UK Flax and Hemp production:

The impact of changes in support measures on the competitiveness and future potential of UK fibre production and industrial use

ADAS
Centre for Sustainable Crop Management
Boxworth
Cambridge
CB3 8NN
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Department for Environment, Food and Rural Affairs
Nobel House
17 Smith Square
London SW1P 3JR
Telephone 020 7238 6000
Website: www.defra.gov.uk

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Information about this publication and further copies are available from:

Crops for Energy Branch
Organic Farming & Industrial Crops Division
Defra
Ergon House
Horseferry Road
London SW1P 2AL
Email address: industrialcrops@defra.gsi.gov.uk
Tel: 020 238 6166

This document is also available on the Defra website.

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EXECUTIVE SUMMARY

Flax and hemp fibre production in the UK is controlled by EC regulations designed to govern the internal market primarily through support given to processors. This report gives an overview of the UK fibre crop sector as these EC support measures change. The impact of these changes is also affected by recently introduced changes which have replaced direct crop based support payments with a single payment system designed to help farms maintain environmental standards, whilst farming in markets more open to global trade pressures.

The impact of this double reduction of subsidy support will vary considerably, and at the individual crop level is affected by crop yield, gross margin and the fibre extraction rate. When receiving support through the Arable Area Payment Scheme (AAPS) of £245 per hectare, flax returned a gross margin of around £241 per hectare. With the move to the Single Payment Scheme (SPS) in 2005, the AAP was no longer paid on a crop basis resulting in a gross margin of £-4 per hectare. If all the loss of the Processing Subsidy is also passed to the grower the gross margin falls to around £-32 per hectare. Advances in the management of the flax crop demonstrated in recent research projects can however mitigate some of the loss in gross margin, and developments in the market place could bring the post-AAP gross margin up to around £162/ha before any effect of the removal of the processor subsidy. If the Processor Subsidy is removed and is all passed on to the grower this could reduce the gross margin to £79/ha. In contrast hemp produced gross margins of around £470 per hectare when receiving £245 AAP. Without AAP this fell to £225 per hectare, and when carrying the full loss of the processor payment the gross margin becomes approximately £134.

If growers have to carry both the AAP removal and the whole of the processor subsidy loss, flax will make losses without significant improvements in management and markets, while hemp remains competitive with other arable break crops. Fixed costs can be three to four times these margin values. Rationalising fixed costs is a whole farm consideration and falls beyond the scope of this report.

Last year the only remaining commercial flax fibre processing plant in the UK closed, however since then Fibre Developments Ltd have set up processing capacity at a site in Cornwall. This is primarily being used to support research and development, with options for increasing the scope of fibre processing at the site to include other crops being investigated. Hemcore Ltd, based in Essex remains the only processor of hemp in the UK.

Transport costs are a significant cost in the production of hemp and flax with local transport rates of around £12/t and with upward pressure on fuel costs these are likely to increase. This is likely to be a significant barrier to the expansion of either crop unless commodity prices generally rise as a response to higher global input costs.

Alternative methods of supporting the processing sector may be needed if they are to provide an effective market for producers and promote a viable domestic natural fibre sector. This would lessen the impact of a complete removal of support for processing, and the switch to the Single Payment Scheme.

As both crops are grown with low inputs, are spring sown and bring some environmental benefits there is some justification for encouraging their wider production. The development of environmental schemes and the reform of fibre support measures need these advantages to be weighed.

All the above changes must be viewed against a technical background of increasing use and versatility of natural fibres. They are being used as composites in resins and concrete, woven and non-woven fabrics and boards; for insulation panels, automotive panels, in papers for teabags and bank notes, and cellulose sheet. The non-fibre components of hemp have established themselves as a high quality animal bedding material. These uses face stiff competition from other global fibre producers.

FAO statistics indicate China is by far the largest producer of flax and hemp, with around 51% and 33% of world flax and hemp production respectively, although there may be some inaccuracies in these figures due to confusion between weights of straw and fibre. In the EU, France, Belgium, Netherlands and Spain are important short and long staple flax producers, and France is the main growing region for hemp. Thus, there are sources of flax and alternative sources of hemp that may be imported if the price is competitive at the point of use (i.e. after transport costs). In recent months shipping costs have become a more important factor in commodity trading. Rising fuel prices and a heavy demand for ships into China have doubled shipping costs.

Higher transport costs per tonne of finished product need a high value per tonne, and relatively high density to keep unit costs down. This favours the import of finished manufactured goods based on natural fibres. Some of these may use tropical produced fibres like Agave or Abaca. A strong domestic base of low cost high quality fibre production is thus needed to enable domestic processors and users to compete in markets open to world trade, but where the transport of low density raw fibre is prohibitively expensive.

Both flax and hemp are low input crops. Yields can vary considerably between season, and both can be vulnerable to wet weather at harvest. This has been eased in the hemp crop now that regulations allow harvests to be taken earlier. Both crops are not particularly responsive to extra inputs so increasing fertiliser use or fungicides does not boost yields. Hemp in particular has few pest and disease problems, although weed competition in early establishment can lower yields. In the short-term good yields can be achieved, weather permitting, by good crop management and the avoidance of crop losses rather than by using yield boosting inputs. In the longer-term plant breeding should bring better varieties with higher yield and possibly better fibre qualities.

Dual-purpose varieties of both flax and hemp offer the chance of better margins through both fibre and seed sales. But both options present challenges if the best of both seed and fibre yields are to be achieved. Waiting for seeds to be produced and ripen, delays harvest and increases the risk of losses to the weather, and in flax the retting quality of waxier hard mature straw can be reduced. Here again a better understanding of the detailed physiology of seed and straw production should lead to better crops.

The overall conclusions of the topics covered by the report are:

Changes in support payments

- Based on historic (2000-2004) yields and prices the removal of AAPS support has currently made flax uncompetitive as a break crop for UK farmers. Improved management and quality can improve this situation and bring the gross margins closer, but still lower than other spring break crops. Hemp is competitive with other common break crops and has a low environmental footprint.

- The effect of the removal of Processing Subsidy on the processors will depend on how much of the reduction can be passed on to the growers of the crops. Retention of the Long Staple Processing Subsidy introduces an 'uneven playing field' to the EU fibre industry as a whole and in the medium to long term will be detrimental. The long staple straw and fibre industry also produces short staple fibre, so retention of the Long Staple Processing Subsidy will effectively provide support only to short staple fibre production associated with the long fibre sector.

- For the growers the impact on gross margins, and thus whether or not they will grow the crop, has been affected by the full decoupling of the AAPS. Alternative methods of support for the fibre sector may be justified and warrant further investigation. Low administrative overheads and simplicity of operation are clear targets if implementing such a system.

- Under the Single Payment Scheme (SPS) if growers grow *any* crop with negative gross margins they are subsidising the production of the crop from the subsidy income which is aimed to keep them farming the land and caring for the environment. Continued production of such crops would over a period of time reduce the value of the whole farm business.

Flax and hemp and the environment

- The low inputs required by both flax and hemp make them attractive crops from an environmental viewpoint. The currently unprofitable flax crop would be more prone to pests and diseases if there was a large increase in area, but at present (for fibre linseed) such an increase is unlikely.

- Their spring sowing, open habit and height can make them good crops for birds, small mammals and some wild flowers.

- As they are different species to the principal farm crops flax and hemp reduce the overall levels of the pests and diseases associated with cereals and oilseeds. Their appearance also adds visual diversity to the landscape.

Utilisation of flax and hemp, and competition from other fibres

- Technical innovation in fibre use and composite development has lead to an ever-expanding range of uses for natural fibres. However, in some cases alternative and cheaper natural fibres may be sourced from the EU or the rest of the world. Any reform of the UK fibre sector needs to take into account these global market pressures.

- Field retting both flax and hemp is a process that increases the risk of loss and damage by bad weather. Alternative methods of removal of non-fibre material (mechanical, enzyme or chemical) could reduce or remove the risk element, but more profit and stability is needed in the fibre sector before wider adoption occurs.

- Whatever the technical merits of new processes and equipment, the underlying market economics must be satisfactory if new uses are to become major uses. The UK development of products that are based on flax has suffered because of this.

- In continental EU countries where long staple flax processing receives a much higher subsidy, short staple fibre processing may have benefited from a better level of support across the flax /fibre processing sector as a whole. This has added stability to the sector.

Agronomy of flax and hemp - the scope for improved returns

- The yields of flax and hemp straw can vary considerably between seasons, but both crops are relatively low input, showing little response to higher inputs of products like fertiliser and pesticides. Indeed higher fertiliser use can be positively detrimental if crop lodging is increased.

- In most cases inputs protect yield from loss to pest or diseases (more so in flax than hemp), rather than promote higher output. These low inputs make the crops attractive from an environmental point of view.

- With the present range of varieties good crop management is needed for good yields, rather than ever-higher inputs. Thus there is limited scope for increasing inputs to offset reductions in support payments.

- The scope for dual-purpose crops warrants further study. Although seed provides additional and high value income it can delay harvest and lead to deterioration in fibre quality. The role of more controlled retting processes may help in this respect, but the overall cost implications of such a step are quite significant.

- The productivity of production systems based on improved dual-purpose crops, needs to be compared with that of systems based on improved single purpose fibre crops. The latter may also be able to add value through bespoke fibre quality specification, and both crops now offer varieties with edible seeds.

Future Scenarios - options and outcomes

- Keeping the present support regime would be costly, as it would have to be extended to cover the EU 25 - (EU 27 from 2007). It preserves the *status quo* but, unless supported by other measures, does not encourage the industry to adapt to meet world competition. This is an essential step if future trade reform measures are to be pursued.

- Abolishing the Short Staple Processor Subsidy and retaining the Long Staple Processor Subsidy does not retain a 'level playing field' across the EU natural fibre sector. It risks the formation of a fibre sector based solely around the existing long staple flax producers, who under the current regime will receive a subsidy €200 per tonne of fibre from 2006/7. Thus short fibre would be inextricably linked to the long fibre market, limiting its ability to react to a different set of market conditions and quality requirements.

- Abolishing subsidies to both the long and short staple flax and hemp sectors would provide the 'level playing field' mentioned above. However as these measures are also accompanied by the removal of the AAPS, this option would probably lead to a decline in the crop areas, especially if both the AAPS and processing subsidy losses were carried by the growers.

- The effects of abolition of both long and short processing subsidies may be ameliorated by support for the development of infrastructure such as small local plants, or machinery rings for producer groups, and by legislative demands for even greater recyclable content of manufactured goods. Infrastructure aid can enhance the competitive position of the sector and make rural and renewable industries better able to compete internationally.

- It seems likely that contract agreements between the processors and growers will be the main drivers influencing the extent of the crop. These would be set by the processors, in the light of how and to what degree support was provided within the sector as a whole.

[*This report was complied by John Garstang, Susan Twining and Dr Jeremy Wiltshire of ADAS.* This report was produced for Defra by ADAS *The views expressed are those of the authors and do not necessarily reflect those of Defra or nay of its agencies. We are grateful for the comments we received from various members of the fibre production and processing industry*].

1. INTRODUCTION AND BACKGROUND

Flax and hemp fibre production in the UK is controlled by EC regulations[1] designed to govern the internal market primarily through support given to processors. This report is designed to give an overview of the UK fibre crop sector as these EC support measures change. These changes will run concurrently with some of the largest changes the agricultural sector has seen in many years, as support payments are decoupled from production and farmers adapt to the Single Payment Scheme (SPS) of support. The switch to a single decoupled payment means that the crop area will be decoupled from the area payment; the farmer no will longer have to grow a crop to be eligible for payment. He must however make sure that his farming operations meet the environmental requirements laid out in the cross compliance regulations. This complex of changing factors is likely to make the final impact on the fibre sector a result of several interacting effects.

The cross-compliance measures will include crop and land management measures that may affect the way growers and processors respond to changes in the fibre regime. However some off-set of the impact may be achieved if some payment can be retained to encourage a developing industry which, to use the Commission's terminology, it not yet at equilibrium. In the UK sector of developing technologies dominated by short staple fibres it is an industry that has perhaps yet to reach an equilibrium that provides a stable financial base for the future. (*see comment p4).*

With reform of the fibre regime imminent, the change from area payment now accomplished, and the technology of production and use ever changing, a report on these impacts and outcomes is needed. This would clarify the future position of flax and hemp in the UK rural sector, for both producers and processors.

Background

*Linum usitatissimum (*its name implies the most useful Linum) is probably derived from *Linum angustifolium,* a multi-stemmed and branched wild species. It has been grown for over 3000 years for the production of flax and linen cloth. All the intervening cultures to the present day have processed and used Linum fibres.

Hemp (*Cannabis sativa*) has an equally long history of providing both fibre for clothing, ropes and sail cloth, as well as oil for lamps. Indeed it could legitimately have rivalled flax for its *usitatissimum* description. A less useful side has been as a source of the narcotic marijuana. Modern varieties grown in the west are low in the narcotic agent tetrahydrocannabinol (THC) and provide fibre for a range of uses, although there have been some trials with the controlled production of higher THC varieties to evaluate the pharmaceutical properties. This narcotic 'legacy' has over the last century, been an obstacle to its more widespread production.

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[1] Regulation 1251/1999 establishing a support system for producers of certain arable crops
Regulation 1673/2000 on the common organisation of the markets in flax and hemp grown for fibre.
Regulation 245/2001 laying down detailed rules for the application of Council Regulation (EC) No 1673/2000 on the common organisation of the markets in flax and hemp grown for fibre, and amending regulations 1093/2001, 1401/2003 and 393/2004.

The way history and culture has dealt with these two crops accounts for the way that we now view them. Long fibre flax produces high quality linen textiles that command high prices when used in fashion and furnishings. Recently the export, spinning and weaving of EU produced line in China has improved margins for apparel manufacturers. This well established traditional industry in Europe relies on maintaining these high value outlets, but Chinese investment is in modern high output equipment that will be capable of supplying global markets including the most important US market.

With the introduction of synthetic fibres, less fine fibres like hemp and short staple flax have been pushed into industrial uses. Polyesters and polypropylene are very adaptable and can be manufactured with varying staple length and thickness. The natural fibre markets have had to adapt. The need for biodegradability and recycling are some of the key strengths of natural fibres, and many of the present commercial applications play to this strength. The use of natural fibres to reduce the weight of boards and composites used in the automotive sector is also valuable, as by 2015 the reuse and recycling of end-of-life vehicle must amount to a minimum of 85% by an average weight per vehicle and per year[2].

Although reuse and recycling are needed by some legislation, it is not at any cost. The European Commission's eco-label award scheme[3] can only be granted to flax and hemp, (and other bast fibres) if the waste water from the retting process meets certain environmental standards.

Revision of the support regime which supports one group of fibre producers (e.g. long staple flax), and lets the other group, (e.g. short staple flax and hemp), operate in the open market, needs to ensure the margins of lower priced 'commodity fibres' are sufficient to pay for meeting the above mentioned environmental standards. If the fibres are sourced from the world markets the processing eco criteria may not be adhered to, and the export of natural fibres if not in surplus may well increase the demand for synthetic fibres in the exporting country. Thus on a global scale the benefits of recycling, pollution control and fossil fuel reductions are lost.

Scope of the report

This report looks initially at the present contribution of the processor payments, and considers the impact of their removal. There is an element of subjectivity in this analysis as it is not possible to fully attribute changes to the income of the processors, to changes they make in payments to the producers of the flax and hemp straw. The development of alternative markets such as that for the non-fibre 'pith' components of the hemp crop will also serve to dilute the impact of the loss of fibre based support payment.

If a proportion of the loss of processor payment feeds through to the growers it will impact on the gross margins of fibre crops at the same time as the switch from area payments to

[2] Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on the end-of-life vehicles

[3] Commission Decision of 15 May 2002 establishing the ecological criteria for the award of the Community eco-label to textile products and amending Decision 1999/178/EC

decoupled single farm payments. Crops now have to justify their position in the crop rotation alongside all the other arable crops grown without area payment support[4].

In the third part of the report the role of environmental schemes such as the Entry Level Scheme (ELS) and cross-compliance environmental demands are considered. Beyond-the-farm environmental programmes such as the End-of-life Vehicle (ELV) Directive[2] offer some inducement for the use of recyclable materials; these also are considered. However such programmes source material globally, and along with continuous technological development offer an outlet where demand for UK sourced material may vary in response to world trading conditions.

The fourth part of the report looks at the utilisation of flax and hemp, global markets and competition from other countries. With the liberalisation of world trade, and trade proposals like the Everything But Arms (EBA) package it seems likely that fibre production may become an important export commodity for many developing economies.

Against all the changes outlined in the first four sections the UK farmer has the opportunity to modify his field operations to increase the efficiency of production. The scope for such increases to offset lower prices from the processor, and to compete with lower priced imports is limited, and can be weather dependent. If yield and profitability cannot be increased, particularly of flax, the net outcome of the whole process will be a contraction of the crop area. The scope for agronomic improvement benefiting fibre crop growers is examined in the fifth section.

The possible future scenarios are examined in the final section.

[4] Throughout this report it is assumed that the single farm payment is entered into the farm accounts at the whole farm level, not at the enterprise gross margin. De**coupled** crop gross margins for each enterprise thus have to be compared without any element support payment.

2. CHANGE IN SUPPORT PAYMENTS

Processing payments

In order to ensure that flax and hemp straw is actually processed, grant of aid is subject to certain conditions, in particular the authorisation of primary processors and the requirement that such processors purchase straw under contract. The processing aid amounts declared in Regulation 1673/2000 are shown in the Table 1.

Table 1. Processing subsidy for EU fibre crops: € per tonne of fibre

Marketing years	Long flax fibre	Short flax and hemp
2001/2002	€ 100	€ 90
2002 – 2006	€ 160	€ 90
2006/2007	€ 200	-

Long flax fibre are fibres that are at least 50 cm long after scutching when arranged in parallel strands. Short flax is material less than 50 cm and like hemp fibres, are obtained by at least partial separation of the fibres and the woody parts of the stem. The regulations also specify limits for impurities and shives in short flax and hemp.

In the UK only short flax fibre and hemp have been produced so the lower rate of subsidy is paid to processors. This difference between short fibre crops and long staple flax was highlighted in the aims of Regulation 1673/2000 that stated 'In order to ensure that overall support is sufficient to maintain traditional production of long flax fibre…. the aid should be gradually increased to offset the gradual reduction in aid per hectare [under the 'Agenda 2000' reforms] and, ultimately the abolition of aid for short fibre flax'. The medium and longer terms support for short staple flax and hemp has thus been doubtful since the start of the decade.

The Commission further stated that the aid for short flax and hemp should be fixed at a level that will give new products and their potential outlets time to reach equilibrium. Given the changing technical developments and financial volatility of new applications and markets for bio-fibres, it is questionable whether such equilibrium has been reached. This lack of 'equilibrium' is more apparent in the short staple fibre market where new applications are continually being developed.

In addition to the above subsidy differences, maximum guaranteed quantities (MGQ) have been established that have set tonnage limits for the production in each Member State. The tonnages allocated to the main producing states are shown in Table 2. Denmark, Greece, Ireland, Italy and Luxembourg could share out a further 5000 tonnes of short staple material

Table 2. Maximum guaranteed quantities of long flax fibre, and short flax fibre & hemp (tonnes).

	Long flax fibre	Short flax and hemp
Belgium	13800	10350
Germany	300	12800
Spain	50	20000
France	55800	61350
Netherlands	4800	5550
Austria	150	2500
Portugal	50	1750
Finland	200	2250
Sweden	50	2250
United Kingdom	50	12100

With free trade and movement of fibre within the EU, these figures give the UK a 0.07% and 9.24% share of the supported market if all countries filled their MGQs. Although lacking the skilled farmer base and technical infrastructure to compete in the long flax fibre market (0.07%), the UK is arguably one of the best placed countries to develop industries based on the short flax and hemp markets. It has a highly professional farmer group operating large units, and a diverse technically advanced and innovative industrial base for developing new uses for fibres. It also has the industry to cope with a dual role crop producing both seed for linseed and hemp oil production, and straw for fibre.

Removing the processing subsidy

The effect of the removal of the processing subsidy depends, in part, on how much of the loss of support is passed on to the growers in lower prices. Table 3 shows how the €90 processing subsidy translates into £ sterling per hectare if the entire subsidy were to be passed to the grower. If long fibre flax were to lose subsidy the equivalent values in line 4 of the table would be over £180 per tonne.

Table 3. Per hectare equivalence of the subsidy paid per tonne of processed fibre

		Flax (historic) [b]	Flax (future) [b]	Hemp
1	Subsidy per tonne of fibre	€90	€90	€90
2	Fibre from straw [a]	0.3	0.30	0.27
3	Straw yield (t/ha)	1.5	4.5	5.5
4	Processing subsidy (£/ha) (1x2x3x0.68)	£28	£83	£91

[a] *From proposals put forward by European Industrial Hemp Association for the reform of the flax and hemp subsidy. July 2002. Assumed rate of exchange is €1 = 0.68p.*
[b] *It is acknowledged that historical flax straw yields are not a true reflection of those achievable with correct management and marketing so both historical and future straw yields are presented.*

If the loss of the processor subsidy is recouped by reductions in the producer prices, the impacts on the flax and hemp gross margins are shown in Table 4. The gross margins under

AAPS in 2004 and the typical gross margins under SPS in 2005 are shown along with the additional effect of passing 50% of the lost Processor Subsidy on to the grower. Just how much of the loss is passed to growers will depend on many factors, not least of which is the profitability of the processing company.

Also in Table 4, are typical gross margins for the 2004 harvested break crops including AAPS payments, and gross margins that can be expected in 2005 from crops without direct support payments under SPS. There is considerable scope for variation about these typical levels, depending on the underlying assumptions used.

Table 4 Comparative Gross Margins for the main arable crops (excluding root crops)

Crop	Gross Margin under AAPS 2004 £/ha	Gross Margin under SPS 2005 £/ha	Gross Margin under SPS minus 50% of processing subsidy
Flax (historic)	241	-4	-18
Flax (future)	-	162	121
Hemp	470	225	180
Winter Oilseed Rape	478	236	236
Spring Oilseed Rape	437	196	196
Winter Beans	442	164	164
Spring Beans	408	129	129
Linseed	370	135	135
Feed Wheat	537	295	295
Feed Barley	403	161	161

Source: ADAS Gross Margins 2004. The inputs and returns used to achieve these margins are outlined in section 5.

Using historic performance (2000-2004), flax has a negative gross margin (-£4/ha) after the removal of the Arable Area Payment support, which would be worsened if part of the processing subsidy were removed (-£18/ha). However, if work carried out by TEXFLAX[5] and Henfaes Research Institute[6] can be translated to commercial practice, the better straw yields and improved fibre quality achieving higher prices, could boost the gross margin of flax (future) to around £162/ha, which is comparable with other spring break crops such as beans and linseed. The impact of the removal of the processing subsidy brings the gross margin down to £121/ha which makes the crop look less attractive than other break crops such as beans or linseed. An increase in flax straw price of £10/t would increase the gross margin after removal of processing subsidy to £166/ha which is more competitive with other break crops. More details of flax gross margin sensitivities are given in section 5.

Hemp remains relatively attractive, and comparable to the better break crops such as winter oilseed rape.

[5] Defra project LK0809 Processing of short fibre flax for high value textile end uses, 2002-2005
[6] Welsh Development Agency and EU Objective 1 funding
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The scope for improving these gross margins are considered in more detail in section 5 on the agronomy of the crops. However, earlier failed operations and the closure last year of the last commercial flax processing plant in the UK suggests the historic performance of flax has been one of failure rather than success. Future success demands that the reasons for failure are identified and addressed. The establishment of Fibre Developments Ltd in Cornwall, initially to support the research in the fibre processing sector, has the potential to develop into a commercial operation, however transport costs would be a limiting factor for production outwith the South West region.

In contrast it seems likely that Hemcore the principal buyer of UK produced hemp will still be able to source home produced hemp straw, provided that the loss of the processing subsidy does not impact too adversely on the business. If a processing company attempted to pass the loss of the processing subsidy completely to its suppliers by a reduction in the price of straw, the crop gross margin could fall to an uncompetitive £134 per hectare. The development of a high quality bedding market based on the absorptive 'pith' components of the plant mean the processor should be able to withstand some of the loss of the fibre support, as this diversification means processor support is now paid on only part of the product stream from the processed crop.

In the cases of both flax and hemp, transport to the processing facility is a key issue, particularly in light of increases in fuel prices. Currently local transport costs are around £12-15/t, which is around 15-20% of the straw value. The number and location of processing facilities will be important in the economics of growing the crops on a wider scale.

Removal of support payments

The removal of the Arable Area Payments takes £245 per hectare out of the farmers' gross margin which has a much greater impact than the complete removal and passing on, of the Processing Subsidy by the processor. To remain in business most farmers will also be receiving a payment through the Single Payment Scheme, provided his farm operations meet the environmental standards set by the cross-compliance regulations. Both flax and hemp are relatively low input crops and so may help in this regard (this is discussed in Section 3).

The relative effects of the loss of the AAP versus the loss of the processing subsidy (assuming all loss is passed to the grower) are shown in Tables 5a and 5b,and 6. As yield and fibre extraction are variable factors the figures for the removal of the processing subsidy are only approximate guides.

Table 5a. The effect on flax (historical) gross margins (£/ha) of progressive removal of processor subsidy support

	% Removal	*Full Processing Subsidy* 0%	25%	50%	75%	*All loss passed to grower* 100%
Full AAP 2004	0%	241	234	227	220	213
SPS 2005	100%	-4	-11	-18	-25	-32

Table 5b. The effect on flax (future) gross margins (£/ha) of progressive removal of processor subsidy support

	% Removal	*Full Processing Subsidy* 0%	25%	50%	75%	*All loss passed to grower* 100%
Full AAP 2004	0%	407	366	324	283	241
SPS 2005	100%	162	142	121	100	79

Table 6. The effect on hemp gross margins (£/ha) of progressive removal of processor subsidy support

	% Removal	*Full Processing Subsidy* 0%	25%	50%	75%	*All loss passed to Grower* 100%
Full AAP 2004	0%	470	447	425	402	379
SPS 2005	100%	225	202	180	157	134

Full removal of both subsidy payments reduces the gross margin by about £273 /ha for flax (historical), £328/ha for flax (future) and £336 /ha for hemp. With gross margins for flax (future) and hemp of £79/ha and £134/ha respectively after complete removal of AAPS and the Processor Subsidy, both crops will add little to overall farm profitability, particularly when fixed costs are taken into account.

Environmental payments such as the Entry Level Scheme will provide extra grower support, but further benefits could come from some preferential view of their role in the environmental management of the farm if deemed valuable enough. This aspect is reviewed in the Section 3.

Conclusions

- Under current market conditions the removal of AAPS support has made flax uncompetitive as a break crop based on historic production figures. However if recent research is widely adopted it suggests that both the yield and quality could improve the gross margin and make it more attractive as a break crop for UK farmers.

- At current commercial yields, hemp is competitive with other common break crops after the removal of AAPS support and has a low environmental footprint.

- The effect of the removal of processing subsidy on the processors will depend on how much of the reduction can be passed on to the growers of the crops.

- For the growers the impact on gross margins, and thus whether or not they will grow the crop, may be affected by how much of the lost processing support is passed on to them. At present the double loss of both the AAPS and reduced processor margins due to the loss of the processing subsidy could reduce production markedly.

- Under the SPS if growers grow *any* crop with negative gross margins they are subsidising the production of the crop from the support payment which is aimed to keep them farming the land and caring for the environment. In the longer term continued production of such crops will run down the asset base of the business.

3. FLAX AND HEMP AND THE ENVIRONMENT

The impact of Environmental Schemes on the uptake of flax and hemp.

Brief description of the schemes

Environmental Stewardship is being launched in England in March 2005, and replaces the existing agri-environment schemes (Countryside Stewardship, Environmentally Sensitive Areas and Organic Farming Schemes). It will comprise of the Entry Level Stewardship (ELS), Organic Entry Level Stewardship (OELS) and the Higher Level Stewardship (HLS). It is set to secure on-farm environmental benefits at levels above those of good farming practice and cross compliance. Although the final details were not available at the time of writing they cannot detract from the fact that flax and hemp provide environmental benefits that arise partly from being low input spring sown crops

Cross compliance consists of set conditions farmers need to meet in order to receive their Single Farm Payment. Cross compliance comprises of two parts, firstly Statutory Management Requirements (SMR) and secondly the maintenance of land in Good Agricultural and Environmental Condition (GAEC). Statutory Management Requirements are set out in 19 EU Directives and Regulations and cover aspects of environmental, public, animal and plant health, food safety and animal welfare. The majority of these requirements are already in place and farmers are already complying with them. The maintenance of land in Good Agricultural and Environmental Condition includes standards covering the protection and maintenance of soil, habitats and landscape features.

The Entry Level Stewardship will build on the cross compliance standards and will encourage simple effective environmental management across a wide variety of farm types. The scheme will be non-competitive and acceptance will be guaranteed, providing all requirements are met. There will be a wide variety of management options including options for field boundaries, trees and woodland, historic and landscape features, buffer strips, and options for arable land. Each management option will be worth a set number of points and it is expected that, in order to be accepted into the scheme, farmers will need to commit to sufficient options to accumulate at least 30 points per hectare. The scheme will last for 5 years and the payment for carrying out the management options will be £30 per hectare a year.

The Organic Entry Level Stewardship will be similar to the ELS but will only be open to registered organic farmers. The majority of the options will be the same as for the ELS but some will not be included, as they will not be suitable for organic farms. The payments for the management options will also be £30 per hectare, but there will be an additional £30 per hectare paid in recognition of the extra environmental benefits created through managing the land organically. The low inputs for hemp production make organic production a possible option for growers.

The Higher Level Stewardship will be more targeted and will concentrate on more complex types of management. The main objectives for HLS will be wildlife conservation, the protection of the historic environment, maintenance and enhancement of landscape character, promotion of public access and understanding, natural resource protection and two secondary objectives covering flood management and genetic conservation. Capital works will be available for restoring, maintaining and recreating particular targeted habitats. Most HLS applications will have to be underpinned by an ELS agreement or application, and will have to be accompanied by a Farm Environment Plan. This is to identify the features requiring management and any environmental risks. A joint ELS/HLS agreement will last for 10 years. Acceptance into HLS is not guaranteed, with only those applications that best meet the scheme objectives being accepted.

Likely popularity of the schemes

The ELS is non-competitive therefore it will be open to any farmer who can meet the requirements of the scheme. It is highly likely that this scheme will be popular throughout England. Similarly, the OELS will be available to all registered organic growers.

The Higher Level Scheme will be targeted towards high priority situations and areas, and the regional targets will be defined within the framework of the Joint Character Areas (based on landscape and habitat) and water catchments. Having defined the targets at regional level, they will be set on a county basis. Whilst there will be a wide range of management options within HLS, any application will have to focus on those that meet the target/objectives for the area. These might for example relate to protecting and enhancing the condition of an SSSI, or providing habitat for a particular farmland bird. Thus although there will be arable options that include reduced input cropping, and possible over wintered stubbles (full details of the schemes are announced on March 3rd), they will not be universally available.

Benefits to biodiversity of flax and hemp in farm rotations

As the move away from spring-sown cereals in recent decades is thought to be a significant factor in the decline in farmland biodiversity, the addition of spring sown crops such as flax and hemp to a rotation should be beneficial to wildlife. It provides the opportunity to leave stubble from a preceding crop over winter. If natural re-growth is also allowed to remain, this will provide a good habitat for many seed-eating birds and over wintering insects.

Whilst spring cultivations and sowing might disrupt early ground-nesting attempts, once sown the land under flax will provide a suitable breeding habitat for lapwings, and an improved habitat for skylarks, as short staple flax is less dense than many other crops, such as cereals and oilseed rape. The hemp crop is more vigorous and rapidly creates a dense leafy cover, making it less suitable for ground nesting birds. However, the crop structure may provide above ground nesting opportunities for some species, e.g. reed bunting.

Seed produced and shed by both crops will provide food for seed-eating birds and small mammals. As UK flax is combined and can be left in the field to ret for three weeks or so, any seed residues will be available for wildlife.

Both crops are grown with low inputs, which will benefit the vegetation and wildlife at the field margins. Flax receives only modest amounts of fertiliser (see page 33) and may occasionally be treated with a flea beetle insecticide at the establishment stage, and/or a fungicide, and/or a herbicide. Assuming such treatments are only used when necessary, overall the crop will benefit biodiversity through the weed cover, albeit sparse, and invertebrate populations, providing food sources that underpin the food chain, to the benefit of birds and small mammals. Grey partridge chicks for example are entirely dependent on insects, including small ground beetles, for the first ten days of their life, before graduating to seeds and leaves. On the other hand, the chicks of the linnet are unusual in that they are fed entirely on seeds.

Hemp receives a fertiliser application (see Section 5), but few further inputs. This should provide general biodiversity benefits e.g. to invertebrates, but successful arable weed establishment within the crop is less likely given the density of cover of the hemp.

The late summer harvesting of both crops will maximise the food/habitat benefits through the breeding season.

Possible impact on the financial viability

The removal of Processing Subsidy and the general tightening of budgets with the changes in the AAPS increase the pressure on both flax and hemp to continue to be managed as low input crops. Hemp in particular is one of the lowest input spring crops available to farmers. Flax, being identical to the more widely grown linseed crops has to contend with flea beetle infestation and *Septoria* infection, the levels of which will be increased by larger areas of linseed.

If the removal of subsidy results in the closure of processing business and the loss of buyers for fibre crops, any biodiversity benefits accruing from the crop areas will be lost, although the benefits due to the varying and probably greater linseed area will remain.

Other inducements

Once changes in direct and indirect support payments have been adjusted, and any environmental inducements have been added to the budgets of fibre crops, the only remaining inducements must come from the market. This is intimately involved with global trade and competition, which is discussed in the next section. In section 4 we also look at technical developments that give further support to the 'green credentials' of short staple flax and hemp. The development of pan-European industries in the automotive, construction material, and furnishing sectors has resulted in companies sourcing the bulk of their eco-products from the most favourable source within the EU or even beyond. The full impact of the fibre production sectors in the new Member States is still being factored in to the EU supply pool.

Conclusions

- The low inputs required by both flax and hemp make them attractive crops from an environmental viewpoint. The flax crop would be more prone to pests and diseases if there was a large increase in area, but at present (for fibre linseed) such an increase is unlikely.

- Their spring sowing, open habit and height can make them good crops for birds, small mammals and some wild flowers.

- As they are different species to the principal farm crops, flax and hemp reduce the overall levels of the pests and diseases associated with cereals and oilseeds. Their appearance also adds visual diversity to the landscape.

4. UTILISATION OF FLAX AND HEMP AND COMPETITION FROM OTHER FIBRES

Fibre materials from flax

Flax fibre is used to produce linen, a tough and durable textile and is produced from a bast fibre, within the outer layers of the stem. Longer fibres are used for spinning into yarn and making textiles. Shorter flax fibres are not long enough for the linen process and can be suitable for spinning into yarns, often mixed with cotton, and also have other, more novel uses, including:

- packaging materials,
- reinforcements for plastics and concrete,
- asbestos replacement,
- panel boards,
- lining materials for vehicles,
- alternatives for fibreglass and insulation.

Flax fibre is hollow and able to absorb up to 12% of its own weight in water, and its strength increases by 20% when wet. It also dries quickly, and is anti-static. For some applications it is a suitable substitute for man-made synthetic fibres such as heavier fibreglass. The fibres are twice as strong as those of cotton and five times as strong as those of wool.

Fibre materials from hemp

Hemp fibre (*Cannabis sativa* L.) has been used for thousands of years, and Cromack 1998[7] cited its long history of production in the UK. Hemp produces 25% more long fibre than flax, and modern uses are many and varied (Table 7). Hemp produces long 'bast' fibre, medium fibre, and the short 'shiv' fibres, or 'hurds', as well as other useful materials, especially the seed oil.

Table 7. Properties and uses of hemp fibre

Fibre type	Properties	Uses
Long fibre	Stronger than cotton anti-mildew anti-microbial biodegradable	textiles for clothing etc. technical textiles, e.g. for: sails tarp awnings carpets rope paper substitute for fibreglass

[7] Cromack, H.T.H (1998). The effect of cultivar and seed density on the production and fibre content of *Cannabis sativa* in Southern England. Industrial Crops and Product, 7, 205 -210.

Fibre type	Properties	Uses
Medium fibre	low lignin levels anti-mildew anti-microbial biodegradable	Paper non-woven applications brake/clutch linings hygiene products (e.g. nappies)
Short core fibre	more absorbent than wood shavings biodegradable	wood-substitute for construction materials concrete/plaster mixes plastics animal bedding packaging mushroom compost insulation material fibre board

Potential substitutes for flax or hemp

There are very many sources of fibre from crops (Table 8), and alternatives to hemp and flax, depending on uses include cotton, jute, sisal, abaca, ramie, coir, kenaf, wood fibre and cereal straw. Other sources of fibre include recycled fibres (especially waste paper), synthetic fibres and animal fibres. The suitability of these as potential substitutes for flax and hemp will depend on production and processing economics, market prices and the properties of the fibres. In considering the rationale for production and use of flax and hemp in the UK, rather than alternative fibres, the important factors are:

- costs of production compared with market prices of imports and alternative fibres;
- the availability of alternative fibres;
- benefits of local production (lower cost of transport, an increasingly important concern);
- current and potential markets for flax and hemp fibre that rely on unusual properties of the fibres.

Following the decline in crop area and closure of processing plants, only small areas of flax fibre are currently grown in the UK. Fibre Developments Ltd., has taken over the only operational flax processing plant and has a small acreage planted in 2005, with plans for expansion from 2006 onwards. Most major secondary processing markets are abroad. E.g. automotive in Germany and spinning in Italy, but there are UK businesses that could use UK produced fibre if a reliable supply can be delivered.

Of the world total plant fibre production, flax and hemp fibres make up 2.5% and 0.3% respectively (calculated from 1998-2003 mean data in Table 3). China is by far the largest producer of flax and hemp. FAO data suggest that China produces around 51% and 33% of world flax and hemp production respectively (averages, 1998-2003)[8], although the accuracy of some of the data may be questionable, with possible confusion between weights of straw

[8] Source: FAOSTAT data, 2004, http://apps.fao.org/faostat/form (accessed 15 October 2004).

and fibre. In the EU, France, Belgium, Netherlands and Spain are important flax producers, and France is the main growing region for hemp. Thus, there are sources of flax and alternative sources of hemp, which may be imported if the price is competitive at the point of use (i.e. after transport costs). In recent months shipping costs have become a more important factor in commodity trading. Rising fuel prices and a heavy demand for ships into China have doubled shipping costs.

Costs per tonne of straw production for flax and hemp are give in tables 14 and 18 respectively, and are approximately £96 per ha for flax and £47 per ha for hemp, with value of straw output per ha of around £30 and £550 for short staple flax and hemp respectively[9]. World prices of plant fibres are very variable, and depend on many factors, principally changes in demand (e.g. growth and development of value-added products such as composites for vehicle production), changes in supply (related to planted area and weather conditions in producing areas), and crop quality (influenced, for example, by the suitability of weather for field retting)[10]. Thus, the influence of the balance between costs of production and world prices, on potential for substitution of fibre produced in the UK by fibre from other sources, will vary from year to year.

The main uses for hemp fibre are given in Table 7, together with alternative, competing materials. Even in specialist markets for which hemp fibre is very suitable, such as cigarette and teabag papers, alternatives are available. For example, Manila hemp is widely used in teabag paper.

Plant fibre sources are very diverse (over 30 species are included in Table 8), and uses of hemp are also very diverse (Table 8). It is considered that most, if not all, uses of hemp fibres could be substituted by use of other fibres[11]. However, there are markets for hemp fibre that could not be substituted in the short term, but could readily be substituted in the longer term. This relates to the need for consistency in end products and manufacturing processes. For example, vehicle manufacturers using hemp fibre for composite materials, used for interior door panels, parcel shelves, etc., wish to source consistent fibre material for the planned production period for the model of vehicle in which the composites are used. The ease of change is shown Daimler-Chrysler plants switching to Abaca (Manila hemp) at its car plants in the Philippines, whilst in Canada and Europe hemp from *Cannabis sativa* is used.

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[9] Source: Nix, J. (2004). Farm Management Pocketbook, 34th Edition.
[10] Source: Wigglesworth and Co. Limited, Annual Fibre Review 2003.
[11] Ian Low, Hemcore, Personal communication.

Table 8. The main vegetal fibres, following FAO classification[12].

Commodity	Definitions
COTTON lint Gossypium spp	Fibres from ginning seed cotton that have not been carded or combed, including fibres that have been cleaned, bleached, dyed or rendered absorbent.
FLAX fibre and tow Linum usitatissimum	Broken, scutched, hackled etc. but not spun. Traditionally, FAO has used this commodity to identify production in its raw state; in reality, the primary agricultural product is flax straw.
HEMP fibre and tow Cannabis sativa	FAO data include raw, retted, scutched, combed fibre, tow and waste.
KAPOK fibre Ceiba pentandra	FAO data cover only fibres that have been crushed, carded or combed for spinning.
JUTE white jute (Corchorus capsularis); red jute, tossa (C. olitorius)	FAO data cover raw or processed jute (but not spun), tow and waste, yarn waste and garnetted stock and may include jute-like fibres.
.JUTE-LIKE FIBRES	Textile fibres extracted from the stems of dicotyledonous plants including: China jute (Abutilon avicennae); Congo jute, malva, paka (Urena lobata; U. sinuata); Indian flax (Abroma augusta); kenaf, meshta (Hibiscus cannabinus); rosella hemp (H. sabdariffa); sunn hemp (Crotalaria juncea)
RAMIE	Ramie fibre is obtained from the bast of the plant. Includes China grass, white ramie (Boehmeria nivea); rhea, green ramie (B. tenacissima)
SISAL Agave sisalana	Sisal fibre is obtained from the leaves of the plant. FAO data cover fibres that are raw prepared for spinning, and tow and waste, including yarn waste and garnetted stock.
AGAVE FIBRES	Including: Haiti hemp (Agave foetida); henequen (A. fourcroydes); ixtle, tampico (A. lecheguilla); maguey (A. cantala); pita (A. americana); Salvador hemp (A. letonae)

[12] Adapted from FAOSTAT, 2004, http://apps.fao.org/faostat/faoinfo/Economic/faodef/fdef09e.htm#9.04 Accessed 21 October 2004)

Table 8 (continued).

Commodity	Definitions
ABACA MANILA HEMP	The fibre is obtained from stalks of certain banana trees – Musa textilis.
COIR	Coir fibre is obtained from the fibrous covering of the mesocarp of the coconut – Cocos nucifera.
OTHER FIBRE CROPS	Other fibres that are not identified separately because of their minor relevance at the international level, including: alfa, esparto (Lygeum spartum; Stipa tenacissima); bowstring hemp (Sansevieria spp.); caroa (Neoglaziovia variegata); fuque fibre (Furcraea macrophylla); Mauritius hemp (F. gigantea); New Zealand flax (Phormium tenax); palma ixtle (Samuela carnerosana). In instances where the fibrous part is normally used for other purposes, FAO data cover only those fibres intended for spinning.

Table 9. Global supplies of fibres[13].

	Global supplies of fibres for years 1998 to 2003 (Mt)						
Fibre type	1998	1999	2000	2001	2002	2003	MEAN
Abaca (Manila hemp)	97,540	99,840	104,430	98,320	100,230	100,230	100,098
Coir	649,320	654,190	682,790	658,390	636,380	636,640	652,952
Other fibre crops	298,711	296,152	270,891	278,013	274,338	276,355	282,410
Cotton lint	18,212,893	18,194,950	18,635,314	21,100,312	18,268,496	19,529,062	18,990,171
Flax fibre and tow	416,545	497,279	505,995	631,209	784,430	773,319	601,463
Hemp fibre and tow	73,629	61,140	50,618	62,917	74,054	82,950	67,551
Jute	2,634,317	2,592,893	2,662,360	2,929,993	2,861,483	2,807,439	2,748,081
Jute-like fibres	442,025	401,491	385,826	425,865	411,630	425,007	415,307
Ramie	126,861	123,992	164,916	201,041	242,766	269,300	188,146
Sisal	283,508	353,891	413,050	305,177	287,142	295,425	323,032
Agave fibres	58,115	54,983	53,825	54,218	54,378	54,428	54,991
Kapok fibre	123,000	124,500	126,700	124,400	125,000	125,035	124,773
Total	23,416,464	23,455,301	24,056,715	26,869,855	24,120,327	25,375,190	24,548,975

[13] Source: FAOSTAT data, 2004, http://apps.fao.org/faostat/form?collection=Production.Crops.Primary&Domain=Production&servlet=1&hasbulk=0&version=ext&language=EN (accessed 15 October 2004).

Table 10. Competing products for established uses of hemp fibre[14]. NA=North America.

Market Segment	Market Primary Location	Hemp Material Used	Significant Competing Natural Fibre Materials	Other Significant Competing Materials
Interior Automotive Plastic Moulding	Europe / Germany	High quality clean fibre	Kenaf, jute, flax	Fibreglass
Pulp & Paper	Europe and NA	Whole stock, fibre, hurd	Wood, flax, kenaf, cotton	Recycled
Textiles	Hundreds of small players throughout NA	High quality long fibre	Cotton, linen, wool	Nylon, polyester
Composite Board	Europe	Tow, hurd	Wood, cereal straw, flax	Polymer
Industrial, low-value end uses (Fillers, Recycling, Absorbents, Plastic)	Europe	Hurd or fibre	Kenaf, jute, flax, wood flour, sawdust	Talc, Calcium Carbonate
Insulation	Europe	Short fibre and hurd	Flax	Fibreglass
Cordage (rope)	Canada / US	Long fibre	Jute, kenaf	Nylon, polyester
Horse Bedding, Chicken Litter	Kentucky / Eastern Seaboard States / Ontario/UK	Hurd	Cereal straw, wood shavings	none

[14] Source: http://www.gov.mb.ca/agriculture/crops/hemp/bko07s04.html, accessed 28-10-04

Table 10 (continued)

Market Segment	Estimated Volume of Market per Annum	Market Primary Location	Hemp Product Used	Significant Competing Natural Fibre Products	Significant Competing all Other Products
Geotextiles	Minimal	North America	Unprocessed stalk	Jute, straw	Polymers
Carpet	Minimal	U.S.	Long fibre	Flax, kenaf	Nylon / polyester, Recycled

Methods of utilisation and proven technical development

If there are changes in the support regime for the short fibre sector in the next 12 to 24 months, technological lifelines are those which are based on current or new cost-effective opportunities that give reliable returns.

Flax and hemp are retted to facilitate extraction of long and/or short fibres. Retting is a microbial degradation of the stems, usually in the field. This is a traditional process that introduces a degree of uncertainty due to variations in the weather.

The field retting process is well established, but is weather-dependent, and so is difficult to control for optimal fibre quality. Under or over retting reduces the value of the fibre, but the crop must be dry when it is baled, otherwise retting (and rotting) would continue after baling. If drying facilities are not available when the crop is correctly retted, the crop may be lost. New fungal sources of enzyme retting are currently being looked into as a solution to this problem[15].

A modified form of field retting is called stand retting. Crops are sprayed with a herbicide to desiccate the crop and initiate the retting process before harvest. This is a low-cost method that decreases the risk of crop failure in UK conditions.

Other types of retting include water retting, enzyme retting and chemical retting. Although non-field retting gives more control of the process care is needed to use the most suitable enzymes or molarity of retting solution. Enzyme retting has been shown to have the potential to improve the utilisation of dual-purpose flax/linseed. The mature stems of dual-purpose flax/linseed plants left in the field until the seed is ripe have harder stems with more cutin and wax. Akin *et al*[16] suggest enzyme retting could be used to increase the value of fibre obtained from this more mature straw. This process would appear to be particularly relevant to UK conditions. High enzyme rates can give finer but weaker fibres (Akin *et al*)[17], whilst sodium hydroxide treatment has been shown to produce uneven fibre surfaces which improve resin adhesion in composites leading to better mechanical and thermal stability.

With more specialist uses for fibres the choice of retting process becomes an integral part of the manufacturing specification. This extra control over the process comes with extra costs.

Retted or unretted stems require further processing to remove the bast fibres from other material. For some applications further fibre cleaning may be required. Fibre separation, or decortication, may be mechanical, or by other methods such as steam explosion or ultrasound methods[18], but the latter two methods are not commercially viable at present.

Decortication can be done without retting, but results in more fibre breakage, and a shorter average fibre length. The Department for Environment, Food and Rural Affairs (Defra) supported a project at Silsoe Research Institute (SRI) to develop a new mechanical process to separate flax fibre from the woody stem material[19]. This decortication process is a low-cost, short-fibre processing technology, using unretted straw, and producing flock flax or hemp in

[15] Source: http://www.ienica.net/crops, accessed 21 October 2004.
[16] Akin, D.E., Morrison, W.E.H.3rd, Rigsby,L.L., & Dodd, R.B. (2001) J Agric. Food Chem. 49(12):5778-84
[17] Akin, D.E., Foulk J.A., Dodd, R.B., & McAlister D.D.3rd (2001). J Biotechnol, 23, 89(2-3); 193 -203
[18] Source: http://www.gov.mb.ca/agriculture/crops/hemp/bko07s02.html, accessed 21 October 2004.
[19] http://www.sri.bbsrc.ac.uk/science/bg/crops.htm

random layers. The use of unretted material avoids weather-dependent variations in quality, increasing the consistency of the extracted fibre. The decorticator used a series of rollers to flex the stems, to crack the woody core into short pieces, and then a rotor studded with steel pins to comb the fibre and separate it from the core at high speeds. This process was scaled up in the FIBRELIN project, funded within the Crops for Industrial Use LINK programme. In an EU project the decorticator was adapted for retted hemp straw. The main conclusions of this project were:

- Fibre can be extracted from unretted hemp stems and used to make composite materials that are as stiff and strong as those made with retted fibre. The percentage yield of fibre was found to be similar for unretted stems as for retted stems.
- Further improvement in composite properties from unretted fibre could be made by removal of more of the waxy epidermis from the stems during fibre extraction.

However, the technology developed in these projects has not been widely adopted. Fibre extraction and cleaning are not new industrial processes, but have been developed and refined over many centuries. It is expected that further technical advances will be incremental rather than revolutionary.

Changes in the markets to date

After fibre extraction and cleaning, further processes are used to produce end products. These processes are many and varied, and improvements in the processes are unlikely to directly influence the impact of support measures on the competitiveness and future potential for UK fibre production.

The development of new products and markets, which may be dependent on process development, can affect competitiveness by changing the economy of scale for production and primary processing. Some appear to have the scope to take significant amounts of crop These include recent market developments in the uses of flax and hemp fibre such as;

- replacement of glass fibre in some composites;
- bio-degradable mats for encouraging new vegetation on soil slopes;
- use in building construction;
- vehicle component products such as gaskets, seat covers, floor mats, and interior panelling.

Scope for future market development[20]

Future market development is likely to involve the expansion of recently developed markets, with an emphasis on recyclable products. There may, also, be more specialisation within newly emerged markets. It is probable that these will support the continuation of the recent increases in world production of flax and hemp fibres (Figures 1 and 2).

The costs of the fibre materials and their processing will be sensitive to changes in support measures, but is the most important driver of future market development. Other important factors may include increased statutory requirement for recycling (*see below*), and a fashion for natural products.

[20] Main source: http://www.ienica.net/crops, accessed 21 October 2004.

The implementation of the Kyoto protocol may make renewable fibres more competitive as various fossil energy control measures are adopted. This will tend to be seen through a drawn out series of changes rather than any one positive change that could offset loss of profitability due to support regime changes. It raises again the issue of whether or not "equilibrium"[21] has been reached between production and markets in the short staple flax and fibre markets. However, artificial fibres based on fossil fuels are still very cheap and can undercut biofibres in many mass markets.

Long flax fibres are used for spinning into yarn and weaving, and knitting. Novel applications for shorter flax fibres in non-textile markets have developed (e.g. geotextiles), and could increase the volume of fibre usage. Novel applications include many of those for hemp fibres detailed below, especially packaging materials, reinforcements for plastics and concrete, asbestos replacement, panel boards, vehicle components, and insulation products.

For hemp, the benefits of high annual fibre yields may become increasingly important in markets currently dominated by wood fibre, and some replacement of wood fibre may occur. The commercial development of green decortication and degumming for hemp could change the balance of world fibre markets, and increase the range of applications for hemp fibre. Hemp has a fibre yield per hectare several times higher than that of trees, but produces less fibre per tonne of raw material (increasing the volume of material to be handled), and has an annual production cycle that requires storage facilities for year-round use. Production of fibre composites is a fast-growing segment of the wood-products industry, and is the largest potential market for hemp fibre. Fibre composites include panelling, medium density fibreboard, plywood trusses, and support beams. Hemp fibre can replace wood fibre without changes to production equipment.

The paper industry also has potential for replacement of wood fibre with hemp. The bast fibre requires cutting prior to paper making, but can produce high quality papers. The shorter core fibres can be used in blends to make newspaper, tissue and packaging materials.

In the EU annual packaging usage includes 12 million tonnes of paper and board, 6 million tonnes of plastics and 10,000 tonnes of polystyrene. Again, there is potential to substitute wood fibre use, but a more important driver of change is likely to be increased political pressure for recyclable packaging materials. The hemp hurds (short core fibres) may be processed into cellophane packing material or into a low cost, compostable replacement for polystyrene.

The market for fibre in building materials can be expected to expand in overall volume, and in diversity of products. Natilin Flax Batt is already an established insulation material made from flax. Its production in the UK has been discontinued but it will continue to be made in France. Hemp hurds and lime can be used to make a cement that is stronger than concrete, five times lighter, has excellent insulation and fire-retardant properties, and is resistant to insects and mould. This material can be used in foundations, walls, floors and ceilings and for interior and exterior plaster. Hemp fibre can also be used in insulation products that are safer than fibreglass and easy to install.

[21] Paragraph 5 of Council regulation 1673/200

Another novel market for hemp is usage in a variety of plastic products. Plant-based plastics from hemp can be completely biodegraded.

The textile market is a more traditional outlet for hemp fibre, but innovation, a natural appeal (compared with synthetic fibres), and biodegradability may lead to increased market share. Compared with cotton, hemp fibres are longer, stronger, more lustrous and absorbent and more mildew resistant.

The development of a high value premium quality bedding market to use the absorbent pith and non-fibre components of hemp has significantly increased the saleable yield of the plant.

Recycling – legislation and industry

If the knock on effects of the changes in subsidy impact on the profitability of panel manufacturers will they seek to recoup some of the lost revenue from the car manufacturers through higher prices? In this situation will the recycling legislation like Directive 2000/53 [End-of-life Vehicles] ensure they continue to buy EU produced fibre, or simply look overseas for cheaper material? The requirement is just that a certain percentage by weight is made up of recyclable material. The provenance of that material is unimportant. The answers to these questions will have a significant effect on the development of the EU fibre sector.

Biofibre components are light, thus contributing to a low percentage of the non-metal component of the vehicle. As metal is largely recyclable the low weight of ancillary components helps to keep up the percentage of recyclable material on a weight basis, irrespective of whether or not they are recycled. Having the ancillary components also recyclable is a benefit to the overall percentage.

The lightness of unprocessed fibre material plays in favour of locally produced material as haulage and shipping rates increase. Light bulky crops carry disproportionately higher freight costs per kilo than denser processed final product. The increasing tendency to question ‘air miles’ of imported fresh produce, and the closer scrutiny of energy inputs that will arise from fuller implementation of Kyoto may mark the start of a period where importing cheap plant based materials becomes less attractive due to fuel levies and shipping costs, irrespective of agreements like EBA. Investment is already moving to the fibre producing countries where semi-finished products are produced. These denser products have relatively lower freight costs, and export jobs from the EU manufacturing sector.

At present natural fibres used in injection moulded composites are recycled through energy recovery, i.e. they are burned. Given the critical shape of mouldings in engineering and construction it is difficult to foresee how biocomposites can be recycled other than by using energy on maceration/grinding and re-extrusion – a process not without effect on the fibre and second moulding structure. In this context it is not surprising that burning is seen by some as a reasonable option.

Good legislation works well. Bad legislation tries to enforce the unenforceable. It seems unlikely that any further regulations on recycling and the use of biofibres will do much to improve the situation unless it supports on-going economic and technical development. Thus as lightness becomes more important in electric and hybrid vehicles so biofibres may increase further in usefulness and value. Joint legislation encouraging very low emissions and low kerb weights (e.g. excise duty, road tax and new vehicle taxation) in conjunction with the End of Life regulations will support such a change.

Despite favourable technical developments and inducements to buyers such as the ELV Directive, the buyers are free to source their supplies of renewable fibre from anywhere in the world. The next section looks at global production of fibres and their uses. As we shall see buyers can easily adapt to new fibres if supply costs and reliability are satisfactory.

Profitability of companies using fibre products.

The structure and profitability of the utilising companies is completely different to the production and processing sector, but competition and tight pricing mean it is equally difficult for profits to be produced. Fine finished fibres can be spun and woven into linen and hemp textiles almost anywhere. Flax fibre spinning, in common with much else, is now being done in China. In addition to being the worlds' main producer of flax it is also importing high quality long flax fibre from western Europe to blend with local fibre to improve yarn fibre and fabric quality.

The common theme of sectors using high volumes of fibres is that they are international in nature. In the automotive industry Ford, BMW, Daimler-Chrysler and others source materials from around the world. They are increasingly under pressure to produce high percentages of recyclable components, and under financial pressure from vehicle plants in low wage economies. To retain market share in regions like Europe manufacturers will undoubtedly have to comply with recycling directives to retain market access. The actual components (door liners, parcel shelves etc) are manufactured by sub-contracting out the work. In the UK processors provides the processed fibres to others to use in manufactured products. In France flax co-operatives have set up to manufacturing plants to supply the French car sector. Techi-Lin was set up as a way of using the lower quality fibres produced by Centrale Liniere Cauchoise. It now uses 800 tonnes of flax fibre per annum to produce door panels for 2000 vehicles per day.

Although the car manufacturers provide the ‘pull’ in terms of demand for fibre based recyclable products, the risk carried by exposure to technical change in the product specification or in variations in fibre supply is carried by co-operative ventures like Techi-Lin. It is difficult to determine what role the long staple flax-processing subsidy has on the overall performance of a flax conglomerate diversifying into other activities. It is however very clear that the absence of any long staple processing in the UK, means higher rates of subsidy cannot be used in this manner. It also raises the question of what will happen to the competitiveness of the UK fibre market if the whole of the processing subsidy is removed.

Construction companies using natural fibre products have more scope to switch to alternative materials (e.g. rockwool for insulation, metal for reinforcing) if supplies of natural fibres become more difficult to source.

World production trends

Alongside the development of these novel markets, there has been an increase in world production of flax and hemp (Figures 3 and 4)[22]. The supply of finished or part finished fibre

[22] Source: http://apps.fao.org/faostat accessed 21 October 2004

products from production and processing countries like China will be attractive to end users if the domestic prices are not competitive after support regime changes feed through to product prices.

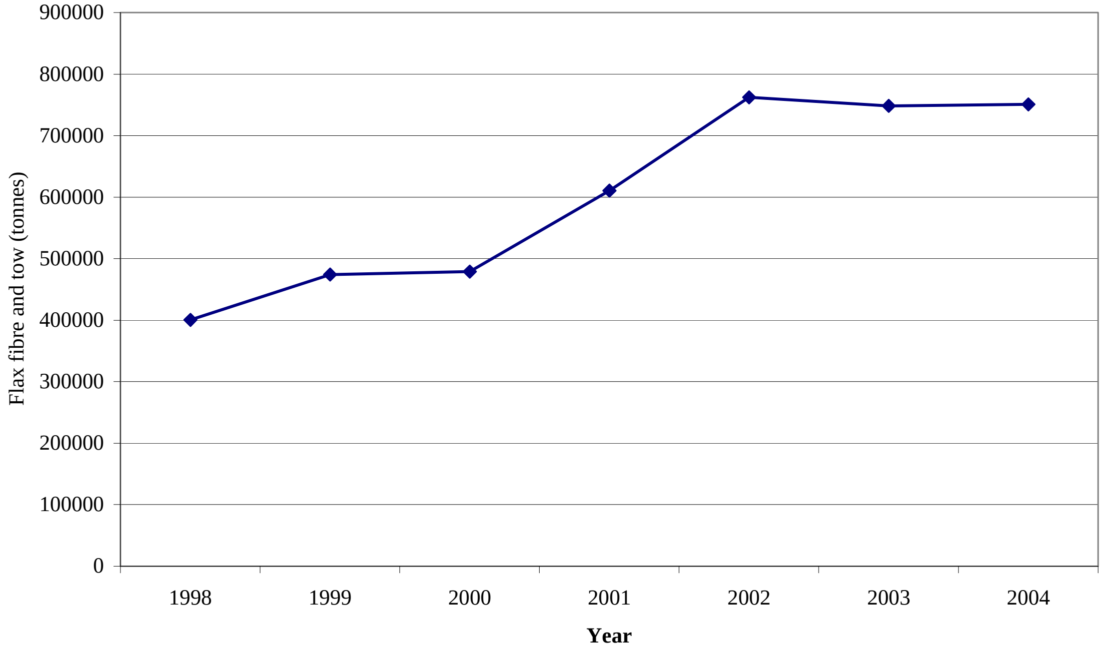


Figure 1. World production of flax fibre and tow, 1998-2004
(from http://apps.fao.org/faostat, accessed 28 January 2005).

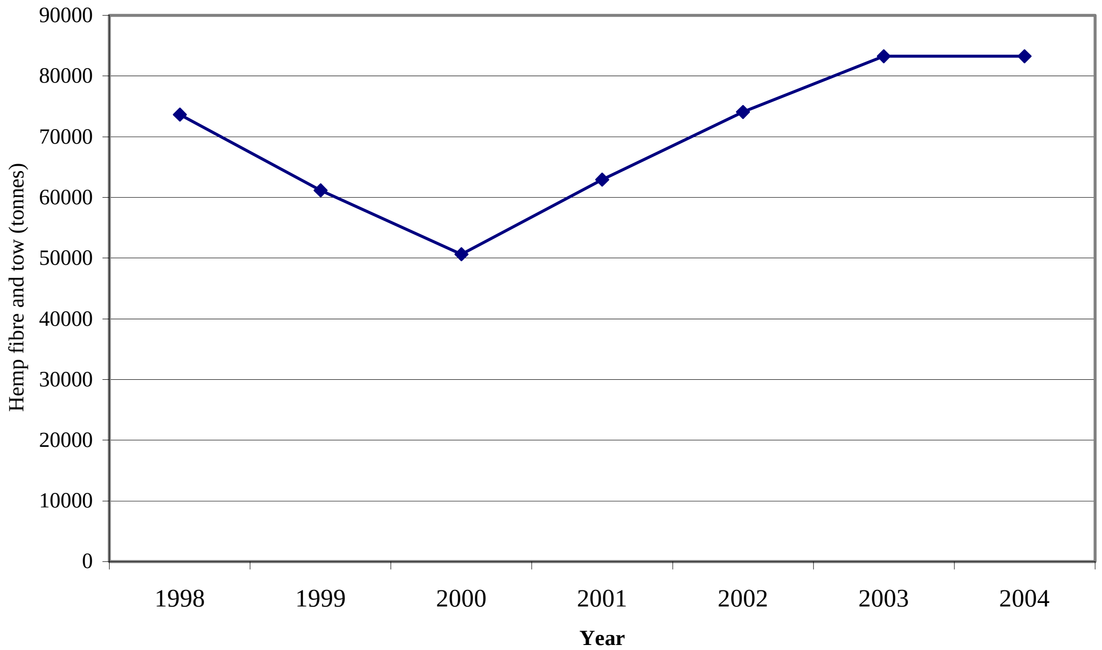


Figure 2. World production of hemp fibre and tow, 1998-2004
(from http://apps.fao.org/faostat/, accessed 28 January 2005).

World production is increasingly likely to impact on EU and UK fibre markets exposed to the freer world trade. Inward capital investment in developing economies is allowing the development of textile processing industries that can compete on a world scale taking fibres from around the globe. Growers must invest in effective management strategies and the best varieties if they are to retain a share of global production. This is reviewed in the next section.

Conclusions

- Technical innovation in fibre use and composite development has lead to an ever-expanding range of uses for natural fibres. However, in some cases alternative and cheaper natural fibres may be sourced from the EU or the rest of the world. Any reform of the UK fibre sector needs to take into account these global market pressures.

- Field retting both flax and hemp is a process that increases the risk of loss and damage by bad weather, but stand retting may help to limit this risk. Alternative methods of removal of non-fibre material (mechanical, enzyme or chemical) could reduce or remove the risk element, but more profit and stability needs to be in the processes before wider adoption.

- Whatever the technical merits of new processes and equipment, the underlying market economics must be satisfactory if new uses are to become major uses. The development of flax using products in the UK has suffered because of this.

- In continental EU countries where long staple flax processing receives a much higher subsidy, short staple fibre processing may have benefited from a better level of support across the flax /fibre processing sector.

5. AGRONOMY OF FLAX AND HEMP – SCOPE FOR IMPROVEMENT

Flax and hemp are some of the oldest crops in cultivation, yet the varietal improvement has only recently started to make progress. This section looks at input management and the scope for improvement. As breeding aspects are to be covered more fully by current Defra funded research (NF0530 Review and analysis of breeding and regulations of hemp and flax varieties available for growing in UK), the comments refer to some issues that will be developed in that report.

The agronomy of the crops can be used to offset some of the intrinsic weakness of both species. Seed rate adjustments and proper fertiliser and disease control can improve crop performance and minimise lodging. Selecting the right location for crops can improve establishment and production. Optimising field performance costs little and increases margins. The data in Table 4 show the margins of hemp can compete with many other break crops. Flax based on historic performance appears to be far less promising, however work is underway through TEXFLAX and at Henfaes Research Institute, Bangor that shows increased straw yield and quality. In this section we look at the detailed make-up of the inputs that contribute to the gross margin and provide sensitivity analyses that give some indication of the impact of yield and price variation on margins.

Flax – Cultivars, yield and crop area

Current varieties

The varieties that are currently approved under IACS for use in the UK are listed in Appendix 1. Most of the varieties available have been selected for their use in long fibre production for high quality textiles such as linen, where yield, fibre length, strength and texture are key components. There are no breeding programmes aimed at meeting the needs of the short fibre market. Where both short straw and seed are produced, seed yield and more recently, oil quality are important.

Unlike linseed and the competing arable crops, agronomic data on the fibre flax varieties in the UK is scarce.

Flax in the UK is grown for the short fibre market, often called tow, rather than the long fibre market for linen, which is more common in France and Belgium. The short fibres are used for industrial purposes such as paper, geotextiles and biocomposites (*see Utilisation section*). Co-products of flax fibre growing are seed, and after processing, shives. The seed is sold as linseed and the shives go into animal bedding and cat litter. Dust from the zero waste processing plant in Wales was also collected to make in to briquettes for fuel.

Specific flax varieties produce stronger and higher yields of fibre compared to dual-purpose varieties. Dual purpose varieties were common in the past but a market demand for higher quality straw has moved the focus to single purpose fibre varieties which provide higher yields, and better quality fibres that command a higher straw price.

The main factors to influence variety choice at farm level are straw and seed yield, lodging and maturation date. In the UK a late ripening lodged crop is generally written-off.

Yields

Flax is grown for its straw yield, however in the past low straw quality and price, has made the seed yield essential to make the crop profitable to grow. Once harvested the straw is processed into fibre and shive.

Where harvesting the seed has been a major component in the crop economics (see Gross Margin costings) the crop is cut with a combine harvester rather than pulled, and the general crop management is one that attempts to optimise the seed and straw yield. This combination of mixed management and harvesting through a combine harvester rather than pulling produced lower straw yields than for long staple crops. Typical on farm straw yields were around 1.5 t /ha and seed yields in the region of 0.75-1.25t/ha. Although in the dry hot summer of 2003 the straw yields were just over 0.5 t/ha

The Eurostat data in Table 11, show all the area, yield and production data for all the significant flax producing countries in the EU 25. The countries where pulled flax is the main crop are immediately apparent from the much higher straw yields per hectare. However the relative size of the short and long fibre markets is indicated by the total amount of maximum guaranteed quantities shown in Table 2 (*page 5*).

Table 11 Flax Straw: EU area, yield and production 2000 – 2003

Area (1000 ha)	2000	2001	2002	2003
Belgium	13.561	17.401	16.015	20.047
Czech Republic	8.332	6.56	5.843	5.684
Denmark	0.001	1.423	0.127	0.072
Germany	102.483	33.044	10.341	16.246
Spain	13.547	0.584	0.084	0.584
France	54.525	67.849	67.417	76.508
Italy	0	0	0.061	0.066
Latvia	1.6	1.4	1.6	1.8
Lithuania	8.6	10.2	9.3	8.9
Netherlands	4.379	4.755	4.096	4.553
Poland	4.082	5.212	5.095	2.927
Slovak Rep.	0.581	0.915	0.538	:
UK	12.089	5.287	2.818	3.853
Yields (100 kg/ha)				
Belgium	66.375	26.026	67.437	67.145
Czech Republic	18.167	26.962	25.501	21.816
Denmark	10	5.348	5.748	10
Germany	:	:	:	:
Spain	7.398	7.209	9.286	7.209
France	68.156	41.945	72.571	69.931
Italy	:	:	43.934	42.727
Latvia	7	5.714	8.75	4.444
Lithuania	8.372	3.922	6.667	11.124
Netherlands	61.338	43.037	60.222	54.03

Table 11 (cont)

Yields (100 kg/ha)				
Poland	3.226	3.246	3.297	3.543
Slovak Rep.	1.463	10.306	16.673	:
UK	12.499	:	:	5.497

Harvested straw production (1000 t)				
	2000	2001	2002	2003
Belgium	90.011	45.288	108	134.605
Czech Republic	15.137	17.687	14.9	12.4
Denmark	0.001	0.761	0.073	0.072
Germany	:	:	:	:
Spain	10.022	0.421	0.078	0.421
France	371.622	284.593	489.25	535.028
Italy	0	0	0.268	0.282
Latvia	1.12	0.8	1.4	0.8
Lithuania	7.2	4	6.2	9.9
Netherlands	26.86	20.464	24.667	24.6
Poland	1.317	1.692	1.68	1.037
Slovak Rep.	0.085	0.943	0.897	:
UK	15.11	:	:	2.118

Source: Eurostat New Cronos database Oct 2004

Yields of straw and seed are a critical factor in the economies of short staple flax production. The relatively low straw yields of up to 1.5 t/ha (compared to hemp at 5-7 t/ha) and lower price make income per hectare low and the seed component essential for maintenance of positive gross margins.

The minimum straw yields under AAPS were set at 2.0t/ha from 2000 so UK yields struggled to meet that target. Flax straw yields are higher in other parts of Europe, with EU 15 average straw yields of 3.7t/ha and 7.1t/ha in 2001 and 2002[23] respectively. This includes the long fibre yields from France, Belgium and the Netherlands, which account for most of the long staple crop production. The harvesting process for long fibre production involves pulling rather than cutting the crop which helps to maximise the yields compared to combining where inevitably some of the crop is left as stubble in the field.

Even taking these differences into account it seems that the UK 2000 and 2003 yield figures show there is scope for improvement. Poor performance may be due to agronomic factors, such as growing on poorer quality land, less attention to detail in managing the crop and less successful retting. It may also be due in part to the marketing of the crop which, historically, has not worked consistently to make the straw be perceived as a valuable extra income stream.

The straw yield potential of the crop is greater than the yields achieved commercially in the past. Recent work in projects such as TEXFLAX[5], FIBRECLEAN[24] and work at Henfaes

[23] Source European Commission, Directorate-General for Agriculture
[24] Defra project LK0805 The production of UK grown fibre 1999-2000

Research Institute, Bangor[6] suggest that commercial straw yields can be as much as 7t/ha although typical yields are more often 4-5t/ha as shown in Table 12.

Table 12 Industrial fibre production from flax – mean and ranges of the variable scored across the fibre flax varieties in 2002 and 2003

	2002 (40kg/ha N)		2002 (80kg/ha N)		2003 (40kg/ha N)	
	Mean	Range	Mean	Range	Mean	Range
Final Yield[25] (t/ha) (dwt)	5.51	4.20-7.18	5.26	3.96-6.76	4.41	3.39-5.11

Source: Henfaes Research Centre, 2005 Dimmock et al

As in many crops, varietal differences in some seasons can easily exceed the differences between good and bad harvest years. Wet weather and lodging have a profound effect on yields, and as mentioned elsewhere can result in crops being written-off. Improvements are needed in these aspects of performance.

Lodging

The ability to withstand lodging is a vital agronomic consideration, as lodged crops tend to rapidly loose yield and quality. Lodging is partly governed by varietal factors but climate and crop management will influence the outcome. High rainfall near crop maturity and high levels of applied or residual nitrogen will increase lodging.

Maturation Date

Harvesting of the seed is followed by a 3 week retting process in the field so an early maturation date is vital to achieve a good seed yield and allow time for field retting and baling and still get the following crop established in good conditions. Late maturity increases the risk of difficult harvests due to bad autumn weather.

Flax Agronomy

Many agronomic factors affect the productivity of the crop. Some like climate are beyond our control. Others like choice of soil type, time of sowing, fertiliser and pesticide use all have the capacity to increase production and improve margins.

Soil

Flax will grow in most soils, however yields are not so reliable on lighter, more drought prone soils, nor on soils prone to water logging. Similarly soils with pH less than 5.5 do not yield well. The optimum pH is around 5.6-6.0. This has been an issue in the past where flax has been grown on ineligible land, often long term pasture land, which tend to have lower pH levels on ploughing, and these need to be corrected with lime before drilling flax. This may also be a factor in the lower yields than other EU countries. The poor margin and changes to the way pasture land is managed under the SPS will reduce the level of speculative cropping.

[25] Straw and capsules

If it is to be grown this should ensure that it is grown on well-maintained arable land where fertility problems are less common.

Climate

Flax is adaptable to most UK climatic situations, although the wetter regions in the West have produced better yields. The crop is susceptible to lodging if conditions are too wet, however, and nitrogen management is critical to avoid the problems of lodged crops. The soil temperatures in the spring are also important to ensure fast establishment so crops have tended to be grown in the South and Midlands.

Climate change may improve conditions for growing flax; in particular during the field retting period where settled weather is essential.

Establishment – seed rates and dates

The crop is usually planted from mid-March onwards, and sowing is usually completed by end April, however some crops are planted later, perhaps to allow early spring grazing of preceding grass by livestock. The earlier drilled crops tend to have a better fibre yield, however this is dependent on the soils being warm at planting (>6°C). If the crop is planted into cold soil, establishment can be delayed and reduced, causing problems with pests and weed control. In common with most drilled crops the seedbed needs to be fine, firm and moist, and avoid compaction.

The seed rate is usually around 50 kg/ha aiming to drill at a depth of 1.5-2.0cm. The target established plant population is 550 plants/m^2 from a sowing rate of around 700 seeds/m^2. There is considerable variation in the seed size between varieties with a consequent variation in seed rate with around 65 kg/ha for large seeded varieties and only 40 kg/ha for small seeded varieties. This seed rate contrasts with linseed, which is grown for the seed portion, which is planted at 25 kg/ha. The higher seed rate for flax ensures longer stems, without branching and a greater fibre yield. Although eligible flax varieties have had to be grown for area aid, the seed rate may have been reduced to encourage higher seed yields, leading to disappointing straw yields. The figures in the Gross Margin tables show this to be a financially sensible move.

Development

Flax plants grow to between 40 cm and 100 cm tall. Flowering starts in July with a branched canopy of blue-white flowers. The flowers are indeterminate in nature, which means that flowering takes place over a period of time and some seedpods will be ripe at the same time as flowering.

Pesticide Use

Flax has only two chemicals specifically approved for use, Fluazifop-P-butyl (Fusilade) and Tepraloxydim (Aramo) both for annual and perennial grasses. However, under the Long Term Arrangements for Extension of Use (2002)[26], operated by Pesticide Safety Directorate (PSD), approved use of chemicals on one crop can be extended to the minor crop. Certain restrictions

[26] The Long Term Arrangements for Extension of Use (2002), PSD

are in place relating to operator and environmental safety and the use is on the understanding that the operation is at the user's choosing and the commercial risk is entirely theirs. The extension of use allows flax to be synonymous with linseed and all chemicals approved for linseed are approved for flax (provided extension restrictions are followed). This widens the range of chemicals considerably and allows all major weeds, pests and disease to be controlled or reduced. A list of approved chemicals is given in Appendix 4.

However the crop area and overall use of pesticides are relatively low, and major fluctuations in the crop area would have little impact on the profitability of the supply sector, and produce little change in the pesticides entering the environment

Pest and Disease

The most common pest of flax is the flea beetle, which has been known to destroy a crop as it emerges, particularly if it is slow growing. As a result seed treatments are commonly used, and often followed up with insecticide sprays. Other pests such as slugs and pigeons can also be a problem at the seedling stage.

Common diseases are *Alternatia linicola*, *Botrytis cinerea*, *Fusarium acenaceum*, *Mycosphaerella linicola*, *Oidium lini*, *Sclerotinia sclerotiorum*, *Phoma exigua* var. *linicola* and *Colletrotrichum lini*. Each of these diseases can cause significant yield reduction if not controlled. At present the low area of the crop means pest and disease levels are generally low. However should a marked increase in areas occur, such as with linseed in the 1990's, pest and disease levels may increase and require added costs for more regular pesticide use.

Weed Control

Flax is not a competitive crop, so despite the relatively high plant population weed control is essential, particularly when penalties can be applied if seed is contaminated with weed seed. Herbicides are usually applied post-emergence dependent on the particular weed spectrum.

Fertiliser Use

Flax is responsive to nitrogen (N) and applications are usually made to the seedbed. In Fertiliser Recommendations for Agricultural and Horticultural Crops (RB209)[27], recommendations for linseed are used for flax, however care needs to be taken with the N levels in order to avoid lodging and to prevent coarse fibres.

Table 13 Nitrogen Recommendations for Spring Linseed (kg N/ha)

	Soil Nitrogen Supply Index			
Soil Type	0	1	2	3
Light Sand Soils	80	50	0-40	0
All other mineral soils	-	80	50	0-40
Organic soils	-	-	-	0-40
Peat Soils	-	-	-	-

Source: RB209 (Fertiliser Recommendations for Agricultural and Horticultural Crops)[28]

[27] Fertiliser Recommendations for Agricultural and Horticultural Crops (RB209), Defra 2003
[28] See also www.planet4farmers.co.uk to obtain an interactive CD version.

Nitrogen rates are usually in the range of 50-70 kgN/ha, however with increasing petroleum prices pushing ammonium nitrogen prices beyond £150/t for 2005 these application rates may reduce. Such a reduction may also fit in with lower returns from revised support measures.

Phosphate (P) and potash (K) application decisions need to be taken for the rotation as a whole, as there is usually no yield response from P and K applications. Maintenance levels are 30 kg/ha for phosphate and 25 kg/ha for potash. These inputs would be little changed by changes in support measures.

Table 14 Phosphate and Potash Recommendations for Spring Linseed

	Phosphate or Potassium Index				
Linseed (1.5t/ha)	0	1	2	3	4
Phosphate	80	55	30M	0	0
Potash	75	50	25M	0	0

Source: RB209

Scope for improve production

The range of factors involved in managing the flax crop show there are many aspects where there is scope for improvement, irrespective of any improvement in the available genotypes. If the reform of the fibre regime and subsidy removal impacts on the gross margins, which already compare unfavourably with competitor crops, there is at least scope to maintain margins through husbandry improvements as has been shown at Henfaes Research Institute[6].

Flax Harvest/Storage

Crop Maturity

Crops are usually desiccated before harvesting. There are various dates for desiccation, but it is usually towards the end of flowering, in order to allow enough time for retting in the field before the next crop needs to be planted. This reduces the seed yield significantly but does improve the fibre yield and quality.

Harvesting

Harvesting in the UK is carried out using a normal combine harvester, allowing the seed to be separated and the straw left behind in the field. The flax fibre is very strong and harvesting can be difficult. Stems can wrap round combine feed mechanisms and can cause blockages inside the machine, especially if the straw is damp.

The harvesting of flax for long fibre production is done by pulling to ensure the yield and length of fibre is maintained. This is a more labour intensive approach and costs are significantly higher. Estimates of total production costs using dew retting and pulling for long fibre production are around £2000/ha[29].

[29] Optimisation of methods of fibre preparation from agricultural raw materials, Dr.J.E.G.van Dam, Agrotechnological Research Institure, Netherlands. 48th CELC Conference, Antwerp 1997.

Retting[30]

The high quality fibres are found in the top one third of the plant. The fibre is bast-type, which means it is part of the outer stem, and must be retted to release the fibres. Retting is the name given to the action of fungi, which break down the tissue holding the fibres. The most common method of retting is dew retting or field retting, where the cut straw is left in the field while the process takes place under natural conditions. It is very weather dependent, requiring a settled spell of dry weather during the 3-4 week retting time, but enough moisture to activate the fungi. If conditions are too wet, over retting can occur which reduces the fibre strength. On the other hand, the dry conditions though August and September 2003 meant there was not enough moisture to facilitate retting and under-retting was a problem. Under-retting means that it is difficult to get good separation of the bast fibres from the core, which is a serious problem for processing. The climate in North Europe lends itself to field retting as the dew in the mornings is usually sufficient to start the process, however climate change may well change this in favour of Eastern European countries.

Other methods of retting have been trialed, in order to remove the variations found in field retting, but all add extra cost. Water retting uses bacteria under anaerobic conditions, but it does have potential problems with water pollution. Enzyme retting produces fewer pollutants but has not yet been commercialised due to the high costs of the enzymes[31]. Both enzyme retting and chemical retting with caustic solutions can improve resin adhesion to individual fibres, but in a very competitive industry such benefits are hard to capitalise on. Enzyme retting can improve the fibre yields from linseed straw, which tends to be more mature than *Linum* cut earlier specifically for flax fibre.

Stand retting has been successfully used in the TEXFLAX and Henfaes studies. In this method the standing crop is desiccated and left to ret as an uncut crop.

Storage

After retting the straw is baled using a round or square baler and stored before collection by the processor. It is important that the straw is dry (less than 18% moisture) before baling.

Haulage to processor

Haulage to the processor was not a major problem until the reforms in 2000 when all but the Welsh plant shut down. This plant has also shut and any crop now needs to be hauled to the Fibre Developments Ltd in Cornwall for processing. The fibre bales are low value commodity items and haulage can be a significant cost relative to their value. In the Gross Margin data in Table 14 the haulage have been over 30% of the field variable costs, however increases in the quality and value of the fibre will improve this situation

Flax Gross Margin Analysis

The gross margin for flax in 2004 based on historic straw yield and price levels, shown in Table 14, is £241/ha which is less than the Arable Area Payment. At £12/t the haulage costs

[30] See also 'Methods of utilisation', page 20
[31] Optimisation of methods of fibre preparation for agricultural raw material, Dr.J.E.G.van Dam, Agrotechnological Research Institute, Netherlands. 48th CELC Conference, Antwerp 1997

are over 50% of the value of the straw. These haulage costs will vary depending on the distance from the processing unit and could be as high as £30/t. The area payment represents 61% of the output, the seed 32% and the straw only 7%.

Table 15 Flax (historical) Gross Margin 2004

	Yield	Price £/t	Total
OUTPUT	t/ha		£/ha
Area Payment			245
Seed Output	0.75	170	128
Straw Output	1.5	20	30
		Total Output	**403**

INPUTS	Product	Rate / ha	Price £ /unit	£/ha
Seed		50 kg	1.4	70
Fertiliser	N	50 kg	0.33	17
	P	60 kg	0.29	17
	K	60 kg	0.2	12
Sprays	Insecticides	0.25 l	3	0.75
	Herbicides	30 g	0.4	12
		0.5 l	22	11
	Fungicides	0	0	0
	Desiccation	3 l	1.6	4.8
Contract				0
			Total Variable Costs	144
			Costs per tonne of straw	96
			Haulage @ £12/t	18
			Gross Margin	**241**

Source: ADAS Gross Margins 2004

This gross margin needs to be seen in context with other options for combinable break crops as outlined in Table 4. Flax gross margins fall well short of performance of other break crops. The most commonly grown break crop is winter oilseed rape, which had a gross margin of £478/ha in 2004. This is nearly £230 greater than flax, and depends slightly on how the loss of processor subsidy impacts on the flax margin. In addition winter oilseed rape is harvested in early August leaving the field clear for following crops.

Sensitivity Analysis

Table 16 shows the range of gross margins achievable at various straw yields and prices, based on the output and costs in Table 15

At low straw prices per tonne the yield of straw has very little effect on the gross margin, with improvements of only £4/ha for each 0.5t/ha increase at £20/t. Even at £45/t for the straw, the GM increases by only £16/ha for an additional 0.5t/ha straw.

Due to the relatively low yields the price paid for the straw has a similarly small impact. At 1.5t/ha yield the margins can be increased by only £8/ha for each £5/t.

The seed yield and prices are the same for all straw yields in the table, however, in reality this yield may increase with the increase in straw. A ±0.1t/ha will change the GM by ±£17/ha making the seed yield a much more important factor in maintaining the gross margins.

The variable costs per tonne of straw can be halved from £144/t to £72/t within the normal range of straw production levels.

Haulage costs are based on and average £12/t but will be dependent on the distance from the processing plant. A ±£5/t in haulage costs will change the GM's at 1.5t/ha yield by ±£7.50/ha.

Table 16 Flax (historical) Gross Margin Sensitivity (£/ha), 2004 and Variable Costs per tonne (£/ha)

Straw Yield (t/ha)	0.5	1	1.5	2	2.5	3	3.5	4
Price (£/t)								
10	227	226	225	224	223	222	221	220
15	230	231	233	234	236	237	239	240
20	232	236	240	244	248	252	256	260
25	235	241	248	254	261	267	274	280
30	237	246	255	264	273	282	291	300
35	240	251	263	274	286	297	309	320
40	242	256	270	284	298	312	326	340
45	245	261	278	294	311	327	344	360
Cost/t straw	289	144	96	72	58	48	41	36

Source: ADAS Gross Margins 2004

Fixed Costs

Most activities for short staple flax are carried out with existing arable crop machinery, so there is unlikely to be any significant change in labour or machinery. The spring planting is often an advantage as it spreads the workload away from the peak September/October winter crop planting window. In addition, on mixed farms, or where manures can be imported, there is an opportunity for spring applications of manures, which will be utilised more effectively than autumn or winter applications. Harvesting is with the usual farm combine and the straw baled with a round baler.

Impact of Moving to Single Payment Scheme

Effect on gross margin using historic yields

Crops harvested in 2005 will be grown under the Single Payment Scheme where growers will receive payments based on a mixture of historic and flat rate payments with no relation to the crops grown. In order to find a place in a rotation flax will need to compete with other break crops such as oilseed rape, beans and linseed. The effect of moving to the Single Payment Scheme on flax gross margins is shown in Table 17. The gross margins are negative or only slightly positive when based on historic yields and prices. If the processing aid were also to be removed the gross margin would reduce by a further £13/ha at 1.5t/ha yield level as discuss in Section 1.

Table 17. Flax Gross Margin Sensitivity (£/ha) and Variable Costs per tonne (£/ha) under the Single Farm Payment Scheme

Straw Yield (t/ha)	0.5	1	1.5	2	2.5	3	3.5	4
Price (£/t)								
10	-18	-19	-20	-21	-22	-23	-24	-25
15	-15	-14	-12	-11	-9	-8	-6	-5
20	-13	-9	-5	-1	3	7	11	15
25	-10	-4	3	9	16	22	29	35
30	-8	1	10	19	28	37	46	55
35	-5	6	18	29	41	52	64	75
40	-3	11	25	39	53	67	81	95
45	0	16	33	49	66	82	99	115
Cost/t straw	289	144	96	72	58	48	41	36

Source: ADAS Gross Margins 2004

Effect on viability and area grown

The inclusion of flax in the AAPS in 2001 reduced the viability of flax in UK agriculture. The typical gross margin of £241/ha was not competitive with other combinable break crops and the area grown plummeted (see Table 11). The payment of the processing subsidy did not flow to the growers in increased prices, and the reduced area meant that commercial processing was no longer viable. The above figures show that passing the loss of the processing subsidy to the growers would increase the level of technical improvement needed for the crop to remain viable.

Research[5, 6] suggests that yield and quality improvements can be made to make flax a reasonable alternative to other break crops. Varieties grown specifically for fibre give higher straw yields and the fibre is of better quality and command higher market prices. If the findings from the research are transferable to commercial situations the gross margin situation is improved significantly compared to the SPS gross margin above, Table 18.

Table 18. Flax (future) Gross Margin

	Yield	Price £/t	Total
OUTPUT	t/ha		£/ha
Area Payment			0
Seed Output	0	170	0
Straw Output	4.5	80	360
		Total Output	**360**

INPUTS	Product	Rate / ha	Price £ /unit	£/ha
Seed		50 kg	1.4	70
Fertiliser	N	50 kg	0.33	17
	P	60 kg	0.29	17
	K	60 kg	0.2	12
Sprays	Insecticides	0.25 l	3	0.75
	Herbicides	30 g	0.4	12
		0.5 l	22	11
	Fungicides	0	0	0
	Desiccation	3 l	1.6	4.8
Contract				0
			Total Variable Costs	144
			Costs per tonne of straw	32
			Haulage @ £12/t	54
			Gross Margin	**162**

Source: ADAS Gross Margins

In the example given in Section 1 Table 4 the move to the Single Farm Payment in 2005, reduces the gross margin of flax to £-4/ha, however with improved production the gross margin could be a more competitive £162/ha. If 50% of the loss of processing subsidy is passed on to the grower the gross margin reduces to £121/ha (Section 1, Table 5b). This is still slightly lower than other spring break crops such as linseed (£135/ha) spring beans (£129/ha) or spring oilseed rape (£196/ha), but with there is still potential to compete in some situations particularly if the straw price or yield were to improve. The flax (future) gross margin sensitivity in Table 19 shows that a change of ±£10/t in straw sale price can change the gross margin by ±£45/ha at the 4.5t/ha yield level. A similar improvement can be seen with increasing yield where every 0.5t/ha is worth £34/ha on the gross margin at £80 per tonne of higher quality straw. This would put flax in a strong position relative to other break crops, however at this stage these yields and prices have not been tried on a commercial basis so remain untested.

Table 19 Flax (future) gross margin sensitivity

Straw Yield (t/ha)	3	3.5	4	4.5	5	5.5	6	6.5
Price (£/t)								
40	-60	-46	-32	-18	-4	10	24	38
50	-30	-11	8	27	46	65	84	103
60	0	24	48	72	96	120	144	168
70	30	59	88	117	146	175	204	233
80	60	94	128	162	196	230	264	298
90	90	129	168	207	246	285	324	363
100	120	164	208	252	296	340	384	428
110	150	199	248	297	346	395	444	493
Cost/t straw	48	41	36	32	29	26	24	22

The popularity of the crop amongst farmers in the future will be dependent on the supply infrastructure, with local processing a key feature in order to keep haulage costs to a minimum. There may also be a hurdle in convincing farmers with previous experience of the crop that the projected yields and prices can be achieved.

Hemp - Cultivars, yield and crop area

Current varieties

The hemp varieties with IACS approval are listed in Appendix 2. These come from many countries across the EU 25; France, Poland, Italy and Spain. As with flax varieties there is little agronomic data in the public domain with which prospective growers can assess the crop varieties against other options.

Although this review is looking at the impact of changes in the fibre regime there are many other uses for hemp that may become more important if the fibre processing grant is discontinued. Higher cellulose content would increase the value of hemp as a biofuel, whilst more primary (coarse) fibres would increase the value for pulping.

All the main varieties currently in commercial trade have been bred for northern latitudes. These low THC varieties have been bred for the long summer days at higher latitudes and flower in response to shortening day length.

Currently the flowering time is earlier than ideal which limits fibre yield, however it does offer opportunities to harvest the seed as an additional output. Optimising fibre yield, seed yield and harvest date is an interesting challenge for breeders.

Yields

Hemp yields in the UK have improved over recent years according to Hemcore Ltd, the sole UK processor of hemp fibre. In 2003 the crop produced in the region of 6.5t/ha, although some farmers can to produce up to 8t/ha.

The UK yield figures are more in line with other EU country yields where yields vary from 3.5t/ha to 7.5t/ha[32].

Table 20 Hemp: EU area, yield and production 2000 – 2003

Area ('000 ha(	2000	2001	2002	2003
Spain	5.264	0.857	0.634	0.857
France	7.074	6.928	7.559	9.341
Italy	0.078	0.04	0.296	0.873
Hungary	0.058	0.068	0.925	0.2
Netherlands	0.792	0.981	2.079	1.461
UK	2.297	2.733	1.396	2.367

[32] Source Eurostat New Cronos Database. October 2004.

Yields (100 kg/ha)	2000	2001	2002	2003
Table 17 (cont)				
Spain	13.387	36.709	67.366	36.709
France	74.347	66.373	71.249	75.765
Italy	56.154	55.25	43.277	34.754
Hungary	96.552	89.412	40.854 :	
Netherlands	58.725	52.334	69.019	69.815
UK	41.184	35.002	43.001	64.001
Harvested production (1000 t)				
Spain	7.047	3.146	4.271	3.146
France	52.593	45.983	53.857	70.772
Italy	0.438	0.221	1.281	3.034
Hungary	0.56	0.608	3.779 :	
Netherlands	4.651	5.134	14.349	10.2
UK	9.46	9.566	6.003	15.149

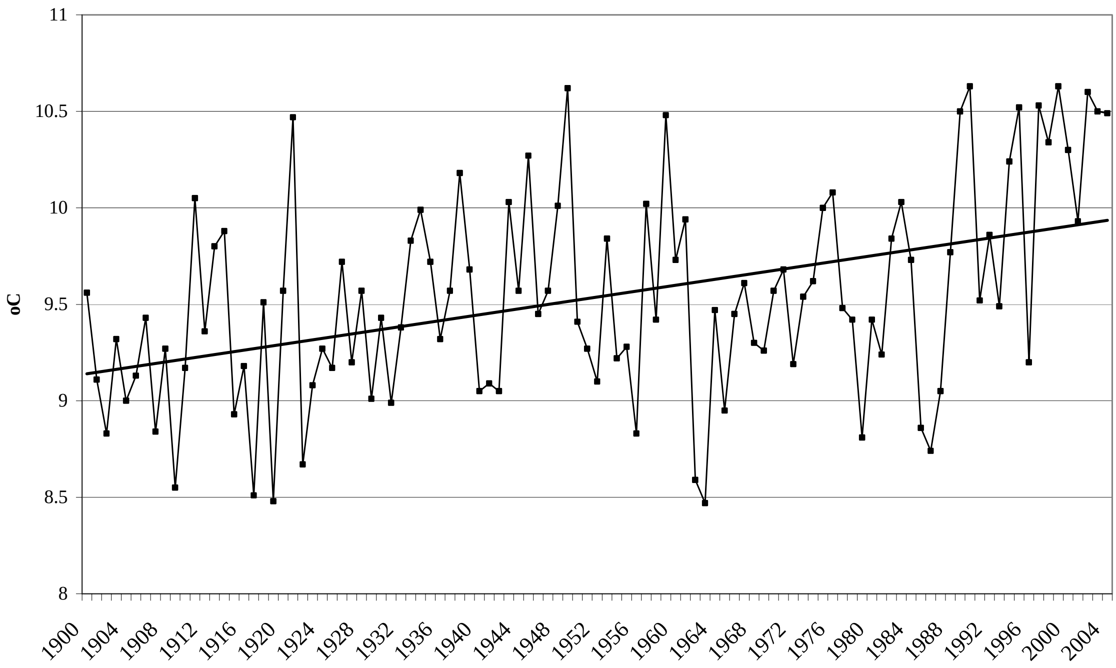
Hemp Agronomy

Soil

Hemp requires a well drained but moisture retentive soil for optimum yield. It can tolerate soil acidity to around pH 5.0 however pH 6.0 and above is more suitable. Water logged, poorly draining soils should be avoided as should light sandy soil with low moisture retention. Hemp seed is small therefore the ability to achieve a fine, firm seedbed is important. It is certainly not a “pastime” crop suited to poor fields and haphazard management

Climate

Hemp is ideally suited to the UK climate. Soil temperatures in the spring need to be around 10°C for rapid establishment and ideally these temperatures should be reached by mid-late April. The extent to which this is affected by climate change will be affected, in part by the winter weather and how the land warms in the spring. Figure 3 shows the trend in mean annual temperatures in central England since 1900. The last decade is notable for the number of high mean values. The straight line is the linear regression. It has a relatively low correlation coefficient.



Source (Met Office Hadley Centre)

Figure 3 Average annual temperature in Central England

Establishment – seed rates and dates

Like flax, hemp for fibre is sown at a higher seed rate of around 500 seeds/m^2 (compared to hemp for seed at 100 seeds/m^2). This improves the long fibre structure demanded by the market. In practice this equates to around 37 kg/ha. It is planted in mid April- early May, ideally into a fine, firm, moist seedbed. The seed is normally drilled to a depth of about 4cm in rows 12.5-25 cm apart[33]. Typical plant populations at flowering are 150 plants/m^2. This low establishment from 500 seeds/m^2 planted is due to the small seed size and its susceptibility to moisture stress.

Development

Hemp grows rapidly once established, often 1.5-2.0 cm per day. Within around 40 days the plants will be 2-4m high and starting to flower. Hemp is a short day plant with early varieties (e.g. Felina 34) flowering when day length falls to 16 hours (mid July), whereas late varieties flower when day length falls to 15.5 hours (early August).

The effect of environmental factors in crop development has been well covered in NF0307 Hemp for Europe: manufacturing and production systems[34], part of the EU Fourth Framework FAIR project CT95-0396.

[33] Henfaes Research Centre, University of Wales, Bangor
[34] http://www.defra.gov.uk/farm/acu/research/reports/rdrep12.pdf (last accessed October 28)

Pesticide Use

Hemp has no approved pesticides; however, as with flax under the long term arrangements for Extension of Use (2002)[35], operated by PSD, approved use of chemicals on one crop can be extended to the minor crop. Certain restrictions are in place relating to operator and environmental safety and the use is on the understanding that the operation is at the user's choosing and the commercial risk is entirely theirs.

The extension of use allows pesticides approved for use on oilseed rape to be used on hemp grown for fibre (again provided extension restrictions are followed). A list of approved chemicals is given in Appendix 4. The extension ensures that there is a full range of chemicals available should the need to use them arise. As with flax the relatively small area grown and low pesticide usage means there will be little impact on the product manufacturers if the area declines.

Pests and Disease

There are very few pest and disease problems. Flea beetle and pigeon damage during establishment is the most common problem. Hemp is susceptible to 3 bacterial diseases and *Septoria cannabis* which is a foliar disease. It is also thought that it may be susceptible to *Botrytis cinerea* and *Sclerotinia sclerotiorum*. Given the height of the crop it is not practical or economical to treat for these diseases later in the crops' development. Damage from root knot nematode has also been noted. It is hoped that genotypes with increased nematode resistance can be developed to limit the losses

Weed Control

Hemp is a very vigorous crop and, provided that the crop is drilled in good conditions and establishes well, usually outgrows any serious competitor weed. As a result it is unusual for herbicides to be used on hemp. The spring planting also allows for a stale seedbed to be achieved through cultivations or spraying before drilling.

Fertiliser Use

Hemp is not specified in Fertiliser Recommendations for Agricultural and Horticultural Crops (RB209) but other sources suggest nitrogen rates of 80-160 kg/ha, and 80-120 kg/ha phosphate and 160-200 kg/ha potash [36]. It is likely that less phosphate and potash will be applied to meet the needs of the whole rotation.

Hemp Harvest/Storage

Crop Maturity

Regulations used to require the crop to be cut after the seed reaches 50% of its final form and size, which is usually late August, however this was changed in 2003 to allow cutting on 1st August. This helps with the retting process and the timely sowing of following crops.

[35] Long Term Extension of Use (2002), PSD
[36] IENICA and Henfaes Research Centre, University of Wales, Bangor

Harvesting

The crop is usually swathed, requiring a contractor with specialist machinery, before being left in the field to ret. As a market for seed develops some growers are waiting for maturity and harvest the crop with a combine harvester to take the seed in addition to the straw.

Retting

Retting time is generally 2-6 weeks from cutting depending on weather conditions and then baled. The straw needs to be turned at least once to ensure even retting and to aid drying. Given the high yields and bulk of the crop even retting and drying are field operations that need care and attention, especially in wet summers. The straw needs to be at less than 18% moisture before baling to ensure good quality fibres.

If climate change produces increasingly wet harvests, in common with all arable crops, both hemp and flax would see higher field losses.

Storage

Storage is important, as the processing plant needs an even supply of hemp throughout the year. Storage is usually on the farm under cover. The delivered price can rise to around £30 per tonne[37] over the course of a season to cover storage costs, and to ensure continuity of supply at the processing plant.

Haulage to processor

Haulage is a major issue with the costs being in the region of £12/t depending on the distance to the factory. If haulage becomes a cross country (or cross channel) activity after processing plant closure, as with flax longer journeys can more than double haulage costs making the crop less competitive.

Gross Margin Analysis of Hemp

The hemp gross margin for 2004 is shown in Table 21, with a gross margin after contract and haulage of £470/ha. The growing costs are limited to seed and fertiliser. Contractors costs include cutting, turning and baling, however increasingly committed hemp growers are looking to purchase this machinery co-operatively which will further increase the overall profit margin. Such investment will need a supply chain with assured long term buyer – processors.

[37] Nix J. Farm Management Pocket Book. 34th Edition 2004.

Table 21. Hemp Gross Margin 2004

OUTPUT		Yield t/ha	Price £/t	Total £/ha
Area Payment				245
Seed Output		0	0	0
Straw Output		5.5	100*	550
			Total Output	**795**

INPUTS	Product	Rate / ha	Price £/unit	£/ha
Seed		37 kg/ha	3.2	118
Fertiliser	N	110 kg/ha	0.33	36
	P	60 kg/ha	0.29	17
	K	60 kg/ha	0.2	12
Sprays	Insecticides	0		0
	Herbicides	0		0
		0		0
	Fungicides	0		0
	Desiccation	0		0
Contract**				74
			Total Variable Costs	258
			Costs per tonne of straw	47
			Haulage @ £12/t	66
			Gross Margin	**470**

***** *Price ranges from £95/t to £115/t depending on time of delivery to the factory.*
***Contract includes cutting (£25/ha), turning (£9/ha) and round baling (£40/ha)*

Some growers are now harvesting the crop with a combine harvester and taking the seed portion for sale. Seed yields of around 1t/ha are achievable with a sale price of around £225/t, which could add £225/ha on to the gross margin. Harvesting seed requires a longer wait until harvest, with a possible increased risk of loss to bad weather, and some decline the fibre quality.

The hemp gross margin shown both here and in table 6 after subsidies have been removed, compare quite favourably with other break crops.

Sensitivity Analysis

Straw yield has a big impact on the gross margin of hemp. A change of ±0.5t/ha yield will change the gross margin by ±£44/ha at £100/t. This along with the yield potential of the crop could significantly improve the on farm gross margin.

Table 22. Hemp Gross Margin Sensitivity (£/ha), 2004 and Variable Costs per tonne (£/ha).

Yield (t/ha)	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9
Price (£/t)											
30	58	67	76	85	94	103	112	121	130	139	148
40	98	112	126	140	154	168	182	196	210	224	238
50	138	157	176	195	214	233	252	271	290	309	328
60	178	202	226	250	274	298	322	346	370	394	418
70	218	247	276	305	334	363	392	421	450	479	508
80	258	292	326	360	394	428	462	496	530	564	598
90	298	337	376	415	454	493	532	571	610	649	688
100	338	382	426	470	514	558	602	646	690	734	778
110	378	427	476	525	574	623	672	721	770	819	868
120	418	472	526	580	634	688	742	796	850	904	958
130	458	517	576	635	694	753	812	871	930	989	1048
140	498	562	626	690	754	818	882	946	1010	1074	1138
150	538	607	676	745	814	883	952	1021	1090	1159	1228
Cost/t straw	65	58	52	47	43	40	37	35	32	30	29

Source: ADAS Gross Margins 2004

The price sensitivity is also significant with ±£55/ha change in margin resulting from a change of £10/t for straw at a yield level of 5.5t/ha. This is an important factor if prices were to drop at the end of the period for the processing grant. Around £60/t is currently paid to the processors in processing grant (€ 90 per tonne of fibre) until 2006. If this is lost and processors seek to recover it from growers it would be equivalent to between around £16 per tonne of straw, if the price cannot be recouped elsewhere (see table 3). If seed sales were added to the output figures this may redress some of the loss, but the final outcome would depend on how much straw was harvested and any impact on quality and field losses due to the later harvest. If producers could regularly achieve yields in excess of 6 t/ha it would go a long way to overcoming this change.

Haulage costs are based on a typical £12/t however the charges vary depending on the distance from the processing plant. Due to the large tonnage per hectare produced a change of ±£5/t on haulage would change the gross margin by ±£27.50/ha. This has implications for the development of the industry where an increase in acreage may mean sourcing from further afield with associated higher haulage charges. Alternatively other plants may be opened.

The production costs per tonne of straw produced change with increasing yield but not so dramatically as with flax. Increasing the yield from 4.5t/ha to 7t/ha would reduce production costs by about one third.

Fixed Costs

Hemp growing does not significantly impact on farm fixed costs. The crop is planted in the spring, which can have minor cash flow and work planning advantages as it avoids the peak of the autumn drilling period. There is also an opportunity to create a stale seed bed, which is particularly advantageous if some of the more aggressive and expensive to control, arable weeds such as black-grass and wild oats are present. The stale seedbed and the following dense crop can suppress weeds and reduce growing costs in following crops.

Some committed growers are looking to jointly purchase equipment such as cutters, turners and balers, rather than employ contractors. This will remove contracting costs and if shared widely, only slightly add to the fixed costs. But as mentioned earlier, such investment is unlikely to be taken up while there is uncertainty over the future of the crop.

Impact of Changing Subsidy Regime

Effect on gross margin

Removal of the crop specific area payment will reduce the gross margin of hemp but it is still competitive with other break crops at current prices, with the typical gross margin being £225/ha. If 50% of the processing costs is also removed the margin drops to £180 (table 6). The data in Table 23 shows that this sort of loss can be offset by increasing yields by about 0.5 t/ha.

Table 23 Hemp Gross Margin Sensitivity (£/ha) and Variable Costs per tonne (£/ha) under Single Farm Payment Scheme

Yield (t/ha)	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9
Price (£/t)											
30	-187	-178	-169	-160	-151	-142	-133	-124	-115	-106	-97
40	-147	-133	-119	-105	-91	-77	-63	-49	-35	-21	-7
50	-107	-88	-69	-50	-31	-12	7	26	45	64	83
60	-67	-43	-19	5	29	53	77	101	125	149	173
70	-27	2	31	60	89	118	147	176	205	234	263
80	13	47	81	115	149	183	217	251	285	319	353
90	53	92	131	170	209	248	287	326	365	404	443
100	93	137	181	225	269	313	357	401	445	489	533
110	133	182	231	280	329	378	427	476	525	574	623
120	173	227	281	335	389	443	497	551	605	659	713
130	213	272	331	390	449	508	567	626	685	744	803
140	253	317	381	445	509	573	637	701	765	829	893
150	293	362	431	500	569	638	707	776	845	914	983
Cost/t straw	65	58	52	47	43	40	37	35	32	30	29

Source: ADAS Gross Margins 2004

Effect on viability and area grown

Hemp remains competitive with other break crops under current SPS crop prices, and given the agronomic advantages it is likely to remain a choice among experienced growers. The impact of the removal of the processor subsidy will further reduce margins if the processor passes on the bulk of the reduction to the growers in reduced returns. The crop is likely to be uncompetitive with other break crops if straw is below around £85/t making a gross margin of £142/ha at a straw yield of 5.5t/ha[38]. This is below alternative break crop options (Table 4) and could jeopardise the future of the crop. Year on year reliability of yield is also an important factor if growers are to stick with the crop.

[38] For the full removal of all support the gross margin in table 6 is £134/ha. This is equivalent to a price of £83/t in the sensitivity table.

If the processing aid is removed the method the processor chooses to recoup the loss of €90 per tonne of fibre, will be crucial in determining growers responses to the change. Given the few inputs and the crops ability to 'look after itself' the growers has few opportunities to do something positive in the field to improve things other than general good management. Switching to a dual purpose seed and fibre crop may be an alternative, but it is relatively untried, and earlier harvesting is now valued by growers as a way of protecting the crop's yield potential.

Conclusions

- The yields of flax and hemp can vary considerably between seasons, but both crops are relatively low input, showing little response to higher inputs of products like fertiliser and pesticides. Indeed higher fertiliser use can be positively detrimental if crop lodging is increased.

- In most cases inputs protect yield from loss to pest or diseases (more so in flax than hemp), rather than promote higher output. These low inputs make the crops attractive from an environmental point of view.

- With the present range of varieties good crop management is need for good yields, rather than ever higher inputs. Thus there is limited scope for increasing inputs to offset reductions in support payments.

- The scope for dual-purpose crops warrants further study. Although seed provides additional and high value income it can delay harvest and lead to deterioration in fibre quality. The role of more controlled retting processes may help in this respect, but the overall cost implications of such a step are quite significant.

- The productivity of production systems based on improved dual-purpose crops, needs to be compared with that of systems based on improved single purpose fibre crops. The latter may also be able to add value through bespoke fibre quality specification.

6. FUTURE SCENARIOS -OPTIONS AND OUTCOMES

The analysis of flax and hemp production in this report shows the two crops to be in two different positions to face the future. The margins on flax after the switch to the SPS were very poor, and the loss of the processing subsidy simply makes matter worse. The closure of the processing plant in North Wales suggests this is also a view taken by others. However, research has shown that there is potential for flax to compete with other breakcrops but this is at present untested on a commercial basis. In contrast hemp appears to produce margins that make it a reasonable break crop for growers to consider. Earlier harvesting and the diversification of the market for by-products outside the fibre market have helped in this respect. The low inputs of the crop are attractive from an environmental viewpoint, and as both are spring crops they enable much valued over winter stubbles to support bird life.

Options for changes

The main options for change are to keep the UK Processing Subsidy; abolishing the Short Staple Processing Subsidy for flax and hemp; abolishing all Processing Subsidies across the EU and possibly increase infrastructure and legislative support, or to modify support in some other non-trade distorting 'green-box' system.

Keep the UK processing subsidy

In essence this means maintaining the *status quo*. This is an increasingly difficult position to hold as it would mean extending the scheme gradually to the new Member States, whilst the general thrust of EU policy is to reduce this type of support. Flax and hemp fibres produced before the 2004/2005 marketing years from the new Member States is not eligible for aid. The present subsidy is paid on fibre from short staple flax with a derogation to allow the inclusion of 15% impurities, and for hemp with up to 25% impurities. This derogation will end in 2005/6, presumably after an agreed reform removes the necessity for it.

With pressure to implement settlements like the Everything But Arms (EBA) agreement, it seems implausible to continue a derogation to allow lower quality material into a regime that was designed to encourage quality. The need to control the cost of the CAP across the EU25 also adds to weakness of the case for continuing the *status quo*. Although flax processing has at present stopped in the UK, other than on a research support basis with the potential to improve commercial processing, the removal of subsidy is likely to impact on the fully functional hemp processing sector that now exists. It will thus impact on the buyers for farmers produce.

As processing is a relatively low-tech industry, and the shipping freight rates have escalated dramatically over the last year, the EBA could result in an import of processed fibre products from other countries. In recent years there has been an increase in the export of fibre to China to benefit from low cost spinning[39]. Collectively these factors paint a picture of a strong overseas fibre production and manufacturing capacity that would be unlikely to be offset by maintaining the domestic processing subsidy.

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[39] Agra Europe. 28 November 2003.

As the UK fibre products are often destined for lower quality non-woven products they are external to the international trade in spun fibres and textiles, and compete with fibres like Kenaf and Jute.

Keeping a simpler subsidy regime was proposed by the European Industrial Hemp Association (EIHA)[40], using yields of technically usable fibre of 30% for flax and 27% for hemp, and payments based overall fibre in the straw. This resulted in slightly lower payments for long fibre (€ 135 / t) and slightly higher payments for short fibre (€94.50). The proposal was claimed to reduce the conflicts between the long and short/total fibre producers.

Abolish short staple subsidy but retain the long staple subsidy

In essence this means abolishing the subsidy everywhere except in Belgium, France and the Netherlands. It may also provide support to plants in the new Member States. There are several issues that arise from this approach.

Long staple fibre is already being exported to China for processing into yarn. If this is the most cost-effective solution the EU support is simply payment to maintain employment and 'traditional' production. If so, are the returns sufficient for the industry to maintain capital investment in the most modern machinery? Whilst the decline of the UK cotton spinning sector caused upheaval on a much larger scale than would be invoked by the flax industry, the experience showed that once low wage economies invest in the most modern machinery it is difficult for high wage economies to compete.

The diversification of the UK hemp industry's markets, its tight commercial control essentially by one operator, and the reasonable margin available to growers suggest there is more capacity to withstand this change than in the flax sector. However much depends on how international and continental fibre processors adapt to the loss of support and the level of infrastructure support they may receive, (*see comments in next section*).

Further export of jobs from the UK to within the EU will occur if processing continues in Belgium, France and the Netherlands, supported in part by the process-aided long staple flax sector of the industry, if short staple flax straw is sent from the UK for processing. With the closure of the last UK processing plant last year, this appears to be the present situation should growers wish to produce flax for processing. At present poor margins for flax and haulage costs would appear to limit this option, pointing to a withdrawal of the UK from the flax industry

The case for adopting this option is weak on both economic grounds and on the equality of trade and support across the EU. This option favours the specialist long fibre flax sector of the EU fibre industry. This could be an option if that sector were totally separate from the short staple operations in the same area. As it is, it would provide local cross subsidies for some short staple producers.

[40] Proposal of the EIHA for the reform of the flax and hemp processing subsidy. July 2002

Abolish all subsidies for both long and short staple flax and hemp

Across the board abolition of all subsidies on fibres would put all the growers on a 'level playing field' in terms of world trade. In 2006/7 it is proposed that the long fibre subsidy payments are €200 per tonne, whilst the short flax fibre will receive no subsidy. In the absence of strict financial demarcation within companies processing long and short staple flax, and producing products from both, it is hard to differentiate the 'traditional linen' long staple subsidy from a subsidy to promote the flax industry generally (both long and short staple), but based around the traditional long staple companies. This seems an anti-competitive arrangement as there is a considerable scope for short staple fibre production across the fields of Europe, but processing will be forced into plants cross subsidised by the long staple support. Haulage rates currently make using these processing plants unattractive financially for all but locally grown crops.

Removal of the subsidy in the UK will impact on companies like Hemcore; removal of the subsidy across Europe will impact on a UK based company like Wigglesworth, but its global span will enable it to adapt. Without a detailed analysis of the financial position of French and Belgian fibre processors it is difficult to see what impact removal of the long staple subsidy will have on them. Certainly the loss of €200 per tonne support payments, which translate into figures of around £180 per hectare would have a marked effect on the attractiveness of the crop.

With any programme of subsidy removal, the timing and duration of the transition phase are important in allowing companies and product lines to adapt. As this process has to work hand in hand with perhaps the modification and implementation of regulations covering recycling and the use of bio-based materials, a well-timed and integrated plan of change is required. A revaluation of the yuan, although unlikely at present, would help EU fibre sector, and industry as whole.

This 'liberalised trade' option opens the whole sector to competition. If all other players took a 'level playing-field' approach this could be worth consideration, but such an approach is not universally applied.

Abolish all subsidies but increase infrastructure or legislative support

We have touched on this option in the previous section. In a free market there is a limit to what can be achieved by legislation. In its best form it encourages - through infrastructure support in the widest sense; strengthening basic demand, easing planning and financial support, and removing trade limits.

The closure of UK based flax processing plants suggests that even with a short staple fibre subsidy in place, the long term prospects were not considered sufficiently attractive even with flax and hemp fibres, and a range of products including insulation products and moulded panels and components.

It may be that the UK infrastructure development is in an intermediate phase as RDA's start to take up the controls for guiding these sorts of development. Unfortunately the recently closed plant in North Wales was a Welsh Development Agency project, so there are clearly financial limits to such levels of support.

Given the increasing costs of haulage, and the acceptance of what appears to be rising prices for crude oil, infrastructure support grants for new processing capacity would appear to be a sensible step in the hemp sector. It is a low input financially viable crop for growers where haulage makes up a significant component of the cost. Developing infrastructures that operate without excessive transport costs also reduces vehicle emissions. Similar infrastructure support would be justified in the flax sector if the increased output promised by research proves to be applicable on a national scale.

This option sits well with the aims of future trade settlements, and offers the opportunities for development of infrastructure to benefit the rural and renewable resources sectors.

Outcomes

The desirable outcome of a change in support measures should be more competitive industries producing profits with fewer subsidies. The undesirable outcomes are business failures and a contraction of production and employment.

Under the present cost structure and market conditions in the UK the short staple flax fibre sector appears to have little future, unless yields and quality achieved in research projects are commercially applicable or subsidy levels return to their previous levels. However this may not be permanent and the situations needs periodic review. Also, niche production, processing and manufacture could be developed on a small scale by enthusiastic artisans selling into high added value markets.

The hemp sector is in a healthier state than the flax fibre. The changes introduced must seek to preserve this situation.

Global freight charges offer some protection against raw fibre import competition, and these costs seem unlikely to fall. But imports of processed products like fibre based automotive components are possible, and could undermine the market for domestically produced fibre unless high levels of efficiency are maintained. On the plus side the UK climate is generally, relatively mild and moist and favours good even growth and fibre development. In short, the UK domestic fibre industry has a promising future if research findings prove to be robust and widely applicable, and the current round of changes in the support mechanisms give time for the industry to adapt.

If the loss of the processor subsidy is carried entirely by the processors, and their future is jeopardised, the market could disappear, and a low input environmentally benign crop would disappear from the countryside. If they can share the loss with growers they risk losing crop area if the margins become uncompetitive with oilseed rape and other break crops. This is the balancing act that legislators and the industry have to resolve. We have reviewed some of the options.

Conclusions

- Keeping the present support regime would be costly, as it would have to be extended to cover the EU 25 - (EU 27 from 2007). It preserves the *status quo* and, unless supported by other measures does not encourage the industry to adapt to meet world competition. This adapting to the world market an essential step if future trade reform measures are to be pursued.

- Abolishing the short staple subsidy and retaining the long staple subsidy does not retain a 'level playing field' across the EU natural fibre sector. It risks the formation of a fibre sector based around the existing long staple flax producers, who will under the current regime will receive a subsidy €200 per tonne of fibre for 2006/7.

- Abolishing subsidies to both the long and short staple flax and hemp sectors would provide the 'level playing field' mentioned above. However as these measures are also accompanied by the removal of the AAPS this option would probably lead to a decline in the crop areas, especially if both the AAPS and processing subsidy loss were carried by the growers.

- The affects of abolition of both long and short processing subsidies may be ameliorated by support for the development of infrastructure, or legislative demands for even greater recyclable content of manufactured goods. Infrastructure aid can enhance the competitive position of the sector and make rural and renewable industries better able to compete internationally. In conjunction with phased changes to the support payments, these indirect support measures should be an attractive option.

- It seems likely that contract agreements between the processors and growers will be the main drivers determining the extent of the crop. These would be set by the processors, in the light of how and to what degree if any, support was provided within the sector as a whole.

GLOSSARY

AAPS	Arable Area Payments Scheme. The support payment which is now being phase out. 2004 was the last harvest on which payments were paid for crops grown.
Bast	The flexible outer layers of the stem providing the bulk of longer fibres (see Appendix 3). Bast fibre plants include flax, hemp, kenaf*, ramie*, and nettle ** See section 4*
Cross-compliance	The requirement that farmers comply with environmental and animal welfare standards in order to receive their single farm payment under the SPS (*q.v.*)
Decoupling	The provision of support payment on the grounds of environmental or social good, and not as payment subsidising production and exports. A fully decoupled payment does not influence the recipients' decisions about production, and allows free market determination of prices.
EBA	Everything But Arms. Trade agreement aimed at giving freer trade conditions between the EU and developing economies, covering all trade except arms
ELS (and HLS and OELS)	Entry Level Scheme (and Higher Level Scheme and Organic Entry Level Scheme). Environmental protection scheme that will be open to all (ELS only). Details to be announced early March 2005.
ELV	End-of-Life Vehicle Regulations, set standards for the percentage by weight of vehicles which should be recyclable at the end of its useful life.
GAEC	Good Agricultural and Environmental Conditions. Management conditions covering protection and maintenance of soil, habitats and landscape
Green box	Farm support measures that are deemed to be non trade-distorting within the context of the WTO negotiations
Harvest index	The ratio of the plant harvested as seed as a proportion of the total above ground plant weight at harvest. Flax linseed is about 0.3 compared to cereals at 0.5 -0.6.
Hurd	Short fibre and other stem materials that can be used where short fibre and cellulosic material is required. (See Appendix 3)
IACS	Integrated Administrative and Control System used to monitor and control payments due under the AAPS (*q.v.*)

Lodging	The state when sideways pressure of wind and/or rain pushes crops to the ground. Crops remain wetter for longer periods and are then prone to rotting.
Ret or Retting	The process whereby either natural fungal and microbial action, enzymes or chemical solutions are used to cause a break down of the cells surrounding the fibre cells, so releasing them for cleaning and processing
Scutching	The process in which the longer bast fibres are separated after retting from the woody core (shiv *q.v.*) parts of the plant, and other non-fibre material. In essence the stems of the plants are subject to combing by drums of steel blades.
Shiv (or shive)	Short fibrous woody part of stems left after scutching (*q.v.*). Useful as a short fibre for particle boards, but high levels are indicative of lower quality material.
SPS	Single Payment Scheme. The farm support regime introduced from 2005 whereby farmers will receive just one payment to cover all their farming activities provided they 'cross-comply' (*q.v.*) with EC requirements laid out in Regulation 1782/2003
THC	Delta 9-tetra hydrocannabinol. The narcotic agent found in some cultivars of *Cannabis sativa*. The levels in fibre types are extremely low and of no value to the drug market.
Tow	The short fibre component of flax, hemp and other bast fibre plants. It can be spun into yarn, or used as a material like cotton wool (see page 27)

Appendix 1

Flax Varieties approved under IACS

Adelie (F)	Diane (F)	Kastyciai	Opaline
Agatha (NL)	Diva (F)	Laura (NL)	Rosalin
Alba	Drakkar (F)	Liflax (D)	Selena
Alizee (F)	Electra (NL)	Liviola (D)	Super
Angelin (F)	Elise	Lorea (F)	Tabor
Argos	Escalina (NL)	Luna	Texa
Ariane	Evelin	Marina	Venica
Artemida	Exel	Marylin	Venus (F)
Aurore (F)	Hermes (F)	Melina (NL)	Verain
Belinka	Iona (NL)	Merkur	Viking
Bonet	Jitka	Modran	Viola (D)
Caesar	Jordan	Nike	
Augustus (NL)			

Country of origin from European Plant VarietyDatabases. Angers

Appendix 1

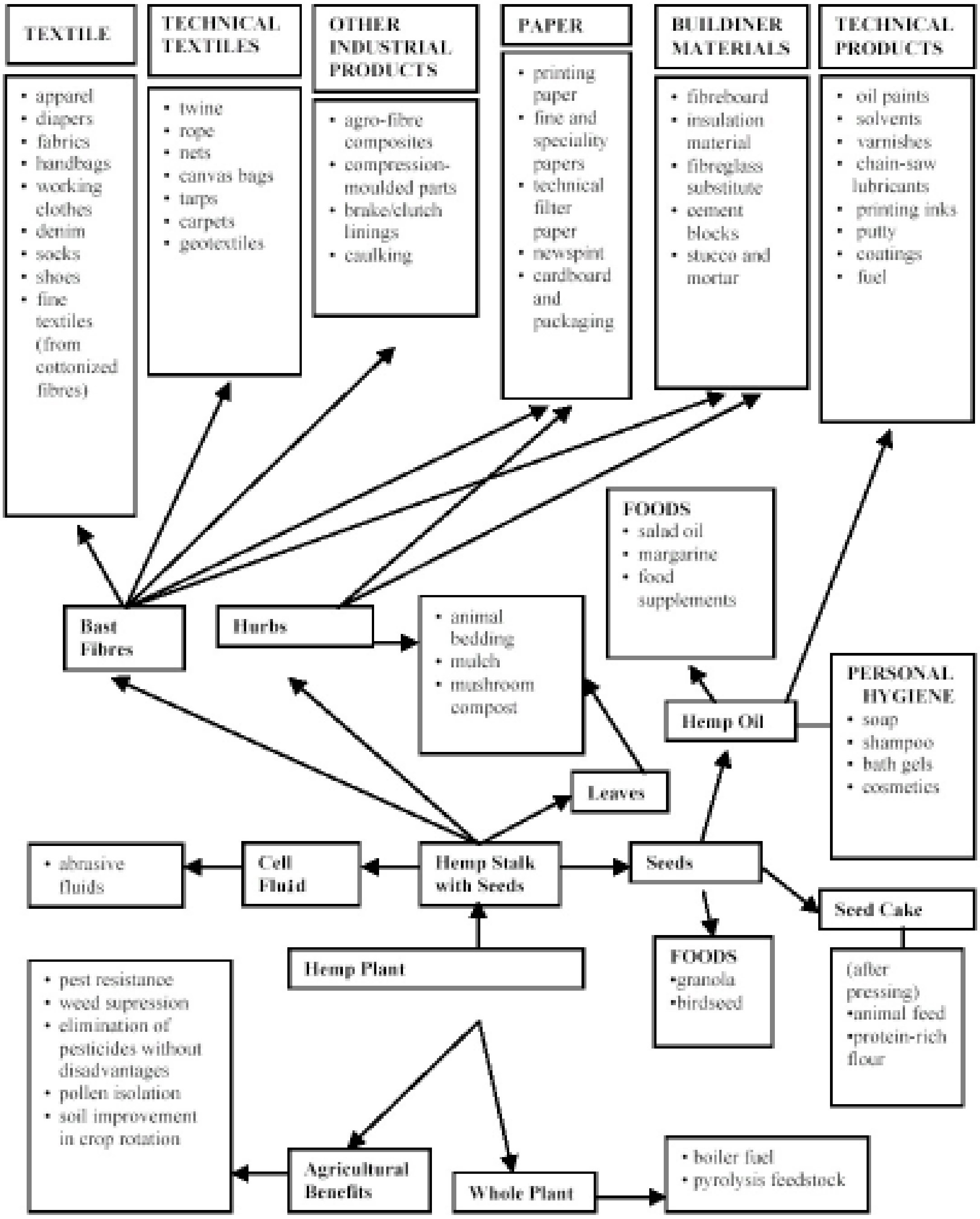
Hemp Varieties approved under IACS

Beniko	Epsilon 68	Juso14	Faramo
Carmagnola	Fedora 17	Red Petiole	Felina 34
Chamaeleon	Felina 32	Santhica 23	Fibriko TC
Cs	Ferimon	Santhica 27	Finola
Delta 405	Fibranova	Uso 31	Uniko B
Delta- Ilosa	Fibrimon 24	2004 Only	
Dioica 88	Futura 75	Bialobrzeskie	

Appendix 3

Structural components of the hemp plant and their uses.

Source: http://www.ienica.net/crops/hemp.pdf



Appendix 4

Approved Products for use on Flax.
Source: UK Pesticide Guide 2004

Use	Active Ingredient	Purpose	Products
Seed treatment	Iprodione	Alternaria	Various e.g.Rovral
	Thiabendazole+thiram	Damping off Fusarium root rot Grey mould	Hy-TL;sHYlin
	Prochloraz	Seed-bourne diseases	Prelude 20LF
Broadleaved weed control	Amidosulfuron	Annual dicots, cleavers	Druid, Eagle,Pursuit
	Bentazone	Annual dicots	Basagran
	Bromoxynil	Annual dicots	Alpha Bromolin; Bravado
	Bromoxynil+clopyralid	Annual dicots	Vindex
	Clopyralid	Annual dicots, creeping thistle, groundsel	Various e.g.Dow Shield
	MCPA	Annual dicots, charlock, docks, hemp-nettle	Various e.e.Agritox, Agroxone
	Metsulfuronmethyl	Annual dicots, chickweed, mayweed	Various e.g. Ally, Jubilee, Lorate DF
Grass weed control	Cycloxydim	Annual grasses, black bent, blackgrass, couch, creeping bent, onion couch	Various e.g.Laser, standon Cycloxydim
	Fluazifop-P-butyl*	Annual grasses, perennial grasses, wild oats	Fusilade
	Propaquizafop	Annual grasses, perennial grasses	Falcon
	Quizalofop-Pethyl	Annual grasses, couch, perennial grasses, columteer cereals	CoPilot, Sceptre
	Tepraloxydim*	Annual grasses, perennial grasses, volunteer cereals	Aramo
BLW and grass weed control	Trifluralin	Pre-emergence Annual dicots and annual grasses	Treflan
Total weed control	Glufosinate-ammonium	Annual dicots, annual grasses, harvest management	Challenge, Harvest
	Glyphosate	Annual and perennial weeds	Various e.g. glyphosate 360, Roundup Biactive
Disease control	Tebuconazole	Powdery mildew	Folicur
Pests	Zeta-cypermethrin	Beetles	Fury, Minuet
Crop control	Diquat	Pre-harvest dessication	Reglone
	Glufosinate-ammonium		Challenge, Harvest
	Glyphosate		Rounup Biactive, Glyphosate 360

Appendix 5

Approved Products for use on Hemp.

Source: UK Pesticide Guide 2004 (Extension of use allowing pesticides approved for use on oilseed rape to be used on hemp grown for fibre)

Use	**Active Ingredient**	**Purpose**	**Products**
Seed treatments	None approved		
Broadleaved weed control	Chlorthal-dimethyl	Annual dicots	Dacthal W-75
	Clomazone	Chickweed, cleavers, fools parsley, red dead nettle, shepherds purse	Apollo 50SC
	Clopyralid	Annual dicots, creeping thistle, groundsel	Dow Shield
	Pyridate	Annual dicots, cleavers	Lentagran WP
Grass Weed Control	Cycloxydim	Annual grasses, black bent, blackgrass, couch, creeping bent, onion couch	Various e.g.Laser, standon Cycloxydim
	Fluazifop-P-butyl	Annual grasses, perennial grasses, wild oats	Fusilade
	Propaquizafop	Annual grasses, perennial grasses	Falcon
	Quizalofop-P-ethyl	Annual grasses, couch, perennial grasses, colunteer cereals	CoPilot, Sceptre
	Tepraloxydim	Annual grasses, perennial grasses, volunteer cereals	Aramo
Broadleaved and grass weeds	Carbetamide	Annual dicots, annual grasses, volunteer cereals	Carbetamex
	Clopyralid+propyzamide	Annual dicots, annual grasses, barren brome, mayweed	Matrikerb
	Cyanazine	Annual dicots, annual grasses	Fortrol
	Metazachlor	Annual dicots, annual meadow grass, blackgrass	Butisan S
	Metazachlor+quinmerac	Annual dicots, annual meadow grass, blackgrass, cleavers, poppies	Katamaran
	Napropamide	Annual dicots, annual grasses, cleabers, groundsel	Devrinol
	Propachlor	Annual dicots, annual grasses	Tripart Sentinel

	Propyzamide	Annual dicots, annual grasses, perennial grasses, volunteer cereals, wild oats	Various e.g.Kerb
	Trifluralin	Pre-emergence Annual dicots and annual grasses	Treflan
Total Weed Control	Glufosinate-ammonium	Annual dicots, annual grasses, harvest management	Challenge, Harvest
	Glyphosate	Annual and perennial weeds	Various e.g. glyphosate 360, Roundup Biactive
Disease Control	Carbendazim+prochloraz	Alternaria, botrytis, canker, light leaf spot, sclerotinia, white leaf spot	Novak
	Carbendazim+vinclozin	Alternaria, botrytis, light leaf spot, sclerotinia	Konker
	Difenoconazole	Alternaria, light leaf spot, black scurf, stem canker	Plover
	Iprodione	Alternaria, botrytis, sclerotinia	Rovral
	Iprodione+thiophanate-methyl	Alternaria, light leaf spot, sclerotinia, black scurf, stem canker	Compass, Snooker
	Metconazole	Alternaria, canker, sclerotinia	Caramba
	Prochloraz	Alternaria, canker, light leaf spot, sclerotinia, white leaf spot	Sportak
	Tebuconazole	Alternaria, black scurf, stem canker, light leaf spot, ring spot, sclerotinia	Folicur
	Chlorothalonil	Botrytis, downy mildew	Bravo
	Vinclozolin	Botrytis, sclerotinia	Ronilan
	Carbendazim+flusilasole	Canker, light leaf spot, phoma leaf spot	Punch C, Contrast
	Prochloraz+propiconazole	Canker, light leaf spot,	Bumper P
	Mancozeb	Downy mildew	Dithane
	Carbendazim	Light leaf spot	Bavistin
	Cyproconazole	Light leaf spot, phoma leaf spot	Caddy, Fort
	Flusilazole	Light leaf spot	Genie, Lyric, Sanction
	Sulphur	Powdery mildew	Thiovit
Pest Control	Deltamethrin	Aphids, beetles, midges, weevils	Decis
	Deltamethrin+pirimicarb	Aphids	Patriot, Evidence
	Lambda-cyhalothrin	Aphids, beetles, midges, weevils	Hallmark
	Lambda-cyhalothrin+pirimicard	Aphids, beetles, midges, weevils	Dovetail

	Nicotine	Aphids	
	Pirimicarb	Aphids	
	Tau-fluvalinate	Aphids, beetles	
	Alpha-cypermethrin	Beetles, midges, weevils	
	Bifenthrin	Beetles, weevils	
	Cypermethrin	Beetles, midges, weevils	
	Deltamethrin	Beetles, midges, weevils	
	Zeta-cypermethrin	Beetles, midges, weevils	
	Methiocarb	Slugs, snails	
	Thiodicarb	Slugs, snails	
Plant Growth control	Tebuconazole	Growth regulator	
	Diquat	Desiccation	
	Glufosinate-ammonium	Desiccation	
	Glyphosate	Desiccation	