FPS COST Action FP 1301

EuroCoppice

STSM Report

Mechanised harvesting in coppiced Eucalyptus plantations

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Summary

Introduction

The last decades have witnessed the rapid mechanization of forest harvesting, in order to maximize productivity, reduce costs and increase operator safety and comfort (Picchio et al. 2012, Bell 2002). Mechanized system brings the industry to the forest, with strong impacts on value recovery and labour.

Even where motor-manual harvesting techniques are competitive due to cheap labour, there is a general objective to introduce mechanization in order to increase production and anticipate future labour shortages. Mechanization may achieve an overwhelming superiority over traditional technology, which makes it a better choice even when utilization rates and labour cost are comparatively low.

Mechanization of forest operations is a key factor for the success of plantation forestry everywhere, and especially in South Africa, where the HIV/AIDS epidemics have severely reduced the numbers and capacity of the available workforce. While coppicing allows fast and cost-effective regeneration after cutting, it also offers challenging conditions to mechanized harvesting.

Therefore, the co-existence of coppicing and mechanization depends on finding viable techniques for the mechanized harvesting of coppiced stands.

The original plan of this STSM was to conduct a study to determine the productivity of a whole-tree mechanized harvesting system in a coppiced Eucalyptus grandis compartments. Due to a temporary shortage of available machines for these operations and a new request by the forest logging company about the effect of coppice density on harvester productivity, we opted to a study in a cut to length harvesting system.

Harvester heads generally handle coppice stands with some difficulty (Spinelli et al. 2010, Suchomel et al. 2011) and the operators working in these conditions have to be very skilled (Suchomel et al. 2012, Spinelli et al. 2009). Furthermore, harvester heads working in eucalyptus plantations have a triangular roller configuration specific for the debarking that makes it more difficult to sneak between adjacent stems (Magagnotti et al. 2011).

For these reasons, the felling coppice stems with a harvester can have a significant productivity loss and it is important to verify and quantify this hypothesis.

The aim of the study was to define if the productivity of a modern harvester decreases when the machine is working with multiple coppice stems, compared to the base level obtained when handling single stems.

The novelty of this study is that we have compared single versus multiple stems in the same stand, with the same machine. This was possible because there was a coppiced stand with one, two or three stem per stool and stools with single sprout have been used as a a proxy for non-coppiced conventional plantations.

Materials and methods

The study was carried out at one Eucalyptus compartment on Sappi Forest Venus Plantation (table 1) in the Mpumalanga Lowveld area and performed in a good weather throughout 4 days (plus one day for reconnaissance and arrangements with Sappi enterprise and the logging company).

Table 1- stand characteristic of the time study plots

Stand characteristic	Unit	
Species		*Eucalyptus grandis*
Age	years	11
Average height	m	33.7
Maximun height	m	43
Minimum height	m	20
Average DBH	cm	21
Maximun DBH	cm	40
Minimum DBH	cm	8
Spacing	m	2.4x2.4

Nine rectangular plots were randomly selected and in eight plot we measured the diameter at the height of 1.37 cm (according to South African standards) of 100 stems (40 in the ninth) and on each of them we paint a number to identify them properly during the time study (fig. 1). Some trees were broken during the harvesting and for that we had a valid dataset of 769 stems (237 single stem records, 508 double stem and 24 triple stem records).

Stumps had been reduced to a final density of one to 3 shoots thanks to one reduction activity, when the shoots were 3-4 meters height.

Figure 1 - Plot number 2

A typical time and motion study was carried out in order to determine machine productivity and to identify those variables that are most likely to affect it (Magagnotti and Spinelli, 2012, Bergstrand, 1991).

Each tree was stopwatched individually, using Husky Hunter® handheld field computer, running the dedicated Siwork3 time study software (Kofman, 1995).

Each cycle considered separately all the main time elements that were considered typical of the harvesting process (table 2).

Table 2 - Description of time elements of the harvesting process

Time element	Description
Move	Any period the tracks are rolling.
Fell	Includes the positioning of the head around the standing tree (begins when the tracks stops), the felling that begins when the chainsaw starts advancing to when the tree starts to fall and the head is horizontal ready to process the tree.
Process	Begins when the head is horizontal and includes the delimbing and debarking (tree is being fed through the delimbing knives) and the crosscut (time when the saw is cross-cutting the logs). Ends when the last assortment has been processed.
Other	Any other productive time (e.g., removing of obstacles, stacking logs).
Delays	Non productive time including mechanical, operational and personal delays.

Productive time was separated from delay time (Björheden et al. 1995). This study was too short for having a solid estimate of non productive time, we used a delay coefficient obtained from long-term studies and we applied a 0.208 delay factor (Spinelli and Visser 2008).

A Waratah HTH616C harvesting head mounted on a tracked Sumitomo SH210 Excavator (fig. 2) was used for the felling and processing - including delimbing, debarking and cross-cutting. Each stem was first delimbed and debarked and then cross-cut by a second pass through the head.

Figure 2 - Excavator Sumitomo equipped with Waratah head

Data were analysed with regression techniques in order to check the statistical significance of any eventual differences between treatments.

A balanced dataset with the same diameter distribution for the two treatments was produced by randomly selecting double stem observations from the larger double stem data pool so that for each diameter class there was the same number of single- and double stems. Supernumerary observations were removed before analysis.

This dataset was checked for linearity, normality and equality of variance. Non-linear data were linearized through appropriate transformations before analysis.

Results

Most of the work time was dedicated to the felling and processing of the stems (fig. 3) and the numbers were very similar for both treatments. Processing included also delimbing, debarking and merchandising.

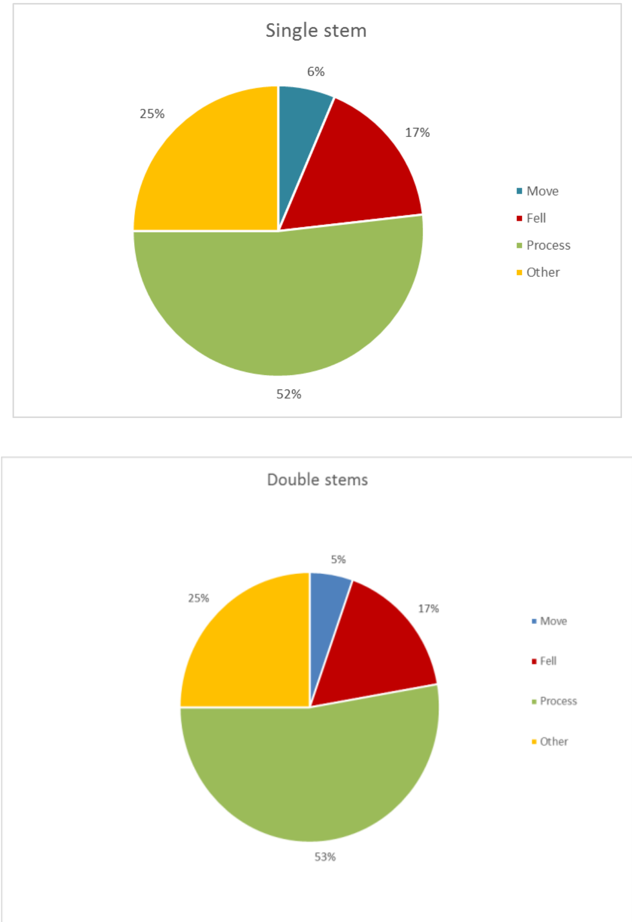

Figure 3 – % of net worktime by activity type and treatment (single and double stems)

The mean harvester productivity was 24.8 m^3 per productive machine hour (PMH), or 20.5 m^3 per scheduled machine hour (SMH).

As predicted, stem size had a strong effect on felling, processing and harvesting time but not on moving time or other work time.

Single or double stems had a statistically significant effect on processing and harvesting time, but no effect on felling time.

Harvesting double stems instead of single stems determined a productivity loss between 2 and 9 %, depending on stem size.

Conclusions

Productivity was influenced by tree size and stool crowding (e.g. one or two stems per stool) and the effect of stem size was much greater than that of stool crowding.

Because of the stool crowding, harvester operator could be obliged to increase cutting height, leaving taller stumps. This aspect was not investigated during the current study but it should be consider.

These results can help the plantation managers to decide about the benefits of coppicing and of coppice stool reduction. In general, the direct cost derived from harvester production losses is moderate, which may support coppicing and the stool reduction strategy.

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Below is a picture of the research team. I would like to thank all of them: this research was successful thanks of their effort and assistance, which they always offered with a smile and a most positive attitude.