AN EFFICIENT HARVEST LINE FOR SHORT ROTATION COPPICES WITH A NEW MOWER-CHIPPER

Hoffmann, T., Ehlert, D., Pecenka, R., Brunsch, R.
Leibniz-Institute for Agricultural Engineering Potsdam-Bornim e.V. (ATB),
E-Mail: thoffmann@atb-potsdam.de

Abstract: The cultivation of short rotation coppice (SRC) such as poplar and willow on agricultural land is of increasing interest for farmers. But high investment costs, high processing costs, low flexibility of the machines as well as high machine weights are problems, which hinder an extensive implementation. Therefore, the development of a simple and low weight mower-chipper was started. The chipper was designed for mounting in front of medium sized standard tractors. The new developed machine has been tested in three harvest periods. Because of the very promising test results an industrial production is in preparation. To analyse the storage behaviour of wood chips different outdoor storage experiments were carried out at practice scale. Storage of coarse wood chips from the mower-chipper was compared with storage of fine chips produced by a forage harvester. Only small differences were found between both chip sizes.

KEYWORDS: SHORT ROTATION COPPIEC, HARVEST, STORAGE, MOWER-CHIPPER

1. Introduction

The cultivation of fast growing trees (short rotation coppice - SRC) such as poplars and willows on agricultural land is of increasing interest in Europe. But efficient harvest technology for SRC crops is still an important question because appropriate machinery is not always available at reasonable costs.
SRC harvesting lines for the supply of different sizes of woody biofuels have been developed, ranging from small wood chips produced with forage harvesters, chunks or billets to whole shoots or bundles of shoot produced with tractor-trailed shoot cutter-bundler machines. Basically, existing harvest technology can be classified into four groups:

- Log lines
- Shoot lines
- Chip lines
- Bale lines

Numerous publications can be found about all these harvesting technologies in the last decades (Stokes and Hartsough 1994; Hartsough et al. 1997; Scholz et al. 2008; Abrahamson et al. 2010). Advantages and disadvantages, costs and harvest capacities were presented and discussed.

Analysing the process chain in SRCs, it can be concluded that high investment costs for suitable harvest equipment, low flexibility regarding tree variety and cultivation scenario as well as high machine weight accompanied by problems during harvest and low capacities are some of the most important obstructions at present.

With respect to minimum process steps and low production costs, chip lines with mower-chippers are advantageous because mowing, chipping and conveying of chips on a transport unit can be performed by only one machine while driving.

Resulting from the unsatisfactory situation in harvesting technology for SRCs, a research project has been started to develop a simple and low weight universal mower-chipper for trees up to 15 cm stem diameter for single rows. The weight of the chipper should be low due to mount the mower-chipper in front of medium sized standard tractors.

For systematic development of a new working principle for the mower-chipper with these features, an answer for following questions had to be found:

- How can be a simple and robust cutter-chipper unit realized?
- How can be simple and save feeding of the cutter-chipper unit with trees realized?
- How to avoid falling down of trees in a horizontal position?

Additional to this questions further information have to be obtained:

- How is the storage behaviour of the chips characterised?
- What are the advantages or disadvantages of the mower-chipper in comparison to commonly used forage harvesters with special cutter-headers?

2. Material and Methods

2.1 Development of a new mover-chipper

The basic idea for the new mower-chipper unit is shown in Figure 1 and 2. To minimise the number of powered parts, the functions of mowing, chipping and conveying of chipped material were realised by a compact and simple mower-chipper unit (tool rotor) rotating in a robust housing. For tree mowing, the tool rotor of the prototype is designed as a disc saw with an outer diameter of 1300 mm. For chipping of severed stems, knives set on spacer blocks are installed on the upper side of the disk saw. Contrary to most mowing disks in other harvesters, the tool rotor is solid and not slotted, thus avoiding chips falling on the ground of the field. As a result of this arrangement, the theoretical maximum chip length is limited by the sum of the height of the spacer block and the chipping knife. The chop length can be altered by using spacer blocks of different heights. For an optimal chipping process, a counter bar is installed on the housing. During cutting and chipping the cut stems remain in an upright position by the help of the guiding arm and the star wheel. After chipping, the comminuted material is accelerated and moved to the outer edge of the housing at a rotation speed of 1000 rpm towards the discharge opening.

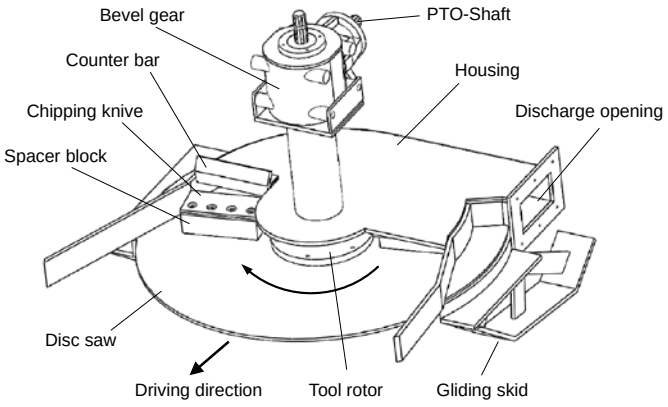

Figure 1. *Principle of the mower-chipper unit*

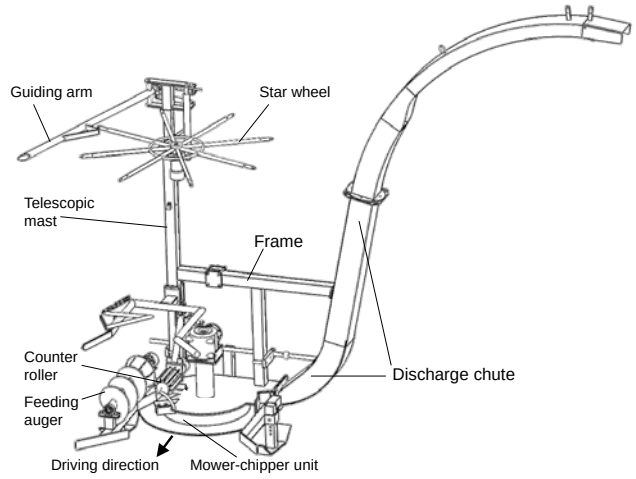

Figure 2. *Overall view of the ATB mower-chipper*

The mower-chipper was tested in three harvest season (fig. 3).
With respect to current standards and end user requirements regarding maximum chips size, the mover-chipper was adjusted to cutting length of 75 mm for the supply of coarse wood chips for later storage tests.

Figure 3. *ATB mower chipper at harvest of poplar*

In comparison to the new developed chipper a self-propelled forage harvester from new Holland with a cutter-header (FR 9060 with SRC-header KUP 130FB) was used on the same test fields. The forage harvester produced usual fine chips because of the cutting drum inside the harvester.

2.2 Storage experiments

The wood chips from the mower-chipper and from the forage harvester were stored in two horizontal silos with 500 m³ in each pile (fig. 4). The silos were equipped with measuring columns for periodical sampling and continuous temperature measurements. Mass losses, mould contamination and moisture content were determined by extracting a column in the first 2 months of storage every 2 weeks, later every 4 weeks. Losses in dry matter were analysed with the help of balance bags. The moisture content of the chips from the balance bags was detected according to the oven dry method. In every column 12 balance bags and 3 temperature loggers (Tinytag TGP-4017 data logger with built-in temperature sensors) were embedded at 3 levels in 0.6, 1.4 and 2.2 m height from the ground.
The mould development was determined with the help of malt extract agar plates. The malt extract plates were analysed after 2 days of incubation at 37 °C to determine the extent of thermophilic mould contamination (Pecenka et al. 2014).

Figure 4. *Storage experiment with fine chips (left) from the forage harvester and coarse chips (right) from the ATB mower chipper (poplar, storage piles covered with permeable tarpaulin, each pile 500 m³)*

3. Results and discussion

The weight of the complete tractor-mounted mower-chipper, tested until March 2015, was about 1.200 kg. The tractor with the mower-chipper can be used as a single vehicle with a pulled trailer. Only one person is necessary to harvest trees.
The field tests have shown that the basic working principle of mowing and chipping trees in an upright position has significant advantages. The breaking and uprooting of trees during cutting can be completely avoided. The stumps showed a clear cut surface after mowing with the circular saw. Trees with stem diameter up to 15 cm and with 10 m height could be successfully harvested in a 18 years old SRC (2 and 4 year rotation).
An effective speed of 3 to 5 km h^{-1} was realized with the test unit. A performance of 0.42 ha h^{-1} and a productivity of 12 t_{dm} h^{-1} were achieved in the year 2013. In 2015 the performance could be increase to 0.5 ha h^{-1} at an average productivity of 15 t_{dm} h^{-1}.

The mower-chipper produces with the used spacer blocks much coarser wood chips than forage harvesters. In contrast to the visual impression both chip bulks can be classified as wood chips of the class P45 according to CEN/TS 14961. Chips of the forage harvester are very close to the maximum content of fines allowed by the standard. The chips of the

mower chipper are close to the maximum content of oversized chips regarding the standard.

The developments of moisture contents, dry matter losses, and temperatures in the two silos are shown in Figure 5 for the first 8 months in year 2013. The temperature in the coarse chip pile remained on a lower level and decrease earlier. The drying process started earlier in the pile with the coarse chips but both piles achieved the same moisture content at the end of the storage period. At the end of the storage period, the fine chip pile has showed mass losses of nearly 24% and the coarse chip pile has reached 27%. The higher porosity of the pile produced of coarse wood chips enables an improved natural aeration and drying of the storage. Connected to this improved aeration – more oxygen flow through the chips and improve the conditions for biological and chemical decomposition processes.

4. Conclusions

The new developed mover chipper is a suitable machine for harvest of trees from SRC. With the investigated harvester, trees with stem diameters up to 15 cm and with a 10 m height could be successfully harvested.

The mover-chipper produces coarser chips in comparison to common forage harvesters with cutter-headers. The coarse chips from the mower chipper do not lead to lower losses during the storage period.

It has been concluded that further investigations are necessary to understand the degradation processes during storage and to find out optimal chip sizes and storage techniques for SRCs.

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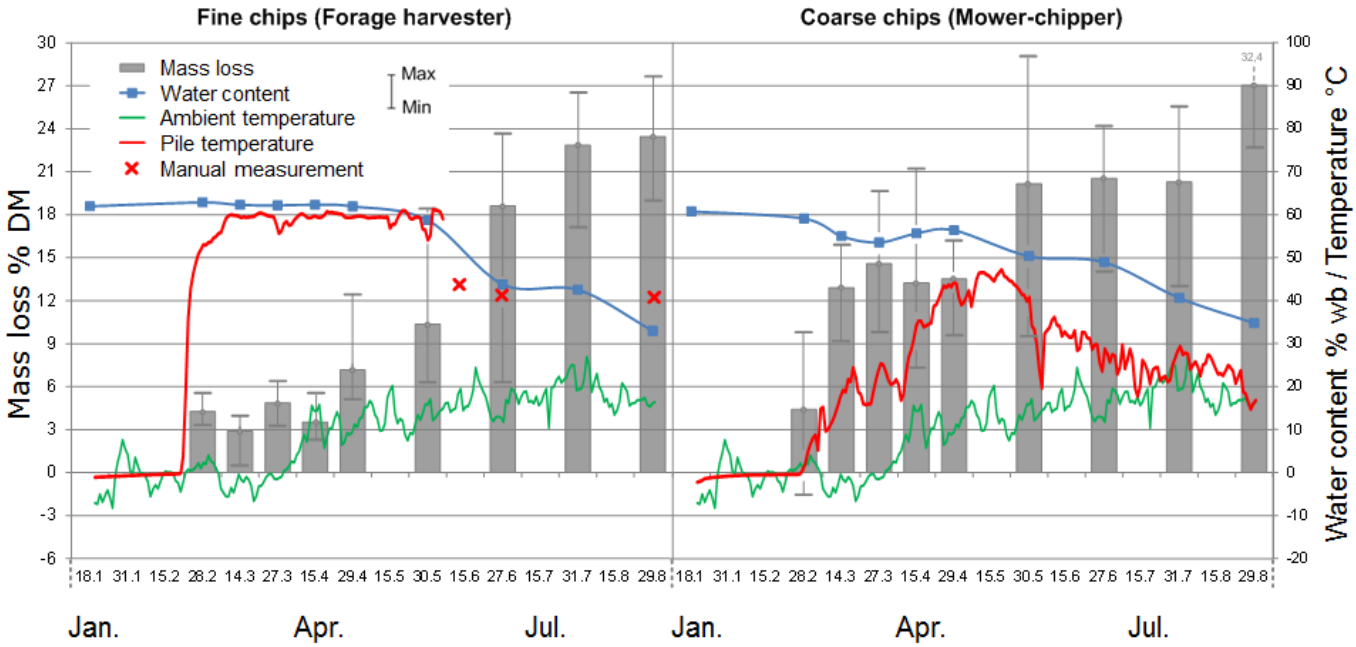

Figure 5: *Development of dry matter losses, moisture content, pile and ambient temperature during 8-month storage of fine and coarse wood chips from poplar in 2013*