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Full scale implementation of short rotation willow coppice, SRC, in Sweden

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Current willow market

Willow (*Salix*) is a relatively new agricultural crop that has been cultivated since the 1970's. Currently 16,000 hectares have been planted in Sweden and these plantations provide wood fuel for district heating schemes. In total willow contributes about 1 % of Sweden's wood fuel requirements. The price of willow wood chips is about 13 Euro per MWh, which is equivalent to that provided from forestry sources.

The willows used in energy forestry belong to the sub-species *Salix*, which are generally bushy in nature and grow to 5-7 m in height and have numerous shoots. Willows are planted as stem cuttings measuring 18-20 cm in length. A willow plantation is assumed to remain productive for at least 25-30 years and during its lifetime, the plantation may be harvested six to ten times, in cycles of 3-4 years. After each harvest new shoots sprout from the cut stumps producing a dense coppice.

Figure 1: Willow – the growing energy industry

Most willow plantations in Sweden today are established on private farms, but administrated by the Federation of the Swedish Farmers Coops, and managed by Agrobränsle AB who is located in central Sweden. Agrobränsle has contracts with 1,250 willow growers, and liaises with processors and utilities to guarantee a proper handling of the crop. The organisation takes care of the harvest and delivery of wood chips to adjacent district heating plants.

As a crop willow covers about 0.5 % of the total arable land in Sweden. During the winter of 2002/03 approximately 2,500 hectares will be harvested which will provide approximately 200 GWh of energy. The average yield level will be in the region of 17.5 oven dry tonnes per hectare from sites in central Sweden and 21 oven dry tonnes from sites in southern Sweden. Most plantations are grown for 4-5 years before harvest, so the annual yield levels are between 4-5 oven dry tonnes per hectare per year.

Harvests will be made from approximately 500 locations. However, these sites include a large number of poor yielding plantations, which have a significant effect on average yield figures. In plantations, which are fertilised and largely weed free, it is possible produce more than 10 oven dry tonnes per hectare annually.

More recent plantings have included new varieties, which will be harvested at shorter intervals of 3-4 years. This is because the bred varieties are much more vigorous than the older clones. In particular, plantations including Tora have shown excellent establishment.

Figure 2: A plantation containing the variety Tora, which provide a yield of 12 oven dry tonnes per hectare per year after the first harvest cycle. Eslöv, Sweden, Jan-2003.

In the mid 1990's there was a "boom" in planting willows in Sweden. The income from cereals was low and the subsidies for planting willow were comparatively high. During the early 1990's farmers were given incentives to grow willow by the Swedish Farmers Cooperatives and a number of farmers planted willows in many places, on both good and poor sites. Decisions taken by the EU around 1996 regarding the CAP programme brought about a reduction in the compulsory "set a side" area and deterred farmers from further large scale plantings. At this time the annual planting rate dropped from 2,000 hectares to 200 hectares in the space of a year. Many farmers and small contractors lost interest in the industry and between 10-15 farmers that produced cuttings withdrew their service.

Latterly, the economics for growing willows have improved significantly compared with other arable crops. This has come about as result of increasing demand for wood fuel for both large and small scale heating facilities. The price for willow wood chips has improved substantially but many farmers retain their negative view of willow from previous mistakes in the industry and it may take time to regain their confidence. Agrobränsle have the long term objective of increasing the area of willow grown in Sweden to 30,000 hectares by 2010, and raising this to between 200,000-300,000 hectares in the decades that follow.

Outside of Sweden, Agrobränsle is developing markets in the UK, Poland and Baltic states where they hope to build on the Swedish example. The company also manages a willow breeding programme acquired from Svalöf Weibull AB on 1 January 2002. Former SW-varieties are now marketed by Agrobränsle.

The company also organises the spreading of sewage sludge as fertiliser on harvested willow plantations. The applications of sludge are often co-ordinated in joint contracts with municipalities as integrated waste to energy initiatives.

New willow varieties

All new willow plantations involve newly bred varieties, which are more productive and have greater resistance against pests and diseases. These factors will bring about more stable yield levels. Until recently there has been a lack of frost tolerant material for certain areas in Sweden. The varieties Gudrun and to a lesser extent Tora can be used in areas that have a high risk of frost.

The choice of variety depends on the specific need of the grower and the climatic conditions of the site. It is also dependent of the availability of cuttings from the producers. Some of the newer varieties such as Gudrun and Tordis are still undergoing multiplication and therefore are not as yet fully available. Cutting producers need at least one years lead time in order to be able to provide sufficient cuttings of each variety. Once they know which varieties are required they can cut back their plantations to produce 1-year old shoots for cutting production the following winter.

Preparation of cuttings

Most material is produced as long rods, which are between 1.2-2.4 m in length. More than 95% are produced as long rods with the remainder being supplied as 20-cm cuttings. The long rods are bundled together and generally comprise 100 metres of cutting material. Bundles are packed in boxes containing approximately 4,400 metres of material for storage and future delivery. Each box is sufficient for a 2 hectare plantation. The short cuttings are packed in smaller boxes containing about 1,500 cuttings each.

Figure 3: Boxes containing long rods of willow for SRC plantations

All material is assessed for quality assurance and checked for growth vigour, mechanical damage and diameter limits (not less than 8 mm at the upper part and not thicker than 22 mm at the base end), before it is placed into the cold store. If something is found to be wrong with the material then a price reduction is levied against the producer or in extreme cases the material is discarded. Fortunately, this happens infrequently.

Rods and cuttings are produced in January-April and stored at -4 to -6 degrees C in large cold stores in central Sweden.

Plantations
Agrobränsle organise the location of plantations and advises farmers on the site preparation prior to planting. The company assesses whether the site is suitable for willow cultivation in terms of its size and whether there are connecting roads close by for transport of the harvested wood chips. Planting is carried out by a number of contractors.

Harvest
Harvesting is also performed by several contractors. There are seven Claas Jaguar harvesters in operation in Sweden today. Most of the plantations harvested in the winter of 2002-03 were located in central Sweden, in the vicinity of Örebro-Uppsala-Stockholm. The wood chip produced was sold and delivered to 15 district heating plants.

The harvesting and transport of such large quantities of wood chips to these boilers at the correct time, according to their requirements (due to climate and temperatures), is a huge logistic challenge. The income from the harvest procedures is very much dependent on how the harvest machinery and transport can be coordinated. The other main task is to balance the delivery of wood chips to the boilers with some facility for buffer storage. Further investigation and development is required to find the optimal system.

During harvesting the willow is chipped directly and loaded into a trailer either driven parallel to the harvester or connected directly to the harvester. This is then transported to freight trucks or other storage facilities. A minimum of two tractors and trailers are required if the harvester is to work continuously. It is often possible to harvest on unfrozen soil, but some fields may be too wet and soft for this operation. In such instances the obvious solution would be to have the harvester, tractor and trailer fitted with tracks. However, such systems are not yet fully developed

The most commonly used harvesting machines are modified maize harvesters with headers adjusted specifically for use with willow. Because, the willow industry is still immature there has been little investment by the large machinery manufacturers. Agrobränsle has often modified its own machinery. For instance, a new type of header in which the mechanic components have been replaced by hydraulic ones was tested in the winter of 2002/03.

Figure 4: Harvester with a modified header

A particular problem with harvesting willow is that certain sections of a plantation grow better than others due to edge effects. This results in very thick stems within areas of the plantation and especially in side rows. It has therefore been necessary to develop a header that is more flexible and powerful. It is hoped that this will be made possible with the newer hydraulic headers.

Fertilisation by using sewage sludge

Productivity of willow plantations and returns for growers has been improved by using sewage sludge as fertiliser. Sludge application is not permitted on food crops and disposal in landfill sites is very costly for municipalities. A number of municipalities have ventured into agreements with Agrobränsle whereby their sewage sludge is used on harvested willow plantations. Often this joint initiative also involves the buy back of wood chips for the municipal heating plant. Örebro and Västerås are the two largest cities supplying sludge to willow plantations. Most new plantings incorporate a specific contract for sludge application. During 2002 about 50% of the harvested plantations were fertilised by sludge (nearly 1,000 hectares).

Policy and steering mechanisms

The demand for willow wood chips is mainly regulated by the price and availability. Different types of wood fuels have been available on the "stock market" for many years and there has been a surplus of fuel due to the import of waste building material, wood from storm damage and an overproduction of waste residues from the forestry. The need of fuel has now increased and the limitation in availability of wood fuel will influence the user to make agreements for more long-term contracts with producers. This situation will help raise the price of willow wood chips and give the willow grower improved returns.

Currently there is a planting subsidy of 5,000 SEK per hectare. It is however, unclear what will happen with this subsidy in the near future though it is hoped that it will remain at this level. The planting grant is extremely important in persuading sceptical farmers to plant the crop. Nevertheless, although the planting subsidy helps farmers in their decision making process, it is unlikely that it will have a crucial role in the overall economics of willow cultivation. Willows have been shown to compare favourably with other crop options.

Research

Energimyndigheten (Swedish National Energy Administration) are responsible for organising different research programmes to enhance the use of renewable energy in Sweden. One of these programmes "Solid biofuels from arable land, 2000-2003" has a total budget of 4.4 million Euro for a four year period. About 30 different projects, mainly dealing with willow, are funded. Most of these projects focus on basic research but a proportion involve a more applied subject matter such as technical improvements to machinery.