STSM Report on

The mechanised harvesting of short-rotation coppices

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1. Introduction

The original aim of this STSM was to focus very specifically on harvesting operations of short-rotation coppices in northern Italy and to collect efficiency and productivity data on the mechanised harvesting machines. Further, it was also aimed at to collect enough information to relate the machines' efficiency and productivity to the standing biomass at the moment of harvesting. The executed work plan deviated from the original work plan proposed in the application: the focus remained on harvesting of SRC, but also extended to all other steps described below. The reason for this was the last minute application, which was based on a preliminary agenda. This agenda could not be executed as not all meetings were confirmed by the time of application and couldn't get confirmed in the end. Furthermore, several harvesting trials could not be monitored because they were not executed at the time of this STSM. Seen the short time between application and execution of this STSM, we were not able to inform the Eurocoppice STSM coordinator (P. Kofman) on the changes made to the original plan, but the local host institution (Dr. R. Spinelli) and the home institution (Prof. Dr. R. Ceulemans) were aware of all changes made at all times between the application for this STSM and the end of this STSM.

2. From poplar breeding to energy production

The aim of this STSM was to gain better insight in the marketing of poplar biomass for heat and or electricity generation. To accomplish this, several stakeholders at every step of the value chain have been visited. In northern Italy the complete value chain of poplar is present and that makes it an excellent study location (Casisi et al., 2015; Gonzalez-Garcia, 2012; Manzone et al., 2014). This study consisted of meetings with stakeholders in every step preceding the heat and/or electricity production with poplar biomass. This chain starts at breeding companies creating new varieties, sometimes specifically bred for short-rotation coppices (Dillen et al., 2011; Sixto et al., 2011). It continues with companies doing field trials to experiment with the best planting scheme, the most productive rotation cycle, management, species (Manzone et al., 2015) etc., as well as operational plantations. After that, harvesting and chipping manufacturers come in to collect the biomass in the field. Ultimately, the produced wood chips are burned in biomass-fuelled power plants to generate the heat and/or electricity that are then transported to surrounding villages (Panepinto et al., 2014; Torchio, 2015).

Poplar breeding

Two breeding centres/nurseries were visited: Allasia (aka Biopoplar) in Cavallermaggiore (CN) and CREA in Casale Monferrato (AL). Both companies were visited on different days, and yielded a lot of information on the breeding process of poplar (and trees in general) due to the personal contact with very experienced breeders. The visits also included site visits to experimental plots with a multitude of different clones being planted for further selection on basis of desired characteristics. It was clear from these visits that the selection process starts with several hundred trees to end up with only a few which can then be commercialised if they proof to be "better" than the already existing clones. Although biomass production is not prioritized as a trait for new clones, it is still very interesting visiting these centres to learn more about how the variance in clones comes to existence.

These companies also include clones bred at other institutes. The purpose of this exchange of planting material is to test all the clones in different environments, in order to assess their potential over a broad range of environments. It was surprising for me to find Belgian clones from INBO planted in Italian fields and it was very interesting to see their different growing habitat due to the differences in soil, climate and management.

Lastly, these companies also maintain nurseries for the production of cuttings of many different (commercially available) clones, used for establishing new plantations. These plants are maintained with specific cutting heights and rotation lengths, as to have as many possible cuttings available at all times. Both Allasia and CREA maintain several of these fields, both of their own clones and clones produced by other breeding institutes.

Experimental and operational plantations

A lot of research is being conducted towards the best planting method, plantation design, plantation management and species for biomass production in Northern Italy. Several companies involved in these types of research were visited, like Veneta Mais in Musile di Piave (VE), Powercrops in Russi (RA), CRIBE (Interuniversity research centre on energy biomass) in Pisa (PI), Renova Energy in Sospiro (CR), Allasia and CREA. One aspect that is researched is the species best suitable for biomass production. This implicates off course that the environment is an unsurmountable variable: on good soils with a lot of water supplied throughout the growing season, poplar is preferred by all researchers. The yields are unmatched, the plants are easy to harvest and handle and the growers are familiar with its cultivation. Little research is conducted towards willow and eucalyptus in this region because it lacks tradition and /or the wood is too difficult to process. Black locust (*Robinia pseucoacacia*) is considered a good alternative for poplar when soils are poor, when the climate is dry, or in steep areas. In these areas and conditions the yield of black locust is higher and plants are less prone to mortality. A problem with black locust however, is the high amount of root outgrowth between the rows, complicating harvesting operations. A lot of research is however conducted on non-woody biomass species like *Miscanthus* and *Arundo donax*. These species seem very interesting in terms of management, yield and fuel quality, but are however little established.

Figure 1. Experimental plantation with two year old black locust in Italy.

Further research is done towards the planting density and its interaction with species and rotation length. All plantations visited were single rows, as this is most convenient for the available harvest machinery. With short rotation coppices (SRC), harvest cycles of two or three years are considered (up to a total plantation age of twelve years) and the planting density is at its highest (5000-8000 plants ha^{-1}). At medium rotation coppices (MRC), harvest cycles are typically five years, with similar plantation lifetimes and lower planting densities. Lastly, medium rotation forestry (MRF) consists of rotation lengths up to ten years, has the lowest planting densities, and is the most traditional management scheme of poplar in Northern Italy. The lower part of MRF stands typically yields high-quality wood for timber, paper or veneer production, while the crown part is used for wood chip production.

Plantation management usually depends a lot on local climatic conditions. The highest yielding plantation was also the most intensively managed one: yields comparable to ten year old plantations were reached after eight years, but this required heavy irrigation and fertilisation. The University of Pisa is conducting a lot of research on the irrigation need of poplar and found that it is very beneficial to fight mortality in the two first rotations. In the consecutive rotations, irrigation gets less important for preventing mortality, but it will nevertheless increase yields. CREA on the other hand found that irrigation remains important throughout the lifetime of a plantation and that fertilisation is always beneficial for yields. Both research institutes agree however, that the cost of irrigation seldom assures the higher yields necessary to recover investment costs. Irrigation is therefore only recommended when the fields can be flooded and when there’s no need for investment in e.g. a drip irrigation system.

Figure 2. The Veneta Mais coppice header at work in a single stem, two year old short-rotation coppice in Musile di Piave (Italy).

Mechanisation

The harvesting of woody biomass is the most expensive and recurrent management action in the complete process of bioenergy production. Different machines have been developed specifically for harvesting SRC plantations. Veneta Mais and AgriAll have been visited, whereby the creation of such machines was explained and showed. Both companies produce a header for an agricultural tractor: Veneta Mais for the Claas Jaguar and AgriAll for the Krone. Next to this, there has also been a showcase of a new planting machine for 1,80 m long rods, developed by Allasia. Finally, an extensive tour to the Pezzolato factory in Envie (CN) was made, where chippers of all sizes are made and developed. It was very intriguing to see how a complex, nicely painted chipper arises from custom made metal parts, made from raw steel products. The correlation between the studied machines' efficiency and productivity, and different plantation management regimes (planting density, rotation length, age) could not be tested in the field, as all machines were only monitored while harvesting one plantation.

At Veneta Mais, the cutter header BE2 (new price € 96.000) was showcased at a 2 ha single row plantation in its fourth rotation (every rotation was two years long). The header is custom made for a Claas Jaguar tractor (860, 880 or 890) and can typically only be used for stems that do not exceed 15cm in diameter. The company was not comfortable with sharing the price of the monitored harvest at this site, but normally charges € 25 ton_{DM}^{-1} (including max 30 km transport of the wood chips to a conversion plant).

At one of Allasia's experimental fields with five year old MRC, the harvest was intensively monitored (Annex 1). The field was established as a testing area for different genotypes, with 30 different mono-genotypic blocks of 20 stools each. The planting design was 2x3m, resulting in 1660 stools ha^{-1}. The trees were felled with a GMT035 (maximum harvestable diameter 35 cm), attached to a Komatsu PC110R (combined weight 10750 kg), which is one of the typical, light weight harvesters for MRC and MRF. Half of the field was completely chipped (treatment “biomass”), while the other half was partly preserved as logs and partly chipped (treatment “integrated”). Chipping was done with a new Pezzolato chipper (model *PTH 1400-820 ALLROAD; table 1*). The biomass stocking was inventoried by measuring stem diameters at breast height (DBH; 130 cm). The efficiency and productivity of the harvester and the chipper were timed during the entire time needed for harvesting the field (Table 2). The harvesting cost was not measured for this harvest, as Allasia used privately owned equipment and personnel, while the Pezzolato worked for free as a demonstration. The price paid by the conversion plant was € 50 per green ton of wood chips.

Table 1. Technical details of the PTH 1400-820 ALLROAD pezzolato chipper

Diesel engine power	Hp/kW	551/405
Max chipping diameter soft wood	mm	600
Max chipping diameter hard wood	mm	560
Knives	nr.	5
Max inlet passage	mm	1400 x 600
Hourly throughoutput	m^3/h	120/140
Drum diameter	mm	820
Hopper width	mm	1330
Lower chain width	mm	1330
Feeding chain length	mm	1700
Hopper height from the ground	mm	1050
Dimensions (L x W x H)	mm	9500 x 2550 x 3400
Weight	kg	26000

Table 2. Average and total values per treatment at the Allasia field trial.

Treatment	Biomass	Integrated
Total nr. of trees	282	256
Average DBH (mm)	155	148
Average moisture content (%)	45.8	43.5
Total nr. of logs	NA	309
Harvest weight (kg)	38900	23640
Harvester working time (s)	5305	11091
Harvester delay time (s)	297	1633
Total harvesting time (s)	5602	12724
Chipping time (s)	5428	3257

Figure 3. Harvesting trial at Allasia with the GMT035 forest harvester. Left: stems harvested for complete chipping. Right: stems harvested partially for logs and partially for chipping

Biomass conversion

The last step in the market chain of biomass is the conversion of the produced wood chips into electricity and/or heat. Small conversion plants tend to produce only heat for personal use, like the installations at CREA and Pezzolato, while the bigger plants produce both heat and electricity, like Rinnova Energy, Allasia and Zignago Power (Figure 4). It was interesting to learn how they store and treat their stock of wood chips and how they get converted. I was impressed by the number of times that the energy got exchanged between different media like air, diathermic and siliconic oil. From there steam is produced that then drives a turbine and so forth…

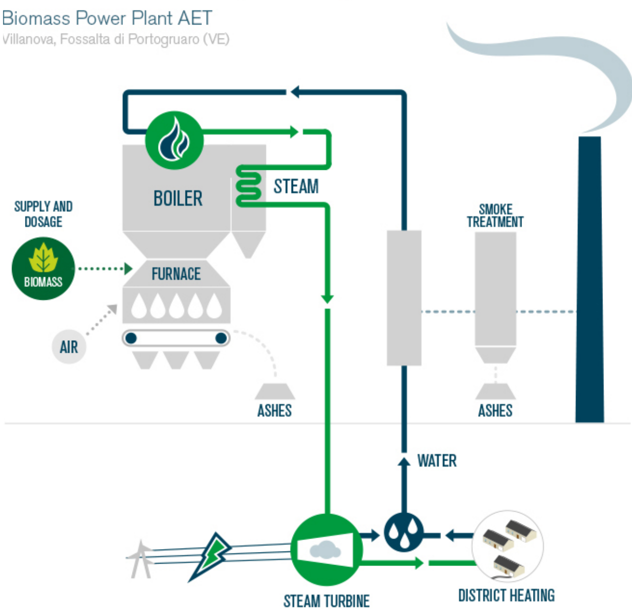

Figure 4. Overview of the Zignago Power conversion plant. (Adopted from www.zignagopower.com/en/impatto-ambientale

3. Acknowledgements

In conclusion I would like to thank COST action FP1301 very much for granting me the opportunity to study this working industry. Before this journey I was rather pessimistic about the growth of this industry in Belgium and I didn't completely understand how it could ever be made profitable. Now I have a much better idea about the dynamics playing between the different players and the things needed to make it work. I would also like to express my sincere gratitude to Dr. Raffaele Spinelli for organising an amazing agenda with a very diverse content and with only interesting stakeholders. His company and experience were of paramount importance during the conducted field work, as were his networking skills to get the permission to conduct it.

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