

Designing an optimized harvesting system for Short Rotation Coppices

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About the project

Dendromass4Europe (D4EU; 2017 – 2022) aims at establishing sustainable, Short Rotation Coppice (SRC)-based, regional cropping systems for woody biomass (dendromass) production on marginal agricultural land. The dendromass produced in SRC (lignous biomass, bark and wood) is supplied to dedicated bio-based value chains that create additional income and job opportunities in rural areas. The supply chains will be tailored for optimum efficiency of supply logistics and for reducing CO₂ emissions. Innovative bio-based materials will help to replace fossil-based materials.



Task and challenges

Our task was to design cost-effective harvesting systems for short rotation coppices (SRC) with poplar. Such systems must be able to produce 4 m long logs with a minimum small end diameter (SED) of 7 or 8 cm, according to factory specifications.

The goals were:

- minimizing harvesting costs (≤ 30 € per Bone-Dry Ton (BDT))
- maximizing log yield (≥ 40 %)

The main challenge with harvesting SRC poplar is the small tree size. Conventional cut-to-length (CTL) machines are designed for trees with an optimum size ≥ 0.2 m³, and their productivity plummets when dealing with trees that are half as big.



Cut-to-length harvesting



Feller-buncher saw

Methods

We tested a large variety of harvesting chains and machines, covering both main harvesting systems: whole-tree harvesting (WTH) and cut-to-length (CTL) harvesting. Overall, twelve full-scale controlled harvesting tests were conducted from 2018 to 2022, in Italy, Poland and Slovakia. Additional work was conducted on the effect of cutting method (saw vs. shears) on stump damage and regeneration, and on the best technique for chipping the biomass component (i.e. tops and branches).



Feller-buncher shear



Light cut-to-length harvester

Results

Several strategies can be implemented to achieve the above-mentioned goals, and namely:

1. Manipulating log specifications, and in particular:
 - reducing SED from 8 to 7 cm allows a 15 % log yield increase at no additional cost
 - reducing log length from 4 m to 2 m allows a 40 % increase in log yield at a 33 % additional cost
2. Resorting to multi-tree CTL harvesting allows a < 10 % decrease in cost
3. Switching from CTL to WTH offers no cost advantage on well developed fields, but may lead to substantial savings in underdeveloped poplar SRC
4. Chain flail delimiting with a new compact prototype can double log yield and decrease harvesting cost in underdeveloped poplar SRC

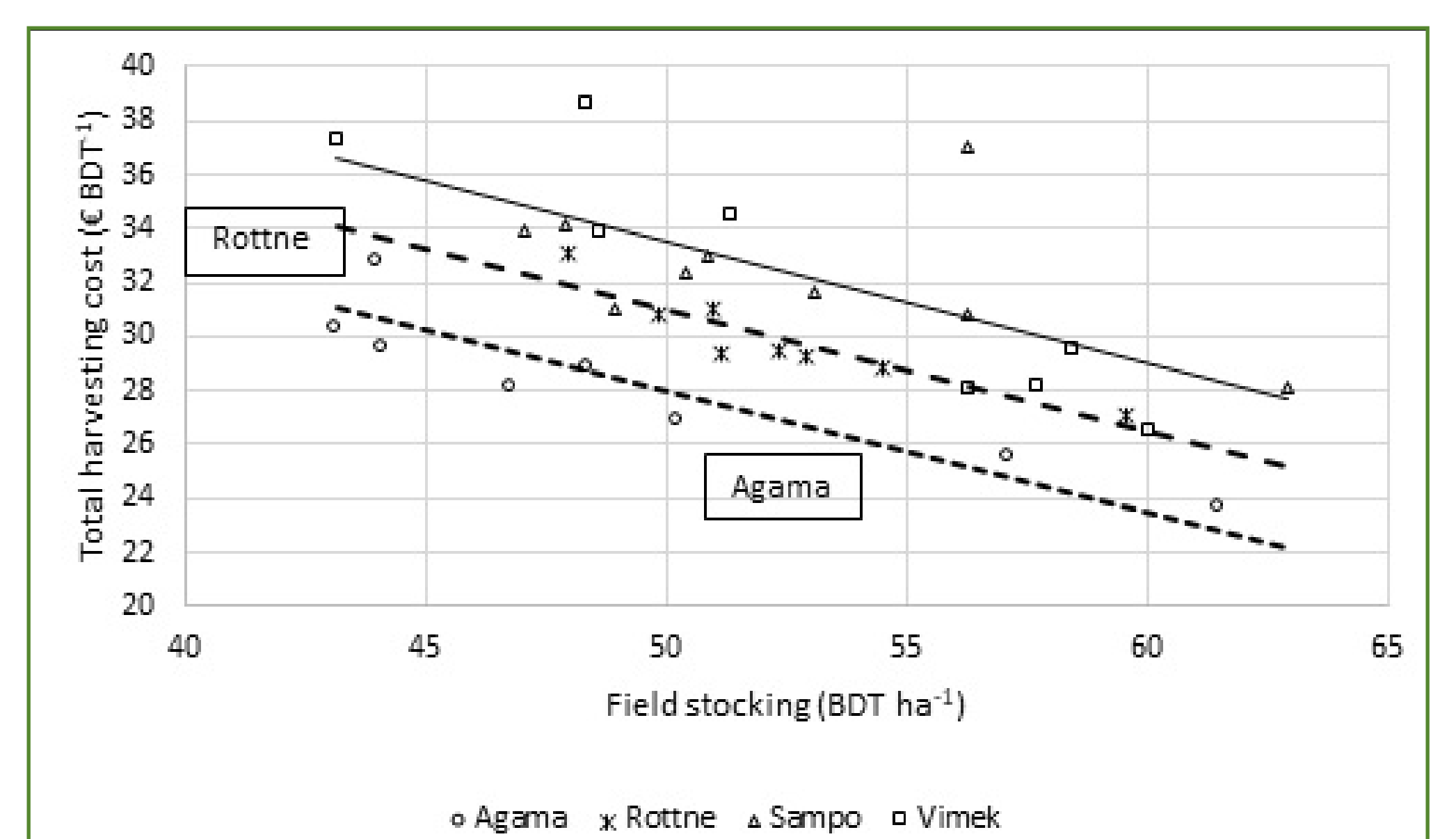


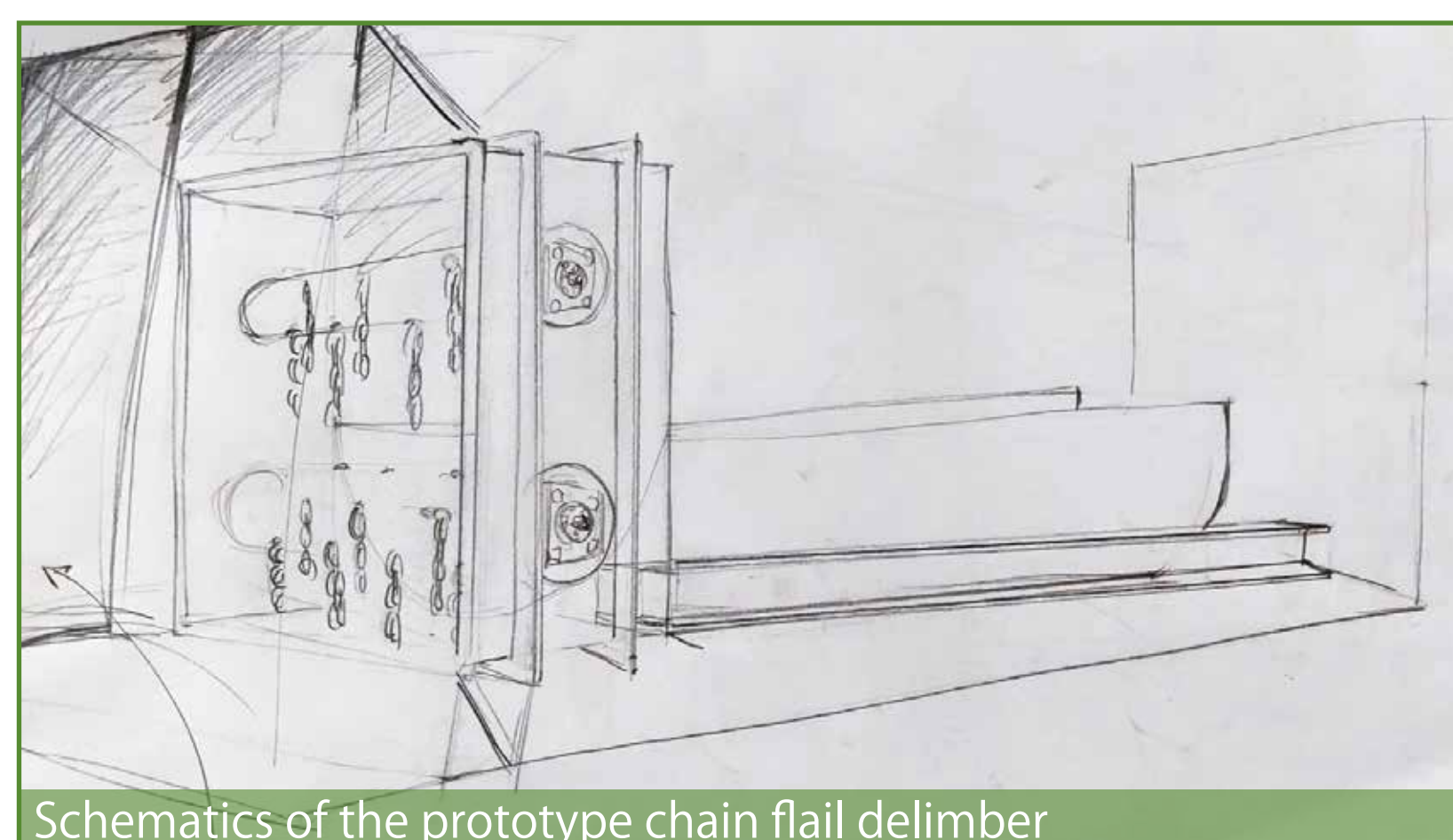
Figure 1: Harvesting cost as a function of field stocking for a range of CTL harvesting options



Forwarding logs



Forwarding whole trees



Schematics of the prototype chain flail delimiter



Details of the chain flail delimiter



Chain flail delimitation operation

Summary

Well-developed poplar SRC (> 40 BDT ha⁻¹) can be profitably harvested with CTL technology at a cost < 30 € BDT⁻¹.

Underdeveloped poplar SRC (< 40 BDT ha⁻¹) are best harvested with WTH technology, based on pre-sorting by the feller-buncher and delimiting with a compact chain flail.



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