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Determination of fuel and power requirement of a branch shredder for different vineyard pruning wastes

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Abstract
The aim of the study was to determine the fuel consumption, torque and power requirement of a shredder machine used in the shredding of vineyard pruning wastes of different grape varieties. In the study, pruning wastes of Boğazkere, Öküzgözü and Şire grape cultivars, which are widely grown in Diyarbakır region, were used for tests. The experimens were carried out at three different rotation speeds of the engine (1500, 2000, 2500 rpm) and feeding rates (kg/h). Depending on these parameters fuel consumption, moment values and power were measured. The branch shredder machine has a 15 HP powerful. There are three chopper blades on the machine. The blades are driven by gasoline engine with the a belt and pulley system. According to obtained test results, per hour fuel consumption, power requirement and moment values increased for all three cultivars depending on the increase in the number of rotation of the blades, both at unloaded and under load. The highest fuel consumption was observed in Boğazkere cultivar, followed by Öküzgözü and Şire varieties, respectively. While the highest fuel consumption value was found as 1.535 kg/h in Boğazkere cultivar, the lowest value was obtained as 0.918 kg/h in Şire cultivar. A similar situation was obtained for power values. The power also increased with the increase in the number of blade revolutions While the highest power consumption value was obtained as 5.560 kW in Boğazkere cultivar, the lowest value was obtained as 3.326 kW in Şire cultivar. Here, there was no statistical difference between Boğazkere and Öküzgözü cultivars, but there was a significant difference between these cultivars and Şire cultivar. When the moment values of the cultivars were examined, the difference between cultivars was found to be very significant ($p<0.01$). The highest value was obtained as 26.26 Nm in Boğazkere variety, the variety with the highest Power and Fuel consumption value, while the lowest value was obtained as 15.65 Nm in Şire variety, which also had low fuel and power requirements.
Keywords: Shredder, Vineyard, Pruning waste, Fuel consumption, Power

INTRODUCTION

Viticulture is one of Turkey's most important agricultural activities. In the vineyard areas where grape cultivation is carried out, a large amount of pruning wastes occur after annual maintenance operations such as shoot pruning and training at different times. Failure to remove and evaluate the pruning wastes remaining in the vineyards creates major problems. This process is tiring, costly and time consuming. In addition, the energy requirement is high.

Vineyard pruning wastes are usually left in the vineyard and burned, or left on the walls forming the border of the vineyard and used for hedge purposes. This creates a basis for both environmental pollution and the formation and proliferation of diseases and pests. These problems require an effective solution. One of the solutions is to decompose the pruning wastes using any machine/equipment and to bring them into the soil as organic residue. Evaluation in this way is important in terms of preventing environmental pollution and reintroducing the wastes to the soil. Thus, it will be of great benefit both economically and in terms of the implementation of recycling activities in agriculture. At the same time, sustainability in agriculture will be achieved by re-evaluating the vine wastes ground in the branch shredder. As a result of the use of pruned branches as organic waste, the use of chemical fertilizers will also decrease.

In order to break up the pruning wastes in the vineyards and orchards and make them useful, machines driven by the tractor PTO in large areas and stationary branch shredders are used in small areas. Various studies are carried out on this subject. In the study of Çanakçı et al. (2018) developed a self-propelled shredding machine prototype that can be used to break down the wastes generated in horticultural activities and return them to the soil as organic matter. Similar studies were conducted by Dereli (2009), Şeflek et al. (2006), Recchia et al. (2009), Spinelli et al (2014), Adamchuk et al. (2016). Pavankumar et al. (2018) designed and manufactured a portable organic waste chopping machine that shreds grape vine and fruit tree pruning wastes in order to demonstrate the importance of organic fertilization. As a result of the experiments of the study, it was stated that the vineyard rods were broken down well with the machine manufactured and these wastes could be converted into organic fertilizers and that the fragmented wastes could be used as biogas and feed as well as meeting the fertilizer needs of the farmer. Similar studies were conducted by Sucipto ve ark. (2020) ve Spinelli ve ark. (2010). Spinelli et al. (2012), Bilandzija et al. (2012), Magagnotti et al (2013), Nasser et al. (2014), Picchi et al. (2018) and Margaritis et al. (2020) stated that solid biomass fuels derived from agricultural wastes and other waste types are in excess for sustainable energy production. They stated that vine pruning wastes are an important fuel source as well as being used as fertilizer. Spinelli et al. (2014) developed and tested a new baling system designed to recover pruning wastes from vineyards inaccessible to conventional tractors as an alternative to on-site burning of pruning wastes from mountain vineyards. Çanakçı et al. (2019) stated that grinding is a critical process in recycling pruning wastes in different ways and choosing the right blades in the machines used for this purpose will contribute positively to obtaining suitable particles and reducing operating costs.

The main purpose of this study is to make some changes in accordance with the structure of the vine rods on a machine used in horticulture, which is currently produced for shredding branches in our country. Thus, it will be ensured that the vineyard pruning wastes are broken down and the fragmented wastes are left on the soil surface, making the wastes more useful. Another purpose is to determine the machine's performance depending on various parameters in working with the machine. With this study, various suggestions are made for both grape producers and machine manufacturers, thus contributing to the widespread use of machinery and thus ensuring sustainability in viticulture.

For these purposes, for small vineyard areas, the shredding of pruning wastes was tested with a branch shredder, which is driven by a thermic motor.

MATERIALS AND METHODS

Materials

Vine branches of Boğazkere (wine), Öküzgözü (wine) and Şire (table) (Vitis vinifera L.) grape cultivars belonging to the region were used as plant material in the study. Pruning branches were obtained from the vineyards of the grape producers in Diyarbakır. The pruned branches were turned into bundles in the vineyard. It was transported to Dicle University Faculty of Agriculture, Department of Agricultural Machinery and Technology Engineering to be tested later, and was kept under a covered porch. In the shredding of the vineyard pruning wastes, a branch shredder machine manufactured by a private company, which has a 15 HP powerful, 4-stroke gasoline engine (starter-battery powered), the chimney system can rotate 360^0, is both fixed and capable of moving in the vineyard by one person is used. There are three chopper blades on the machine. The blades are driven by three replications gasoline engine with the a belt and pulley system (Figure 1).

Figure 1. Branch shredding machine used in trials

The tests were carried out at 1500, 2000 and 2500 rpm chopper blade rotation speeds. The number of revolutions was adjusted with the engine accelerator pedal, and a DT-2236 revolution tachometer device was used in the measurements (Figure 2). From the moment the weighed material was fed to the machine, the time was measured with a chronometer. Dikomsan type balance (Figure 2).with a capacity of 15 kilograms (kg) was used for the weigth of test materal during the study. BMI brand digital caliper was used to determine the diameters of the vineyard pruning wastes. Also, precise weighing processes required to determine the moisture content of the product were made with a 0.1 precision VIBRA brand electronic balance. Oven drying method was used to determine the moisture content of the branches. For this, NUVE FN 500 brand drying oven (Figure 2) was used to determine the moisture content. In order to determine the moisture content of the branches during shredding, five samples were taken from each cultivar and weighed with precision scales and kept in a drying oven at 105 ºC for 24 hours. At the end of this period, the samples were weighed again. At the end of drying, the moisture content of the shoots was determined as % according to the wet base (ASABE, 2006). Moisture contents of pruning branches were measured as 38.10% for Boğazkere cultivar, 38.80% for Öküzgözü cultivar and 38.30% for Şire cultivar.

In order to measure the amount of fuel consumed at different rotation speeds, number of blades and feed rates, ISOLAB brand 500 milliliter (ml) graduated separation funnel made of glass material was used (Figure 3). For fuel measurement, the fuel tank on the machine is disabled and the fuel is directly entered into the engine through a 500 ml graduated glass funnel (Figure 3). Feeding time has been taken into account for the calculated fuel values. Trials were carried out at constant feeding amounts (kg/h). For each trial, the branches, which were weighed with scales beforehand, were tried to be fed to the machine in the same time as possible. Fuel consumption was determined by measuring the amount of fuel that decreases depending on the number of revolutions in each trial. Experiments were made in three replications. The mean values of three replications were used.

Figure 3. Graduated glass funnel

Figure 2. Balances, drying cabinet (oven), caliper and speed measuring device

Methods

During the trials, fuel measurements were made during the unloaded operation of the machine as well as all grape varieties and blades rotations. Experiments were made in three replications. Specific fuel consumption, which is the amount of fuel consumed for each kilowatt (kW) power unit as a result of one hour of engine operation, is calculated using the equation given below (Dinçer, 1981; Sabancı, 1993; Georging ve Hansen 2004; Srivastava ve ark. 2006; Sessiz ve ark. 2020).

$$be = 3600/(Hu.\eta)$$

Where;

be : Specific fuel consumption (kg/kW.h) (be =0.276)

Hu : Lower calorific value of fuel (kj/kg) (constant: 43.472 kj/kg)

Ƞ : Total efficiency of the motor % 30 (constant: 0.3)

The power values were calculated by proportioning the fuel consumption value measured during the trials to the specific fuel consumption (kg/kWh) and using the equation given below (Dinçer, 1981; Georging and Hansen 2004). Fuel consumption measured in L/s depending on time. It was then converted to (kg/h) to calculate hourly fuel consumption. Density (kg/l) = 0.7475 was taken into account in the calculations.

Pe= B/be

Where;

Pe : Power drawn by the shredder, kW

B : Per hour fuel consumption of the engine (kg/h)

be : Spesific fuel consumption (kg/kWh)

Moment values were also calculated using the equation given below (Dinçer, 1981; Sabancı, 1998; Saral et al.,2008; Sessiz et al. 2020).

Md=(9550.Pe)/n

Where;

Pe : Power drawn by the shredder, kW

Md : Moment, Nm

n : Number of shredder rotations, min^{-1}

For statistical comparison between data, JMP, 13. Version, package program was used. Trials were planned according to random plot design using analysis of variance (ANOVA). Comparisons were made according to the LSD test and 5% and 1% significance.

RESULTS AND DISCUSSION

In the calculations, density (kg/l) = 0.7475, Hu (kj/kg) = 43.472 (heating value of fuel), total efficiency = 0.3, Be (kg/kWh) = 0.276 (specific fuel consumption) were kept constant (Georgin et al. 2005).

The LSD test results obtained according to the variance analysis results based on the variety are given in Tables 1 and 2. When Table 1 and Figure 3 were examined together, the difference between the cultivar was found to be significant in terms of fuel consumption ($p<0.05$). While there was no difference between Boğazkere and Öküzgözü cultivars, the difference between these cultivars and Şire cultivar was significant. While the highest fuel consumption value was found as 1.535 kg/h in Boğazkere cultivar, the lowest value was obtained as 0.918 kg/h in Şire cultivar.

A similar situation was obtained for power values. While the highest power consumption value was obtained as 5.560 kW in Boğazkere cultivar, the lowest value was obtained as 3.326 kW in Şire cultivar. Here, there was no statistical difference between Boğazkere and Öküzgözü cultivars, but there was a significant difference between these cultivars and Şire cultivar (Table 1 and Figure 4). When the moment values of the cultivars were examined, the difference between cultivars was found to be very significant ($p<0.01$). The highest value was obtained as

26.26 Nm in Boğazkere variety, the variety with the highest Power and Fuel consumption value, while the lowest value was obtained as 15.65 Nm in Şire variety, which also had low fuel and power requirements (Table 1 and Figure 2).

Table 1. LSD test results for average Fuel Consumption, Power and Moment values measured depending on the grape variety *

Cultivar	Fuel Consumption Kg/h	Power kW	Moment Nm
Unloaded	0.666	2.391	11.330
Boğazkere	1.535a	5.560 a	26.26 a
Öküzgözü	1.246 a	4.513 a	21.22 b
Şire	0.918 b	3.326 b	15.65 c
LSD	0.1095	0.396	1.628

* There is no difference at the 1% significance level between the means denoted by the same letter.

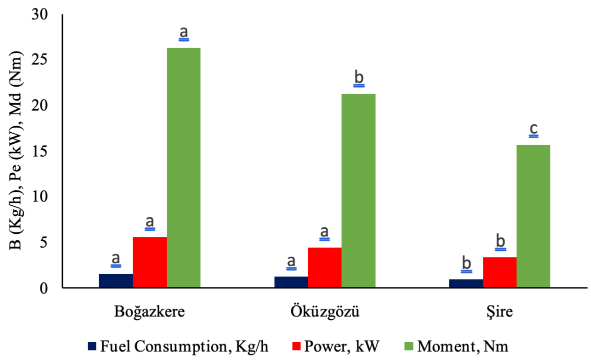

Figure 4. Average Fuel Consumption, Power and Moment values measured depending on the variety.

Average LSD values of fuel, power and moment depending on blade rotation speed are given in Table 2 and Figure 5. As can be seen in Table 2, per hour fuel consumption, power requirement and moment values increased for all three cultivars depending on the increase in the number of rotation of the blades, both at unloaded and under load. The difference between the rotation speed in all three cultivars was found significant ($p<0.01$). While the highest fuel consumption was obtained as 1.614 kg/h at 2500 rpm, the lowest fuel consumption was obtained as 0.822 kg/h at 1500 rpm.

The difference between the revolutions was found to be significant in the power consumption values. Similarly, the power requirement was highest at 2500 rpm and was 5.847 kW. The lowest power requirement was obtained as 2.976 kW at 1500 rpm.

When the moment values are examined depending on the number of revolutions, there is no statistically significant difference. The highest moment value was 22.333 Nm at 2500 rpm and the lowest moment value was 18.942 Nm at 1500 rpm.

Table 2. LSD test results for average Fuel Consumption, Power and Moment values measured based on blade rotation speed*

Blade rotation speed	Fuel Consumption Kg/h	Power kW	Moment Nm
rpm			
1500	0.822 c	2.976 a	18.942 a
2000	1.263 b	4.577 b	21.859 a
2500	1.614 a	5.847 ab	22.333 a
LSD	0.10668	0.3865	0.483

* There is no difference at the 1% significance level between the means denoted by the same letter.

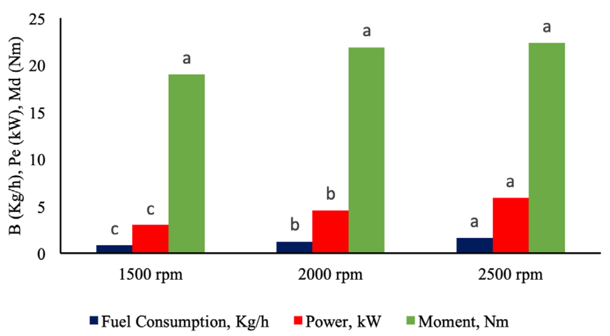

Figure 5. Average Fuel Consumption, Power and Moment values measured based on blade revolution

CONCLUSION

The results obtained depending on independent parameters at the end of the tests carried out in this study for the shredding of pruning wastes are given below.

Per hour fuel consumption increased for all three cultivars in unloaded and loaded conditions due to the increase in the number of revolutions of the chopper blades. Hourly fuel consumption value at unloaded changed between 0.554 L/h (0.414 kg/h) and 1.170 L/h (0.875 kg/h). The difference between all cultivars in the loading condition was significant. The highest fuel consumption was observed in Boğazkere cultivar, followed by Öküzgözü and Şire varieties, respectively. The power also increased with the increase in the number of revolutions. The lowest value for Boğazkere variety was 3,628 kW at 1500 rpm, while the highest value was 6,962 kW at 2500 rpm. During the disintegration of the pruning shoots of Öküzgözü cultivar, 2,938 kW was obtained at the lowest revolution speed and 5,917 kW at the highest revolution. The situation in the cultivar of Şire; While the lowest power value was 2.362 kW at 1500 rpm, the highest power value was 4.666 kW at 2500 rpm. The moment values also increased as the number of blade revolutions increased. This increase varied according to the number of revolution and the cultivar. Moment values according to three different revolutions were between 23,098 and 29.080 Nm in Boğazkere cultivar and between 18.708 and 22.601 Nm in Öküzgözü cultivar, while it was recorded between 14.106 Nm and 17.802 Nm in Şire cultivar.

COMPLIANCE WITH ETHICAL STANDARDS

This research study complies with research and publishing ethics.

Peer-review

Externally peer-reviewed.

Conflict of interest

The authors declare that they have no competing, actual, potential or perceived conflict of interest.

Author contribution

The contribution of the authors to the present study is equal. All the authors read and approved the final manuscript. All the authors verify that the text, figures, and tables are original and that they have not been published before.

Ethics committee approval

Ethics committee approval is not required.

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Data availability

All relevant data is inside the article.

Consent to participate

Not applicable.

Consent for publication

Not applicable.

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REFERENCES

Adamchuk, V., Bulgakov, V., Skorikov, N., Yezekyan, T., Olt, J. (2016). Developing a new design of wood chopper for grape vine and fruit tree pruning and the results of field testing. Agronomy Research 14(5), 1519-1529. Retrieved from https://agronomy.emu.ee/

ASABE Standarts (2006). S358.2: 1:1 Measurement forages. 52nd edn. American Society of Agricultural Engineers, St Joseph MI. Retrieved from https://www.asabe.org/

Bilandzija, N., Voca, N., Kricka, T., Matin, A., Jurisic, V. (2012). Energy potential of fruit tree pruned biomass in Croatica.

Spanish Journal of Agricultural Research 10(2), 292-298. Retrieved from https://revistas.inia.es/index.php/sjar

Çanakçı, M., Topakçı, M., Karayel, D., Ünal, İ., Çakır, M., Yiğit, M., Özdemir, E. (2018). Kendi Yürür Bir

Budama Artığı Parçalama Makinası İşletme Giderlerinin Belirlenmesi. Tarım Makinaları Bilimi Dergisi, 14 (2), 127-134 (in Turkish). Retrieved from https://dergipark.org.tr/tr/download/article-file/622610

Çanakçı, M., Topakçı, M., Karayel, D., Ağsaran, B., Kabaş, Ö., Yiğit, M. (2019). The effect of different blades on the performance values of a pruning chopper used to improve soil properties. Bulgarian Journal of Agricultural Science, 25 (No 5), 1052–1059. Retrieved from https://www.agrojournal.org/

Dereli, İ. (2009). The effects of different blades on performance of stalk choppers used in vineyard. Ege University, Graduate School of Natural and Applied Sciences, Department of Agricultural Machines and Technologies, Master Thesis, Izmir, Turkiye, 69 pp.

Dinçer, H. (1981). Agricultural force machinery**.** Ankara University Faculty of Agriculture Publications.

Georging, Carroll E., C. Hansen. (2004). Engine and tractor power. American Society of Agricultural Engineers. 4th edition, 1-16. Retrieved from https://www.asabe.org/

Magagnotti, N., Pari, L., Picchi, G., Spinelli, R. (2013). Technology alternatives for tapping the pruning residue resource. Bioresource Technology, 128, 697-702. Retrieved from https://www.sciencedirect.com/journal/bioresource-technology

Margaritis, N., Grammelis, P., Karampinis, E., Kanaveli, I-P. (2020). Impact of torrefaction on vine pruning's fuel characteristics. J. Energy Eng, 146(3): 04020006. Retrieved from https://www.hindawi.com/journals/jen/

Nasser, R., Salem, M., Al-Mefarrej, H., Abdel-Aal, M., Soliman, S. (2014). Fuel charasteristics of vine prunings (*Vitis Vinifera L.*) as a Potential Source for Energy Production. BioResources, 9(1), 482-496. Retrieved from https://bioresources.cnr.ncsu.edu/

Pavankumar, SB., Sachin, KR., Shankar, R., Thagaraja, B., Madhusudhan, T. (2018). Design and fabrication of organic waste shredding machine**.** International Journal of Engineering Science Invention, ISSN(online): 2319-6734 ISSN(print): 2319-6726. Retrieved from https://www.ijesi.org/

Picchi, G., Lombardini, C., Pari, L., Spinelli, R. (2018). Physical and chemical characterictics of renewable fuel obtained from pruning residues. Journal of Cleaner Production 171. 457-463. Retrieved from https://journals.elsevier.com/journal-of-cleaner-production%20

Recchia, L., Daou, M., Rimediotti, M., Cini, E., Vieri, M. (2009). New shredding machine for recycling pruning residuals. Biomass and Bioenergy 33, 149–154. Retrieved from https://www.sciencedirect.com/journal/biomass-and-bioenergy

Sabancı, A. (1993). Thermal engines**.** Çukurova University Faculty of Agriculture Publications.

Saral, A., Onurbaş Avcıoğlu, A., Eliçin, A.K. (2008). Thermal engines application examples**.** Ankara University Faculty of Agriculture Publications.

Sessiz, A., Eliçin, A.K., Turgut, M., Pekitkan, F.G. (2020)**.** Agricultural machinery basics. Nobel Publications.

Spinelli, R., Magagnotti, N., Nati, C. (2010). Harvesting vineyard pruning residues for energy use. Biosystems Engineering 105. 316-322. Retrieved from https://www.sciencedirect.com/journal/biosystems-engineering

Spinelli, R., Picchi, G. (2010). Industrial harvesting of olive tree pruning residue for energy biomass. Bioresource Technology, 101, 730-735. Retrieved from https://www.sciencedirect.com/journal/bioresource-technology

Spinelli, R., Nati, C., Pari, L., Mescalchin, E., Magagnotti, N. (2012). Production and quality of biomass fuels from mechanized collection and processing of vineyard pruning residues. Applied Energy 89. 374-379. Retrieved from https://www.sciencedirect.com/journal/applied-energy

Spinelli, R., Lombardini, C., Pari, L., Sadauskiene, L. (2014). An alternative to field burning of pruning residues in mountain vineyards. Ecological Engineering, 70, 212-216. Retrieved from https://www.sciencedirect.com/journal/ecological-engineering

Srivastava,A.K. Goering C.E., R.P. Rohrback, Buckmaster, D.R. (2006). Engineering principles of agricultural machines, second edition. American Society of Agricultural and Biological engineers. https://doi.org/10.13031/epam.2013

Sucipto, A., Kurnia, A., Halim, A., Irawan, A.P. (2020). Design and fabrication of multipurpose organic chopper machine. Materials Science and Engineering, 725, 012021. Retrieved from https://www.sciencedirect.com/journal/materials-science-and-engineering-a

Şeflek, A.Y., Çarman, K., Özbek,O., (2006). Budama Atıklarının Parçalanmasında Kullanılan Makinanın Performans Değerlerinin İrdelenmesi. Tarım Makinaları Bilimi Dergisi, 2 (3): 219-224 (in Turkish). Retrieved from https://dergipark.org.tr/tr/pub/tarmak