not interest bearing, however, a balance must be made between the requirement for capital and the need for the co-op to provide services at a competitive rate.

Many co-ops prefer to build general reserves as a capital source because it is 'permanent' capital to the co-op, and it does not need to be repaid when members leave.

Share issues

Shares can be issued out of profits based on member throughput. There are several advantages to this method of capital retention:

- Tax deductible for the co-op (but not for the member)
- Increases members' shares in the co-op
- Increases potential to distribute surplus to members by way of interest payments

Share allocations are taxable (at the time of allocation) in the hands of the member. Co-ops may distribute a cash component to cover any potential tax liability. This tax issue generally prevents many co-ops from allocating profit to share accounts.

Qualifications loans

Some co-ops transfer part of the annual surplus to members' loan accounts. Terms of repayment will be included in a Members' Agreement or a separate Loan Agreement. Members' loans are generally sources of long-term capital and repayment is usually made after an agreed period following termination of membership or can be transferred to incoming members. Different loan accounts can be agreed with members and allocated according to the throughput of different commodities supplied by members through their co-op.

Revolving funds

Revolving funds are used and involve allocating profit to, or retentions from, individual members in line with their usage of the co-op. The investment allocated in a particular year remains in the co-op for a set period (e.g., 3-years) when it is repaid to members, to be replaced with the subsequent allocation. This type of capital is relatively fixed and is increasingly used to provide the co-op with cashflow. Again, tax is due by the member on any profit allocation at the time the allocation is made rather than when the fund is paid to the member, therefore most revolving funds are based on retention of levy rather than an allocation of profit.

Co-op finance – external

Potential sources of external (non-member) finance include:

- Bank Finance. This can be in the form of either overdraft or fixed term loans (secured by the co-op's assets, debtors, and member guarantees).
- Preference Shares**.** Non-voting preference shares may be issued to members and non-members alike. A preference share would normally be paid a (higher) rate of interest in contrast to an ordinary share that may not be paid interest at all.
- Loans and Bonds. Loans or bonds from non-members can be agreed at the same or different rates to members.
- Creditors. As in any business, securing preferential credit terms from suppliers can provide a cost-effective source of finance for co-ops, and is particularly useful in a start-up situation.

Finally, there are two important aspects concerning the use of external finance:

- It should not allow voting rights to the capital provider concerning the main business of the co-op.

- It can lead to a conflict of interest where the desire for the external investor to maximise the returns and value of their investment conflicts with the desire of the members to provide a cost-effective service that maximises their profit.

**7.4 New generation co-operative**

The New generation Co-operative (NGC) structure became common in north America with the establishment of legislation in the 1990's that was attractive to producers especially when commodity prices were too low to sustain profitable farm operations. NGCs enabled farmer producers to raise capital and invest in downstream value-added processing as a route to improve the prices for farm produce. NGCs created tradable co-op shares ("deliverable rights") moving the traditional co-op model closer to a PLC model, where the co-op share price can move up or down. NGCs are in effect closed co-ops. The only way a farmer member can increase his/her tonnage delivered to the NGC is by purchasing more deliverable rights from a fellow member. The value of the shares/deliverable rights can move up or down depending on the performance of the NGC. It also allows a farmer an exit from the co-op, as he/she can sell their deliverable rights in the future. In a traditional co-op, the value of the co-op share remains the same.

NGCs maintain many traditional characteristics of producer co-ops including one member one vote, patronage-based distribution of profit, and being member-owned and controlled. Many marketing co-ops already restrict membership to manage volume and quality on behalf of the collective and their customers, but NGCs take this further by selling shares carrying 'delivery rights' to raise required capital. Membership tends to be set at a low or nominal price, like a traditional co-operative, but a pre-established number of delivery rights is set at a price sufficient to generate capital requirements.

The goal would be to ensure delivery right shares amount to at least 50% of equity. The actual process of establishing the NGC is otherwise very similar to that of a more traditional producer co-operative.

Delivery rights allow members to market their production to the co-operative, with a percentage of the sales value retained by the co-op for reinvestment. The co-op will only sell the number of 'delivery rights' required to meet processing needs. Similarly, it is not possible to deliver more than a producer's number of delivery rights. One of the big advantages of the NGC model is that it de-risks the supply of feedstock to the processing plant. Members have a legal obligation to deliver the tonnage specified.

It is a two-way contract for members to deliver requirements and the co-op to accept the agreed amount. There is no obligation to fully commit to the co-operative. A fundamental difference with NGC's over traditional co-ops is in risk management for members. If the quantity or quality of the goods does not meet the NGC's standards, the grower will be required to purchase goods from another grower to fulfil their commitment. The grower is otherwise responsible for paying any difference that the NGC pays to fill the requirement.

It is not clear how this might work for hemp when other sources of material in the locality are not available.

The NGC contract issued to members is based on a pre-agreed price. In addition to contracted supply, the NGC may venture into the open market through a mix of futures and options to hedge their position and provide any balancing supplies. Similarly, a grower may sell non-contracted grain on the futures market. They may do this directly but more likely via a trader or their local 'Elevator' (co-operative or private grain storage facility). NGCs usually manage the flow of the raw product to their facilities by establishing delivery schedules for each member. These schedules require members to fulfil their annual delivery obligation in instalments spaced throughout the year. This limits co-op owned (capital intensive) or leased (operationally expensive) storage requirements.

Return on capital - Members receive their share of the NGC's surplus, which is proportionate to the number of delivery rights held. Their capital investment serves to create a more profitable "home" for their respective farm's production than would otherwise be available. These delivery rights (shares) are tradeable at a price determined by the market assuming strong demand. The value of shares can go down as well as up based on the cooperative's performance. They are not, however, redeemable by the NGC. Typically, a grower-member can choose to transfer or sell their shares to other members, pending approval from the board, but they do not have the automatic right to sell to non-members.

## 8. Grower Co-op structure and function

The three options mentioned in Section 7 have been reviewed to identify which might work best for the hemp supply chain. Any of the three options could work depending on the level of investment forthcoming and investors with the proposed management structure of the Decortication Company.

8.1 Option 1– A co-op to organise farm production.

This option suits a scenario where there are a group of farmers group growing hemp, a decortication company that processes baled hemp into hemp fibre and shiv, and a manufacturing company that processes the hemp fibre into building industry products.

With a 2,000ha target there could be 60 farmers growing an average of 33 ha each year. Some may want to invest in the decortication company, but it is likely that the majority may wish to just grow the crop and sell it on.

The Farmer Co-op would be set up to:

- Organise farm production
- Manage farmer members expectations
- Provide an administrative function
- Co-ordinate purchase of seed
- Provide field staff to advise on agronomy, cutting and baling timing
- Purchase or lease equipment, or co-ordinate contractors
- Co-ordinate crop delivery to the decortication company plant
- Establish co-op grower charges on a per hectare basis
- Negotiate on pricing and deal with any quality issues
- Continuously improve grower and co-op performance through a programme of knowledge sharing and trials
- As well as any other co-op management and financial functions

Farmer members would be asked to collectively cover the cost of running the co-op and for capital investment.

8.1.1 Costs of running the co-op may consist of the following**:**

- Salary for a Co-op manager and would this be a full time or part time position.
- Cost of admin support – likely to be required on a part time basis
- Cost of dedicated agronomy support – would this be the manager or an additional post? Likely to be a part time role focussed largely on cutting and baling decisions.
- Costs of undertaking knowledge sharing and setting up local trial plots – could be managed in house or subcontracted.
- Costs of contractor work namely cutting, tedding and baling the crop.
- A processing charge from the Decortication Company were the co-op to retain ownership of the processed crop for sale to the manufacturer.

Farmer Co-op machinery or provided by contractor?

- Cost of modified drum or drums for a forage harvesters to cut the crop – does the Co-op purchase this or does the contractor purchase it? Approximate cost - £75k per drum. Two likely to be required for 2,000ha.
- Cost of a modified Kemper type forage harvester header suitable for a hemp crop. These headers may be available from contractors who harvest maize silage. The header costs around £62k with the modification costing approx. £6k. One header is needed for each forage harvester.
- Cost of engineered three bar cutters to give the co-op flexibility to work when contractors might be busy with other work. Approximate cost £35k per cutter.

Farmers will prepare the soil and sow their own crops. Thereafter, much of the equipment required can be provided by contractors. This includes self-propelled forage harvesters to cut the crop – two for 2000ha. These foragers will need the multi knife grass silage drum to be replaced by a modified hemp drum with a single knife and a slightly modified Kemper type header. Additionally, a three or four blade cutter could be used in the early years and kept as backup thereafter, although the forager option is likely to deliver a better product for decortication.

Next there are several tedders required to invert and rake up the crop - approximately two 9m and three of 18m going by the Netherlands case study, and finally several big square balers, which should be readily available in the area. Forager cutting is likely to be a contractor job. Tedding and baling will also be a contractor operation, augmented by farmers who already own the correct equipment.

Grower co-op management and administration

The grower co-op will require a manager, a part time fieldsman, a part time administrator and accountancy support when needed. Ideally the co-op manager would also undertake field duties overseeing cutting and baling timings and liaison with contractors, as well as crop planning, licences, seed orders and sales. Agricultural knowledge is desirable for organisation for oversight of performance improvement and management of the growers. Admin and financial support is likely to be part time involving anything that can’t be handled by the manager or is more efficiently delivered by others. The managers post could be covered by part time work in the build up years to a level where full time is necessary, provided that the grower co-op work could be done timeously. Premises may not be required if the staff could work from home.

Grower co-op costs

The following is a rough estimate for co-op equipment and staff that will be paid for by farmer members on the basis of hectares of hemp grown.

Grower co-op management and administration – assume £75k per year once at full capacity of 2,000ha. Annual cost - £37.50 per hectare.

Equipment costs) – one modified forager drum (£75k), and one modified Kemper header (£68k), share of one backup three blade cutter (50% of £35k) per 1,000ha. Total cost - £160k. If five years usage annual cost is £32,000 or £32 per hectare.

Total co-op or grower cost is approx. £70 per hectare.

8.1.2 Hemp bale storage requirements

Will additional hemp bale storage be required? The Decortication Company budget assumes that around seven days requirement of approx. 380 tonnes of hemp bales will be stored at the Decortication site. This also assumes that each farm has capacity to store their hemp bales in existing sheds prior to transport to the Decortication Company site.

Standard square bales weighing approx. 500kg and measuring 2.4x1.2x0.9m require 2.6$m^3$ of space. A tonne requires 5.2$m^3$. If stored five bales high (4.6m), 380 tonnes require 429$m^2$ of floor space, which equates to 20m x 21.5m, at the Decortication site.

A calculation for farm storage requirements shows that 25ha producing 150tonnes of baled hemp requires 780m3 or 170$m^2$ of floor space at 5 bales (4.6m) high.

8.1.3 Hemp price

In this scenario, farmers remain price takers and will have to negotiate the price for their product probably on an annual basis. It is possible that several of these farmers may also be Decortication Company members and may have some influence in price negotiation.

The hemp bale purchase price must be pitched at a level that encourages farmers to commit to growing the crop for several years. If it is pitched too low and farmers have no barrier to ceasing hemp production, decortication and manufacturer plant supply could drop below the critical level that keeps the operation viable. Pricing of hemp must work for all parties.

8.2 Option two – a co-op to organise farm production and further processing.

This may be the preferred option if there is a realistic chance that farmers could invest in a sizeable share of the decortication companies' capital investment spend.

CAPEX spend on the Decortication plant is likely to run to a level of £4.5 million. It is hoped that grant funding may be secured for a proportion of the capital spend but this is uncertain. If farmers were to raise £1 million this would require 40 farmers to invest an average of £25k. It is likely that substantial investment will be required from other investors to raise sufficient capital to allow the decortication and cleaning line to be installed. Farmer and investor meetings would need to be held to run through a prospectus for the Decortication Company.

There is some risk for farmers as they must invest a large amount of capital, but this may be mitigated by tax advantages of an Enterprise Investment Scheme. Use the Enterprise Investment Scheme (EIS) to raise money for your company - GOV.UK (www.gov.uk)

8.3 Option three – a joint venture between a co-op and Hemp Manufacturer to organise farm production and further processing.

There would be advantages to a Hemp Manufacturer investing in the Decortication Company to provide a reliable supply of hemp for their factory, in tandem with farmers and other investors. Advantages of this scenario are that Hemp Manufacturers, the Decortication Company and Farmer Growers could all influence the strategy and running of the processing plant. It offers the potential for transparency on the costs of farm production, processing, and manufacturing of industrial products and, to inform appropriate returns for all parties and lead to greater efficiencies through information sharing.

Any of the three options may apply, depending on the objectives of the three parties.

8.4 Interview with an established co-op

A meeting was held with the manager of a local co-op that grows agricultural crops, pays a contractor for processing and sells to wholesalers. Some of the main points made were:

- Members should share the risk of growing the crops and be paid on overall co-op performance rather than individual yields or quality. Avoid bonus payments as this would lead to problems.
- The co-op manager should play a key role in fostering a co-operative spirit and encourage farmers to work together for everyone's collective benefit.
- Product quality and a reputation as a reliable supplier are the key factors for a successful relationship with buyers. Quality control needs to be a priority.
- Prices of agricultural produce are best re-negotiated on an annual basis due to the changes that can occur in input costs and previous seasons experience.
- Best to have a co-op with all members investing in capital or running costs based on their committed hectares.
- Expansion of hectares can be quite rapid once the farmers see that the co-op is providing a good crop margin for them.
- Advantages in being certified for the LEAF Marque – establishes sustainable credentials.

## 9.Decortication Company finances

This section analyses the income, expenditure and surplus of a Decortication Company buying baled hemp from a Grower Co-op and selling products to Hemp Manufacturers.

A detailed Ten-Year Cash Flow has been produced to allow an assessment of net cash flow and to allow modelling of different scenarios. To obtain a clearer picture of profitability, additional work would need to produce a Profit and Loss Account before setting up a hemp decortication business.

For the purpose of this study processing involves:

Purchasing hemp and flax bales from farmers and passing them through a decortication and cleaning plant to produce the following products:

1. Hemp fibre suitable for making insulation batts and boards (350kg bales). Hemp fibre is then sold to Manufacturing Companies for conversion into insulation materials.
2. Coarse shiv hammer milled that can be sold on for inclusion in insulating boards, structural boards and hempcrete.
3. Coarse shiv hammer milled that can be packed in 20kg for horse or pet bedding
4. Fine shiv and short fibres compressed into briquettes suitable for using on wood burning stoves (11kg packs) sold to wholesalers by the Decortication Company.

### 9.1 Costing assumptions

Hemp price ex-farm

The budgeted price for big square bales of hemp stored on farm has been estimated from enquiries to established growers in summer 2024, and calculations of a price that would make hemp attractive enough for farmers to want to join and invest in a hemp production co-op.

Hemp buyers were understandably reticent to disclose full details of their purchasing to a potential competitor and gave us an approximate guide price of around £250/tonne. One business was paying up to £300/tonne for smallish quantities of baled hemp.

We would suggest that a suitably attractive price for new growers would need to start at around £270/tonne for a 6.0t/ha crop to provide a margin that competes with cereal and oilseed crops currently grown on farm based on 2024 crop net margin calculations. Note that cereal prices were relatively low in 2024.

If the hemp ex-farm price is set too low farmers will continue to grow their current range of crops rather than risk a new crop that they have no experience of growing.

Secondly, the main purpose of forming a grower co-op would be to produce crops at a price that does not follow boom and bust fluctuations of a global markets but is tied in at a sustainable level that allows a fair margin for grower, processor and manufacturer. The defining factor of this model is the value of product the manufacturer sells rather than hemp spot price markets. The price the manufacturer gains from its market is also subject to the laws of supply and demand and from competitors pricing of similar products.

9.2 Decortication Plant Products

Prices for baled hemp fibre and hemp shiv have been set at hemp fibre £725/tonne, and shiv for adding to insulation boards, including in structural boards, or adding to hempcrete valued at £430/tonne.

The market for hemp fibre is strong at present but markets for shiv are less certain. Ideally as much shiv as possible would be sold bulk to the construction industry in bulk lorries, but this market is yet to fully develop. Alternatively, shiv can milled and sold as horse and pet bedding with a price of around £400/tonne, however this requires relatively costly processing kit and the effort required to build sales for a new product. A proportion of the shiv could be incorporated into insulation products, but volumes are unlikely to be large.

Briquettes make use of materials that would otherwise be wasted and have been included at £225/tonne. This will require staff costs spent on marketing and co-ordinating sales to several wholesalers or retail outlets. It also requires specialist briquette equipment and packaging.

Processing outputs

The following example of processing output applies to Years 6-10 of the Ten-Year Cash Flow.

Fig 36. Processing output and value

| **Years 6-10 Total Sales** | | | | |
|---|---|---|---|---|
| **Item** | **Numbers** | | | |
| Hectares | 2000 | ha | | |
| Average yield | 6.0 | tonnes/ha | | |
| Total tonnes | 12000 | tonnes | | |
| **Output** | **%** | **tonnes** | **£/tonne** | **Total £** |
| Hemp fibre | 25% | 3000 | £725 | £2,175,000 |
| Coarse shiv - boards, hempcrete | 45% | 5400 | £430 | £2,322,000 |
| Bagged shiv for bedding | 10% | 1200 | £400 | £480,000 |
| Briquettes | 12% | 1440 | £225 | £324,000 |
| Dust | 8% | 960 | £0 | £0 |
| Total | 100% | 12000 | | £5,301,000 |

Total output is £5,301,000 for this volume of throughput and mix of products.

9.3 Decortication process costs

Production costs taken from an established year of the Ten-Year Cash Flow are shown in Fig.37, to the nearest £1,000. Prices have been obtained from sources including hemp manufacturers, farm-based hemp businesses, equipment suppliers, and a farmer co-operative. An explanation for each cost is shown at 9.4, that follows this table.

Fig 37. Indicative list of processing costs

This is an indicative list of costs in years 6-10 when production peaks at 2000ha. Actual cash flow results vary year on year. Figures rounded to the nearest thousand pounds.

| | Annual cost – Year 10 | Total cost | Note |
|---|---|---|---|
| **Labour** | | | |
| Decortication line | £250,000 | | 1 |
| Management, admin and marketing | £100,000 | | 2 |
| Total | | £350,000 | |
| **Machinery** | | | |
| Repairs - plant | £40,000 | | 3 |
| Lease charge - loaders | £25,000 | | 4 |
| Total | | £65,000 | |
| **Power** | | | |
| Electricity - plant | £600,000 | | 5 |
| Machinery fuel & electricity | £40,000 | | 6 |
| Building electricity | £20,000 | | |
| Total | | £660,000 | |
| **Rent and rates** | | | |
| Rent – sheds and other | £120,000 | | 7 |
| Rates | £0 | | 8 |
| Total | | £120,000 | |
| **Finance charges** | | | |
| Bank interest | £68,000 | Average for 10 years | 9 |
| Loan interest | £65,000 | | 10 |
| Total | | £133,000 | |
| **Insurance** | | | |
| Factory and some stored crop | | £40,000 | 11 |
| **Processing consumables** | | | |
| Packaging and other materials | | £67,000 | 12 |
| **Haulage and storage** | | | |
| Haulage | £180,000 | | 13 |
| Storage paid to farmers | £72,000 | | 14 |
| Total | | £252,000 | |
| **Professional fees** | | | |
| Consultancy and accounts | | £10,000 | 15 |
| Other contractors | | | |
| **Contingency allowance** | | | |
| Contingencies at | 10% | £100,000 | 16 |
| **Total Operating Costs** | | **£1,797,000** | |

Total processing costs are estimated to be approximately £1.797 million for Years 6-10. This includes an additional £100k for contingencies. Included are all costs arising from the point hemp bales arrive at the premises including ex farm haulage costs haulage costs to the Decortication plant.

The other major costs that must be factored in is purchase of hemp from the Grower Co-op. In Year 10 this amounts to 12,000 tonnes at £270/tonne = £3.240 million.

Total costs are therefore £3,240 million + £1,708 million, a total of £5,037 million.

9.4 Processing costs – list of assumptions

1. Four processing plant staff per shift at average total salary cost of £35k for foreman and £30k for other workers, adjusted down for number of hours worked. This allows for one person loading the line, one taking off straps and operating a bale cutter, one supervising and one taking off product at the end of the line. Some of these staff can double up on loading, unloading and moving product around the site. Likely to be at full capacity of two eight-hour shifts per day by Year 6-10. Total cost £250k per annum.
2. Salary for a factory manager product marketing and an administrator. Budgeting £100k per year.
3. Repairs to decortication and cleaning line plant. These are robust, uncomplicated machines but there is potential for breakdowns and wear and tear caused by foreign material entering the system via bales. Contingency of £40k per year.
4. Leased equipment. One loader worth approx. £70k new over eight years, two forklifts worth approx. £25k each over five years. Annual charge of £25k.
5. Electricity charges are likely to be the biggest cost. Decortication and cleaning line – estimate 625 Kw per hour. Calculate 3529 running hours for 12,000 tonnes at 3.4 tonnes per hour (85% efficiency on 4 tonnes per hour). 3529 hours x 625 Kw hours x 28p per Kw hour = £600k
6. Fuel for loaders and electricity for forklifts. Calculated based on company information on forklifts and best estimate of loader fuel usage. Fuel powered forklifts use 5l/hour x 3529 hours at £1.30/l is £23k. Four machines not in constant use, 45% time - £40k. Power general factory - £20k.
7. Rent based on £3 per square foot x 40,000 square feet (3716 square metres) = £120k.
8. Rates – farm premises zero rated.
9. Interest charges. Bank interest or Interest on working capital at 10% per annum. Based on an average of the previous year and the current years cumulative cash flow figure. To avoid circular references this has been calculated in a separate line below the spreadsheet then manually entered.
10. Loan interest – calculated from an amortization table for a 15-year payback at 10% interest rate. This is a capital plus interest payment.
11. Insurance. Will require insurance for the processing plant building. Also, insurance for any new build central storage belonging to the co-op. Farmer storage would be covered through their own policies. Budgeted figure - £40k per year.
12. Packaging and other materials associated with bagging up shiv for horse bedding and packaging for briquettes. Shiv horse bedding – plastic packaging at 27.50/tonne, briquettes for log burning stoves packaging at £15.45/tonne, hemp bale twine at £4/tonne baled.
13. Haulage. Haulage is based on transporting the crop from farms to factory in curtain-sider lorries. Calculated value £15/tonne. £180k for 12,000 tonnes.
14. Storage is based on payments that farmers might receive for storing bales on their own farms for a long period. Based on 50% of 12,000 tonnes stored for 6 months at £1 per month = £36,000.
15. Consultancy and accounts. Payment for consultancy, accountancy and any other specialist service.

16. Contingencies – a contingency figure of 10% of all cash flow costs, apart from purchase price of baled hemp, has been added. This has been moderated to a maximum of £100k as the operation becomes established.

## 9.5 Processing margins and sensitivity analysis

### Output

Fig 38 shows potential output from the decortication plant taken from the 10 Year Cash Flow. Processing 12,000 tonnes of crop from 2000ha produces a sales output of £5.3 million.

| Years 6-10 Total Sales | | | | |
|---|---|---|---|---|
| **Item** | **Numbers** | | | |
| Hectares | 2000 | ha | | |
| Average yield | 6.0 | tonnes/ha | | |
| Total tonnes | 12000 | tonnes | | |
| **Output** | **%** | **tonnes** | **£/tonne** | **Total £** |
| Hemp fibre | 25% | 3000 | £725 | £2,175,000 |
| Coarse shiv - boards, hempcrete | 45% | 5400 | £430 | £2,322,000 |
| Bagged shiv for bedding | 10% | 1200 | £400 | £480,000 |
| Briquettes | 12% | 1440 | £225 | £324,000 |
| Dust | 8% | 960 | £0 | £0 |
| Total | 100% | 12000 | | £5,301,000 |

## 9.6 Ten Year Cash Flow

Fig 39. A summary Ten Year Cash Flow is shown below. (A full version of this cash flow can be found in the Appendices).

| **Production and cash flow** | | **Year 1** | **Year 2** | **Year 3** | **Year 4** | **Year 5** |
|---|---|---|---|---|---|---|
| Hectares | ha | 200 | 400 | 700 | 1200 | 1600 |
| Average yield | tonnes/ha | 5.5 | 5.5 | 6.0 | 6.0 | 6.0 |
| Total tonnes ex farm | tonnes | 1100 | 2200 | 4200 | 7200 | 9600 |
| Total sales | | £489,225 | £978,450 | £1,867,950 | £3,191,400 | £4,248,000 |
| Total expenditure | | £1,115,099 | £1,271,188 | £2,050,180 | £3,266,149 | £4,173,298 |
| Net cash flow | | -£625,874 | -£292,738 | -£182,230 | -£74,749 | £74,702 |
| Cumulative cash flow | | -£625,874 | -£918,612 | -£1,100,842 | -£1,175,591 | -£1,100,889 |
| **Production and cash flow** | | **Year 6** | **Year 7** | **Year 8** | **Year 9** | **Year10** |
| Hectares | ha | 2000 | 2000 | 2000 | 2000 | 2000 |
| Average yield | tonnes/ha | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 |
| Total tonnes ex farm | tonnes | 12000 | 12000 | 12000 | 12000 | 12000 |
| Total sales | | £5,301,000 | £5,301,000 | £5,301,000 | £5,301,000 | £5,301,000 |
| Total expenditure | | £5,068,748 | £5,044,748 | £5,018,748 | £4,988,748 | £4,969,748 |
| Net cash flow | | £232,252 | £256,252 | £282,252 | £312,252 | £331,252 |
| Cumulative cash flow | | -£868,637 | -£612,385 | -£330,133 | -£17,881 | £313,371 |

Comment on the cash flow

Net cash flow is negative up to year 4, turning positive in Year 5 and reaching £331k by Year 10.

Cumulative cash flow peaks at -£1.175 million in Year 4, gradually becoming positive by Year 10.

An allowance of £150k for plant installation and £130k for equipment shipping is included as a one-off payment in Year 1 expenditure.

Purchase of hemp bales ex farm is the largest item of expenditure at £3.24 million at full production in Years 6-10 with hemp bales valued at £270 per tonne.

Processing costs including labour and electricity work on a sliding scale, as more hemp is processed between Years 1 and 6. Processing is pro rata for one worker shift per day up to 6000 tonnes (1000ha), then up to 2 worker shifts per day at 12,000 tonnes (2000ha) processed.

A contingency figure is included each year at 10% of processing costs up to a maximum of £100k.

Finance charges, included in total expenditure, consist of bank interest at 10% per year on the average of each years cumulative cash flow. An allowance has been made for a loan taken at 10% interest over 15 years for £500k – capital and interest payback estimated at £65k per year. These rates are likely to be around 5% above base rate if the Decortication Company is a new start and has no track record and no reserves. This assumes that the remaining capital has been provided through equity investment and some grants. If all the CAPEX and working capital requirements could be met by equity investors, then these high interest rates could be avoided.

Note that the cash flow surplus is not the same as profit as other non-cash costs such as depreciation need to be factored in. Hemp processing equipment is relatively long lasting, and enquiries will need to be made on how this should be assessed. A Profit and Loss Account and Balance Sheet needs to be undertaken to factor in these other items but has not been completed at this stage.

The surplus would then be split between the Decortication Company and Investor Dividends. If surplus is £300k then the Decortication Company could retain £100k per year to build up reserves. This would leave £200k per year to pay out as dividends to investors. This needs to be based on investors being prepared to back the company over a long-term period and acknowledge that dividends may take several years to be realised.

9.7 Cash Flow Sensitivity Analysis

A cash flow sensitivity analysis has been undertaken altering the following:

Yield – reducing yield from by 0.5t/ha from 6.0 to 5.5t/ha, an 8.3% reduction.

Price – reducing product price by 10% for the larger outputs – hemp fibre and shiv. Prices reduced to £652/t and £387/t respectively.

Hectarage grown – reducing hectares grown from 2000 to 1600ha (20% reduction).

Base performance is Year 10, 2000ha, 6.0t/ha and hemp and shiv at £725/t and £430/t respectively. The following table shows the difference each single reduction makes from base performance.

Fig 40. Sensitivity analysis table

| Max hectares | Hemp yield | Hemp fibre | Hemp fibre | Bulk shiv | Bulk shiv | Established year surplus | Positive net cash flow | Positive cum cash flow |
|---|---|---|---|---|---|---|---|---|
| ha | t/ha | tonnes | £ | tonnes | £ | £k | Year | Year |
| 2000 | 6.0 | 3000 | 725 | 5400 | 430 | 331 | 5 | 9 |
| 2000 | 5.5 | 2750 | 725 | 4950 | 430 | 215 | 5 | 10+ |
| 2000 | 6.0 | 3000 | 652 | 5400 | 387 | -520 | 10+ | 10+ |
| 1500 | 6.0 | 2520 | 725 | 5342 | 430 | 71 | 5 | 10+ |

Comment on sensitivity analysis

Base year – a surplus of £331k is generated in Year 10 with a positive net cash flow in Year 5 and a positive Cumulative cash flow in Year 9. Overdraft interest paid is £616k over 10 years at 10% interest rate. Cumulative cash flow peaks at around -£1.2 million in Year 4.

Reducing farm hemp yield from by 0.5t/ha from 6.0 to 5.5t/ha alters the Year 10 surplus to £215k, a difference of £116k. Positive net cash flow still occurs in Year 5. Cumulative cash flow is reducing year by year but stands at -£329k in Year 10. Bank interest payments are £815k over the 10 years.

Reducing product price by 10% for hemp fibre and bulk shiv has a dramatic impact. Year 10 surplus drops to -£520k, a difference of £851k. This is mainly due to a drop in sales value from £5.3 million to £4.8 million and an upward spiral of overdraft and bank interest charges. Cumulative cash flow is -£4.3 million. Bank interest payments are £2.1 million over the 10 year period.

Having hectares peak at 1600ha from Year 5 onwards generates a surplus of £71k in Year 10. Net cash flow turns positive in Year 5 however the Cumulative cash flow sits at -£810k in Year 10. Bank interest payments are £880k over the ten-year period.

9.8 Conclusions

While the base scenario can be seen to work, generating positive net cash flow by Year 5 and Cumulative cash flow by Year 10, and a £331k surplus in Year 10, finances are sensitive to some quite small changes.

Reduction of main product prices has the biggest impact, with a 10% drop rendering the business unviable.

The 8% reduction in crop yield has the least impact on Year 10 surplus and although net cash flow is positive for 5 years, the cumulative cash flow remains significantly negative at the end of year 10 at -£329k. This is not an irrecoverable position, but it would take a long time to turn cumulative cash flow positive.

Likewise, for the 1600ha peak crop, surpluses are too small to make a significant dent in the cumulative cash flow.

The finances would look different if the working capital of around £1.2m could also be raised from investors with deferred payments and an interest rate of around 5%. This might be a stretch given the large amount of capital to be raised for capital expenditure - £4.7m required, less say £1m grants if available = £3.7m.

**10. Timeline of events**

Throughout this study we have gained an appreciation of the steps that need to take place to set up a grower co-op and a decortication business.

It's a lengthy and complex process, given that farmers need to be convinced that investing in a co-op will secure long term gains for their business and the decortication company needs to know that they have a guaranteed supply of hemp bales to process and sell on to manufacturing businesses. And both the decortication company and the grower's co-op must have to have confidence that the manufacturing companies will grow demand and continue to pay a price that allows them to make profits.

Clearly the parties need to work together based on trust to avoid "chicken and egg" scenario where no-one wants to commit unless the other party moves first.

The following is an indicative timeline of events for a separate grower co-op, decortication plant and manufacturer to set up production. It includes the main steps and a rough indication of time. Note that it is likely to take a minimum of two years between initial farmer meetings and installation of the decortication plant. Note that there is generally a 12-month period between ordering decortication and cleaning equipment and it being ready to ship.

Fig 41. Timeline of events

| Approx timing | Grower Co-op | Decortication company |
|---|---|---|
| Year 1 Q3 | Initial open meeting on hemp growing farm | |
| Year 1 Q4 | Follow up open meeting to provide more detail on hemp and its potential to stimulate interest. | |
| Year 2 Q1 | Complete feasibility studies. | Plan processing plant and gather quotes from builders and equipment suppliers. |
| Year 2 Q1 | Initial meeting with selected farmer group to run through costings and gain feedback | |
| Year 2 Q2 | Prospectus prepared for farmers | Initial discussions on forming the Decortication Company. |
| Year 2 Q2/Q3 | Open farmer meetings on forming a Grower Co-op.<br><br>Co-op set up. Appoint board to oversee next steps. | Meetings with prospective buyers of processed hemp. Meetings with investors to finance Decortication Company capital spend.<br><br>Formation of Decortication Company. |
| Year 2 Q3 | Meet Decortication company to agree supply, pricing and contracts | Meet Manufacturing Company and Grower Co-op to agree supply, pricing and contracts |

| | | |
|---|---|---|
| Year 2 Q3/Q4 | Recruit farmers to join the co-op, commit to growing hemp and invest in capital costs | Place orders for building work and decortication line equipment. Anticipate one year between order and shipping of equipment |
| Year 2 Q4 | Organise farmers to obtain hemp growing licences and order seed. Sow first year crops. | Appoint plant manager and recruit staff |
| Year 3 Q2 | Sow first year hemp crops – April/May | |
| Year 3 Q3 | Appoint co-op manager and recruit first staff | Plant installation, allow 2-3 months, including test run period. |
| Year 3 Q2/Q3 | Oversee crops, engage and train contractors. | |
| Year 3 Q3 | Harvest first crops - September | Process crop from September onwards – plant up and running |
| Year 3 Q3/Q4 | Increase existing farmers hectarage and recruit new co-op members. | Plant operates on a part time basis until reach 1000ha when one shift can operate full time |
| ???? | Co-op with full membership. | Plant reaches full capacity when grow 2000ha of hemp – two shifts required almost full time. |

**11. Risk mitigation**

Fig 42. Risk management and mitigation strategies

| Risk | Likelihood<br>H, M, L | Mitigation |
|---|---|---|
| Lower than expected demand for hemp fibre - stockpiled hemp/flax bales, reduced output. | L | Ensure that main and back up markets are investigated before setting up Decortication Company |
| Inability to source seed – European supplies are limited and may be difficult to source enough for rapid hectarage expansion | M | Short term risk. Talk to seed suppliers to ensure that needs can be met well in advance of orders. Investigate potential of growing hemp seed in Scotland or UK. |

| | | |
|---|---|---|
| Slow build-up of markets for shiv – stockpiles of shiv that cannot be easily stored. | H | Special focus building sales of shiv products. Viability of plant depends on selling for a price of £400+ per tonne. |
| Farmers not attracted to grow the crop – price seen to be low relative to cereals. | H | Detailed preparation of case and margins before approach farmers. Evidence that hemp grows well in Scotland. Evidence of market demand for product. |
| Farmers adverse to risk at a time of volatile input costs, crop prices and inheritance tax concerns. Need to retain cash to see business through tough times and become more risk averse. | H | Definite risk in the short term. Looking further ahead the hemp supply chain could be sold as a safer, more profitable, longer term prospect if linked to strong demand from construction industry. |
| Annual crop tonnage lower than contract requirements. | M | Build reserves of stock in good years. If short import crop from elsewhere. |
| Adverse weather – some unharvested crop | M | Co-op averages payments or uses financial reserves to smooth out production peaks and troughs.<br><br>Spread of farm locations over wider area may help minimise risk of harvest loss due to exceptionally wet weather. |
| Fuel and electricity costs continue to rise | M | Safety margin in contract agreements?<br><br>Explore on site renewable energy supply. |
| Fertiliser costs high, difficult to obtain | M | Less affected than other arable crops as lower fertiliser input than winter cereals. |
| Loss of crop through fire in a store | L | Stored on various premises with much on farm and only around a week's supply at decortication plant – fire insurance essential. |

## 12.Product Markets

Prospects for commercial applications of industrial hemp fibre/shiv.

The utilisation of industrial hemp for its fibre and co-products (shiv) is in its infancy in Scotland. Pioneering product development and accreditation is currently underway as demonstrated by IndiNature based in the Scottish Borders. Delivering into the construction market, IndiNature's product range so far includes IndiTherm, IndiBreathe and IndiSilence; biobased vapour breathable insulation and acoustic fibre materials. These products maximise carbon capture, emissions avoidance and energy savings and unlike other insulative material which ends up in landfill, they can easily be reused at end-of-life or reprocessed into the same products.

The founders of IndiNature began their work in 2016 developing U.K. certified insulation products. Their work has included a partnership with a team of biotechnology researchers at the University of Edinburgh, funded by the Biotechnology and Biological Sciences Research Council. IndiNature is now recognised by multiple European and U.K. climate and entrepreneurial innovation initiatives, winning places and awards throughout the EU and Scotland for successfully developing the world's most environmentally sustainable, low-carbon construction material. Although the technology developed by this company is pioneering, founder Scott Simpson asserted it would be beneficial to have local hemp crops in Scotland, necessary to supply the plant-based insulation system end-product developed by his company.

New processes are under development utilising heat treatment to compress fibres and shiv to produce denser, heaver panels that would provide an alternative to conventional MDF (medium density fibreboard) and plywood. MDF is made by breaking down wood into fibres, combining them with resin and wax, and then compressing them into sheets under heat and pressure. However, it is vulnerable to moisture and can swell if exposed to water.

New products such as these will ultimately contain differing ratios of decorticated fibre and shiv or indeed the decortication process may not be necessary at all. Raw un-decorticated hemp from the field could be crushed and chopped to provide a homogenous substrate for onward processing into boards and even hemp 'wood,' as pioneered in the States currently.

Additionally, the onward processing of a homogenous 'crush and chop' material has been investigated by the Rowett Institute for its suitability in the development of sustainable growing media, using vermiculture, for soft fruit and vertical farming in Scotland. This is an exciting development particularly as it may provide an alternative to the current use of peat and coco-coir based products. It also opens up opportunities to exploit the shiv co-product arising from a decortication facility without the need for high risk capital investment in further processing.

In the context of developing new markets aligned with Scotland's current processing facilities, the development and production of composite boards and uses in hydroponics in the fruit and horticultural sectors appear to offer achievable ambitions without prohibitive investment requirements. Further funding is however required to develop and secure these markets.

Beyond the scope of this project and Scotland's geographical boundaries, the range of applications and uses derived from the hemp stalk is considerable globally. The following is a not-exclusive summary of product markets either emerging or established, which provide a backdrop to further opportunities for Scotland.

Cloth Textiles

Hemp fabrics are biodegradable, breathable, and moisture-wicking. Hemp produces much higher quantities of stronger and more versatile fibre than cotton and as fast fashion faces criticism, hemp offers an eco-friendly alternative. In 2005 the Stockholm Environmental Institute conducted a study comparing the ecological footprint of producing hemp, cotton, and polyester. The results show hemp being more ecologically neutral than other fibres, particularly in water usage. As an example, cotton requires 9,758 kg of water per kg while hemp needs between 2,401 and 3,401 kg of water per kg. This represents a 75% water saving. As a consequence of these environmental positives, big brands from around the world are increasingly interested in hemp and some (IKEA, Patagonia and LEVI to name but three) already include hemp textiles in their ranges. It would make an ideal partial or complete substitute for cotton in denim and for many other applications, including products like cotton wool and face wipes. Recent European R&D started developing hemp lyocell, an environmentally responsible skin-soft fabric and is now marketed as Hempcel, a registered trademark of EnviroTextiles LLC.

Home Textiles

Hemp can be used in curtains, mattresses, upholstery, rugs, and towels. Hemp textiles continue to be produced in Europe, unfortunately because of the relatively high raw material prices, due to lack of fibre supply and the scarcity of manufacturing facilities, production is limited as it mainly represents a niche market. However, recent developments on the global scale have given a real impetus to hemp fibre production, particularly in China. Their army is issued with hemp uniforms and socks because hemp fabric is breathable, naturally antibacterial, resistant to UV light, mould and mildew, and extremely durable. Indian textile traders are eager to import hemp yarns and textiles for manufacturing, as is already the case for flax, and look to Europe as a possible high-quality source market. Due to a clear and growing interest from consumers for natural and sustainably sourced fibres and products, an increased demand and major growth is expected in the coming years.

Paper and Pulp

Hemp produces high-quality, long-lasting paper with fewer chemicals than wood-based paper. Potential for niche applications like archival paper, art paper, or high-end packaging. Today, approximately 80% of hemp paper produced is used for cigarette papers and other specific applications, but it has the potential to be used more widely as heavy duty cardboard, food packaging, sanitary papers and also for filtration and absorption purposes. Past applications included a wide range of everyday products including banknotes, bank bonds and stamps.

Mature hemp stalks are rich in cellulose: they contain around 65-70% cellulose (wood contains around 40%, flax 65-75% and cotton up to 90%), and they only take 5 months to mature. This high cellulose content coupled with the fast growth of hemp stalks – compared to years for forest wood – in an industrial setting, typically yields a pulp production up to 4 times that of a mature tree plantation, on a per hectare basis. Furthermore, hemp paper can be recycled 7-8 times, compared with only 3-5 times for wood pulp paper. Hemp paper does not necessarily require toxic bleaching chemicals as the whitening can be achieved with hydrogen peroxide, however, there are other preferable agents such as oxygen, ozone, peracids and polyoxometalates. Whilst the demand for hemp paper is steadily increasing, current economic conditions do not make the production of large-scale hemp paper a competitive and viable option due to the vast difference in pulp prices which are affected by subsidies to the wood-pulp industry, economies of scale considerations as well as unequal laws governing the use of the whole hemp plant.

Automotive

Composite Materials: Hemp fibres are used in bio composites for car door panels, dashboards, and insulation. Major car manufacturers (e.g., BMW, Mercedes) already use natural fibre composites.

Bioplastics

Hemp fibres can be incorporated into bioplastics to reduce reliance on fossil fuels, offering lightweight and strong materials for packaging, construction, and consumer goods.

Ropes, Nets, and Non-Wovens

Traditional uses for ropes, nets, and mats are still relevant, especially in the marine and agricultural sectors

Construction

Hempcrete: A sustainable alternative to concrete, hempcrete is used for insulation, walls, and flooring. It offers excellent thermal performance, breathability, and carbon sequestration. Hempcrete is a composite material made from hemp shiv mixed with a lime binder; it provides a natural, vapour-permeable, airtight insulation material, which has good thermal mass and an effective thermal performance. Using Hempcrete in a building creates healthy (chemical-free and damp-free) indoor environments. It is a "better-than-zero-carbon material", locking away more carbon for the lifetime of the building than was emitted during its construction. It is used to form walls, in combination with a timber structural frame. It can also be used to create an insulating floor slab or roof insulation, allowing the entire thermal envelope of the building to be formed from Hempcrete.

Making one ton of steel emits 1.46 tons of $CO_2$, and 198kg of $CO_2$ are emitted to make one ton of reinforced concrete. Conversely, one square meter of timber framed, hemp-lime wall (weighing 120kg), without considering the energy cost for the transportation and placement of the material, sequesters 35.5kg of atmospheric $CO_2$ for the lifetime of the building. In addition, hempcrete is non-flammable, resistant to mould and bacteria, naturally regulates humidity and has an exceptional thermal and acoustic performance

Plaster and Render: Mixed with lime, hemp shiv is used for insulating plaster and renders in eco-friendly buildings. Hemp is already specified extensively in hemp-lime construction (particularly for conservation and self build) but there is market potential for much wider use, by developing a range of insulation and plaster board products suitable for modern methods of construction. Government has set the construction industry targets to reduce emissions by 76% before 2050 (18.9MtCO2e), whilst also pushing for construction of up to 300,000 houses annually. As traditional masonry buildings, this would typically embed an additional 15MtCO2e (Citu, 2021). Construction of 100,000 houses using hemp derived products could save 5.3MtCO2e, achieving 28% of the construction industry's target reduction, but this requires a minimum 10-fold increase in UK hemp cultivation.

Animal Bedding

Hemp shiv is a superior alternative to wood shavings or straw for animal bedding due to its high absorbency, low dust, and natural odour control.

Mulch and Soil Conditioning

Shiv can be used in landscaping as mulch or a soil improver due to its biodegradable nature and water-retention properties.

Bioenergy

Hemp biomass, including shiv, can be processed into biochar, biogas, or solid biofuels for renewable energy applications. Industrial hemp represents a potentially important new UK bioenergy crop that can be used to support the transition away from fossil-based power generation. This potential has been recognised by Drax Group, the largest bioenergy power generator in the world with its main facilities based in North Yorkshire, and by growing consortia such as Rare Earth Global (REG). The BDC has facilities that will be used to assess the processing of hemp biomass into pellets and subsequent analysis. Working with Drax and REG, the BDC will evaluate hemp as a mainstream biomass crop

Filtration and Absorbents

Shiv's absorbent properties make it suitable for cleaning oil spills or filtering water in industrial settings.

Energy storage

Hemp nanosheets are carbon nanosheets made from hemp that can be used to create high-performance energy storage devices. Hemp fibres are cut, cleaned, and dried, then carbonized through a hydrothermal process. The process can be activated at a high temperature in an inert atmosphere such that the hemp nanosheets have a high specific surface area, good electrical conductivity, and a significant volume fraction of microporosity. Hemp nanosheets can be used in supercapacitors, which are energy storage devices that can be used in electric cars and power tools. Hemp nanosheets are a less expensive alternative to graphene, a carbon nanomaterial that's often used in supercapacitor electrodes. It is reputed that hemp nanosheets can be manufactured for a quarter of the cost of graphene nanosheets.

## 13. Market Constraints and Future Policy

The farming of industrial hemp is increasing. According to recent estimates, the global hemp market, by value, is projected to grow fourfold by 2030, to about £13 billion. Upward of 40,000 ha will be cultivated alone in Europe in 2025. However, the UK is not currently taking advantage of new opportunities and hemp markets growing across the globe. In contrast, several EU member states and the US, are enjoying growing markets, supported by a combination of financial incentives and more benevolent legislative frameworks.

However, the use of industrial hemp remains controversial as, although industrial hemp and cannabis are classified in the same genus and species, Cannabis sativa L., industrial hemp is often mistakenly associated with cannabis grown for its high content of the psychotropic compound tetrahydrocannabinol (THC), while industrial hemp varieties have concentrations of tetrahydrocannabinol below legally authorized levels. Industrial hemp may be defined as a Cannabis sativa L. plant, or any part of the plant, "in which the concentration of tetrahydrocannabinol in the flowers and leaves of the inflorescence is not more than the regulated maximum level as established by authorities having jurisdiction". This definition, if adopted, would be consistent with the three main international drug control conventions, namely, Single Convention on Narcotic Drugs, 1961, as amended by the 1972 Protocol;

Convention on Psychotropic Substances, 1971; and United Nations Convention against Illicit Traffic in Narcotic Drugs and Psychotropic Substances, 1988. In the Single Convention on Narcotic Drugs, 1961, a distinction is made between cannabis grown for the production of drugs, therefore falling within the scope of the convention, and that grown for industrial or horticultural purposes and therefore not falling within the scope of the convention. There is a need to resolve concerns regarding industrial hemp and its characteristics in order to unlock initiatives surrounding its economic and environmental potential.

One potential component of such initiatives could be to advocate for and foster an industrial hemp sector, for exploitation and valorisation based not only on fibre and shiv but also on a "whole plant" approach that uses all parts of the plant that would help promote the establishment of various production chains.

Industrial hemp value chains have the potential to be carbon negative and ecologically sustainable and can therefore effectively supplement strategies for sustainable development and the transition to clean energy. Practical experiences worldwide highlight the need for Governments to establish a regulatory and institutional framework supporting the exploitation of all parts of the industrial hemp plant. In this regard, the categorization of industrial hemp as an agricultural commodity subject to regulatory oversight by an agricultural department, as in many member countries of the European Union, rather than a controlled substance, as in the United Kingdom of Great Britain and Northern Ireland, is of paramount importance.

Industrial hemp has agronomic properties that can generate considerable environmental benefits. Due to the regenerative properties of the plant, the cultivation of industrial hemp can boost other crop yields when it is included in crop rotation. Industrial hemp can be used in ecological reconstruction and land reclamation due to its ability to remove heavy metals from the ground. In addition, industrial hemp can help mitigate the effects of climate change, as it captures significant amounts of carbon dioxide by storing it in both stems and roots during photosynthesis. Industrial hemp may capture more carbon dioxide per hectare than other commercial crops or some forests. This implies that its cultivation can be further monetized by integrating it into carbon offset schemes or as part of nationally determined contributions to reducing greenhouse gas emissions.

Finally, industrial hemp can contribute to food security. Hempseeds are rich in essential fatty acids (omega 3 and omega 6), proteins, carbohydrates (particularly insoluble fibres), vitamins and minerals. Given such potential, several countries have undertaken regulatory reforms to promote the industrial hemp sector, such as Australia and New Zealand. Regulatory reforms have also been enacted in Africa, for example in Malawi, Uganda and South Africa; Asia, for example in Thailand; and Central and South America, for example in Colombia, Ecuador, Paraguay and Uruguay. A regulatory framework allowing for the exploitation of all parts of the plant would facilitate the implementation of industrial strategies in order to optimize product diversification and increase the resilience of farmers and processors. Such strategies could adopt a whole-plant approach. The valorisation of all parts of a plant enables the creation of production chains able to provide growth in rural areas, in manufacturing and in the food processing industry. Diversity in final uses also implies flexibility in setting up a sectoral policy framework. An appropriate strategy would first consider the development of production processes that are easily transferable in order to, for example, reduce the risk of low returns due to oversupply. The development and production of hemp-based concrete and insulation materials may be the most viable areas of focus in countries with an emerging industrial hemp sector. In addition, such products could be integrated into sustainable urban development plans. Belgium for example now legislates for 5% natural fibre content in all building insulation

Hemp value chains can boost growth in rural areas and contribute to both manufacturing and food processing industries. However, to fully exploit such potentialities, countries may have to take specific actions. A clarification of the legal status of hemp with respect to that of intoxicant cannabis substances would be the first step needed by governments. This would help minimize financial risks for domestic producers associated with possible legal actions. A precise understanding of production constraints imposed by regulatory frameworks in potential destination markets would also be necessary to identify opportunities. In addition, regional cooperation may be a strategy for developing countries with a view to establishing viable and sustainable value chains.

Four policy areas deserve particular attention: information, a regulatory framework, sustainability and industrial strategy:

## 13.1 Information

At the national level, there is a clear need to improve collation, availability and accessibility of information. Efforts need to be devoted to improving the current state of information about all aspects of this commodity. Therefore, as a first important and urgent step, additional categories need to be included to cover not only fibre, but for instance, hemp seeds, hemp seed oil, hemp seed products, hemp oleoresins and essential oils. A country-specific classification can be used to define such categories. The most comprehensive product schedule, so far, has been implemented by Canada, and may offer a useful benchmark for further development of a national classification. Some additional resources need to be devoted to the systematic collection and systemic treatment of information in the context of a coordinated action plan. The formation of a Parliamentary backed, Scottish steering group, comprising representatives from the various stakeholders in the industry would provide the initial steps to delivering on this.

## 13.2 Regulatory framework

The distinction between intoxicant and non-intoxicant hemp cultivars is still subject to controversy in most political arenas both at country and international level. Arguments on both sides are often not corroborated by existing empirical evidence and scientific knowledge. Therefore, legislations in vigour in most countries, even the most permissive ones, do not allow a full exploitation of the hemp plant's potential in its many uses.

Cultivation of non-intoxicant C. sativa L. cultivars should be permitted in all countries even though it may require strict governmental control. Moreover, an approach favouring THC threshold in final products, rather than in the field, should be adopted to incentivize a whole-plant approach and uses. THC levels can be easily modified in semi-processed inputs, whereas the control of THC contents in cultivated plants can require a large set of agronomic techniques and competences. Alternatively, raising the THC thresholds in crops up to levels scientifically recognized as non-intoxicant could be envisaged by legislators. This would allow increasing the pool of varieties useable in hemp production chains, thus de facto increasing the possibility to cultivate cultivars best adapted to specific environmental conditions and characteristics.

The European Industrial Hemp Association (EIHA) actively lobbies for policies on behalf of its European members to unlock barriers, promote growth and support innovation within the industry. This is a collective organisation that is clearly both absent and missed as a result of Brexit. In attending the 2024 Annual Conference in Prague it was evident just how much work is done by the organisation on behalf of growers and how close the links are with the DG AGRI (Directorate-General for Agriculture and Rural Development) who were present at the event. The mission of the Directorate-General for Agriculture and Rural Development (DG AGRI) is to support and promote a knowledge and evidence-based green and digital transition towards a sustainable, competitive, and resilient EU agriculture, rural areas and food systems. To achieve this, it develops, implements, monitors, and evaluates the Common Agricultural Policy (CAP) so that its specific economic, environmental, and social objectives, building on the Treaty objectives, notably to ensure food security at all times, are jointly met.

It was evident too at the conference how, under the Green Deal EU initiatives, member states are at liberty to offer direct subsidies to their hemp growers; France, Romania and Poland currently partake in this scheme. Under Scotland's Agricultural Reform 'List of Measures' there is an opportunity to support hemp and reward farmers in delivering 'in-field' measures that will achieve the desired outcomes for soil health, cropping diversity, carbon and climate mitigation priorities.

13.3 Sustainability

Several dimensions of sustainability can be considered in relation to hemp. The environmental and societal dimensions involved the plant's exploitation, and their interconnections are core to the success of any hemp-related policy. C. sativa L. is a multipurpose plant that offers several agricultural benefits such as soil and water decontamination, and CO2 absorption. In terms of CO2 absorption, hemp can be more efficient than any other crop, even trees. About 1.65 tons of CO2 can be absorbed per ton of hemp harvested. On a land-use basis, assuming a yield average of 5.5 to 8 tons/ha, this can represent between 9 and 13 tons of CO2 absorption per hectare harvested. In comparison, forests typically capture between 4.5 tons/ha (i.e. conifer forests) of CO2 per year during the first 20 years of tree growth. Moreover, hemp farming requires very low or no inputs, and has a positive effect on soil and biodiversity, while its processing produces zero waste, as all parts of the plant can be used or further transformed, depending on prevailing legislation. In other words, hemp farming can offer environmental benefits that can be considered in policies aimed at mitigating the effects of climate change and restoring healthy ecosystems. Moreover, as hemp cultivation may help concretely to maximize the use of land, it may also contribute to increasing incomes of farmers and rural communities.

13.4 Industrial Policy

Due to its versatility, given the possibility to use all parts of the plant, hemp appears to be a natural candidate for the establishment of national or regional value chains. The diversity of products that can be made using various parts of the hemp plant, and the differences in the degree of sophistication of their respective production processes, are potentially attractive features. Moreover, hemp cultivation could be further monetized by integrating some carbon compensation schemes on a voluntary basis. Diversity in final uses also implies flexibility in setting up a sectoral policy framework. Owing to its botanical characteristics, a whole-plant approach should be considered as a first-best strategy. This is all the more desirable because of the still relatively small size of the hemp market and the economic constraints inherent in such markets. A whole-plant approach allows the identification of both primary and secondary markets. An appropriate strategy would first consider the development of production processes that are easily transferable to reduce the risk of low returns due to negative market developments such as oversupply. A whole-plant approach could only be implemented if a conducive regulatory framework is in place. This implies that, initially, some legal reform may need to be considered. Policy actions may then be identified and acted upon to help select the best cultivation strategy that facilitates the choice of cultivars and the cultivation method. Such choices would be driven by the main final use that is targeted. Due to the plant's characteristics, the policy plan of action should be, in most cases, based on a local network of operators, capable of providing the harvest and first processing, connected to a community having the necessary technology and knowledge.

11.5 In summary

The UK Government should reform outdated regulations like the Proceeds of Crime Act to allow the industrial hemp sector to scale up. Inaction is costing the UK jobs, tax revenue and climate progress in stark contrast to the developments seen in the other countries like France, Germany and the U.S. Clear policy frameworks are needed to support both farmers and manufacturers. Growers should be allowed to harvest, produce from all parts of the plant – including flowers and leaves – and market any kind of product, whilst maintaining compliance with the THC content limits. Industrial hemp products are not drugs (they do not have the potential to relieve pain and suffering) nor narcotics (there can be no misuse, abuse or dependence). Therefore, and reflecting in particular the spirit and objectives set out in the UN Single Convention on Narcotic Drugs, hemp and its derivatives should be considered outside the scope of international drug controls.

Public policies should promote hemp use in food, feed and manufactured products and finance the development of sustainable value chains. The maximum THC level allowed on the field should be increased from 0.2% to 0.3% in line with EU legislation in order to allow access to more new varieties best suited to our conditions and allow farmers to potentially export product competitively.

Reasonable and science-based guidance values for THC in food and feed should be established.

All hemp derived raw materials should be permitted as natural ingredients for cosmetics. Hemp derived food, CBD and cosmetics markets are probably those where the hemp sector has already proved how it can deliver in terms of quality and sustainability. However, a clear, common and science-based regulatory framework is still missing. This uncertainty limits investments; hence, the proper development of a fibre and shive value chain.

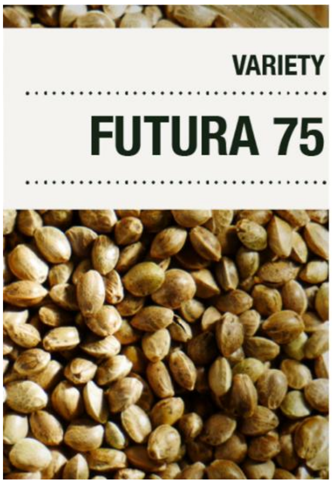
The contribution to the environment of the hemp plant should be recognised and the use of hemp for carbon farming encouraged with a government–backed carbon credit scheme to make hemp commercially viable and push credit prices higher.

The UK should value and promote the use of hemp fibres for the production of short and long fibre for textiles and favour the establishment of sustainable value chains.

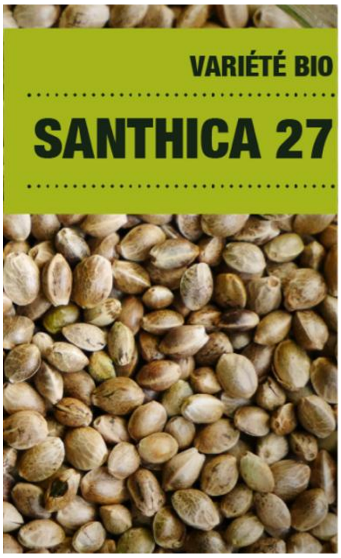
The use of hemp-based construction and other materials should be incentivised both in public and private sectors, with clear goals for the total or partial substitution of other less sustainable alternatives. A perfect circular economy will be achieved when hemp will finally be the object of massive investments for valuing the lower part of the plant, including the fibre for textile industry, the shives for construction materials and the carbon storage potential for offsetting emissions during the green transition. This will happen only if public policies finally recognise the real value of hemp in the decarbonisation of the economy.

## Appendices

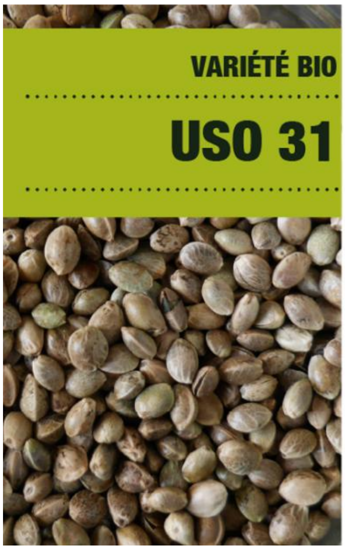
Appendix 1 - Details of industrial hemp varieties trialled in 2024




- Monoecious Variety.
- Always limited availability because of popularity.
- Full UK Registration
- Dual purpose variety – seed and fibre. Particularly in Southern Europe. Good CBD yield, but below 0.2% THC.
- Relatively early. Earlier than Santhica 27.
- A second choice for a lot of UK growers, but tends to yield well.
- High resistance to lodging – higher than Santhica27.
- Highest seed vigour score year on year.



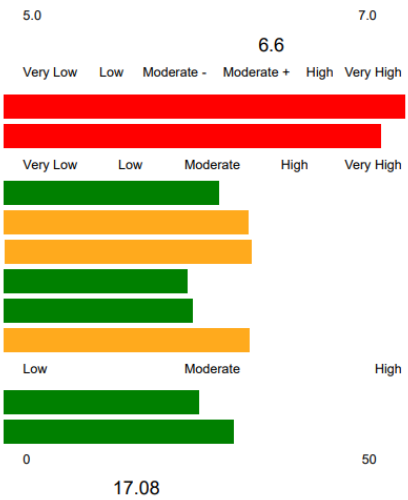

- Monoecious Variety. 0.02% THC – very low, hardly detectable.
- Highest yielding variety in UK trials last year. Tallest.
- Highest germination capacity of registered material from HempIT.
- Variety of choice for most UK growers for fibre crops.
- Medium maturity.
- Medium resistance to lodging – possibly due to height.
- True fibre variety, not for seed.
- Performs well year on year in Yorkshire.
- Interesting to see if it is too late for further North.
- Always limited availability because of popularity.
- Full UK Registration




- Monoecious Variety. 0.2% THC
- Older Variety – approx. 15 years.
- Still very popular across Northern Europe because of it's earliness, and balance between seed and fibre yield.
- Elsoms use this as a control in all trials because of its maturity.
- If optimal sowing – beginning May, full flowering is normally seen end of July/first week August.
- Offers growers a broader harvesting window if large areas to cut, and machinery is being shared.
- Typical growing cycle 122 – 127 days for seed, and less for fibre.
- High fibre content.
- In the trials last year, it yielded well, not quite as high as Santhica27 OR Futura75
- Full UK Listing.

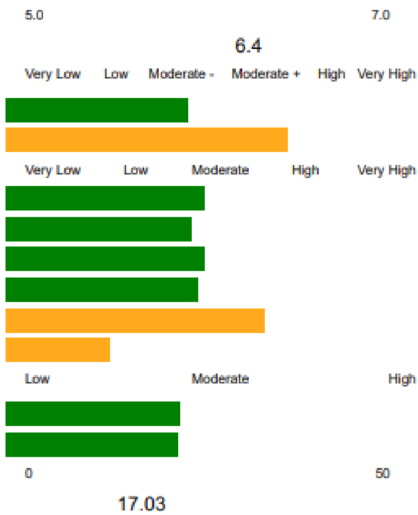
## Appendix 2 - Trial site soil analysis: Easter Howgate site

| Determination | Result | Units | Target Value | Target Status | Status |
|---|---|---|---|---|---|
| pH | 6.6 | | | | 6.6 |
| Extractable Phosphorus | 85.4 | mg/l | 4.5-9.4 | M- | |
| Extractable Potassium | 653.9 | mg/l | 76-140 | M- | |
| Extractable Boron | 0.83 | mg/l | 0.6-1.0 | M | |
| Extractable Copper | 11.0 | mg/l | 1.6-8.4 | M | |
| Extractable Magnesium | 257.2 | mg/l | 61-200 | M | |
| * Extractable Manganese | 7.3 | mg/l | 2.6-20 | M | |
| Extractable Sulphur | 7.3 | mg/l | 6.1-10 | M | |
| Extractable Zinc | 13 | mg/l | 1.6-10 | M | |
| Extractable Calcium | 1900 | mg/l | 1000-3000 (**) | M | |
| Organic Matter (LOI) | 8.27 | % | 4-10 | | |
| Extractable Sodium | 17.08 | mg/l | | | 17.08 |
| Lime req (Arable) | 0.0 | t/ha | | | |
| Lime req (Grass) | 0.0 | t/ha | | | |
| * Total Nitrogen (Kjeldahl) | 2780 | mg/kg DM | | | |




## Trial site soil analysis: Angus site

| Determination | Result | Units | Target Value | Target Status | Status |
|---|---|---|---|---|---|
| pH | 6.4 | | | | 6.4 |
| Extractable Phosphorus | 7.56 | mg/l | 4.5-9.4 | M- | |
| Extractable Potassium | 212.6 | mg/l | 76-140 | M- | |
| Extractable Boron | 0.69 | mg/l | 0.6-1.0 | M | |
| Extractable Copper | 3.05 | mg/l | 1.6-8.4 | M | |
| Extractable Magnesium | 111.6 | mg/l | 61-200 | M | |
| * Extractable Manganese | 7.7 | mg/l | 2.6-20 | M | |
| Extractable Sulphur | 14 | mg/l | 6.1-10 | M | |
| Extractable Zinc | 0.72 | mg/l | 1.6-10 | M | |
| Extractable Calcium | 1500 | mg/l | 1000-3000 (**) | M | |
| Organic Matter (LOI) | 5.45 | % | 4-10 | | |
| Extractable Sodium | 17.03 | mg/l | | | 17.03 |
| Lime req (Arable) | 0.0 | t/ha | | | |
| Lime req (Grass) | 0.0 | t/ha | | | |
| * Total Nitrogen (Kjeldahl) | 1680 | mg/kg DM | | | |



Appendix 3 - Full data : Crop gross margins and net margins 2024 with industrial hemp at 3 yield points

| 2024 harvest | | 1st winter wheat | 2nd winter wheat | winter barley | winter feed oats | winter oilseed rape | spring barley | spring milling oats | spring beans | Hemp low yield 4.5t/ha | Hemp medium /low yield 5.0t/ha | Hemp medium /high yield 6t/ha | Hemp high yield 7t/ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sales | | | | | | | | | | | | | |
| Grain yield | t/ha | 7.96 | 6.63 | 6.73 | 6.93 | 3.58 | 5.97 | 5.91 | 4.71 | | | | |
| Grain price | £/t | 205 | 205 | 178 | 177 | 410 | 205 | 191 | 230 | | | | |
| Grain income | £/ha | 1632 | 1359 | 1198 | 1227 | 1468 | 1224 | 1129 | 1083 | | | | |
| Straw sold | t/ha | | | | | | | | | 4.50 | 5.00 | 6.00 | 7.00 |
| Straw price | £/t | | | | | | | | | 270 | 270 | 270 | 270 |
| Straw income | £/ha | | | | | | | | | 1215 | 1350 | 1620 | 1890 |
| Income | £/ha | **1632** | **1359** | **1198** | **1227** | **1468** | **1224** | **1129** | **1083** | **1215** | **1350** | **1620** | **1890** |
| | | | | | | | | | | | | | |
| Variable costs | | | | | | | | | | | | | |
| Seed | £/ha | 80 | 111 | 109 | 71 | 75 | 97 | 71 | 140 | 350 | 350 | 350 | 350 |
| Fertiliser/ trace eleme | £/ha | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 204 | 204 | 204 | 204 |
| Sprays | £/ha | 189 | 276 | 132 | 48 | 164 | 65 | 48 | 157 | 10 | 10 | 10 | 10 |
| Agronomy fees | £/ha | 15 | 15 | 13 | 12 | 12 | 12 | 10 | 15 | | | | |
| Levies | £/ha | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | | | | |
| Sundries | | 14 | 14 | 10 | 14 | 11 | 12 | 10 | 10 | 10 | 10 | 10 | 10 |
| Total variable costs | £/ha | 302 | 420 | 267 | 148 | 265 | 189 | 142 | 325 | 574 | 574 | 574 | 574 |
| Gross Margin | £/ha | **1330** | **939** | **931** | **1079** | **1203** | **1035** | **987** | **758** | **641** | **776** | **1046** | **1316** |
| | | | | | | | | | | | | | |
| Farmers operational cost £/ha | | | | | | | | | | | | | |
| Plough | £/ha | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 | 58 |
| Seedbed preparation | £/ha | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| Roll | £/ha | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 0 | 0 | 0 | 0 |
| Fertilise @£10/pass | £/ha | 40 | 40 | 30 | 30 | 30 | 20 | 20 | 10 | 10 | 10 | 10 | 10 |
| Spray @£12/pass | £/ha | 60 | 60 | 48 | 48 | 84 | 36 | 36 | 48 | 12 | 12 | 12 | 12 |
| Combine /mow | | 86 | 86 | 86 | 86 | 86 | 86 | 86 | 86 | 26 | 26 | 26 | 26 |
| Tedder x2 | | | | | | | | | | 30 | 30 | 30 | 30 |
| Row | | | | | | | | | | 15 | 15 | 15 | 15 |
| Bale contractor £5.50/bale | | | | | | | | | | 49 | 55 | 60 | 71 |
| Cart corn/ bales | | 28 | 28 | 26 | 26 | 14 | 24 | 24 | 14 | 9 | 10 | 11 | 12 |
| | | | | | | | | | | | | | |
| Total operational cost | | 344 | 344 | 320 | 320 | 344 | 296 | 296 | 288 | 269 | 276 | 282 | 294 |
| **Net Margin £/ha** | **£/ha** | **986** | **595** | **611** | **759** | **859** | **739** | **691** | **470** | **372** | **500** | **764** | **1022** |

## Appendix 4 - Full Ten-Year Cash Flow Spreadsheet – Output

| | | Year 1 starting | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Production area, yield and tonnes** | | **01/09/2026** | **01/09/2027** | **01/09/2028** | **01/09/2029** | **01/09/2030** | **01/09/2031** | **01/09/2032** | **01/09/2033** | **01/09/2034** | **01/09/2035** |
| Hectares | ha | 200 | 400 | 700 | 1200 | 1600 | 2000 | 2000 | 2000 | 2000 | 2000 |
| Average yield | tonnes/ha | 5.5 | 5.5 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 |
| **Total tonnes** | **tonnes** | **1100** | **2200** | **4200** | **7200** | **9600** | **12000** | **12000** | **12000** | **12000** | **12000** |
| **Output (percentages)** | | % | % | % | % | % | % | % | % | % | % |
| Hemp fibre | | 25% | 25% | 25% | 25% | 25% | 25% | 25% | 25% | 25% | 25% |
| Bagged shiv for bedding | | 0% | 0% | 0% | 5% | 8% | 10% | 10% | 10% | 10% | 10% |
| Shiv bulk - boards, hempcrete | | 55% | 55% | 55% | 50% | 48% | 45% | 45% | 45% | 45% | 45% |
| Briquettes | | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% |
| Dust | | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% | 8% |
| Other output 1 | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Other output 2 | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Total | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| **Output (tonnes)** | | tonnes | tonnes | tonnes | tonnes | tonnes | tonnes | tonnes | tonnes | tonnes | tonnes |
| Hemp fibre | | 275 | 550 | 1050 | 1800 | 2400 | 3000 | 3000 | 3000 | 3000 | 3000 |
| Bagged shiv for bedding | | 0 | 0 | 0 | 360 | 720 | 1200 | 1200 | 1200 | 1200 | 1200 |
| Shiv bulk - boards, hempcrete | | 605 | 1210 | 2310 | 3600 | 4560 | 5400 | 5400 | 5400 | 5400 | 5400 |
| Briquettes | | 132 | 264 | 504 | 864 | 1152 | 1440 | 1440 | 1440 | 1440 | 1440 |
| Dust | | 88 | 176 | 336 | 576 | 768 | 960 | 960 | 960 | 960 | 960 |
| Other output 1 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other output 2 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total tonnes | | 1100 | 2200 | 4200 | 7200 | 9600 | 12000 | 12000 | 12000 | 12000 | 12000 |
| **Output (£)** | | | | | | | | | | | |
| Processing plant sales | £/tonne | | | | | | | | | | |
| Hemp fibre | £725 | £199,375 | £398,750 | £761,250 | £1,305,000 | £1,740,000 | £2,175,000 | £2,175,000 | £2,175,000 | £2,175,000 | £2,175,000 |
| Bagged shiv for bedding | £400 | £0 | £0 | £0 | £144,000 | £288,000 | £480,000 | £480,000 | £480,000 | £480,000 | £480,000 |
| Shiv bulk - boards, hempcrete | £430 | £260,150 | £520,300 | £993,300 | £1,548,000 | £1,960,800 | £2,322,000 | £2,322,000 | £2,322,000 | £2,322,000 | £2,322,000 |
| Briquettes | £225 | £29,700 | £59,400 | £113,400 | £194,400 | £259,200 | £324,000 | £324,000 | £324,000 | £324,000 | £324,000 |
| Dust | £0 | £0 | £0 | £0 | £0 | £0 | £0 | £0 | £0 | £0 | £0 |
| Other output 1 | £0 | £0 | £0 | £0 | £0 | £0 | £0 | £0 | £0 | £0 | £0 |
| Other output 2 | £0 | £0 | £0 | £0 | £0 | £0 | £0 | £0 | £0 | £0 | £0 |
| **Total ouput value** | | **£489,225** | **£978,450** | **£1,867,950** | **£3,191,400** | **£4,248,000** | **£5,301,000** | **£5,301,000** | **£5,301,000** | **£5,301,000** | **£5,301,000** |
| Hemp ex farm price | £/tonne | £270 | £270 | £270 | £270 | £270 | £270 | £270 | £270 | £270 | £270 |
| Hemp ex farm tonnage | tonnes | 1100 | 2200 | 4200 | 7200 | 9600 | 12000 | 12000 | 12000 | 12000 | 12000 |
| Hemp purchase price | £ | £297,000 | £594,000 | £1,134,000 | £1,944,000 | £2,592,000 | £3,240,000 | £3,240,000 | £3,240,000 | £3,240,000 | £3,240,000 |
| **Margin over purchase price** | **£** | **£192,225** | **£384,450** | **£733,950** | **£1,247,400** | **£1,656,000** | **£2,061,000** | **£2,061,000** | **£2,061,000** | **£2,061,000** | **£2,061,000** |

## Appendix 5 - Full Ten Year Cash Flow Spreadsheet – Expenditure and Net Cash Flow

| Cash flow calculations | | | Year 1 starting | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Output** | | | **01/09/2025** | **01/09/2026** | **01/09/2027** | **01/09/2028** | **01/09/2029** | **01/09/2030** | **01/09/2031** | **01/09/2032** | **01/09/2033** | **01/09/2034** |
| | Sales | | £489,225 | £978,450 | £1,867,950 | £3,191,400 | £4,248,000 | £5,301,000 | £5,301,000 | £5,301,000 | £5,301,000 | £5,301,000 |
| **Expenditure** | | | | | | | | | | | | |
| Pre-processing | Hemp ex farm purchase | | £297,000 | £594,000 | £1,134,000 | £1,944,000 | £2,592,000 | £3,240,000 | £3,240,000 | £3,240,000 | £3,240,000 | £3,240,000 |
| | Haulage - farm to processing | | £16,500 | £33,000 | £63,000 | £108,000 | £144,000 | £180,000 | £180,000 | £180,000 | £180,000 | £180,000 |
| | Storage payment - farmers | | £6,600 | £13,200 | £25,200 | £43,200 | £57,600 | £72,000 | £72,000 | £72,000 | £72,000 | £72,000 |
| Labour | Decortication line | | £29,968 | £51,944 | £87,500 | £150,000 | £200,000 | £250,000 | £250,000 | £250,000 | £250,000 | £250,000 |
| | Plant manager , sales&admin | | £25,000 | £20,000 | £40,000 | £80,000 | £90,000 | £100,000 | £100,000 | £100,000 | £100,000 | £100,000 |
| | Plant shipping &installation | | £280,000 | | | | | | | | | |
| Machinery | Plant repairs | | £20,000 | £40,000 | £40,000 | £40,000 | £40,000 | £40,000 | £40,000 | £40,000 | £40,000 | £40,000 |
| | Lease charge loader/forklifts | | £15,000 | £25,000 | £25,000 | £25,000 | £25,000 | £25,000 | £25,000 | £25,000 | £25,000 | £25,000 |
| Power | Electricity - plant | | £55,000 | £110,000 | £210,000 | £360,000 | £480,000 | £600,000 | £600,000 | £600,000 | £600,000 | £600,000 |
| | Electricity & fuel - loaders, lighting heat | | £5,000 | £7,333 | £14,000 | £24,000 | £32,000 | £40,000 | £40,000 | £40,000 | £40,000 | £40,000 |
| | Power - factory general | | £5,000 | £3,667 | £7,000 | £12,000 | £16,000 | £20,000 | £20,000 | £20,000 | £20,000 | £20,000 |
| Rent & rates | Rent | | £120,000 | £120,000 | £120,000 | £120,000 | £120,000 | £120,000 | £120,000 | £120,000 | £120,000 | £120,000 |
| | Rates | | £0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Insurance | Insurance factory | | £2,500 | £20,000 | £20,000 | £20,000 | £20,000 | £20,000 | £20,000 | £20,000 | £20,000 | £20,000 |
| | Insurance - stored crops | | £2,292 | £6,111 | £8,750 | £20,000 | £20,000 | £20,000 | £20,000 | £20,000 | £20,000 | £20,000 |
| Consumables | Packaging materials | | £3,139 | £6,279 | £11,987 | £30,449 | £47,198 | £67,248 | £67,248 | £67,248 | £67,248 | £67,248 |
| Professional fees | Consultancy/accountacy/other | | £70,000 | £30,000 | £10,000 | £10,000 | £10,000 | £10,000 | £10,000 | £10,000 | £10,000 | £10,000 |
| Contingencies | Variable rate, max £100k | 10% | £65,600 | £48,653 | £68,244 | £100,000 | £100,000 | £100,000 | £100,000 | £100,000 | £100,000 | £100,000 |
| **Total expenditure** | **excluding finance charges** | | **£1,018,599** | **£1,129,188** | **£1,884,680** | **£3,086,649** | **£3,993,798** | **£4,904,248** | **£4,904,248** | **£4,904,248** | **£4,904,248** | **£4,904,248** |
| Finance charges | | 0% | £0 | £0 | £0 | £0 | £0 | £0 | £0 | £0 | £0 | £0 |
| | Overdraft interest | 10% | £30,000 | £73,000 | £95,000 | £107,000 | £107,000 | £91,000 | £67,000 | £41,000 | £12,000 | £0 |
| | Loan repayments | 10% | £65,500 | £65,500 | £65,500 | £65,500 | £65,500 | £65,500 | £65,500 | £65,500 | £65,500 | £65,500 |
| **Total expenditure** | **including finance charges** | | **£1,114,099** | **£1,267,688** | **£2,045,180** | **£3,259,149** | **£4,166,298** | **£5,060,748** | **£5,036,748** | **£5,010,748** | **£4,981,748** | **£4,969,748** |
| **Total sales** | **from above** | | **£489,225** | **£978,450** | **£1,867,950** | **£3,191,400** | **£4,248,000** | **£5,301,000** | **£5,301,000** | **£5,301,000** | **£5,301,000** | **£5,301,000** |
| **Net cash flow** | | | **-£624,874** | **-£289,238** | **-£177,230** | **-£67,749** | **£81,702** | **£240,252** | **£264,252** | **£290,252** | **£319,252** | **£331,252** |
| **Cumulative cash flow** | | 0 | -£624,874 | -£914,112 | -£1,091,342 | -£1,159,091 | -£1,077,389 | -£837,137 | -£572,885 | -£282,633 | £36,619 | £367,871 |
| | | | **Year 1 starting** | **Year 2** | **Year 3** | **Year 4** | **Year 5** | **Year 6** | **Year 7** | **Year 8** | **Year 9** | **Year10** |