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LOGISTICS SYSTEM FOR THE PROCESSING OF BIOMASS RESULTING FROM PRUNING THE VINE IN THE MURFATLAR VINEYARD

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Abstract: In the technological process of maintaining grapevine plantations, an important role is played by the winter pruning processes that are carried out during the vegetative rest period. As a result, a large amount of biomass that can be exploited by winegrowers can be used to obtain industrial bio–fuel or used as a source of energy in its own regime to reduce heating costs in the cold season. The experiment was carried out on four varieties of economic interest from the Murfatlar vineyard: Fetească neagra, Cabernet Sauvignon, Sauvignon blanc and Fetească regală. Several factors were analyzed: the average biomass removed from 30 vines of each variety, the method of biomass harvesting, the time and fuel consumption per hectare, the average weight of the biomass before and after drying and the total mass obtained after drying for each variety. The results showed weight differences between varieties. For the Fetească neagra variety, the weight at the time of collection was 645.84 kg/ha, for the Fetească regală variety, the weight reached 155.16 kg/ha. In the conventional way, the fuel consumption following the wood material collection operations reached 11.6 liters per hectare, while, through the baling and transport process, the consumption was 8.3 L/ha, registering a difference of 3.3 L/ha. After storage and drying, differences in moisture loss were recorded, thus in Fetească neagră the moisture decreased by a percentage of 24.573%, and in Fetească regală which recorded a loss of 33.657% of the initial weight. The average collection time was 2 hours and 24 minutes per hectare and did not show significant differences between varieties because the slope and elevation are the same for all the varieties examined.
Keywords: canes, baling, energy output, biofuel

1. INTRODUCTION

The world nations are faced with the challenge of achieving significant increases in renewable energy. In Europe, this requirement started the development of effective methods of support and strategies. An increase in energy production is necessary for the reduction of emissions and other objectives such as those related to the security of energy supply (European Parliament DIRECTIVE 2009/28/EC). Achieving a fifth of optimal production requires significant investment in renewable resources. Annual estimates of renewable energy production support would be 60 – 70 billion euros, compared to current investments of 20 million euros (*De Jager et al., 2011 and Ragwitz et al. 2011*).

In the context of the global transition to renewable energy, to the detriment of fossil resources, biomass represents an inexhaustible energy resource. Biomass is defined as non–fossilized organic matter formed as a result of biological processes (*Velazquez–Martı et. al., 2006*). This type of residues can bring important benefits, including reducing greenhouse emissions, increasing energy efficiency or lowering the price of raw materials for biofuel production (*Pari et al., 2014; Neri et. al, 2016*)

At the global level, biomass is a source of carbon and can be used as a raw material in several industries. In the Romanian agricultural area, an average of the resulting biomass is estimated at approximately 442,847 t/year. In the viticulture field, woody residues produce significant amounts of biomass in the form of canes resulted from winter pruning operations carried out on vines in Romanian vineyards, with estimated amounts of 1.5 and 2.5 t/ha annually. (*Tenu et al., 2019*).

Most winegrowers tend to destroy biological material by burning or mulching without having a management plan for the resulting waste or methods for its recovery (*FAO, 1997*). At the same time, placing the canes, whole or chopped, on the interval between the rows of vines increases the danger of crop infestation and the number of phytosanitary treatments applied (*Duca et al., 2016*). Until now, the lack of economic interest in reusing the by–products resulting from a grapevine plantation for the purpose of obtaining bio–energy has led to the underdevelopment of this field due to the lack of information regarding qualitative and quantitative technical data. The trend of recent years has been to develop logistic exploitation systems to create the best alternative for bioenergy supply without reaching an optimal result (*Brozek et al., 2012*).

Among the major problems faced by this system are: the variety of viticultural exploitation conditions and the small surface areas and the high–cost technologies used. This study aims to develop and test a system for collecting, transporting, storing and drying biological viticultural material in order to obtain a by–product with the aim of using it as wood material in the composition of pellets, briquettes or as a thermal resource in its own location as a cost–reducing method, in the existing conditions of grapevine plantations of Romania.

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2. MATERIALS AND METHODS

The experiment was carried out in the vineyard area of the Research and Development Station for Viticulture and Enology Murfatlar in 2021, which has 183 ha of cultivated land. Four representative varieties for Romania were selected for the physico–chemical characteristics of the resulting wood, where the energy output of the material was taken into account and the vigor of the variety from which the amount of wood removed was estimated and the approximate amount of resulting biomass per hectare.

Thus, the selected varieties were: Fetească Neagră (Figure 1) – Old Romanian variety with very high growth vigor and short vegetation period that requires less fertile, calcareous soils and grafting on less vigorous rootstocks to reduce vegetative growth. It is a variety resistant to frost and drought and sensitive to Powdery Mildew and Downy Mildew; Cabernet Sauvignon (Figure 2) – Variety originating from the Bordeaux region, it was introduced to Romanian vineyards in the 20th century. This variety has a late ripening period. The buds have a medium–vigorous growth. Shoots are long with medium or short internodes.

The variety develops optimally in areas with a moderate climate. It is a frost–resistant variety and has a medium sensitivity to diseases; Sauvignon Blanc (Figure 3) – this variety for high–quality wines is a vigorous type with vertically directed shoots with short internodes. It has poor frost tolerance. It is a variety susceptible to Downy Mildew, Powdery Mildew and Grapevine Moth, and the fruit load varies between 14 and 16 buds. The variety is grown in 41 wine centers in Romania; Feteasca Regală (Figure 4) – variety created in Romania with medium growth vigor and high fertility, having a percentage of over 80% of fertile shoots, is sensitive to drought and has an average resistance against common diseases in this region.

Figure 1 – Fetească Neagră

Figure 2 – Cabernet Sauvignon

Figure 3 – Sauvignon Blanc

Figure 4 – Fetească Regală

The experiment started immediately after the end of the winter pruning stage of the vines in 2021. For each selected variety, plots with an area of 1 hectare were chosen, each with a slope of 2–3° and distance from the site of storage of biological material to each plot of approximately 200–300 m. Before starting the collection system testing, each selected variety was subjected to the winter pruning process. The pruning was made by hand using pruning shears. To increase efficiency, immediately after cutting, the canes were placed in the middle of the row to increase the effectiveness of biomass collection.

The experimental model was carried out based on the technical–economic context of the Murfatlar viticultural area and is applied to areas exceeding 10 hectares following the logistic technology of collection, transport, storage and drying of the biomass resulting from winter pruning from a vine plantation. In the logistical composition of the system, a 35 KW Goldoni RONIN 50 tractor was used, equiped with a 2800 rpm Lombardi engine, 2199 cm^3 cylinder capacity, EURO III air cooling, 8% power/torque reserve, all–wheel drive 4x4, 24–speed gearbox selective, 12+12 with reverser and "fast reverse" system, rear independent power take–off with 540/ 1000E rpm, hydraulic rear lifter with controlled position and force of 1600 kg, fuel tank capacity of 45 liters, weight of 1585 kg and maximum speed of 30 km/h.

For the biomass collection technology, it was decided to use a trailed vine baler that is used by pressing the recovered biomass into small round bales, with automatic unloading using sensors. The machine works in vineyards with a planting distance between 2 and 2.2 meters, a cross slope of up to 6° and processes bales with maximum dimensions of 60 cm x 90 cm x 50 cm (Figure 5). Bale retreval was done manually by collecting and transporting the bales at the end of the row. To transport the bales to the storage area, an

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8 m³ trailer was used, equipped with front and rear grids adapted for round bales to increase the storage space in the trailer. The storage area is a semi–open space with a roof that has a capacity of 2240 m³ and an aproximate deposit capacity of 8296 bales (Figure 6).

Figure 5 – Baling machine attached to tractor

Figure 6 – Semi–open storage area

A timer was used to measure the action time of the baler machinery for each variety tested. To measure the amount of fuel used, the tractor tank was filled to maximum capacity before the baling process started (Figure 7). Following the completion of baling the vine canes, the amount of fuel remaining was extracted and measured with a large capacity graduated cylinder. A graduated ruler was used to measure the dimensions of the bales, and a digital scale was used to measure the weight of the bales (Figure 8).

Figure 7 – Tractor fuel consumption monitoring

Figure 8 – Bale size measurements

3. RESULTS

The winter pruning takes place before the start of weeping, placing the procedure of baling the canes between the end of this stage and the beginning of the vegetation period of the vine. Differences were recorded between the 4 selected varieties in terms of tractor consumption; baling timing per hectare between the 4 plots and the number of resulting bales was dependent on the variety (Figure 9). Thus, for Fetească Neagra, the baling time per 1 hectare was 2 hours and 39 minutes, where a number of 69 bales resulted, while the fastest time was in the plot with the Sauvignon Blanc variety, meaning 2 hours and 9 minutes, where the number of bales was 35. For the Cabernet Sauvignon and Fetească Regală varieties, the resulting times were 2 hours and 36 minutes, respectively 2 hours and 12 minutes, and the amount of wood mass baled was 36 and 51 bales respectively.

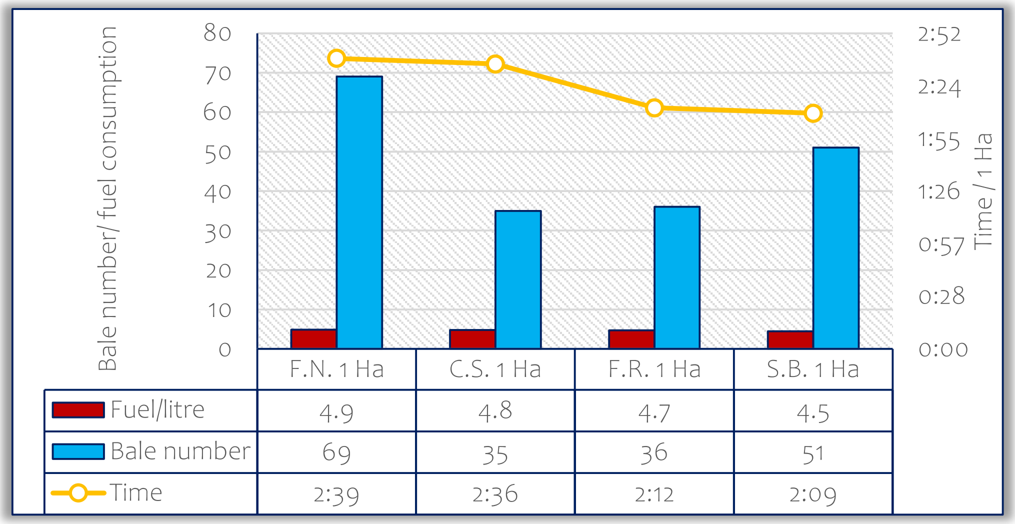

Figure 9 – Bales collected per variety, fuel consumption and time of baling per hectare

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The differences in time and number of bales was mainly influenced by the vigor of the exploited variety, so that the varieties with significant growth created difficulties for the machine due to the greater amount of the removed wood or the length, thickness and elasticity of the canes (Fig, 10).

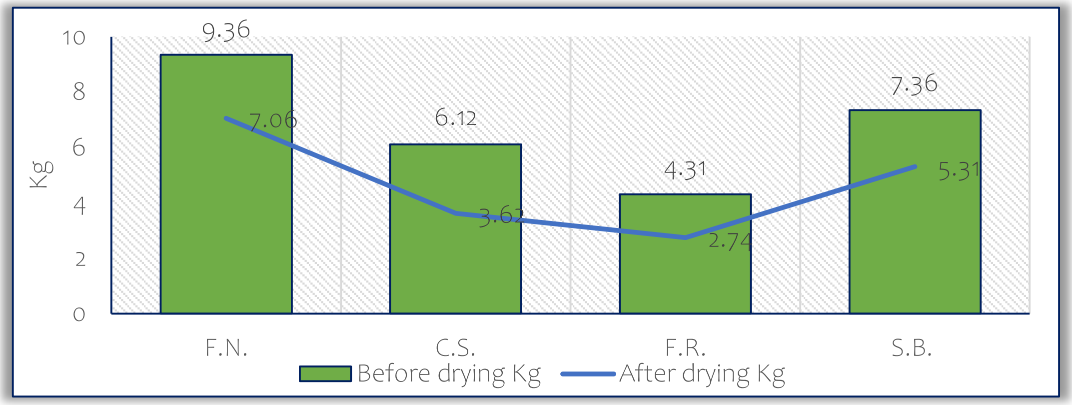

Figure 10 – Weighing of bales before and after drying process

This effect was also imposed on fuel consumption so that there were differences in the amount of fuel used per hectare, where in the plot of the Fetească Neagră variety, the tractor consumed 4.9 l/ha compared to 4.5 l/ha in the plot with the Sauvignon Blanc variety (Table 1).

Table 1. Comparison in consumption between baling and coventional way of collecting biomass

Conventional		Baling	
Biomass raking from row	3.6 l/ha	Fetească Neagră	4.3 l/ha
Biomass raking from alley	4.0 l/ha	Cabernet Sauvignon	4.8 l/ha
		Fetească Regală	4.2 l/ha
		Sauvignon Blanc	4.7 l/ha
Biomass dragging to the storage area	4.0 l/ha	Transport to storage area	3.8 l/ha
Total	11.6 l/ha	Total	8.3 l/ha

At the same time, the fuel consumption of the entire logistic chain for the baling of vine canes recorded an average consumption of 4.5 l/ha, to which is added the fuel used during transportation to the storage place, meaning 3.8 l/ha. Thus, a total consumption of 8.3 l/ha was recorded through the baling process with 3.3 l/ha lower than the conventional way of removing biomass (removal of biomass from the row and alley by raking; biomass transport by dragging at the storage place) which recorded a consumption of 11.6 l/ha.
After storage, the produced bales were weighed, thus the average weight of the bales resulting from the Fetească Neagra variety was 9.36 kg, and for the Cabernet Sauvignon, Fetească Regală and Sauvignon Blanc varieties, the average weight of the bales was 6.12 kg, 4.31 kg, respectively 7.36 kg, meaning an average of 4.68 kg per bale for all 4 analyzed varieties.

Table 2. Percentage of reduction in weight after biomass dry

Variety	Percentage
Fetească Neagră	24.573 %
Cabernet Sauvignon	40.850 %
Fetească Regală	33.657 %
Sauvignon Blanc	27.854 %
Total	31.7335 %

The woody mass of the vine accumulates amounts of water that represent 40–45% of the total weight of the canes, this biological character represents an impediment in the reuse of biomass to obtain thermal energy, thus it is necessary to implement a drying process. To reduce processing costs, the wood material was placed in a semi–open storage area to allow natural drying. The drying time lasted 5 months, starting in March and ended in August, where the highest temperatures of 2021 were recorded and allowed the wood to dry out. Thus, the weight per bale decreased by an average of 2.1 kg compared to the weight of 4.68 kg before drying process started (Table 2).
Regarding the amount of wood removed per hectare, the average amount reported before drying was 347.64 kg/ha. Following the drying process, the total weight of the biomass decreased, on average by 101.92 kg/ha, representing a percentage reduction of the total weight of 31.7335 % compared to the initial weight. The most amount of reduction in weight was observed at Cabernet Sauvignon variety with 40.850% and the least reduction in weight recorded was for the Fetească Neagră variety with 24.573 % (Figure 11).

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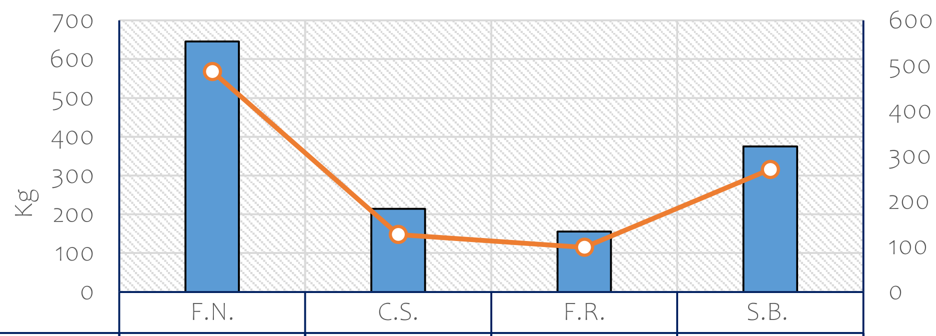

	F.N.	C.S.	F.R.	S.B.
Before drying Kg	645.84	214.2	155.16	375.36
After drying Kg	487.15	126.7	98.64	270.81

Figure 11 – Weighing of total eliminated biomass before and after drying process

4. CONCLUSIONS

The results obtained indicated beneficial effects for reducing the fuel used in the biomass collection and transport system compared to the classic and conventional system and recorded a decrease in consumption by 3.3 liters on average. The biomass exploitation and collection time recorded an average of 2 hours and 9 minutes per hectare, and the average number of bales was 47, differences being recorded between varieties due to their vigor and the amount of wood removed. The drying process of the wood material took place in a semi–open space over several months, where the weight of the bales decreased by 31.7335% of the initial weight. The resulting woody material produced average amounts of 245.8 kg/ha that can be used to reduce heating costs in the cold season or to form briquettes or pellets.

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