ÇOMÜ Zir. Fak. Derg. (COMU J. Agric. Fac.)
2024: 12(1): 140-148
ISSN: 2147–8384 / e-ISSN: 2564–6826
doi: 10.33202/comuagri.1430164

Research Article

Determination Size Distribution of Shredded Vineyard Pruning Residues According to Variety

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Received Date: 01.02.2024 Accepted Date: 16.04.2024

Abstract

In this study, it was aimed to determine the particle size distribution of vineyard pruning residues shredded with a shredding machine according to grape variety. Pruning residues of three grape varieties, respectively, Boğazkere, Öküzgözü and Şire were used for the experiments. A wood chipper machine powered by a 15 HP (11.20 kW) thermal engine was used for shredding experiments. Trials were conducted at three different engine speeds (1500 min^{-1}, 2000 min^{-1}, 2500 min^{-1}). There are 3 shredding blades on the machine's chopper unit. The blades are driven by a gasoline engine with the belt and pulley system. The study was carried out at three different blade rotation speed. Particle size distribution was determined for each rotation speed and grape variety. Sieves with diameters of 12.5-50.0 mm were used to calculate the particle size distribution. According to the results, an inverse relationship was obtained between the blade rotation speed and the size length of the shredded branches for all varieties. The ratio of the size and length of the chopped/chopped residues passing through the sieves varied according to the blade speeds. Also, significant differences were found between varieties ($p<0.01$). The best shredding was obtained in Boğazkere variety at all blade rotation speeds. As the speed of the chopper blades increased, better chopping occurred. In other words, as the number of revolutions increased, the particle size decreased. The best particle size distribution for all varieties was obtained at a blade rotation speed of 2500 min^{-1}. As a result, it was concluded that it would be beneficial to operate at as high speeds as possible in order to obtain small branch pieces of the desired size.

Keywords: Shredder, vineyard pruning shoots, particle size reduction, particle size distribution

Bağ Budama Artıklarının Parçacık Boyut Dağılımının Çeşide Göre Belirlenmesi

Öz

Bu çalışmada, bir dal parçalama makinasıyla parçalanan bağ budama artıklarının üzüm çeşidine göre parçacık boyut dağılımının belirlenmesi amaçlanmıştır. Denemeler için Boğazkere, Öküzgözü ve Şire olmak üzere üç üzüm çeşidinin budama artıkları kullanılmıştır. Parçalama deneyleri için 15 HP (11.2 kW) gücündeki termik motorla çalışan bir dal parçalama makinası kullanılmıştır. Denemeler üç farklı motor devrinde (1500 min^{-1}, 2000 min^{-1}, 2500 min^{-1}) yürütülmüştür. Makinanın kıyıcı ünitesinin üzerinde 3 adet parçalayıcı bıçak bulunmaktadır. Parçalayıcı ünite, kayış-kasnak yardımıyla hareketini motor milinden almaktadır. Çalışma, üç farklı bıçak dönü hızında (1500 min^{-1}, 2000 min^{-1}, 2500 min^{-1})yürütülmüş olup her devir sayısı ve üzüm çeşidi için parçacık boyut dağılımı belirlenmiştir. Parçacık boyutu dağılımını hesaplamak için 12.5-50.0 mm çaplara sahip elekler kullanılmıştır. Sonuçlara göre, tüm çeşitler için bıçak dönü hızı ile parçacık boyut uzunluğu arasında ters bir ilişki elde edilmiştir. Eleklerden geçen kıyılmış artıkların boyut uzunluklarının oranı, bıçak devirlerine göre farklılık göstermiştir. Çeşitler arasındaki fark da önemli olmuştur ($p<0.01$). En iyi parçalama, tüm bıçak dönü hızları için Boğazkere çeşidinde elde edilmiştir. Kıyıcı bıçakların hızı arttıkça daha iyi parçalama meydana gelmiştir. Yani, devir sayısı arttıkça parçacık boyutu küçülmüştür. Tüm çeşitler için en iyi parçacık boyut dağılımı ise 2500 min^{-1} bıçak devir hızında elde edilmiştir. Sonuç olarak, istenilen büyüklükte küçük dal parçalarının elde edebilmek için mümkün olduğunca yüksek devirlerde çalışmanın yararlı olacağı sonucuna varılmıştır.

Anahtar Kelimeler: Öğütücü, bağ budama sürgünleri, parçacık boyutundaki küçülme, parça boyut dağılımı

Introduction

Vineyard and horticulture cultivation are carried out intensively in the world and in Türkiye. Türkiye is sixth largest grape producer of worldwide with an estimated production of 4 million tons in 550,000 ha production area in 2017. It is the biggest exporter of raisin grapes. Each year over 200.000 tons golden coloured raisins is exported all over the world. The grape export is 170.000 tons valued at 133 million $ (Anonymous., 2019). Also grape is a valuable product that is consumed as both table and wine and grape juice. Table grapes have been included in the human diet since ancient times. The global production of table grapes reached 22.7 million tons in 2017 (Anastasiou et al., 2018). Grapes are the most widely grown commercial fruit crop in the world, and also one of the most popular fruit crops for horticultural production. Grape growers constantly search the ways in order to maximize their profits all over the world (Özdemir et al., 2017). Even though grape has always been a valuable, pruning and harvesting processes in vineyards are still mainly performed by manually. After annual cultivation operations in viticulture, a huge amount of pruning residues occur and are left in the vineyard. Pruning residues that remain in the vineyards creates major problems such as environmental pollution and the formation and proliferation of diseases and pests. For such types of problems, an effective solution is required. Especially pruning residue and other vegetal residues generated during the cultivation of vineyard and garden products should be recycled and brought back into production through successful residue management (Recchia et al., 2009; Spinelli et al., 2012). One of the methods of utilizing agricultural waste is, and perhaps the most important one, to reduce the size of the pruning residues by shredding them with a chopping machine and mixing the shredded branches into the soil and using them as organic fertilizer (Sessiz et al., 2021; Öngoren and Sessiz., 2023). Additionally, residue can be utilized in different ways, such as renewable energy, compost, paper industry, board and chip use (Çolakoğlu, 2018). In addition to high cost of chemical fertilizers, unconscious use of chemical fertilizers adversely affects human, animal and environmental health. Therefore, recycling the pruning residue obtained from vineyards and orchards to the soil and using it for fertilizer purposes provides great benefits in terms of both successful cost management and environmentally friendly agricultural production (Hande and Padole, 2015; Pari., at al., 2015; Scupto et al., 2020). Agricultural residues generated after pruning, harvesting and cultivation in vineyards and orchards are generally kept in the vinyards. For a more effective residue management, mechanization tools and mechanical equipment should be used during and after pruning operation (Marti et al., 2012; Öngören and Sessiz., 2022).

Beside like this research, various studies were carried out on this subject. 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 (2010), 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. 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. Pekitkan et al. (2022) determined shredding energy values at different moisture levels for 7 different plant species (Juniperus Drupacea, Pyracantha Coccinea, Shrub, Pine, Oleaster, Peach and Oleander). They argued that obtained results in the study can be used in the design of a machine to be developed for the effective and efficient shredding of the pruning residues of the tested varieties.

One of the parameters affecting the quality of pruning residue is the size distribution of particles. Pruning residue is one of the important plant residues and branch shredding and chopping machines are used to evaluate these residues. The aim of the study was to determine of size distribution of vineyard pruning residues chopped by a shredding machine according to variety. For this purpose, a branch shredding machine, which is powered by a thermal engine to shred vineyard pruning residue, was tested stationary for different types.

Material and Method

Vine branches of Boğazkere (wine), Öküzgözü (wine), and Şire (edible) (Vitis vinifera L.) grape cultivars were used as plant material in the study (Figure 1a). Pruning branches were obtained from the vineyards of the grape producers in Diyarbakır province. The pruned branches were turned into bundles in the vineyard. Then, it was transported to Department of Agricultural Machinery and Technologies Engineering for tests and it is stored under a closed porch two months until experiment. For shredding experiments, a 15 HP wood chipper machine powered by a gasoline engine with 3 shredding blades was used (Figure 1b, c).

(a) (b) (c)

Figure 1. Pruning branches and shredding machine and chopper blade

In order to evaluate the performance of the branch shredding machine, experiments were carried out by pre-setting the engine speed and shredder blade speed on the machine to 1500 min^{-1} , 2000 min^{-1} and 2500 min^{-1} . Settings were made with the throttle. The amount of material (feeding rate) fed for each trial (kg/h) was determined by keeping time to be homogeneous. Depending on these parameters, particle size characteristics were determined for each type. DT-2236 measuring device (revolution tachometer) was used to determine the blade revolution numbers.

The sieving method was used to calculate the particle size distribution of the shredded residues after the fragmentation of the vineyard pruning branches. Specially made sieves with hole diameters of 50, 40, 30, 20 and 12.5 mm were used for this study (Figure 2). The pruning residues of Şire, Öküzgözü and Boğazkere cultivars are divided into three repetitions according to three different cycle numbers. After weighing the pruning residues with a scale, sieving was carried out from the sieve with the largest hole diameter to the smallest, lasting 15-20 seconds. After sieving, the branches remaining on the sieves were weighed again and the values were recorded. The amount of residue passing through each sieve was calculated over the total sieved amount and converted into % ratios (Şeflek et al., 2006; Demir, 2007; Dereli, 2009; Sessiz et al., 2021; Öngören and Sessiz, 2022).

Figure 2. Sieves in different hole diameters used in the study and sieving

Dikomsan type balance with a capacity of 15 kilograms (kg) was used in the sieving method used to calculate the product amount and particle size distribution used for each rotation speed number and cultivar during the study. Precise weighing processes required to determine the moisture content of the product were made with a 0.1 precision VIBRA brand electronic balance. NUVE FN 500 brand drying oven was used to determine the moisture content. BMI brand digital caliper was used to determine the diameters of the vine branches to be used in the measurement of cutting resistance.

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. Moisture contents of pruning branches were measured as 38.10% for Boğazkere cultivar, 38.80% for Öküzgözü cultivar and 38.30% for Şire cultivar. The branch diameter of the varieties used in the experiments increased downwards, and the average diameter values were changed between 3.20-8.30 mm. Branch lengths were chanded average between 65-110 cm.

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

The distribution of particle sizes formed by the pruning residues of the cultivars used in the experiments at different revolutions of the engine are given in Figure 3 for Boğazkere, Figure 4 for Öküzgözü, and Figure 5 for Şire. When all cultivars were evaluated together, it was observed that there were differences between them in terms of particle sizes. There were differences in all cultivars according to the sieve diameter depending on the number of revolutions. The best fragmentation occurred in Şire cultivar. However, the proportion of particle sizes sieved through a sieve with a diameter of 12.5 mm was around 1% in all cultivars.

As can be seen in Figure 3. the ratio of the size lengths of the shredded pruning residues sieved through the sieves of different hole diameters for Boğazkere cultivar differed according to the blade rotation speed. There was an inverse relationship between the number of revolutions and the branch shred size. For example, while the ratio of dimension lengths of 50 mm and above particles at 1500 min^{-1} constitutes 41% of the total, the length size distribution ratio of the particles decreased to 28% at 2000 min^{-1}, and this ratio decreased to 21% at the blade rotation speed at 2500 min^{-1}. Considering the smallest particle size ratios, it will be seen how important the number of revolutions is. For example, while the ratio of particle size distribution with 12.5-20 mm dimensions at 1500 min^{-1} was 25%, this ratio increased to 28% at 2000 min^{-1} and to 38% at 2500 min^{-1}. As can be seen from the figures formed from the data obtained, the particle size decreased as the number of revolutions increased. In other words, as the speed of the chopping blades increased, better chopping occurred. A similar situation occurred in all varieties. This situation shows that the effect of the speed of the shredder blades revolution on the brunches shred is important, rather than the variety. Similar results were found by Sessiz et al. (2021).

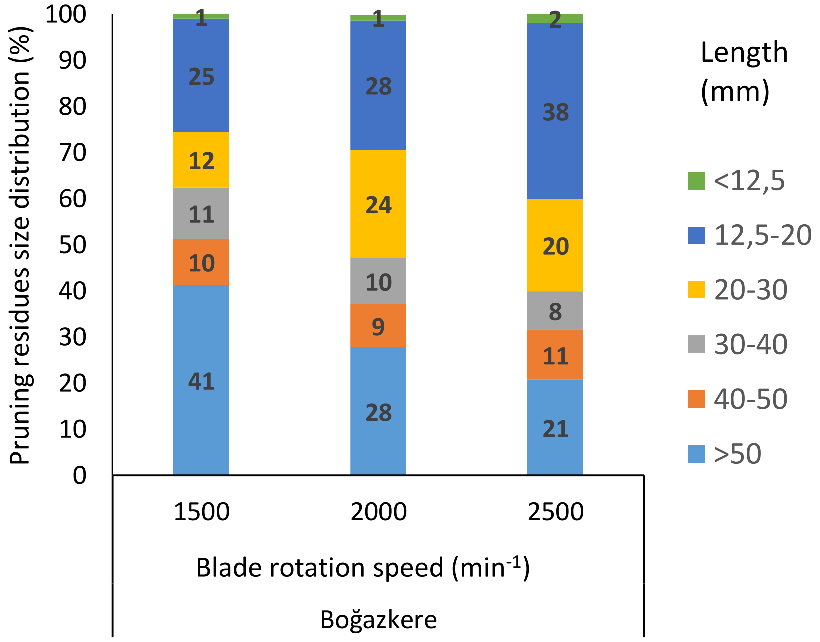

Figure 3. Size distribution of pruning residues belonging to Boğazkere variety

Figure 4 shows the size distribution ratios of the fragmented pruning residues of Öküzgözü cultivar. As can be seen from the figure, as the number of revolutions increased in Öküzgözü, the size of the shredded pruning residues decreased. Thus, when the values are examined; While the rate of particles of 50 mm and above at 1500 min^{-1} was 57%, the length ratio of particles in the range of 12.5-20 mm was obtained as 19 at 2000 min^{-1}, the length ratio of particles of 50 mm and above was 41%, and the length ratio of particles in the range of 12.5-20 mm was 24%. At the highest speed of 2500 min^{-1}, the particle sizes were further reduced, and this ratio was 35% for 50 mm and more fragmented residues and 31% for the size-length ratio of the residues in the range of 12.5-20 mm. As can be seen from these values, when the number of revolutions is increased, the branches are better broken down, so the residues obtained at high revolutions are smaller. Therefore, while the proportion of large particles is higher at 1500 min^{-1}, the proportions of small particles have decreased. The opposite situation occurred at 2500 min^{-1}. In this revolution, the proportion of large particles is lower and the proportion of small particles is higher.

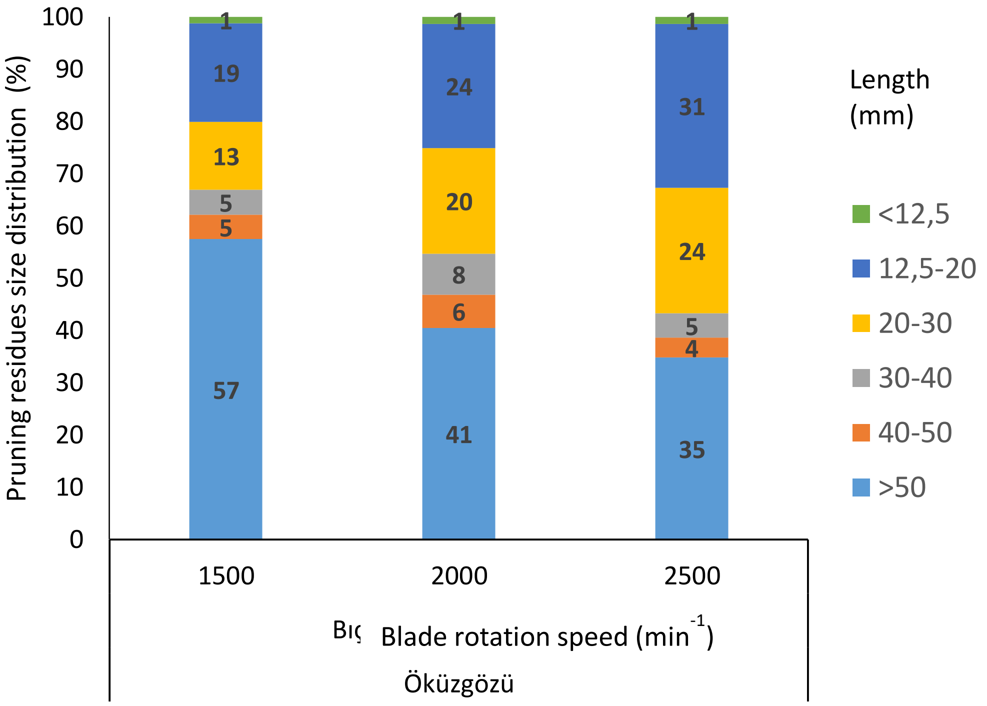

Figure 4. Size distribution of pruning residues belonging to Öküzgözü cultivar

When the size distributions of the particles belonging to the Şire cultivar are examined (Figure 5), the lengths of the branches shredding in the Şire cultivar, as well as in Boğazkere and Öküzgözü cultivars, showed a significant increase and decrease according to the number of revolutions. Compared to the other cultivars, the particle sizes decreased more at high revolutions. For example, the size distribution of vineyard pruning residues; At 1500 min^{-1}, the particle length ratio of 50 mm and above is 59%, between 40-50 mm 10%, between 30-40 mm 9%, between 20-30 mm 13%, 12.5-20 mm 8% and 12.5 mm was below 1%. If it is at 2000 min^{-1}; The length ratio of 50 mm and above particles was 40%, between 40-50 mm 7%, 30-40 mm 7%, 20-30 mm 20%, 12.5-20 mm 26% and below 12.5 mm 1%. At the highest speed of 2500 min^{-1}, the particle length ratio of 50 mm and above is 19%, between 40-50 mm 9%, between 30-40 mm 10%, between 20-30 mm 19%, between 12.5-20 mm. The length ratio of particles below 42% and 12.5 mm was measured as 2%. When all these values are examined together, it is seen that the pruning branches of the Şire cultivar are quite well shred by the shredder blades. While the proportion of the longest particles decreased by 40% from low to high speed, the proportion of the shortest particles increased by 34%.

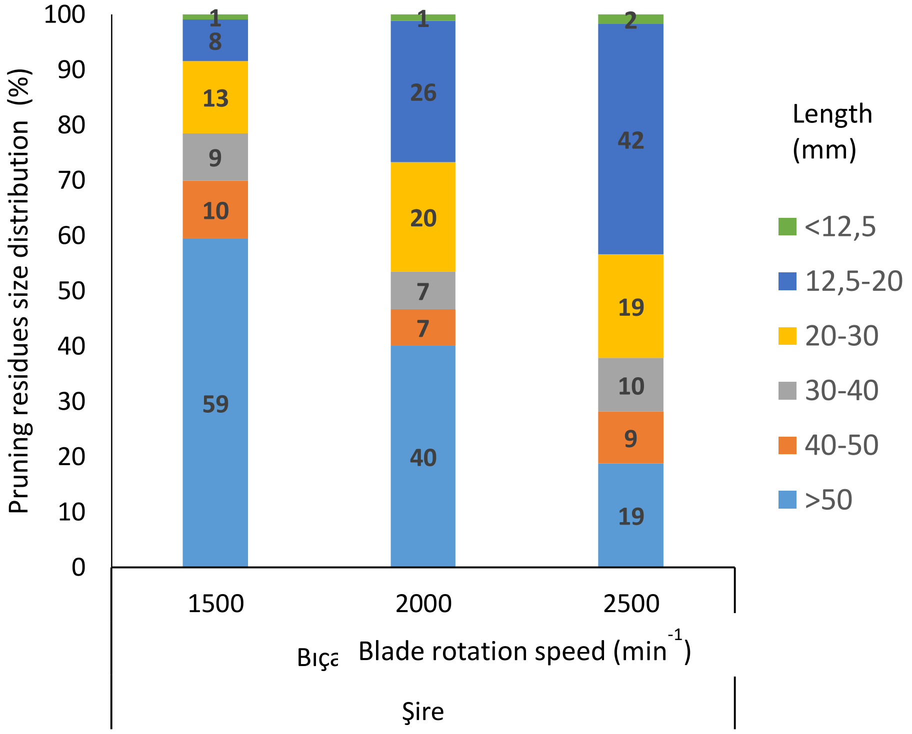

Figure 5. Size distribution of pruning residues belonging to Şire cultivar

When other studies on the subject are examined; Dereli (2009), Aygun and Çakır (2014) states that the particle size values obtained as a result of the shredding of the vineyard shoots in the shredding machines are in the range of 0-100 mm, while Sucipto et al. (2020) stated that the chopping machine they designed and manufactured could cut organic residues in sizes ranging from 1 to 50 mm. The differences between these values are due to the differences in the structural features of the machines, the material used and the working parameters.

Conclusion and Recommendations

There were an inverse relationship between revolutions and the branch shredding size for all cultivars. The ratio of the size lengths of the shredded pruning residues passing through the sieves differed according to revolutions. The difference between cultivars has also been significant. The best shredding was obtained in Boğazkere cultivar at all revolution. The better shredding occurred as the speed of the chopper blades increased. The size distribution has the best results at 2500 min^{-1} . Therefore, it was concluded that it would be more beneficial to work at high revolutions as possible, as well as to increase the number of blades in order to obtain a better performance and small branch pieces of the desired size. When the particle size distributions of the pruning waste produced in different periods by the varieties used in the experiments were examined, there were differences in particle sizes in all varieties. Likewise, there were differences in all varieties according to the sieve diameter depending on the number of revolutions. As the number of revolutions increased, particle sizes decreased.

As a result, it has been seen that a machine used in horticulture, which is produced to shred and grind branches in our country, can be used to shred vineyard pruning residue by making some changes in accordance with the structure of the vineyard sticks, and the shredded residue can be left on the soil surface, making the residue more useful. Pruning wastes that are not evaluated with this study will be shredded and the wastes will be evaluated as organic residue. If pruning branches are used as organic waste, the use of chemical fertilizers will also decrease. It will contribute to the sustainability of both the product and the soil. A healthier product will be obtained for the consumer. This will also increase the market value of the product. The farmer will earn better income. Additionally, the production of pruning waste shredding machines and their use by farmers will become widespread.

This may lead to the opening of a new production area. Mechanical methods to be applied as a result of sharing these methods with relevant people will contribute to both agricultural and scientific literature.

Acknowledgment

We thank Dicle University Rectorate and DUBAP coordinator for their support. This article was produced from a Master's Thesis prepared by Nurgül ÖNGÖREN.

Researchers' Contribution Rate Declaration Summary

The authors declare that they have contributed equally to the article. The authors of the article declare that they do not have any conflict of interest.

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