Analyzing different machines for mechanized harvesting of hardwoods in Italy

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Abstract

Many low-quality hardwood stands that originate from former coppice forests are existing. Due to increasing use of wood for energy purposes, these forests are regarded as an underutilized resource. As manual felling is rather expensive (mainly due to high labour costs), mechanized systems which could be applied to hardwood stand gained in importance.

In northern and central Europe, most felling operations are carried out in mechanized systems. Costs are lower compared to manual systems due to high productivities. Furthermore, the operator hazards associated with felling are reduced.

Today, many small-tree feller- bunchers are available on the market (e.g. Bracke or Naarva). These products are designed mainly for softwoods and for hardwoods with low density, like birch. However, in central Europe, large areas are stocked with hardwoods of high density, e.g. chestnut, oak, beech and robinia. For this reason, a number of Italian manufacturers have got into the production of new beefed-up fellers, specifically designed for hardwoods. These machines are supposed to be suitable for coppice harvesting operations, as well.

Goal of the study was to determine the performance of these new machines, on the one hand through interviews to the operators and on the other hand by carrying out field studies of the machines under representative work conditions, as offered by commercial operations. Thereby data concerning usage intensity, fuel consumption, reliability and productivity were collected. As a result, advantages as well as disadvantages of different machines were identified, the productivity and the related processing costs were evaluated and suggestions for improvement developed.

Background

In Italy, there are many low-quality hardwood stands that originate from former coppice forests. Like all over Europe, many of these coppice forests were not managed due to several reasons (e.g., rural emigration to the cities, introduction of fossil fuel heating in households, both leading to a declining market for coppice products) (Laina et al., 2013).
However, coppice forests gained renewed attention during the past two decades because of various reasons. For instance, with rising living standards, protective, environmental, social and cultural functions of forests became more important (Spiecker, 2003). Also, due to increasing use of wood for energy purposes revival of coppice management is being considered as one option to fulfil the market demand for wood biomass for energy (Matula et al., 2012).

Problem outline

The commonly used harvesting system in hardwood forests is motor manual felling and extraction with forwarders or cable skidders, depending on log size, slope gradient and other factors (Bigot and Cuchet, 2003). However, further mechanization of coppice felling operation is desirable for two main reasons

i) manual felling is rather expensive (mostly due to high labour costs). This is especially true for small dimensioned trees which are typical for coppice forests

ii) most of the fatal accidents occur during manual felling operations (Albizu et al., 2013).

However, up to now harvesters are not used in coppice stands because it is difficult for the harvester head to approach stems growing in clumps (Spinelli et al., 2014). Besides stems are not straight as for most softwood species, but they often show a marked sweep. Branches are also larger and have steep insertion angles (Suchomel et al., 2011). Furthermore, coppice stands present additional challenges that make harvesting technically and economically difficult, including small stem size or multiple stem structures from resprouting. However, the main problem remains the capacity of a harvester head to approach stems growing in a clump. In particular, penetration of the head inside the clump is hindered by the feed rollers and the multiple delimbing arms, which are held back by the other stems surrounding the target stem.
For this reason feller-bunchers may prove a better option, since they are more compact and may approach stems with less difficulty. In fact, a number of small-stem feller-bunchers are available on the global market, and some of them have met with widespread popularity. That is the case of Nordic thinning equipment, such as the various Bracke, Naarva and Nisula brands. Unfortunately, Nordic machines are designed for handling Nordic wood species, such as pine and birch. The wood of these species is much softer (shows a lower density) than the species managed as coppice in Central and Southern Europe, such as Beech, Chestnut and Oak. For this very reason, several Italian manufacturers have developed new feller-buncher designs, which are larger and stronger than the Nordic ones, without getting as cumberson as full-size Northamerican units. Some of these feller-bunchers have been on the scene for several years, whereas others have just been launched on the Italian market. In any case, no studies have ever documented their field performance, especially when harvesting coppice.

Focus of the study

The goals of the study were: 1) to determine the performance of some of the new feller-bunchers, specifically designed for the harvesting of hardwoods forests 2) to get a picture about the current practices of mechanized coppice forests harvesting. Technically the analysed machines were supposed to be suitable for coppice harvesting operations, but until now no studies have been carried out to assess productivity figures (e.g., productive and non- productive time, costs) and other relevant parameters (e.g., quality of the cut).

Methods and Material

Field studies of three different machines were carried out under representative work conditions, as offered by commercial operations. The three machine models represented three technically different cutting mechanisms, namely: single-bladed shear; two-bladed shear; hot-saw. In five case studies data concerning time consumption, usage intensity, investment costs, fuel consumption, reliability and productivity were collected. Time elements were recorded with a Husky FS/2 handheld field computer running selfprogrammed time study software with an accuracy of 1 second.

The following studies have been carried out:

1. **Mediterranean oak coppice**
   This study was carried out in a 20 years old mixed oak coppice stand (Q.cerris, Q. pubescens, Q. Ilex, Fraxinus ornus) in Marsilliana (Province Grosseto). The stocking was 131 odt/ha.
   A Comaf hotsaw was used on a Hitachi Zaxis 210 machine for the harvesting. Some remaining trees were left on the site. The duration of the time study was 3.75 h and 613 stems were felled.

Figure 1: Mediterranean oak coppice (left) and used harvesting machine with hot-saw (right)

2. **Temperate chestnut coppice**
This study was carried out in a 20 years old chestnut coppice stand in Carmignano (Province Prato). A Conterno Occelli Forest Cut head was used on a CAT 317 LN Excavator (Shear 2008). The duration of the time study was 3.76 h and 49 big stumps and 331 smaller stems were felled (13 odt in total).

Figure 2: Temperate chestnut coppice (left) and used forest cut head (right)

3. **Bank consolidation black locust coppice**
This study was carried out in a 26 years old riparian stand of pure Robinia pseudoacacia L. coppice, with sporadic Sambucus undergrowth, grown along a riverbank in Ottobiano (Po- region). For felling, a Biasi single-cur shear was used on a Hitachi EX175 3-piece boom excavator. The operation was a clearcut, often at 1-3 m height above ground to reduce risk of shear damage (as Robinia is too hard and resistant for the shear).

Figure 3: Black locust coppice growing in a river bank (left) and harvesting (right)

4. **Ditch buffer strip mixed-hardwood coppice**
This study was carried out in a buffer strip of cypress and white poplars, grown between two fields of agricultural land in Brenta d' Abbà close to Padua.
Poplars were 5 years old and growing in the second cycle (15 years old roots). The operation was a clearcut but at least one stem per tree was remaining in a height of 2 m. In the study, a strip of almost 300 m was harvested with a shear on a FH EX 135 excavator.

Figure 4: Ditch buffer strip mixed-hardwood coppice (left) and harvesting (right)

5. **Poplar short rotation forestry**
This study was carried out in a single-stem short rotation forestry. It can be seen as a benchmark for top productivity under ideal conditions. The 7 years old Max and Monviso clones were felled using a Biasi single-cur shear on a Hitachi EX165 3-piece boom excavator.
The sticking was 92 odt/ha and 312 were felled during the 2 hour’s time study.

Figure 5: harvesting of poplar SRF (left)

The following parameters have been collected for each study:

1. Placename, municipality and province
2. Forest type
3. Species
4. Rotation length (and total age of forest stands) (y)
5. Mean slope (%)
6. Samples of dbh (cm) and height (m) of felled trees
7. Plot surface (m²)
8. Stumps and stems (pieces/ha)
9. Stocking (odt/ha)
10. Removal (odt/ha)
11. Quality of the cut (clean cut, fibers pulled out, split or chewed off bite)
12. Type, weight (t) and costs (€) of the base machine
13. Type, weight (t) and costs (€) of feller-buncher head
14. Fuel consumption (l/ h)

The following parameters have been calculated for each study:

1. Biomass per tree and total amount of biomass harvested (in odt)
2. Productive and non-productive working time ()h)
3. scheduled and productive machine hours (smh and pmh total and per hectare)
4. Oven- dry tonnes per scheduled and productive machine hours (odt/smh, odt/pmh)
5. Costs (€/h, €/odt)

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