**Translation of "Supplemento a l' Informatore Agrario – 33/2009" - Italy**

Biomasses

- Pruning picker –up shredder's economical and technical efficiency.

## Hazelnut pruning residues harvested by Comby TR 160.

To increase the value of the chopped product, it must be destined to the compost production or, advised solution, used like fuel to produce thermal energy in small- medium heating systems.

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The biomass obtained like waste material of the agricultural sector can assume a roll which goes beyond the simple operation of ground cleaning. The use of pruning residues, mainly for energetic aims, favours an action of sustainable recovery in environmental, agronomic and economic terms of energy, which is lost forever with material cremation practice near the orchard. In this way it is possible to value the waste like fuel with high energetic content, ideal to produce thermal energy in small heaters and also thermoelectric energy in transformation implants of higher power. In fact, during these last years, the energetic re-use of residual biomasses from agricultural activities is a practice which is diffusing always more.

The international and national energetic sceneries are characterized by an increasing demand of energy and the need to produce it, recurring to renewable sources of energy, makes the energetic recovering one of the compulsory road to go along to face the always increasing energetic request. In National level (Italy) the pruning residues estimate is totally calculated in 6 millions of tons, obtained on an agricultural surface used as woody cultivation for fruit (vine, olive tree, apple tree, pear-tree, peach-tree, citrus trees, almonds tree, hazel) of about 2,7 millions of hectares, equal to 2,2 t/ha per year of wooden cellulose residues (Istat, 2002; Cotana and Costarelli, 2005; Monarca et al., 2007; Nati et al., 2007). Our country's recent legislative measures, in fact, provide for a bigger valorisation also of these agricultural sources, with production promotion of electric energy based on the employment of bio fuels.

In this ambit the use of the Pruning picker –up shredder Comby TR160 can be valued. This is a machine produced by FACMA in Vitorchiano ( VT). It is able to gather the pruning residues, placed in regular windrows and to carve them for a subsequent energetic valorization. We explain the experimental proof results. It took place in a young hazelnut orchard (12 years) (figure 1), nearby the agricultural firm Le Pigne in locality San Marco di Teano (Caserta). This activity co-ordinated by the "*Unità di ricerca per l'ingegneria agraria del Consiglio per la ricerca e la sperimentazione in agricoltura (CRA-ING)",* falls within the Frumed project for the fruit growing value in southern areas, funds by the "*Ministero delle politiche agricole, alimentari e forestali".*

## The machine and the work yard.

The machine is a trailed Pruning picker –up shredder (photo 1). The minimal power requested is 40kW, but it is advisable, to grant an optimal functioning, the employment of a tractor with a power included between 50 and 60 kW. The machine is composed by 5 functional elements:

- A pick-up system placed in the front of the machine, able to pick –up from the ground the chopped-off branches to convey them towards the trituration system. The organ is composed by a horizontal shaft with vertical teeth, with opposite rotation in respect to the direction way to favour the pruning harvest from the ground (photo 2).
- An organ placed to triturate the chopped-off branches, composed by a rotor and a horizontal axle above which are hinged oscillating hammers with sharp board. This system permits to triturate chopped-off branches with a maximum diameter of 80 mm (photo 3).
- A metallic grill placed between the rotor and the trailer. The dimensions of the shred materials depend on the metallic grill, which can be replaced depending on the size that you want to obtain;
- A dump trailer in which the product is conveyed, with net capacity of 3,28 $m^3$, length of 2,24 m, width of 1,60 m and maximum height of 0,97 m .
- A trolley with an axle and two free wheels, endowed with a metallic loom with a pantograph raising which permits to download the trailer at a maximum useful height of 2,60 m.

All the mechanical organs in rotation are powered by the tractor power take off, while the trailer raising and the dump have a hydraulic functioning. The machine is endowed with a shaft for the linkage to the tractor rear shifting hook. The total length is 4,87 m, the height is 2,00 m and the width is 1,83m.

The work yard is composed by the machine, a tractor and a driver. During the proof an old tractor with 50 kW of power has been used. The machine once placed on the windrow, starts to gather the chopped-off branches from the ground thanks to the pick-up system, which conveys them directly through the crusher . The crushed material is forcedly pushed trough the grill in the internal part of the trailer. Once finished the gathering in the windrow, thanks to a manoeuvre at the end of the row, the machine is replaced and it proceeds in the opposite way and, once the container is full, the work is stopped to proceed with the material download at the field board.

## Economic and technical results.

The sampling effectuated on the sample areas before the harvesting have obtained a medium quantity of 11,57 kg of chopped-off branches per area.

The material dimensions characteristics are shown in the graphic 1. The typification in the different classes underlines that more than 70% in weight of the sample is included between 6,3 and 25 mm.

The work developed in the total proof surface involved the necessity to repeat for three times the transport and download operations at the field board. In total the machine produced 8,21 $m^3$ of crumbled product with 43% of dampness, for a total mass of 1,89 tons, equal to 1,43 tons/ha (*table 1*). The material left on the ground by the machine after the passage was on average 1,42 kg per surface, 58% of wood splinters and 41,5% of chopped-off branches entire parts. The harvesting loss was estimated at about 88 kg/ha corresponding to 5,79% of the total material gathered. The whole pruning remained on the ground is constituted by branches of excessive length. The work was executed with swiftness, making notice a gross work capacity of 1,15 ha/hour to harvest the biomass present in 13.260 $m^2$, corresponding to a gross time of 0,87 hours/ha (table2).

The graphic 2 shows the times division percentage of each working phase and it underlines the biggest employment of the machine in the harvest (47,53%), but it is important also the time spent for the transport and also to download the product (28,82%) in reference to a medium course of about 250 m.

The results of the unproductive times were about 14,5%, they must be attributed for the major part to the pick-up system stoppage caused by the excessive quantity of chopped-off branches, which forced the operator to effect small operations of rear gear. The economic valuation

of the work yard is based on the costs analysis of the machines and manpower employed, the basic elements considered for the calculation are mentioned in the *table 3*. The elaboration final results with the determination of the operation costs per hectare and per product unit are mentioned in the *table 4*.

## Conclusions

The results obtained in the experimentation show that the machine is valid and able to carry out the work easily. The productivity obtained permits to take away in less than 1 hour the biomass of the pruning present in a surface of 1 hectare. The operation cost, about 38 euro/ha, is quite reasonable and also the cost per unit of chopped product, equal to 26euro/t, results competitive. This material, to be better valued, should be destined to the compost production or, other advised solution, it should be used like fuel in the production of thermal energy in small-medium heating systems. The product, even if it appears homogeneous, because of the reduced diametric dimensions of the chopped-off branches, often presents sizes in longitudinal sense superior to 120-150mm (*photo 4*), this characteristic could create blockage problems when they are used in biomass centrals based on a system of Archimedean's screw feed. This problem can be easily get over, adopting convey systems of fuel based on movable elements, which can push the pruning residues and are relatively indifferent to the typology and dimensions of the material.

Considering the quantity of the work developed, in the specific case of hazelnuts, it must be underlined that the material lost in the field could represent a problem in the next phase of mechanical harvesting of the fruit. In fact, the residual woody chips would be harvested with the hazelnuts, increasing the costs for the following cleaning of the fruit. This problem can be solved, effecting the traditional shredding of the grass. In the exam of the working times it was noticed a high value of unproductiveness of the machine which could be considerably reduced, forming more regulars windrows and with a width inferior to the machine front work.

Table 1

The results of the relieves on the sample areas before the harvest.

| | Values |
|---|---|
| Wood splinters production ($m^3$) | 8,21 |
| Volume medium mass ($kg/m^3$) | 230,55 |
| Wood splinters production in weight (t) | 1,89 |
| Wood splinters production per hectare (t/ha) | 1,43 |
| Wood splinters dampness ( %) | 43 |
| Anhydrous production (kg s.s./ha) | 810 |
| Harvesting loss (kg/ha) | 88 |
| Total production (kg/ha) | 1.520 |
| Loss incidence (%) | 5,79 |

The entire pruning remained on the ground is constituted by branches of excessive length.

Table 2

| Times and capacity of the machine work | |
|---|---|
| | Values |
| Effective time (hours/ha) | 0,41 |
| Operating time (hours/ha) | 0,74 |
| Unproductive time (hours/ha) | 0,13 |
| Gross time (hours/ha) | 0,87 |
| Effective speed (hours/ha) | 2,69 |
| Operating speed (hours/ha) | 1,50 |
| Gross speed (hours/ha) | 1,28 |
| Effective capacity (hours/ha) | 2,42 |
| Operating capacity (hours/ha) | 1,35 |
| Gross capacity (hours/ha) | 1,15 |

The work was executed with swiftness , making notice a gross work capacity of 1,15 ha/hour to harvest the biomass present in 13.260 m².

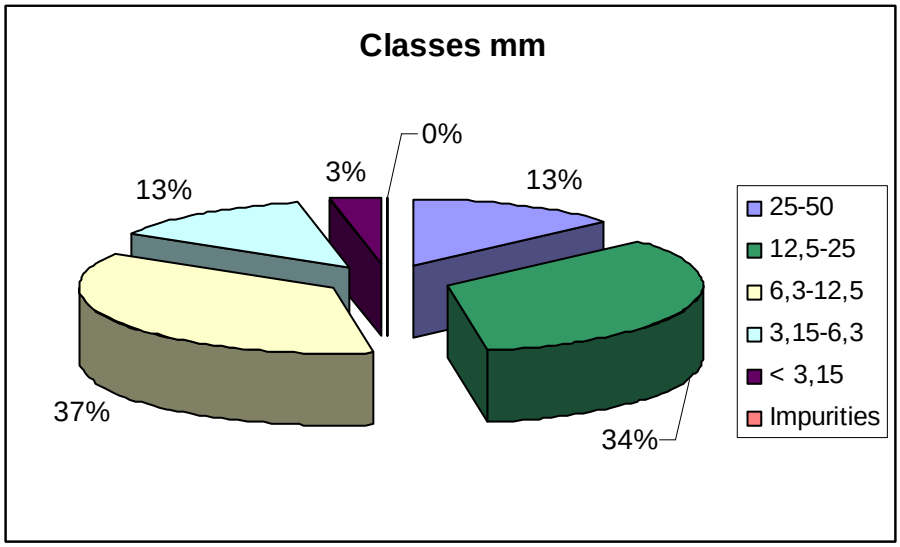
Table 3

| Principal technical and economic elements of the work yard and relative operational cost | | |
|---|---|---|
| | Fiat DT 76-86 | FACMA Comby TR 160 |
| Value of the new machine (euro) | 20.000 | 15.500 |
| Recovery value (euro) | 2.150 | 1.660 |
| Useful life (years) | 10 | 10 |
| Employment per year (hours) | 1.000 | 300 |
| Nominal power (kW) | 50 | - |
| Interest rate (%) | 6,0 | 6,0 |
| Fuel consumption (L/hours) | 8,56 | - |
| Fuel facilitate cost (euro/L) | 0,77 | - |
| Machine cost (euro/hour) | 16,60 | 13,40 |
| Driver cost (euro/hour) | 13,50 | - |
| Operating cost per hour (euro/hour) | 30,10 | 13,40 |
| Hourly cost of the work yard (euro/hour) | 43,50 | |

Table 4

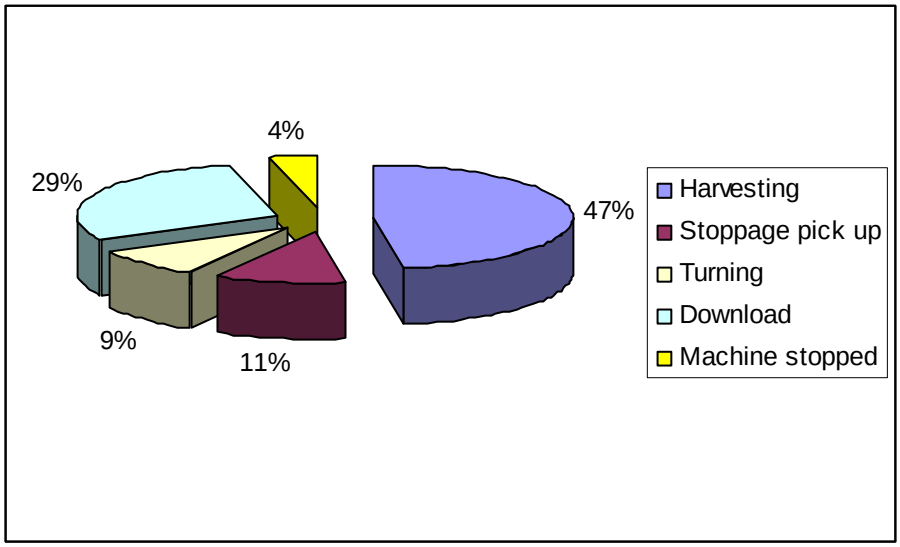
| Work productivity and work yard costs | |
|---|---|
| | Value |
| Gross productivity in volume (m³/hour) | 7,13 |
| Gross productivity in weight (t/hour) | 1,64 |
| Work yard costs (euro/hour) | 43,50 |
| Cost per ton (euro/t) | 26,47 |
| Cost per hectare (euro/ ha) | 37,79 |

The operation cost 37,79 euro/ha is quite reasonable and also the cost per unit of chopped product, equal to 26euro/t, resulted competitive.




**Graphic1**: **(%) break down of the material chopped in the different dimensional classes.**

More than the 70% in weight of the sample is included between 6,3 and 25mm.




**Graphic 2**: (%) **break down of the work yard phases.**

The unproductive times resulted of about 14,5%, it must be attributed for the major part to the pick-up system stoppage.

Photo1: Trailed machine Comby Tr 160 at work
Photo2: Front pick up system of the machine
Photo3: The hammer of the trituration system of the machine
Photo4: Chopped material with longitudinal dimensions often superior to 120- 150mm.
Figure 1: scheme of the hazelnut orchard with the sample area marked

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The authors thank FACMA which furnished the machines and Francesco Palmiero owner of the agricultural firm Le Pigne to offer the hazelnuts orchard object of the proves.