Developing of a New System for Short Rotation Forestry Harvesting

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ABSTRACT

During these last years we are watching a deep, structural change of the "most traditional" agricultural sector. Let's think, for example, about the OCM tobacco or about the OCM sugar which foresee the reorganization of whole productive areas and of various industrial installations. Only in the Italian region, Emilia-Romagna, within the plan of reorganization of the saccariferous, sugar beet chain, they expect the realization of a bio-mass power plant of an installed power of 30 MWe, with a catchment area of about 9000 and invested a SRF. The purpose of this work is to supply scientific, technical support for the realization of operating machines. The developed prototype can cut down the trees and put them in windrows parallel to the rows of the installation for a following chopping by choppers provided with a pick-up. The developed methodology allows to obtain a product with a lower level of humidity, so reducing the fermentative cases which were registered during the storage, to protract the harvest time of the product and to reduce the consolidation of the soil due to the passage of the picker. The prototype is a semitowed machine which can be put in front of a tractor of the minimum power of 90 kW or at the back of a tractor of the same power but provided with a reversible guide linked up to the PTO. The natural process of product dehydration put in windrows with regard to the interaction of the various factors affecting the process itself, the performance of the choppers provided with a pick-up harvesting the windrows, are reported.

Keywords: Chopped product, mower cum chopper and loader, Italy.

1. INTRODUCTION

Poplar cultivation, growth as SRF, has gained importance in recent years. The most suitable unit to harvest this crop seems to be the self-propelled Class Jaguar machine or the Spapperi machine; both of them work by harvesting and chopping in a single passage. Despite several advantages of this technique, some negative aspects may be encountered. One possible solution may involve cutting and chipping in two different phases.

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For products with a lower moisture content, it is necessary to reduce fermentation during storage. It is also necessary to increase the harvesting window as well as to reduce the soil compaction, due to the harvester's passage on the ground.
According to this technique, already in use by CRA-ING (CRA-ING patent, 2002), plants are cut down and felled at 90° with respect to the forward movement of the tractor. This allows for subsequent orderly piling of plants on the field edge where, once dried, they can be chipped (Pari, 1999).
In contrast to the harvesting technique based on the single passage system mentioned above, a new kind of unit has been developed by the F.lli Mantovani Society in Bovolone (VR). The new machine was designed to cut plants and subsequently place them on windrows in a manner parallel to the transplant rows. The machine is then used to chip plants, in combination with a chipper machine equipped with a pick-up. CRA-ING has conducted the basic tests during the SRF (R2S2 Root 2 years and Stalk 2 years) poplar cultivation period, under the supervision of the Sadam–Eridania Society in the nearby district of Granarolo Faentino (RA).

2. MATERIALS

2.1 The Harvesting Machine

The unit used for poplar cultivation is composed of a tractor and a cutting aligner machine from the Mantovani Society. The added tractor is a FENDT Farmer 412 Vario 4040 with a power of 94 kW, overall mass of 5240 kg, 540/65 R24 front tires and 600/65 R38 rear tires.

2.1.1 The SRF cutting-aligner Mantovani Machine

This model of the newly cut and aligned SFR machine is called the Mantovani cutting-aligner machine (table 1).

Table 1. Technical data of the machine

Cutting-aligner machine		
Side play at work	m	3,6
Side play during transporting	m	2,55
Height	m	2,8
Length	m	1,9
Total mass	kg	1700
Pneumatics		205/65/15
Cutting		
Diameter of the circular blade	mm	800
Thickness of the circular blade	mm	10
Tooth	N°	80
Rotation speed	rpm	700-1000
Minimal cutting height	mm	50
Conveyor and transport		
Scrolls	N°	4
Length of the conveyor scroll	m	0,6
Length of the transport scroll	m	2
Rotation speed of the scrolls	rpm	300
Scrolls height from the base of the machine	m	2

The developed prototype is a model that can cut plants and align them between rows; this is a semi-towed harvester that can be combined with a preceding tractor at a minimum power of 90 Kw (Fig. 1) or added to the rear part of a tractor of equal power with reversible drive.


Figure 1. Mantovani cutting-aligner machine during poplar harvesting

The machine has an overall mass of 1700 kg and outside side-play of 3600 mm, and it mounts, on a power loom made of section bars, a set of cutting devices as well as a set of conveyor and transporting plants devices. The machine has also mechanical parts that are used to orient plants toward the inter-row (Fig. 2, particular a, b, c).

Figure 2. Specifications of the cutting (a), conveyor (b), and transporting of the machine (c)

The cutting system is made of a blade of the diameter and width of 800 mm and 10 mm, respectively. The blade comes its motion from the power of the tractor through a referral which multiplies the number of turns so that the blade can operate at 700-1000 rpm. The cutting height can vary, depending on the vertical wheels placement that support the machine.
The conveyor system comprises a screw positioned in a horizontal and parallel fashion with respect to the forward movement of the machine, a section bar on the side (which can vary in height and length) and a device star-shaped. While the screw and the section bar devices gather plants to the transport device, the device star-shaped facilitates entrance of the plants into the transport system, preventing possible flooding.
The transport system is formed by a pair of counter-rotating scrolls, which are screw-shaped and orthogonal in relation to the forward movement of the machine. These are placed at a height of 2

m, while a scroll and parallel spacer bar are placed at the baseline. According to this method, the cut plants, still standing, can be shifted by a distance of up to 2 m. Thus, the plant's baseline will come into contact with the soil, whereas the machine advances while connected to a side support that helps to adapt plants to the inter row, placing them parallel to one other (Fig. 3). The screws/scrolls move throughout the hydraulic system, allowing the machine to regulate rotation speed according to the particular cultivation characteristics.

Figure 3. Plants felled and positioned in windrows parallel to the direction of the machine

2.2 Fields

The harvesting trials were carried out in March 2008 at the experimental fields of the Sadam Eridania in the district of Granarolo Faentino (RA).

The experimental planting (Fig. 4) was 2 years growth (realized in March 2006) and had never been harvested (R2S2); it was formed from different cutting clones obtained from the Alasia Franco firm at the Alasia Plant and from Experimental Poplar Institute.

Figure 4. Single rows of two years roots and two years stalks planting made up of different clones of poplar

Field surveys have reported the average distance among rows to be between 2.82 m and 0.52 m, with 7436 plants/ha. The percentage of leaks is estimated to be 0.87% on average.

The rectangular-shaped and level field expanded over a total area of 1.12 ha (net area 0.92 ha) and comprised 20 rows of 141.4 m average length.

3. METHODS

Tests on poplar cultivation have been carried out according to the technique published by the Aberdeen University Department of Forestry (Mitchell, et al 1997) in the "Guidelines to SRF harvesting tests". These trials have been conducted both before and after the harvesting process in order to evaluate the outcome of machine use. Plant moisture content was calculated according to the standard methodology of the Specified Techniques of the Comitè Europeen de Normalisation (TS/CEN, 2006).
The starting point for our determination of working times was the standard methodology of the Commission Internationale de l'Organisation Scientifique du Travail en Agriculture (C.I.O.S.T.A.), with the help of the Italian Association of Genio Rurale (A.I.G.R.) 3^{A} R1 software was used to record important times with respect to harvesting operations and subsequent development. Damage to the ground, cutting height, stump damage and product losses were analysed in order to evaluate the quality of the work in relation to the characteristics of this machine.

4. RESULTS

4.1 Morphological and Productive characteristics of Poplar Cultivation

Plants seemed to be in good health, without many weeds. The height and average diameter of plants were 8.03 m and 64.7 mm, respectively, whereas the maximum transplant diameter was 110 mm. The data collected allowed us to confirm that poplar cultivation had not suffered previous felling; there was a stem for each stump.

4.2 Working times

Table 2 displays the working times calculated during the cutting and alignment testing. Only operational times were measured because the machine had already been prompted on the ground during the test performance. The accessory times, totally formed by times for turns, resulted to be 20.62% partly due to the difficulty of managing small turn dimensions and the maintenance times, 11.45%, due to feeding system flooding. The operational performance was equal to 67.93% with respect to the operating time. The machine worked at a speed of 0.60 m/s (2.17 km/h), reaching operational work capacities of 0.565 ha/h. Because cut production was 55 t/ha, hourly performance was 31.03 t/h.

Table 2. Working times and productivity of the machine

Operating time	Effective time	%	67,93
	Time for turns	%	20,62
	Time for supplying or unloading	%	0
	Maintenance time	%	11,45
	Accessory time	%	32,07
Performance of the machine	Operative yielding	%	67,93
	Effective speed	m/s	0,89
	Operative speed	m/s	0,60
	Effective working capacity	ha/h	0,83
	Operative working capacity	ha/h	0,565
	Hourly operative production	t/h	31,03

4.3 Quality of the work

Product losses consist of small-dimension stems (0.8 t/ha) and lateral branches (0.5 t/ha).
Overall losses were 2.36 % of the cut and swath/windrow product. Production can be harvested, including 56.45 t/ha (28.22 t/ha/year) of lost product, corresponding to 26.53 t/ha of dry matter (13.26 t dm./ha/year).
To this end, analysis results have highlighted an average moisture value of 53% for the break-down/felling of plants.
The average height of the cut seems to be 110 mm, except for plants on the first part of each row, for which the cut is 200 mm. In the last case, the plants received a start-up cut from the partly mechanical lift plate/disk, due to limited machine movement at the turning point.
Regarding cut quality, 2.72% of sampled stumps displayed irrelevant vertical cracks; 3.80% of the stumps exhibited no account flaking, and only 0.54% demonstrated middle to high levels of flaking. In all, 92.39% of stumps had not suffered any damage.
The damage on the ground involved irrelevant soil compaction due to the presence of furrows with an average depth of 15 mm in the path travelled by the unit (i.e., the tractor in combination with cutting aligner machine).

5. CONCLUSIONS

According to the start-up tests, the prototype described above performed well during the poplar-cutting and windrowing stage; whether performance could be further improved by reducing flooding in the machine may be studied in the future.
These studies confirmed the feasibility of cutting plants and putting them in windrows at the centre of the poplar row.
In the future, it will be important to evaluate the natural process of dehydration in the products placed in windrows, in relationship to the various factors affecting the process itself (climatic factors, period of year, soil moisture, presence of weeds, etc.); to verify the performance of the chopper provided with a harvest pick-up during harvesting and when the windrowed product was chipped.
In conclusion, the improvement of this system could facilitate improved agro-energetic chain handling by relying on a wider harvest gap in order to encourage product dehydration on the ground and to reduce storage and soil compaction problems.

6. REFERENCES

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