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HARVESTING OF SHORT ROTATION COPPICE WILLOW

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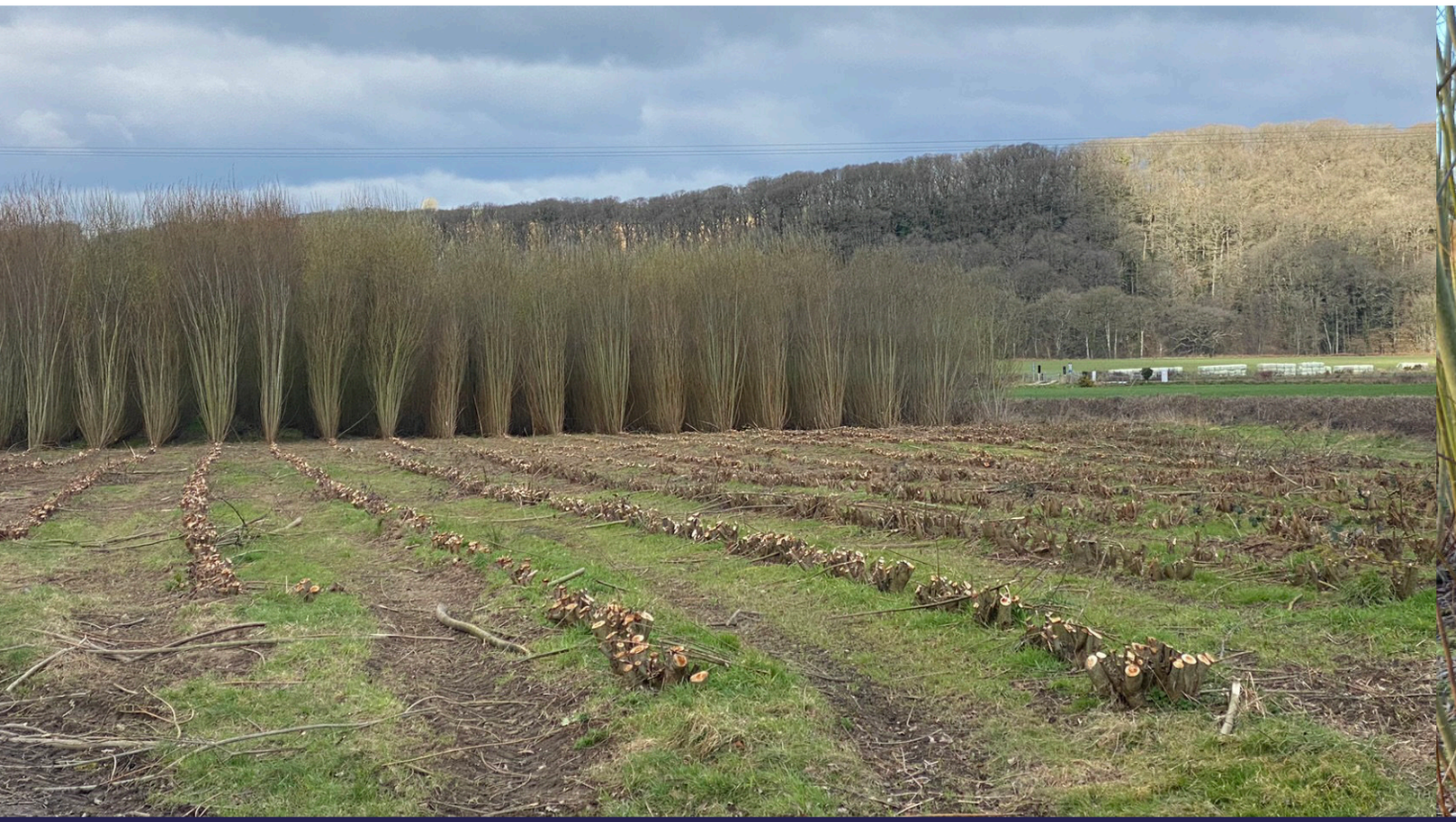
Summary

- Willow is harvested every three to four years depending on the plant growth and soil conditions. Ideally, harvesting should occur during the dormant season in winter (mid-October to early March) after leaf fall and before bud break. However, the UK's maritime climate means that ground conditions are often not suitable and most commercial harvests are carried out in the spring, summer or autumn.
- Harvesting is the single largest cost component of willow biomass production accounting for about 32 – 60% of costs over the life cycle of the crop (20 plus years).
- Several ways of mechanical harvesting have been explored. The direct cut and chip method is most widely used in the UK. In the past, whole stem harvesters and baling systems have been available. Small scale growers also manually harvest with chainsaws or use forest excavators with tree shears[1].
- Efforts to reduce harvesting costs by improving the performance and reliability of the harvesters and chip collection system are essential for the profitability of willow production.



Introduction

Willow is a short rotation woody crop that rapidly produces large amounts of biomass. The harvested willow biomass can be processed into renewable energy, heat, and other products such as livestock and poultry bedding, biochemicals, bio-packaging, and more. Willow is harvested in a three-to-four-year rotation cycle after establishment and can be harvested seven or more times before replanting. It requires minimal crop maintenance between harvests.

Harvesting is the single largest cost component of willow production[2], accounting for about 32 – 60% of costs[3] over the life cycle of the crop (20 plus years). As such there should be efforts aimed at reducing the harvest cost by having reliable high performing harvest systems[4] to improve the harvesting efficiency and increase the profitability of willow biomass production. One of the Biomass Feedstocks Innovation Programme projects[5] (Net Zero Willow[6]) is aiming to do this by producing a tracked harvester with integrated bunker.

Before planting an SRC plantation, the logistics of harvesting must be considered. For instance, it is important to create an efficient plantation design[7] based on the harvesting method (mechanical or manual) and factor in headlands (unplanted areas around the edge of a crop field) to accommodate the efficient turning of machinery and reduce harvester downtime.

Timing of willow harvest

Willow harvesting should be carried out on a three-to-four-year rotation cycle. Current practice is to harvest three years after the initial planting. Previously, growth in the establishment year was cut back to promote coppicing. However, commercial experience suggested that this led to lots of immature plants being killed before they could properly establish.

Willow harvesting should be done during the dormant season in winter (mid-October to early March) after leaf fall and before bud break in early spring.

The ideal situation would be to harvest willow when the ground is frozen. This avoids excessive loads on the soil by the harvesting machines. However, such optimal conditions are hardly ever feasible in the UK's maritime climate with mild winters.

Harvesting on frozen ground

However, harvesting windows are not exact. The timing can depend on several factors such as the yield of the crop, the soil conditions and the availability of harvesting contractors. Harvesting can be delayed for a year or two if the growth of the plant is poor due to drought or competition from weeds, insects, or pests. In some circumstances there is no choice but to delay harvesting until the following year especially if weather conditions are unsuitable. Experience suggests that harvesting in poor conditions leads to soil damage and erosion resulting from deep furrows forming in the field. It can also lead to additional costs borne by the contractor due to tyre punctures caused by slipping and sliding into previously harvested stools. Climate change is making the timing of harvests even more difficult.

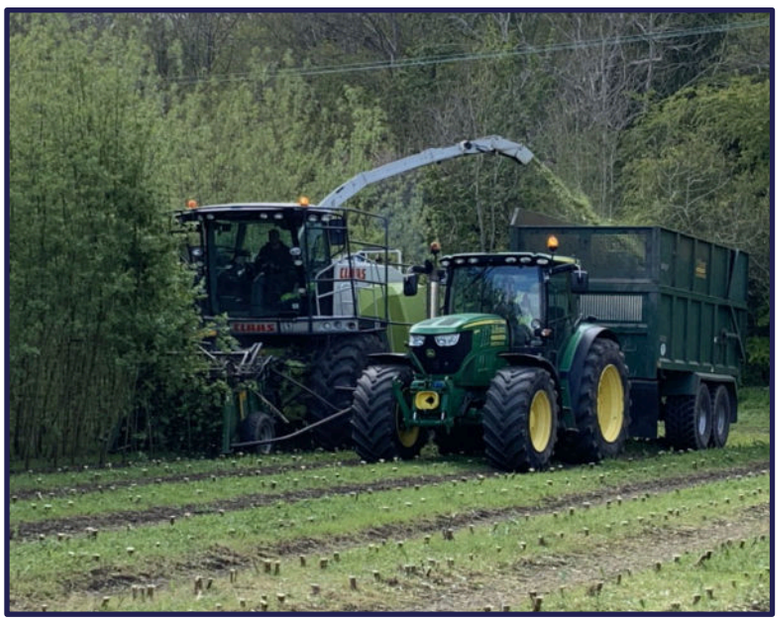
Most commercial harvesting currently takes place in spring, summer or autumn. This is far from ideal as the wood chip will be contaminated with leaves, which increases the moisture and ash content[8] and makes the biomass fuel more abrasive to boiler systems. Furthermore, the harvested plant biomass removed from the field deprives the soil of carbon transfer[9] and nutrients recycled into the soil.

Harvesting Systems

There are various ways of harvesting willow involving either a single step or two-step method of harvesting[10]. With the single step, the willow crop is cut directly from the stump and chipped in one operation. While with the two-step harvesting, the willow crop is first cut, stored, and naturally air-dried before later chipping and processing into the desired end product. In most situations mechanical harvesting is the only option. In small plantations (usually less than 3 hectares) it is logistically possible to manually harvest and remain economically viable[11].

Mechanical Harvesting

Mechanical harvesting is the only option for harvesting large-scale willow plantations[12], where the large capacity of the machines can be fully utilised, and the high capital cost can be spread over large harvest volumes. Studies[13] have shown that to increase profitability, it is essential to have machinery available that can produce high-quality wood chips at low cost and be easily managed during storage and transport. There are five contractors currently operating in the UK. They operate various modified forage harvesters that cut and chip willow in a single pass[14].



Mechanical Harvesting

Cut and chip harvest system

With the cut and chip harvester, the willow plants are harvested in a single operation and directly chipped and transported to the end user or storage site. The harvester either pulls its own trailer to collect the harvested material or more usually uses a tractor-trailer combination, which travels alongside the harvester and receives the chips blown from the

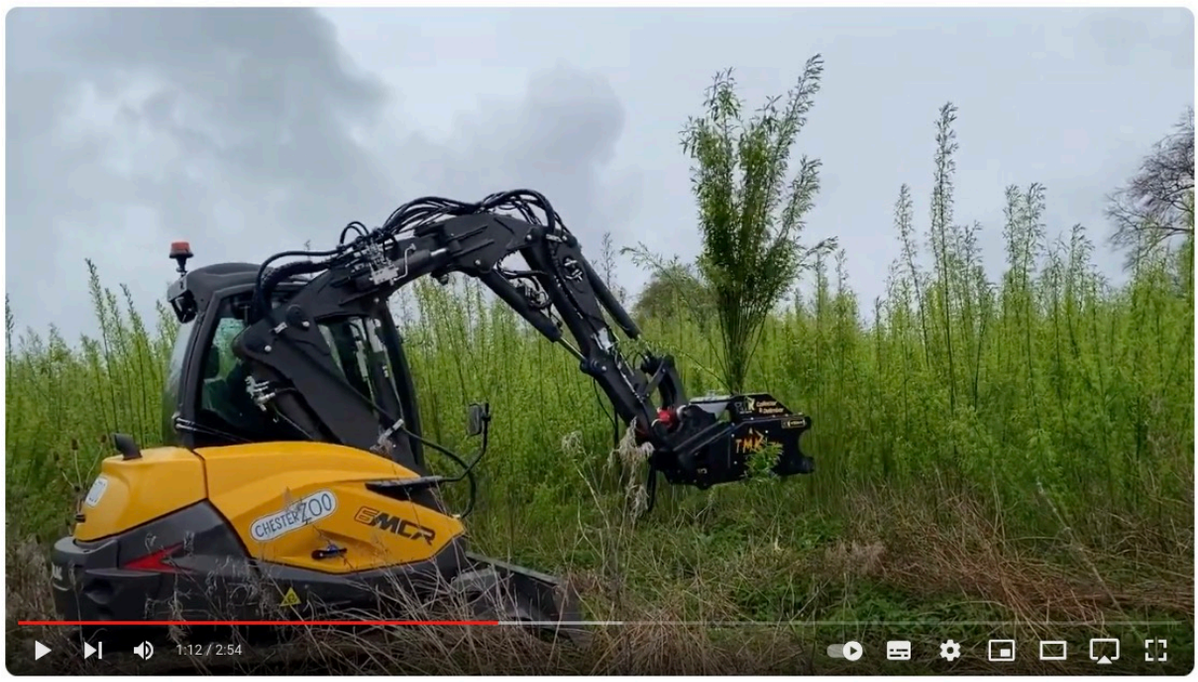
harvester. To optimise efficiency, the harvester downtime should be reduced by keeping the harvester moving and harvesting the willow crop on a continuing basis, while two or three tractors and trailers work in tandem to continuously collect the chips and move them to the load staging area or directly to the end user. The plantation design and staging area should be well laid out to facilitate machinery movement and turning at the end of the rows. Chips produced from the cut and chip harvester, however, have a high moisture content and may require further drying to reach lower moisture content for efficient thermal combustion into energy. Dry chips can attract higher prices from the consumer but this is generally offset by the requirement for additional handling, storage, and fuel costs required for direct drying.

Manual harvesting

Manual Harvesting

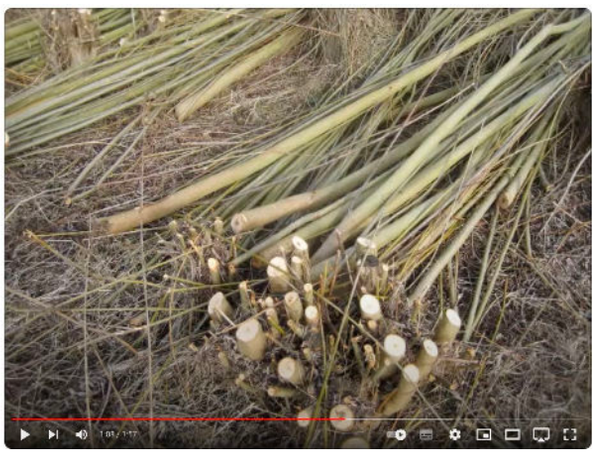
Manual harvesting involves the felling of the willow plants with a chainsaw[15] or brush cutter[16] and collecting the logs manually or with a tractor, followed by direct feeding of the logs into a chipper. Alternatively, the logs can be collected and stored and chipped later. Manual harvesting is labour intensive, requiring a minimum of two persons, and is best suited for harvesting small scale plantations, but is less costly and therefore an affordable option for small scale farmers who lack the resources to purchase expensive harvesting machinery. It can also be used in situations where it is the sole available option when commercial operated machinery is not available when needed, although it is less efficient and less productive compared to the use of mechanical harvesters (one report[17] indicated that it takes on average 45 hours to manually harvest 1 hectare of willow containing about 18,000 plants). A study[18] reported harvesting cost varying from €16.3 ha^{-1} to €23.2 ha^{-1}, suggesting manual harvesting an affordable option for small scale farmers even though gross production rates are very low (0.10 - 0.11ha/h to cut

and lay). Another study showed that manual harvesting exposes workers to noise, uncomfortable work postures, and high cardiovascular loads. This study suggested that motor manual harvesting operations should consider the compatibility of equipment and operational conditions to the workers undertaking such tasks.



https://www.youtube.com/watch?v=MU5R5cluPok

It should be noted that manual harvesting results in the stool height rising as chainsaw operators do not always go to the base of the stems[19]. This makes it almost impossible to revert back to the direct cut and chip method in the future.



https://youtu.be/KXFO43-qRHw

Conclusion

There are several options available for harvesting SRC in the UK. The choice depends on local availability of contractors and machinery, age of the plantation and soil conditions. All of the current options are workable but not ideal for UK conditions. New innovations are being developed that should increase efficiency, reduce costs, enable field working during optimum seasonal windows and have lower impact on soils.

Endnotes/Hyperlinks

1: https://www.biomassconnect.org/technical-articles/case-study-src-willow-self-supply-and-use-in-a-farm-scale-community-heating-scheme/

2: https://link.springer.com/article/10.1007/s12155-013-9347-y

3: https://link.springer.com/article/10.1007/s12155-012-9262-7

4: https://onlinelibrary.wiley.com/doi/full/10.1002/fes3.82

5: https://www.biomassconnect.org/innovation/

6: https://www.biomassconnect.org/feedstocks-projects/net-zero-willow/

7: https://www.sciencedirect.com/science/article/pii/S0961953411003953

8: https://link.springer.com/article/10.1007/s12155-014-9540-7

9: https://www.biomassconnect.org/technical-articles/what-effect-does-planting-biomass-crops-have-on-soil-carbon/

10: https://www.mdpi.com/2077-0472/10/4/116

11: https://www.biomassconnect.org/technical-articles/case-study-src-willow-self-supply-and-use-in-a-farm-scale-community-heating-scheme/

12: http://www.coford.ie/media/coford/content/publications/projectreports/cofordconnects/HAR29_LR.PDF

13: https://www.sciencedirect.com/science/article/pii/S1364032117302782

14: https://www.sciencedirect.com/science/article/pii/B9780123562555500377

15: https://hrcak.srce.hr/228256

16: https://jtatm.textiles.ncsu.edu/index.php/BioRes/article/view/BioRes_12_2_3560_Talagai_Brush_Cutters_Felling_Operations

17: https://www.cse.org.uk/news/view/2016

18: https://www.sciencedirect.com/science/article/pii/S1537511012001602

19: https://www.crops4energy.co.uk/manual-harvesting-of-short-rotation-coppice-watch-the-video/

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