Alternative Biomass Supply Chains for Biomass Plantations with Medium Rotation Periods

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Abstract:
The aim of the study was to analyze two alternative supply chains for 5 year old short rotation coppice (SRC) regarding productivity, costs and energy efficiency. Harvesting trials with alternative arrangements of the overall supply chain from the field to an energy plant were carried out (chipping at the field or at roadside), both with the poplar clones AF2 and Monviso. Results of the felling operations showed comparable productivities for both supply chains, also the productivity of the chipping process was not statistically significant influenced by the alternatives. However, results showed that the productivity of the felling and chipping was significantly affected by the clone type. It was higher in Monviso which had smaller diameters at breast-height compared to AF2 trees, but higher wood densities and higher yields. In terms of costs, the supply chain "chipping at roadside" was more expensive because of additional working steps (crosscutting and forwarding). However, this alternative might be interesting to focus on under specific conditions. The consumptions of fossil energies followed the same pattern as costs and were significantly related to both, supply chain and clone.

Keywords: poplar, mechanization, supply chain, productivity, harvesting costs, energy use

1 Introduction

Biomass plantations with rotation periods of 5 - 10 years became attractive as they offer good value recovery (Spinelli et al. 2008). Trees are larger dimensioned compared to very short rotations, have lower bark to fibre ratios (Guidi et al. 2008) and offer high energy conversion factors. However, when it comes to harvesting, agricultural foragers cannot be used due to the size of the trees (Spinelli and Hartsough 2006, Grosse et al. 2008). Instead, trees are felled using forest harvesters with single grip technology.

2 Material and methods

Harvesting trials with alternative arrangements of the overall supply chain from the field to an energy plant were carried out (Figure 1). In supply chain A (chipping at field) trees were harvested by a Valmet harvester. They were chipped later directly at the field. The chips were continuously blown into tractor-trailer units and transported to a collection point. In supply chain B (chipping at roadside) trees were harvested by the same machine, crosscut manually with a chainsaw and forwarded to a place at 150 m distance where the concentrated piles of biomass were chipped and transported to the central collection point using the same machines like in A). Both supply chains were tested under similar conditions on SRC fields which were established with the poplar clones AF2 and Monviso. Analyzed aspects were productivities, costs and energy efficiencies.

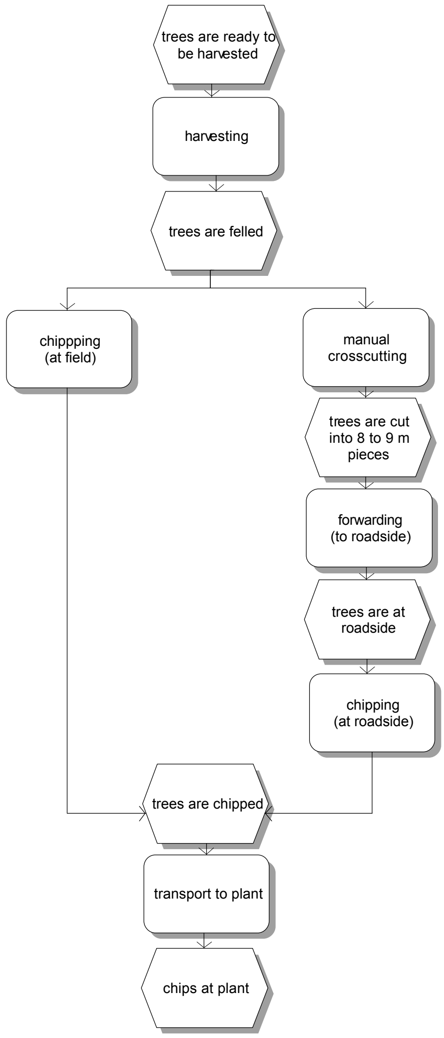

Figure 1: Analyzed supply chains

3 Results

It was noticed that Monviso poplars offered statistically significant larger tree sizes and higher stockings (biomass per hectare) but smaller diameters at breast-height compared to AF2. Average yield was 18 and 16 oven-dry tonnes (odt) per ha, respectively for Monviso and AF2.

The average machine productivities per working step are reported in Figure2. Results showed comparable productivities for both supply chains in felling and chipping operations. The working steps crosscutting and forwarding occurred only in the alternative B (chipping at roadside). For both working steps, productivities were slightly higher for Monviso, probably because of the higher stockings. However, results showed that productivities of the working steps felling and chipping were significantly affected by the clone types. It was higher in Monviso.

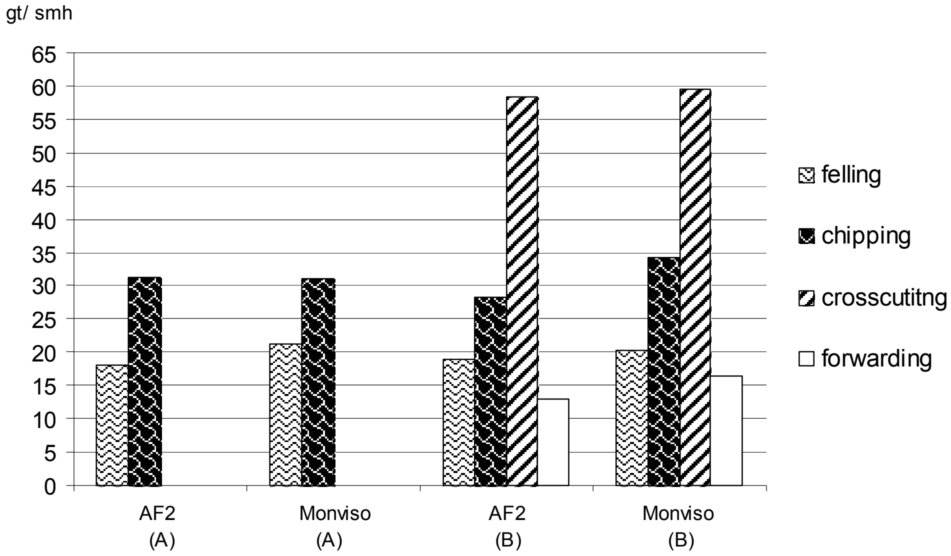

Figure 2: Productivities, per alternative, in fresh tons per scheduled machine hour (ft/smh)

In terms of costs, the supply chain B (chipping at roadside) was more expensive because of the additional working steps crosscutting and forwarding (Figure 3). The use of fossil energy followed the same pattern as costs (Figure 4) and was significantly related to both, alternatives and clones.

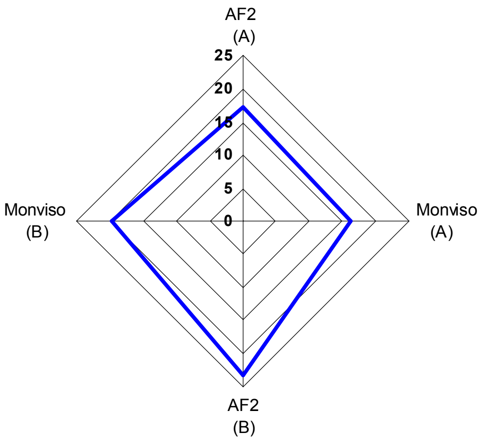

Figure 3: Costs, in Euro per fresh ton

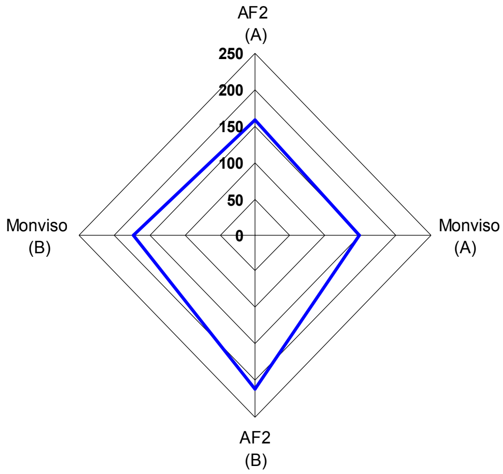

Figure 4: Use of fossil energy, in Megajoule per oven-dry ton

4 Discussion

The productivities of felling and chipping were not influenced by the alternatives. Supply chain B (chipping at roadside) was more expensive due to the additional working steps crosscutting and forwarding (Figure 3). More fossil energy was used in supply chain B for the same reasons (Figure 4). However, supply chain B (roadside chipping) has a higher potential for improvement and offers significant technical advantages, particularly in difficult terrain (e.g., wet soils). In particular, the forwarders used for biomass extraction have a much better floatation compared to the tractor-trailer units, which allows stand access under wet soil conditions, as well as reduced soil compaction and stool damage. Furthermore, roadside chipping is well suited for storing biomass in the form of stacked tree sections at the roadside.

Acknowledgement

Support for this study was provided by Pellerei – Ago AG and by COST Action FP0902 within the scope of its 4th STSM programme.

5 References

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