COPPICE RESOURCES LTD

Guide to Short Rotation Coppice

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Short rotation coppice (SRC), grown as an energy crop, is made up of a mix of willow varieties planted at high densities and harvested on a 2 to 4 year cycle. The crop is perennial, the rootstock or stools remaining in the ground after harvest with new shoots appearing the following spring. The viable life of an SRC plantation could be up to 30 years.

The varieties used for energy cropping have been produced through the UK or European willow plant breeding programmes to ensure high yields, resistance to rust (the main disease of willow) and a growth habit which allows ease of harvesting (straight, erect stems). The parental stock of many of the varieties is *Salix viminalis*, the basket or Osier willow, a UK native shrub species. A mix of four or more varieties is planted at each site, the mix providing a further means of reducing disease and pest burden.

**Establishment**

**Site selection**

A proposed SRC site must meet the requirements of the Defra Energy Crops Scheme which includes a minimum site size of 3ha if the grower wishes to be eligible for the Establishment Grant. From a commercial viewpoint, a site should preferably be at least 5ha in size, if possible 10ha or more.

Field shape should ideally be square or rectangular but as this is rarely the case choose fields that minimise the need for short row lengths or require no changes in direction when planting. Choosing fields that can be harvested economically is of critical importance.

Slope should ideally be 7% or less, definitely no more than 15% to ensure safe conditions at harvest.

Appropriate access will be required for all machinery involved in establishing and harvesting the crop eg gate widths should be at least 4m as the harvesters are 3.5m wide. If gates are only 3.5m wide then the machinery must be able to access them head on, not entering from an angle. Weight restrictions on any bridges that must be crossed should be checked or height if access is beneath them, not only for farm machinery but also if high-sided vehicles are to be used for the collection of the harvested material.

A storage area for drying the harvested wood chip may be needed on site if none is available elsewhere on farm. This should also include an area for loading the delivery vehicles. Storage areas should either be hard-standing or on free-draining land. Approximate storage areas are:

- 2% of the cropped area
- 1m$^2$ per fresh tonne of wood chip based on a stack 4m high

SRC has been established on a wide variety of soils now from heavy clays to sand. Poor establishment can occur, especially on heavy clay sites, where compaction might prove a problem; sub-soiling to 40cm should prevent this. As clays tend to be colder in the spring this can also lead to slower rates of establishment although, once established, SRC on clay soils can be highly productive. Weed control, critical for good establishment, is difficult on organic soils. The most inappropriate soils for SRC would be free-draining sand and gravels where the water table is more than 1 to 1.5m below ground level as drought risk would be high.

Soil pH should be in the range 5.5 to 8.
Willow SRC can tolerate flooding but not being permanently waterlogged. Annual rainfall of 600 to 1,000mm will provide ideal water availability; less than 600mm/yr may lead to poor growth due to insufficient moisture available whilst more than 1,000mm/yr might cause problems at harvest.

**Plantation design**

SRC can reach 8m in height at maturity therefore the crop’s visible impact on the local landscape and neighbouring properties must be considered alongside the operational parameters when choosing a site. Care must be taken to ensure important views from public rights of way are not obscured nor views from nearby houses. The incorporation of wide headlands or rides can usually overcome these problems.

Headlands of 8m are needed at the ends of rows to allow for vehicle turning at harvest. Two to 4m headlands are usual along the edges of the crop depending on cross compliance requirements or whether machinery access is needed eg for hedge trimming. Public rights of way must be left open, usually requiring a ride of 4 to 6m in width.

Planting under overhead powerlines or over underground services such as gas/water/fuel pipelines must be agreed with the appropriate authority or utility - usually wayleaves have to be left unplanted, the widths of the rides dependent on the authority or utility’s requirements.

Maximum row lengths should be 350 to 400m to allow for sludge application (if required) and also for efficient harvesting (full trailers need to exit without driving over the crop). Rides of 8m width should be left between each set of rows.

**Land preparation**

As a perennial crop SRC can be in the ground for the long term, probably for at least ten years depending on the length of contract and/or the grower’s wishes. Ensuring land preparation is carried out effectively is ESSENTIAL - it has a direct impact on how well the SRC establishes, the overall financial cost of establishment, the yield at first harvest and therefore the income from the harvested crop.

Moisture conservation within the seedbed is critical for successful establishment. Attention must be given to maintaining winter moisture and also retaining spring rainfall within the soil profile so that it is available for the establishing crop. As the cuttings are planted to a depth of 20cm it is vital that the whole of this soil profile is well structured and the soil particles of a size that allows moisture retention.

Ploughing to the appropriate depth, sub-soiling where necessary and weed control are also the vital basics of land preparation. It is far cheaper and easier to eradicate invasive perennial weeds such as couch, dock, thistles, etc prior to planting than trying to control them once the crop is growing. Remedial weed control is expensive, can check the growing willow and may well be avoidable if land preparation is done efficiently.

**Land restoration**

Where agricultural land no longer exists due to sand and gravel extraction for example, it can be recreated as shown in the photograph below. SRC will grow on reclaimed and restored land, including colliery spoil and landfill sites, as long as the land is reclaimed appropriately.
The ideal soil depth above the cap on landfill sites is 1.5m. Lime generally needs to be added to colliery spoil to bring the pH up to 5.5 or above. For all reclaimed land going into SRC production it is recommended that organic matter is incorporated into the soil mix. The commonest material used is digested or treated sewage sludge generally in the form of sludge cake or compost supplied by the local Water Company although composted green waste is also now being used. Sludge cake can also be applied to agricultural land where it is incorporated during the land preparation work, to increase the organic fertility and water holding capacity of light land and to improve the soil structure of heavy land potentially improving drainage.

6: Composted sludge cake being applied during land preparation

**Planting**

Willow for energy crop planting is supplied in the form of rods (1.5 to 2.5m long stems) which are harvested during the winter and held in cold storage to just prior to planting. A number of varieties are now available for energy cropping, all having gone through plant breeding programmes to ensure high yield, disease resistance or tolerance and erect stems for ease of harvesting. All commercially useful varieties are protected by European Plant Breeders’ Rights and are expressly prohibited from being harvested on farm and used as planting material.

Planting takes place in the spring, from March to June. Up to 15,000 cuttings (each 18-20cm long) are planted per hectare. The cuttings are planted in twin rows 0.75m apart with the twinned rows 1.5m apart. These spacings allow standard agricultural machinery, fitted with wide tyres, to work over and along the twinned rows unimpeded. Planting density is adjusted by setting the spacing of the cuttings along the rows.

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0.75m  1.5m  0.75m
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Direction of planting

Mechanised planting machines are used commercially with the Swedish Step planter and Danish Egedal planter each planting four rows in one pass. Work rates of 1ha per hour are achievable where the land is well-prepared, the field size is 10ha or more and the field shape regular.

The cuttings are inserted vertically into the soil with approximately 1cm above ground and the soil compressed around them. Cambridge rolling (two passes) should be carried out immediately after planting to consolidate the soils, help preserve soil moisture and to provide a good surface for herbicide application.

A mix of pre-emergence residual herbicides should be applied immediately after rolling, certainly no later than 5 days after planting, for broad spectrum early season weed control. The quality of the seedbed is critical to this operation. A good, fine seedbed will allow a seal on the soil surface to be created and help reduce the need for further herbicide applications. However, depending upon the weeds present it may be necessary to apply follow up contact sprays for specific problems. The aim is to eliminate competition so that the crop can grow and develop to its maximum potential.
7: Step planter

8: Egedal planter

If SRC is to be planted on ex-grassland or long-term set-aside it is essential to control leatherjackets by spraying in the autumn prior to planting and again with the pre-emergence herbicide.

9: Post-planting spraying

Rabbits are one of the main pests of newly planted SRC and it is vital to protect the young crop from them, particularly for the first 18 months after planting and ideally up to first harvest. The best but most expensive method is to erect rabbit fencing to British Standard, buried and turned out. Other pests that can cause similar damage are deer, hares and grazing birds such as geese however these generally cause only localised problems.

10: SRC on badly prepared land

11: SRC on well-prepared land - same age and stage of harvest cycle as that in photo 10
Both of the above photos show how rapidly and efficiently SRC can establish on good, well-prepared land.

As an alternative to chemical control a mechanical weeder (photo 14) can be used. The tines run between the willow rows and cultivate the top layer of soil. This has the effect of disturbing and severing weed roots and effectively killing them particularly in hot, dry conditions.

CRL have also developed an inter-row or under-canopy sprayer (photo 15) designed to fit between the rows of growing willow so a total herbicide can be applied which kills weeds on contact but avoids damage to the willow. The sprayer has nozzles on “drop legs” to avoid drift onto the willow canopy and therefore prevents this from being damaged. This is an extremely effective way of controlling grass and broad-leaved weeds if necessary during the first year’s growth.

**Cutback**

One to 3 shoots generally arise from each cutting and can reach up to 3m in height by the end of the first season’s growth depending on soil quality and efficiency of land preparation. During the late winter/early spring following planting, the crop should be cutback to within 10cm of ground level. This encourages the growth of multiple stems or the true coppice and also provides a further opportunity to apply herbicide before canopy closure. Due to the amount of open ground within an establishing SRC crop it is inevitable that annual weeds grow during the first year so, in order to control these a contact herbicide needs to be applied after cutback but before bud-break. Application timing is critical - there must be a green cover of weeds for the herbicide to work but the willow shoots must not have appeared otherwise they will be damaged.

A few sites may not need to be cutback but only if growth is exceptionally good and there is little weed development during the first year. The crop can be left to grow on for 2 or 3 years to harvest.
After cutback canopy closure is fairly rapid. This cuts down the amount of light reaching the ground surface and acts as a form of natural weed control.

Crop management

Fertiliser

Digested or treated sewage sludge can be applied to SRC after cutback and after harvest.

No fertiliser should be applied during the establishment year ie from planting to cutback.

Digested (treated) sewage sludge can be applied if it is feasible under local Water Company and national regulations for sludge application to agricultural land. It can be applied in liquid form (slurry - around 4% dry solids), as composted cake (25% dry solids) or as granules or pellets (95% dry solids). The form of sludge available to growers will depend on the local Water Company’s methods of production. Under the Code of Good Agricultural Practice for the Protection of Water (COGAP, 1998\(^1\)) no more than 250kg organic

N/ha/year should be applied to agricultural land. Growers should also check the current rules related to nitrate vulnerable zones.\(^2\)

Where sludge has been applied, growers’ subjective opinions are that the crop has benefited especially on nutrient hungry soils.

Slurry is normally applied between April and June, coinciding with the time of year when sludge application to conventional crops can be difficult. The slurry is applied directly to the ground surface through a dribble bar fed via an umbilical system (photo 18). The series of pipes is aligned with the row spacings so there is no contamination of the crop plus any potential problem with smell is minimised. It may be possible to apply slurry in the second year of the harvest cycle depending on the height of the crop.

![Liquid sewage sludge being applied after cutback](Image)

18: Liquid sewage sludge being applied after cutback

Standard agricultural spreaders fitted with wide tyres and with rear discharge and vertical beaters are used to apply composted sludge providing an even spread of sludge across approximately 10m (photo 6). This method is ideally suited to SRC below 50cm in height.

**Pest control**

Spraying against leatherjackets, the larval stage of the cranefly or daddy-long-legs should be carried out in the autumn prior to planting and again with the pre-emergence spraying on all land previously in long-term set-aside or ex-grassland. Care must be taken to ensure that the larvae do not migrate into the crop from any untreated headlands. Leatherjacket damage becomes evident when the newly emerging willow shoots are found lying on the ground following attack just below the soil surface. Leatherjacket damage is usually confined to the establishment year.

Slugs can cause problems on SRC grown on wet, heavy land by stripping the leaves from young stems within a few weeks of planting and also by damaging emerging shoots below the soil surface. If the soil is rolled and effectively consolidated after planting, slugs have difficulty populating a site as they prefer to move between the larger particles of unconsolidated soils.

Rabbits, if present, should be kept out of the crop or well controlled for at least the first 18 months of crop growth and ideally up to first harvest. The crop should be able to withstand any rabbit damage (within reason) after first harvest.

Roe and Muntjac deer will graze the crop but, as fencing would be extremely expensive, sacrificial planting, ie high density planting adjacent to the areas where deer may enter the crop would be a more economic

\(^2\)http://www.defra.gov.uk/Environment/water/quality/nitrate/nvz.htm
Scotland: http://www.scotland.gov.uk/Publications/2003/04/17071/21662
answer to the problem. Deer cause damage by nibbling the tops of young stems which can lead to multiple shoot development at around 30cm or more above ground and this can cause problems at harvest.

The main invertebrate pest is the willow beetle of which there are three species, the brown, blue and brassy. Both the adults and larvae feed on willow leaves. The adults over-winter under the bark of mature trees, in fence posts, etc emerging as the temperature increases during late winter/early spring. They move into the edge of the coppice to feed prior to mating after which they move further into the crop. If the beetle population reaches critical numbers of more than 75/m² adults shaken from the canopy during the edge-feeding stage, then spraying with an appropriate insecticide using an orchard-sprayer or equivalent should reduce numbers enough to prevent serious damage. Overspraying an entire plantation would prove costly both financially and ecologically as the insecticides used are not specific and would destroy many beneficial insect species.

19: Adult willow beetles over-wintering in fence post

Remedial weed control

The most efficient and economic means of controlling weeds is during land preparation. If weeds do become a problem during the establishment year ie between planting and cutback, it is possible to treat them using a hooded knapsack sprayer if the weeds are localised or by the use of an inter-row sprayer (Photo 15) which directs the herbicide away from the growing crop. There are also a small number of herbicides that can be applied overall to the growing SRC through a normal agricultural sprayer that are crop safe. These generally have a small (but useful) range of target species (eg grasses or thistles). Extreme care must be taken when using any broad-leaf herbicides within the growing crop to prevent serious damage.

Once canopy closure occurs, usually within a couple of months after cutback, the coppice in effect controls its own weeds due to reduced light levels reaching the ground surface.

At maturity the crop can reach 8m in height and is too dense to walk through easily. The underlying vegetation is usually no more than a ground cover and does not cause any detrimental effects on crop growth or yield. The ground flora is beneficial in that it provides habitat for invertebrates and small mammals, many of which predate pest species.
Harvesting

Harvesting usually takes place on a 3-year cycle, the first harvest being taken 3 years after cutback although on some sites where yields are high, a 2-year harvest cycle is becoming more common. The ideal time for the work to be carried out is between early October and late March although it is feasible to harvest during spring and early summer if the ground conditions preclude winter harvesting.

SRC can be harvested as whole rods (stems), billets (approximately 5 to 20cm lengths) or chip. Whole rod harvesting is unusual due to the limited number of machines in Europe able to do the work. Harvested rod storage is straightforward, the piles usually being left on the headlands to dry. The downsides of this method are the amount of waste rods left in the field at harvest or after collection from the storage piles and the need to chip the rods before use.

Billet harvesters cut whole stems, cut the stems into billets and then blow these into an accompanying trailer. Billet storage is straightforward due to the amount of natural ventilation within the stacks but, in most cases, the billets will need to be chipped prior to use.

Chipping dried rods and billets can prove difficult as the wood tends to shatter rather than chip and large amounts of dust and fine material is produced.

Direct-chip harvesting is the method used by CRL who have an in-house designed and built SRC header which is operated with a Claas Jaguar forage harvester. This system has been used commercially by CRL since 1999. The stems are cut, chipped and blown into an accompanying trailer. The size of chip can be adjusted depending on the end-user’s specification.
Wood chip storage

CRL have developed a simple method of storing the harvested wood chip which allows efficient natural air drying to occur. Freshly harvested willow SRC is usually around 50% moisture content (MC). Most energy end-users will need to chip to have a MC of 35% or below. This reduction in MC can usually be achieved within two to three months if the chip is stored correctly.

The wood chip in photo 26, produced by the CRL harvester, shows a consistently clean, quality SRC fuel. This fuel has multiple uses due to its ease of handling and its ability to flow well through machinery processes. As chip it is suitable for use in grate and fluidised bed burners but it can also be readily processed for other uses that require a finer, drier fuel specification.

Markets for end-use

Wood chip from purpose-grown SRC can be used in domestic and small-scale commercial wood heating boilers, for industrial heat generation, for use in combined heat and power (CHP) plants, dedicated biomass power stations and for co-firing. It can also be processed into Grade 2 wood pellets generally for use in domestic and small-scale pellet boilers.

The fuel specification ie most commonly chip size and moisture content but also in some cases chemical composition and calorific value will be set by the end-user.
27: Biojoule East midlands pellet plant

28: Industrial heating boiler

29: Small-scale commercial heating fuel store

30: Biomass co-firing - Drax

31: Sembcorp biomass power station

32: Biomass boiler for district heating scheme
Removal of SRC

Research carried out by the Forestry Commission\(^3\) has shown that, regardless of soil type, typically 75-95% of willow SRC roots occur within the top 20/30cm of the soil. Small fibrous roots were found to a depth of over 1.3m in some soils but were few in number. This compares to many conventional arable crops growing in uncompacted soil where roots reach a depth of 1-1.5m. Typically at least two-thirds of the SRC roots were less than 1mm diameter with the diameters decreasing with increased depth. It was found that regular harvesting of the coppice was found to inhibit large root development.

![Willow SRC structural roots in situ](image1)

![Length of horizontal, structural root](image2)

Due to the rooting habit of SRC removing the crop at the end of a contract is not as difficult as most people think.

The final harvest is taken, new shoots are allowed to grow to around 20cm in height and the crop is then sprayed with glyphosate. As the structural roots grow horizontally and within the top 30cm of the soil they should be severed by running alongside the stools with heavy-duty agricultural discs. The stools can be left to rot down or mulched by using a bush-hogger.

The site can then be grassed or returned to conventional arable cropping. Volunteer willow shoots are not a problem as cereal and grassland herbicides are highly effective at controlling them. Final harvest to re-cropping should take 12 to 18 months but can be completed in 1 month should this be required.

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