NON-FOOD CROPS

POST note 125
March 1999

This POSTnote looks at developments in non-food crops since the 1995 **POST** Report, *Alternatives in Agriculture*[1] It covers crops grown for fuels, chemical feedstocks, general industrial purposes (e.g. fibre), and for cosmetics and pharmaceuticals, but excludes timber, foodstuffs for animal consumption and tobacco. It has been produced as background to the current House of Lords Science and Technology Committee enquiry into the same subject, and for more general interest.

INTRODUCTION

Before petrochemicals became widely available, agriculture played an important role in the supply of materials for industry: e.g. vegetable oils for soap; flax and cotton for weaving; and hemp for ropes. Plants also 'powered' land transport by feeding draught animals and were the main source of pharmaceuticals.

This note sets out the current status of the non-food crops industry in the UK and considers future prospects, in their global context (such as historically low oil prices) Several key points are addressed:

- The opportunities for growing non-food crops in the current agricultural situation and the barriers to further development
- The potential for non-food crops to replace current conventional resources (e.g. fossil fuels and chemicals derived from them)
- The environmental impact of these crops and products
- The likely role of genetic modification.

THE STATE OF UK AGRICULTURE

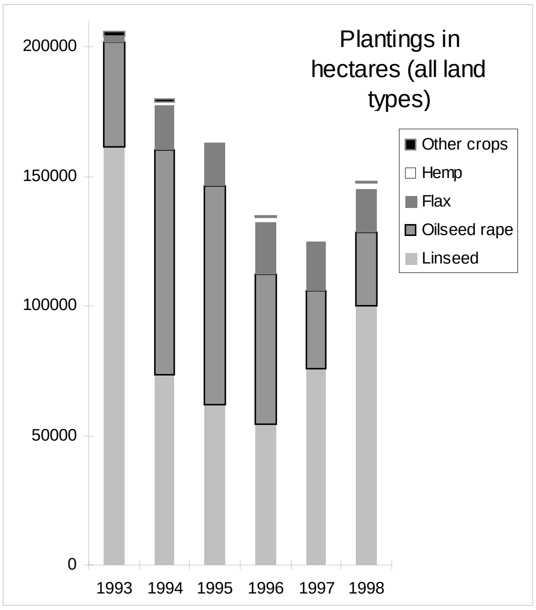
Agriculture in the United Kingdom is facing a serious financial crisis. The knock-on effects of BSE, the world economic crisis, and cheap imports of both basic and processed foods, are all part of the problem. Every sector of agriculture has been affected because much produce from arable farming is used as fodder on livestock farms. The result is that many farmers are now diversifying into other areas of business, are selling land, or doing both. One area of activity with possibilities for expansion is the production of crops for non-food uses.

In 1998, approximately 150 thousand hectares (kha) (roughly four times the size of the Isle of Wight) of UK land carried non-food crops (excluding timber), out of a total arable land area of over 6.3 million ha, i.e. under 3%.

UK NON-FOOD CROPS

The main UK non-food crop is linseed (**Figure 1**), covering just over 100 kha in 1998. Although this area has almost doubled in the last three years, it is well below the 1993 level of 161 kha. The second most important crop is oilseed rape (OSR), covering 28 kha. Plantings of this crop were also considerably greater in the mid-1990s, but they have not recovered (86.8 kha were grown in 1994). Two crops that have gained in importance since the last **POST** report (because of higher aid levels than for linseed) are the fibre crops flax and hemp (see **Table 1**). Other non-food crops grown in small quantities include lavender, chamomile, evening primrose and borage.

FIGURE 1 UK NON-FOOD CROPS[2]



Source: Intervention Board, Alternative Crops Unit (MAFF), Agriculture in the UK 1996, Agricultural and Horticultural Census 1998.

Two important crops that are not shown above are wheat and sugar beet. These are primarily grown for food and only a small proportion is used by industry. Demand for wheat as a source of starch is, however, increasing. About 150,000 tonnes (roughly 1% of total production) are now used annually by UK industry, covering about 22 kha. The straw from various crops can also be used for industrial purposes.

[1] **ISBN 1 897941 75 7, January 1995**

[2] **Includes linseed grown on 'maincrop' land as well as on set-aside land. Some linseed oils can be used for food purposes.**

TABLE 1 FLAX AND HEMP PLANTINGS IN THE UK UNDER THE EU PRODUCTION SCHEME FOR FIBRE CROPS (000ha)						
Year	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Flax	2.2	17.4	16.9	20.2	19.2	16.7
Hemp	0.4	0.9	1.1	1.7	2.3	2.6

Source: MAFF Alternative Crops Unit

CURRENT USES OF NON-FOOD CROPS

The range of possible uses for non-food crops is extensive. Many are listed in the 1995 **POST** Report and in a guide to *Crops for Industry and Energy in Europe* produced by the European Commission in 1997. **Table 2** gives examples of some of the main products derived from non-food crops in Europe. The following sections, starting with energy crops, provide more details of non-food crop activities in the UK.

Generally, the lower volume crops attract the highest prices as they tend to be used in high value-added products such as pharmaceuticals and toiletries. Some non-food crops are used directly or with minimal processing (e.g. reeds for thatching), while others need greater processing to extract specific chemicals, oils, starches etc. Even crops to be burnt for electricity generation usually require processing (e.g. drying and chipping or baling) to make them suitable for a power station to handle.

The market for high value ingredients for health and body products is strong, although the demand on land is never likely to be particularly high: in the order of tens of hectares, rather than thousands. The fortunes of bulk crops (e.g. hemp and linseed) depend both on incentives to grow them and on demand from the marketplace. For example, hemp (*Cannabis sativa*[3]) has recently been rediscovered and marketed as one of the most versatile of non-food crops. It has now become a ubiquitous commodity available in everything from herbal remedies to paper, training shoes and varnish. Hemp also attracts a crop-specific subsidy from the EU (see **Table 3**). Processors aim to extract maximum value from hemp by using all its components.

Energy crops: Project Arbre and others

Project Arbre will be the first power station to be fuelled by willow short rotation coppice (SRC) (and wood chips from conventional forestry) under the Non-Fossil Fuel Obligation (NFFO)[4]. Construction is under way near Selby, Yorkshire, and the 10MWe (gross) plant is expected to be commissioned in November 1999.

SRC is a closely planted, and rapidly growing, tree crop (usually willow) which regenerates from the cut stumps and can be harvested repeatedly on a cycle as low as 3 years. The mean yield from SRC is currently around 7 tonnes/ha/year, with research suggesting that breeding (including using genetic modification) and better site conditions could give yields of 14-15 tonnes/ha/year. Swedish work has produced some willow types with yields of 20-22 tonnes/ha/year, although circumstances may not be directly transferable to the UK.

TABLE 2 EXAMPLES OF EUROPEAN NON-FOOD CROPS, CLASSIFIED BY END-USE.	
Agrochemicals	Spurge, pyrethrum, annual wormwood, caraway, quinoa
Board, composites, building and insulation materials	Hemp, flax, kenaf, cotton, common reed, miscanthus, sunflower
Cordage & sacking	Hemp, kenaf, nettle
Cosmetics and toiletries	OSR, amaranth, caraway, linseed, evening primrose, jojoba, pot marigold, coriander, bugloss
Dyes	Woad, madder, safflower
Energy and fuels	OSR, sunflower, willow, miscanthus, poplar, reeds, spurge, cordgrasses
Industrial raw materials	OSR, sunflower, castor, chicory, crambe, kenaf
Lubricants and waxes	OSR, linseed, spurge, rain daisy, honesty, meadowfoam
Paints, coatings and varnishes	Linseed, pot marigold, rain daisy, stokes aster, hemp
Paper and pulp	Hemp, flax, kenaf, miscanthus
Pharmaceutical products and nutritional supplements	Amaranth, caraway, borage, honesty, hemp, meadowfoam, linseed, evening primrose, mallows, field scabious
Plastics and polymers	Honesty, castor, meadowfoam
Resins & adhesives	Rain daisy, stokes aster
Soaps, detergents, surfactants, solvents and emulsifiers	OSR, coriander, hemp, spurge, cuphea, poppy, gold of pleasure, castor, quinoa
Textiles	Hemp, flax, nettle

Note: not all these crops are currently grown in the UK.

Source: Crops for Industry and Energy in Europe (European Commission 1997)

[3] Hemp growers in the UK require a licence from the Home Office (currently £270, rising to £300 in 1999) and may grow plants only with a low content of psychoactive chemicals.

[4] The NFFO sets a contract price for electricity produced from sustainable sources for periods of up to 15 years. The difference between this price and the price of electricity from other sources is financed through a levy on electricity generated using fossil fuels.

TABLE 3.COMPENSATION AND SUBSIDIES OF RELEVANCE TO NON-FOOD CROPS (ENGLAND, 1998).

	Rates per hectare
Set-aside and voluntary set-aside	
EU compensation under AAPS:	£306
Lower rates are paid for less productive land, for some additional voluntary set-aside land under the residual activities of a previous scheme, and for set-aside in other parts of the United Kingdom.	
Forestry Commission Woodland Grant Scheme	
Planting grants to establish short rotation coppices for biomass production (ultimately for energy generation).	
On set-aside land	£400
On non set-aside land	£600
Locational supplement for Project Arbre (depending on land used, see text)	£400/600
EU (AAPS) crop subsidies on non set-aside land	
Linseed	£467
Other oil seeds	£398
Cereals	£241
Protein crops	£349
EU subsidies for crops grown for fibre production on non set-aside land	
Hemp	£501
Flax (depending on method of harvesting)	£536/465

Source: Alternative Crops Unit, MAFF.

So far, about 200 ha of SRC have been planted for Project Arbre, but an adequate fuel reserve in the area requires about 2000 ha. The main drawbacks to achieving this are the cost of establishing SRC (about £2000/ha) and the lack of income until the crop is harvested. To compensate, an arrangement has been made, under the Woodland Grant Scheme (WGS), for a 'locational supplement' to be paid to farmers and landowners planting SRC within approximately 60 km of the Project Arbre power station. The supplement (to come from existing WGS funds) will raise the available establishment grants to £1000/ha on all land categories. Project Arbre will pay an annual income to the farmer until harvesting and, in addition, EU compensation for set-aside land will still be available. The Ministry of Agriculture, Fisheries and Food (MAFF) are running seminars in the area to raise awareness of the opportunities.

Two larger wood-fired power stations are now in the planning stages (near Carlisle and in the Welsh Borders). Although initially intended to take waste forestry products, they could be fired by SRC, but would require plantings of 16-20 kha. Another power station is planned for Sutton, Cambridgeshire (31 MWe), fired by straw.

The DTI is currently reviewing the potential of renewable energy and a report is expected soon. Under consideration is how to achieve an initial target of 10% of the national electricity supply from renewable sources by 2010. To meet this from energy crops would require some 100-150 kha to be planted. In addition to SRC, other biomass crops, mainly grasses, could be grown in the UK. These may be more attractive to farmers because they would provide annual or biennial yields.

One of the most promising alternatives or complements to SRC is *Miscanthus* (elephant grass). This perennial can be planted and harvested using standard farm machinery, requires little or no fertiliser or herbicides, has few pests, and produces 12-18 tonnes of dry matter/ha/year. Its relatively high silica and chlorine contents may cause some problems: the former produces a slag during combustion; the latter may give rise to corrosion and emissions of chlorohydrocarbons. A recent report for MAFF[5] called for a full technical and economic assessment to be conducted on the suitability of *Miscanthus* as a fuel. This should include an examination of the ash and gaseous emissions as possible sources of pollution. Other research is needed into increasing yields, the effects of fertilisers, more efficient harvesting and drying techniques and pest and disease circumstances in commercial scale plantings.

Energy crops and the environment

The Government expects energy from renewable biomass under NFFO schemes 1-5 to achieve savings in CO_2 emissions equivalent to 200-400 ktonnes of carbon. Other environmental benefits are also possible:

- SRC sites can be wildlife havens, (*Miscanthus* planted areas less so)
- Sewage sludge, landfill leachate, animal manure and slurry can be applied to land planted with SRC as a means of waste disposal, and as a source of nutrients and irrigation.
- SRC and *Miscanthus* can be grown on metal-polluted sites as part of a programme for clean-up and land stabilisation. Metals taken up by the plants can be extracted from the ash after combustion.

The principal environmental issue with biomass crops is their water demand. Various studies have shown that SRC uses more water than normal agricultural crops. The rate of water vapour release for poplar SRC may be 50-100% higher than for short vegetation crops. Thus, it is likely that planting would have to be restricted to wetter, mainly western, parts of the country. The water demand may even be positive, in helping to counteract water-logging.

[5] **Review of Research on Biomass Crops. KJ Brent for MAFF, May 1998.**

Non-food crops can be the basis for low emission liquid biofuels (e.g. 'biodiesel' and bio-lubricants from OSR, and alcohols made from the fermentation of plant sugars). These products are renewable, biodegradable, have a very low sulphur content, and burn with reduced emissions compared with standard petrol and diesel. However, since the last POST report there has been little take-up in the UK other than for niche markets where environmental sensitivity is a major concern: e.g. boat fuel on the Norfolk Broads, and lubricating oil for certain harvesting machines (where considerable loss of oil to the environment can occur). The move by traditional oil companies to produce low sulphur diesel from fossil fuels appears to have undermined one of the key potential markets for biodiesel, namely cleaner fuel for vehicle use in urban areas. Questions remain as to whether liquid biofuels can be competitive without subsidy or tax incentives.

Bulk chemicals from non-food crops

Oils The main crop oils used by industry in the EU are extracted from OSR, sunflowers and linseed. Respectively, these are rich in oleic, linoleic and linolenic fatty acids. In addition, there are varieties of these crops that produce high concentrations of other oils: for example, oil from High Erucic Acid Oilseed Rape (HEAR) typically contains 50-60% erucic acid, used in the manufacture of polythene. Around 15 types of OSR, producing oils with different compositions (tailored for different markets) are now in, or close to, commercial production in the UK.

For example:

- Epoxidised oils (oils modified by adding oxygen) can be used as plasticisers and stabilisers in PVC processing, and as low viscosity binders in solvent-free paints and resins. They can replace volatile organic compounds (VOCs) which are now regulated.
- Laboratory studies suggest that adding hydroxyl units can change the viscosity of the individual fatty acids so that they might be used as friction modifiers in lubricants
- Crop oils can also be polymerised. Again, this is useful for surface coatings, and oils with long-chain fatty acids (i.e. chains with >20 carbon atoms) can be polymerised to make bio-plastics.
- In the production of soaps and detergents, short-chain fatty acids (with 8-14 carbon atoms in a chain) are the most desirable. Typically, these are derived from imported palm kernel oil and coconut, but sunflower and OSR oil may also be used. Household detergents and personal care products based on such oils offer low toxicity, mild, biodegradable surfactants with a 'green' image. This is a growth industry in the developed world. The sales of surfactants based on carbohydrates and renewable fatty acids or alcohols saw a six-fold expansion in western Europe in the five years to 1997.
- For industrial uses crop-derived surfactants may have technical advantages over conventional products for cleaning and wetting in highly alkaline systems, and for cleaning hard surfaces and textiles and in the construction industry as plasticisers. These help to modify the handling properties of cement and concrete and can reduce the amount of water that is required[6]. In principle, all classes of surfactants could be made from renewable resources.
- The agrochemical industry uses some crop oils as the basis of biodegradable emulsifiers and solvents used in crop sprays.

Starches The UK uses around 750,000 tonnes of plant-derived starch annually, 60% in paper and cardboard manufacturing, and the remainder in adhesives, agrochemicals, surfactants, plastics and for water purification. There are small volume, high value markets in pharmaceuticals and cosmetics, while ICI has been investigating using plant-derived starch in paint formulation.

There is a good opportunity to increase the volume of starch crops grown in the UK as 75% of plant-derived starch currently comes from imported maize. In the UK, wheat and potatoes are the principal starch crops grown, but peas and oats could also be valuable and planting them would add to farm biodiversity.

Fibre crops

The two main crops grown for fibre in the UK are flax and hemp, although agricultural residues (e.g. straw from cereal and oilseed crops) are also important sources. MAFF is currently funding a programme of research projects to assess whether seven other crops (including *Miscanthus*, nettle and marshmallow) might also be economically viable.

The main outlet for straw in the UK is as a replacement for wood in the manufacture of paper and various construction-quality boards (e.g. MDF and particle board). Straw is also used in pollution control (to mop up oil spills) and as a padding material. Its principal advantage is low material cost. For construction boards, a drawback of straw has been the presence of natural waxes that can reduce the bonding ability of the industry's preferred resins. In turn, this can limit the acceptable straw content to relatively low proportions.

6 LINK seminar on Sustainable Surfactants, 4/11/98.

There are many potential markets for plant fibres in textile manufacturing: e.g. clothing, soft furnishings, padding, lining and insulation material, and geo-textiles (used to stabilise soils). However, the UK has few processing facilities for turning flax and hemp into fibre.

Plant fibres can also substitute for glass fibres in fibre composite materials. The plant fibres (e.g. from flax) are as strong as equivalent sized glass fibres, are lighter, 25-50% cheaper, easier to cut, do not cause skin irritation and can be recycled, or burnt to recover energy. The automobile industry is looking to replace fibreglass in this way, with a potential market of 80 ktonnes of fibre.

For all fibre crops, there is still considerable scope for research and development into harvesting and processing techniques, improving yields, and improving fibre consistency[7]. Better integration of the growing, processing and marketing sectors would also be of advantage. Additional positive factors of different crops may need to be emphasised. For example, the leaf canopy of hemp is so dense that spraying for weed control is not necessary. For flax, there could be advantages in farmers separating the fibres into three grades before sale: this would require good quality control and some on-farm processing, but the product would command a higher price.

Specialist crops

There are over 50 specialist crops grown in small quantities in the United Kingdom: they are not discussed here in any detail. Their uses include pharmaceuticals, inks, lubricants, agrochemicals, perfumes, paints and industrial enzymes. The UK health and cosmetics market, a traditional user of herbal and vegetable extracts, was worth £850 million in 1995, with 53% coming from non-food products.

ASSESSING ENVIRONMENTAL ADVANTAGES OF NON-FOOD CROP PRODUCTS

Non-food crops are a renewable source of material and many of the products derived from them are biodegradable. The overall environmental advantages compared with using more conventional materials are not, however, self-evident.

Some industries find the renewable aspect alone to be an attractive way of meeting their own environmental aims, and there can be a marketing advantage in a finished product carrying a 'made from renewable resources' label. Proving that the product is actually better for the environment is much more difficult. This involves conducting a detailed life cycle assessment (LCA), comparing the alternative materials at each stage of their production and use, including any potential for re-use, and considering their eventual fate.

LCAs for non-food crops are complicated by having to compare the impacts from two very different systems: agricultural production and the petrochemicals industry. Some aspects are relatively straightforward, such as assessing the energy consumed to make the final product. For agriculture this would include indirect energy consumption used in producing fertilisers for the original crop. Other aspects involve subjective evaluations which are open to interpretation: for example, considering which other crops could have been grown on the land and their impacts, and whether a product is likely to be recycled, landfilled or burnt at the end of its life.

There is no co-ordinated programme for conducting non-food crop product LCAs. Only a few full LCAs have so far been carried out in the UK[8]: on OSR-derived lubricants, fuels, plastics and surfactants, though there is additional work in Europe. Some limited LCAs, which compare products only from the raw materials stage (rather than how those raw materials were produced), have been conducted and some commercial LCA databases are now available (e.g. for the paints and coatings industry). The work reported does suggest environmental advantages from the use of non-food crop derived products.

Without LCAs to provide the evidence, there is as yet no clear way of assessing if non-food crop products really are better than the alternatives on offer. Neither is there a recognised labelling system to identify the full environmental credentials of a product to potential customers.

INCENTIVES FOR GROWING CROPS

Almost all of the non-food crops that are grown in the UK (apart from a small group with high commodity value) attract some form of subsidy either from the UK government or the EU (**Table 3**), a situation which has not changed since the earlier **POST** report. This makes the entire activity somewhat vulnerable to changes in fiscal and support policy.

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[7] **Report on the status of non-food crops in the UK by the Alternative Crops Technology Interaction Network (ACTIN) for the Interactive European Network for Industrial Crops and their Applications (IENICA), February 1999**

[8] **E.g. by the Energy Technology Support Unit (ETSU), Reading University, and the Scottish Agricultural College.**

The main source of support (for both food and non-food crops) is the EU's Arable Area Payment Scheme (AAPS). This provides crop-specific subsidies for some crops (including linseed) and also compensation for land which the EU requires to be 'set-aside' from cereal production.

There are restrictions on how this land may be used[9], but a range of crops may be grown for non-food markets (including some which would normally be grown as food crops). For the 1998-99 crop season, a minimum of 5% of any arable farmer's land must be set-aside. Further land may be set-aside voluntarily. In the UK, almost all non-food crops that do not receive a crop subsidy are planted on set-aside land.

In addition to the crop and land subsidies described above, the final products of certain crops may attract other subsidies. For example, electricity produced from the burning of SRC may also attract subsidy under the NFFO.

However, despite these subsidies, the area of land planted with non-food crops has decreased since 1994. The most significant change has been in the area of set-aside land planted. This reached a peak of 104 kha in 1994 and has fallen steadily to just under 31 kha today. The change may reflect that set-aside compensation is now around £50 / ha less than it would have been if the payment had kept pace with inflation since 1994. Most commentators do not see set-aside policy, in itself, as sufficiently sound enough a basis to promote non-food crops.

REVIEW OF THE COMMON AGRICULT-URAL POLICY

Consultations are currently under way on how the Common Agricultural Policy should be reformed in light of EU expansion. This will affect the AAPS system and the various incentives or subsidies given for crop production. Proposals for change were set out by the European Commission in 1997 in the document "*Agenda 2000: For a Stronger and Wider Europe*". Some of the key proposals that will affect non-food crops are:

- All subsidies for the cereals sector should be given as non-crop-specific area payments.
- The compulsory set-aside rate should be fixed at 0%. Voluntary set-aside will still be allowed and will also receive the non-crop-specific area payment.
- Crops that are not already subsidised will not be eligible for any new subsidy.

[9] **E.g. herbicide use and grazing times are restricted.**

If accepted, these changes could have a major impact on non-food crop production in the EU. Planting on set-aside land may decline further, and new crops may not be introduced without subsidies that at least match those available for existing crops. Linseed is thought to be most at risk as this currently receives almost double the AAPS subsidy for cereals. In the past, linseed has been highly susceptible to subsidy rates: planting was more than halved in 1994 when the rate of subsidy was announced late. The EU already imports around two thirds of its linseed oil from the Americas.

COMPETITION FOR NON-FOOD CROPS

There are three key factors that usually determine if a non-food crop product is used, rather than a traditional feedstock: price, quality/consistency, and security of supply. In some niche markets there may be other factors: for example, there is a small demand from the Jewish community for Kosher packaging materials which do not contain tallow.

Price is of major importance for the bulk non-food crops, as these tend to be competing with other low cost materials from well established sources (e.g. the wood pulp and mineral oil industries). As discussed, incentives for growing crops can be critical, as can be the income from secondary products, which are used to offset the price of the primary product. For example, the crushed meal that is left after extracting oil from OSR can be sold as a high protein cattle fodder. For the manufacturers there is also the cost of adapting existing machinery or processes, or both, to use non-food products. If capital investment is required or if an extra processing step has to be introduced then this could be a major disincentive.

Quality typically means having a product that is consistent, has a high proportion of the component that the user industry requires, and has a low content of undesirable materials. For example, the surface coatings industry (paints, lacquers and varnishes) may require an oil containing more than 80% linoleic acid, but to be useful it must also have less than 5% saturated fatty acids, whereas a higher fatty acid content may not be a problem for the surfactants industry. For the fibres industry, crop fibres will always be somewhat heterogeneous (e.g. in length, fineness, and elasticity) compared with artificial fibres.

Quality can often be improved through better separation technology (e.g. to remove poor quality material or farming rubbish from fibre crops), or through improvements in process management (e.g. to ensure that identical-looking OSR seeds with different oil compositions are kept apart). In this latter case, the development of rapid testing equipment could be valuable. Quality improvements may also come from plant breeding or genetic modification. However, there are biological limits to what can be achieved while still having a plant that will grow successfully.

Security of supply is perhaps the biggest problem to overcome (e.g. when compared with petrochemicals). Farm crops are subject to flooding, drought, frosts, diseases etc. (as well as human error and wars) and it is inevitable that some crops will fail. The crops also take time to grow so demand has to be predicted at least a growing season in advance, so that it may be impossible to increase supplies if demand for a product rises suddenly. Furthermore, non-food crops need to be stored between harvest time and eventual use. This can be costly for industry, and may prove unattractive in the current ethos of 'just-in-time' manufacturing where a minimum of raw materials is held at any one time. A partial solution to this problem would be for the same crop to be grown in both the northern and southern hemispheres, so that demand can be met from at least two major harvests each year.

OTHER FACTORS AFFECTING NEW DEVELOPMENTS

Regulation Under EU regulations, all 'new' chemical products[10] must now be notified to the member state 'competent authority' (in the UK, the Health and Safety Executive and the Secretary of State for the Environment). Notification involves supplying a technical document containing the results of tests to evaluate potential hazards, including possible harmful effects on humans and the environment, and an assessment of the risks (to the environment, workers, and consumers). Once this has been accepted, the chemical can be given an 'ELINCS' (European List of Notified Chemical Substances) registration.

A chemical is considered 'new' if it is not listed in the European Inventory of Existing Commercial Chemical Substances (EINECS). The EINECS database lists over 100,000 chemicals on the market in the EU between January 1971 and September 1981. An EINECS registration does not, however, guarantee that the chemical has passed any of the same tests required for 'new' chemicals. Indeed, the European Commission has identified three priority lists of EINECS chemicals for which full-scale risk assessments need to be carried out. There are also inconsistencies in EINECS: for example, epoxidised linseed and soya oils are listed, but epoxidised OSR oil is not.

Chemicals that are not listed in either EINECS or ELINCS must undergo the notification tests before they can be marketed. The burden on industry can be considerable and may be a major factor in limiting the development of products from non-food crops. The ELINCS registration work is time consuming. Each new chemical must be assessed separately and work must begin if 10kg or more of chemical is produced. Full registration is needed for production at the tonne scale, costing £100,000-150,000 for each chemical.

The DETR has recognised the potential problems associated with EINECS/ELINCS and is currently consulting on whether it would be appropriate to seek changes to the legislation[11]. One solution might be generic registration.

The growing of new non-food crops also faces regulatory barriers: farmers are restricted in what chemicals (e.g. pesticides and herbicides) they can spray on to new crops. Each chemical has to be approved for each crop by the Pesticides Safety Directorate and, again, this is time-consuming and can be costly. Manufacturers often do not carry out their own tests on what are likely to be small volume crops, in which case the farmer would have to apply for 'off-label' approval, something that its cost is likely to deter.

Genetic modification (GM) If plants are genetically modified then there are restrictions on where and when they may be planted[12]. Policy in this area may also develop in the light of recent concerns about this subject.

Genetic modification can produce higher yields of chemicals, fibres or biomass from non-food crops with improved quality. Much of the generic research being carried out on GM food crops should be directly applicable to non-food crops (e.g. GM for herbicide or drought resistance). More specific modifications (e.g. to produce unusual chemicals) may need to rely on research by the potential user industry. At present, much of this work appears to be technology-led (with seed companies engaged in speculative research), rather than being driven by industry demands. Recent concerns about the environmental effects of growing food crops could also affect policy for non-food crops.

A new method of transferring DNA using plant viruses (under development at the Scottish Crop Research Unit and elsewhere) may help overcome some of these

[10] Both natural and synthetic products.

[11] Sustainable production and use of chemicals, consultation paper on chemicals in the environment, DETR, 1998.

[12] See *Genetically Modified Foods: Benefits and Risks, Regulation and Public Acceptance*, POST, May 1998.

concerns and improve the GM process. Plant viruses are relatively easy to modify to produce different chemicals, and the number of plants producing the foreign gene can be multiplied simply by injecting leaf sap from a treated plant into a new host. After a few weeks, valuable concentrations of desired chemicals could be extracted from all parts of the plant. However, the viruses do not actually transfer any genetic material to the host, nor is it usual for the viruses to be transmitted in seed or pollen, or by insects, fungi or nematode worms. It is therefore very unlikely that there would be any gene-flow into other cultivars or the wild population.

The potato virus X (PVX) is potentially one of the most useful. It can infect 240 different plant species and can be made to produce foreign chemicals as a protein 'overcoat' to the virus. After harvesting, these can be separated for use as free-standing chemicals. Because large proteins can be expressed using the virus as a vector, there is the possibility of using this method to grow vaccines and many other high value pharmaceuticals.

Research and co-ordination activities There are now efforts to co-ordinate UK and EU non-food crop activities. The Alternative Crops Technology Interaction Network (ACTIN) was set-up in 1995 to provide a UK focus for non-food crop products and to encourage their wider use as raw materials for industry, for example, by creating cooperative initiatives between researchers and the agricultural industry. ACTIN also represents the UK on two EU bodies: the European Renewable Materials Association and IENICA (see footnote 5). The future of EU research support will depend on the final shape of the Fifth Framework Programme (to start in 1999), but over £150 million was available for non-food crops research under the Fourth Framework Programme. In the UK, MAFF annually funds around £1 million of non-food crops research through its Alternative Crops Unit; much of this has been through LINK programmes on *Crops for Industrial Uses* and its current successor, *Competitive Industrial Materials from Non-Food Crops*. Among other major research funders are the BBSRC, the Scottish Office, and the DTI (the last for energy crops).

CONCLUSIONS

While the most immediate gain in importance of non-food crops might be as renewable energy and building resources, the longer term future could also see a highly flexible agricultural chemical production industry, where conventional crops are inoculated with GM plant viruses a few weeks before harvesting to produce whatever base chemical or drug is currently in demand.

On the other hand, decreasing incentives to grow the crops (as a result of Agenda 2000), the cost to manufacturing industry of adapting to plant-based raw materials, regulatory problems, and attitudes to GM technology, could mean that non-food crops (and products made from them) become increasingly marginal.

At present there are opportunities to grow more non-food crops in the UK, and for more of their products to replace conventional resources. For this to proceed without running into the opposition that has confronted some other recent proposals for agricultural and environmental change, the overall environmental benefits of non-food crops need to be comprehensively assessed before any major expansion programme.

Further efforts will be required to reduce costs while at the same time increasing the quality and security of supply. Some supporters of increased use of non-food crops point to recent forecasts of future 'tightness' in world energy markets but energy prices would need to rise significantly to create market conditions for some of the energy options considered.

Also, the UK is not alone in turning its attention to the potentials of non-food crops. Both Germany and the USA have recently initiated government schemes to promote research and commercialisation of non-food agricultural products, while a similar scheme begins in April 1999 in Japan. While this may be taken as a welcome sign that there is a convergence of thinking, competition between producers could become as intense as with food crops, with other countries benefitting from more favourable natural conditions than in the UK.

Much of the research for this note was conducted by Dr T Bradshaw, formerly Specialist Assistant to the House of Lords Select Committee on Science and Technology, during a period of secondment to POST. POST, however, retains responsibility for its contents.

Some useful Web sites related to the subject of this note are:

Alternative Crops Unit, Ministry of Agriculture, Fisheries and Food: www.maff.gov.uk/farm/acu/acu.htm
ACTIN: www.actin.co.uk
Non-food Agro-industrial Research Information Dissemination Network: www.nf-2000.org
IENICA; www.csl.gov.uk/ienica