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Determination of Coefficients and Biomass Potential for Pruning Residuals in Some Olive Varieties

Gıyasettin ÇIÇEK[1], Sarp Korkut SÜMER[2], Cem Ömer EGESEL[3], Sait Muharrem SAY[4], Arda AYDIN[5]
[1,2,5]Çanakkale Onsekiz Mart University Faculty of Agriculture Department of Agricultural Machinery and Technologies Engineering, Çanakkale, [4]Çukurova University Faculty of Agriculture Department of Agricultural Machinery and Technologies Engineering, Adana, [3]Çanakkale Onsekiz Mart University Faculty of Agriculture Department of Agricultural Biotechnology, Çanakkale
[1]https://orcid.org/0000-0001-8260-1667, [2]https://orcid.org/0000-0001-7679-6154, [3]https://orcid.org/0000-0003-0255-5678
[4]https://orcid.org/0000-0003-2525-734x, [5]https://orcid.org/0000-0001-9670-5061,
✉: giyas@comu.edu.tr

ABSTRACT

As a result of pruning operations in olive orchards, large amounts of biomass material are produced every year. In this study, it was aimed to determine the pruning residual coefficients in olive varieties grown in Southern Marmara Region of Turkey. Amount of pruning residuals and its energy potential due to olive cultivation of the region was determined.. The coefficients were compared with the values obtained from different countries. Possible uses of the residual biomass were also investigated. The study material consisted of young (0-25 years), full-yield (25-50 years) and old (over 50 years) trees of Ayvalık, Gemlik and Domat, widely grown olive varieties in the Southern Marmara Region. The experiment used a randomized plot design sampling 5 trees for each age and variety. The average coefficients of determination for pruning residues were calculated as 33.62 kg tree^{-1}year^{-1} and 5668.63 kg ha^{-1}year^{-1}. Energy potential from pruning residues were determined to be 5.16 PJ for Southern Marmara Development Region.

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Zeytin Ağacı Budama Artık Potansiyelinin Hesaplanmasına Yönelik Katsayının Belirlenmesi

ÖZET

Zeytin bahçelerinde budama işlemleri sonucu her yıl büyük miktarlarda biyokütle materyali ortaya çıkmaktadır. Bu araştırmada, Türkiye'de Güney Marmara Kalkınma Bölgesi kapsamında yetiştirilen zeytin çeşitlerinde, budama artık katsayılarının belirlenmesi amaçlanmıştır. Çalışmada çeşitlere yönelik budama kütle miktarları dikkate alınarak belirlenen katsayılar ile bölgenin zeytin tarımı kaynaklı budama artık ve enerji potansiyeli de belirlenmiştir. Biyokütleye konu olan söz konusu artıkların değerlendirilme olanakları araştırılmış, araştırma sonucunda elde edilen katsayılar farklı ülkelerde ve bölgelerde elde edilen değerlerle karşılaştırılmıştır. Araştırmada Güney Marmara Kalkınma Bölgesi'nde yaygın olarak yetiştirilen Ayvalık, Gemlik ve Domat zeytin çeşitlerinde, gençlik devresinde (0-25 yıl), verim devresinde (25-50 yıl) ve yaşlılık devresinde (50 yıl üstü) olan bahçelerde tesadüf parselleri deneme desenine göre belirlenmiş 5'er ağaçta budama yapılmıştır. Yapılan çalışmalar sonucunda ağaç başına budama katsayısı 33.62 kg ağaç-1yıl-1, alan bazlı budama katsayısı 5668.63 kg ha-1yıl-1 bulunmuştur. Bu değerden yararlanarak zeytinliklerin birim alanının 50711.18 MJ ha-1yıl-1, Güney Marmara Kalkınma Bölgesi'nin ise 5.16 PJ budama artığı kaynaklı enerji potansiyeline sahip olduğu belirlenmiştir.

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INTRODUCTION

Turkey, one of the important olive producers in the world, produce 8.98% of olive and 2.42% of olive oil in the world (FAOSTAT, 2016). The olive production is practiced as many as 35 provinces throughout the country (Tan, 1995). About 10% of olive trees are in Çanakkale and Balıkesir provinces, collectively named as Southern Marmara Development Region (SMDR) (Table 1).

One of the factors that cause serious yield and quality losses in olive cultivation is improper or untimely pruning. Pruning is considered as the most important cultural practice for reasons such as establishing and maintaining the proper shape of crown, ensuring vegetative and generative growth balance, preventing periodicity or reducing its effect, rejuvenating the trees and bringing the C / N balance back to an optimum level (Can and Özer, 2018). The main purpose of pruning is to keep real yield as close to potential yield as possible (Castillo-Ruiz et al., 2017). As a result of pruning in orchards, large amounts of biomass material are produced annually. Some of these residues are as burning material, some are shredded and mixed into the soil, and most of them are burned and destroyed without any use. Pruning residues from orchards are not only creating environmental pollution, but also obstructing working conditions in production areas (Koçer and Kürklü, 2018). Olive growing countries develop different pruning systems to facilitate cultural processes such as care and harvest and to reduce costs (Atmaca and Ülger, 2017). Pruning olive trees is a periodic cultural operation in which less productive branches are cut and the trees are rejuvenated (Toledano et al., 2012). The pruning activities, which are generally performed lightly every year and heavily in alternating years (Al-Masri, 2012), yields the highest amount of the residues (62% of the total) in olive production (Martin-Lara et al., 2017). These pruning residues consist of thick branches (25% by weight), thin branches (50% by weight) and leaves (25% by weight) (Romero-García et al., 2014; Fillata et al., 2018).

Table 1. Data for the olive production in Turkey and SMDR (TÜİK, 2019)
Çizelge 1. Türkiye ve Güney Marmara Kalkınma Bölgesi'nde zeytin üretim ve ağaç verileri

	Balıkesir	Çanakkale	SMDR*	Turkey	SMDR/Turkey, %
Number of trees (*Ağaç sayısı*)	11512614	5458284	16970898	177843966	9.54
Area (ha) (*Alan*)	82990	32467	115457	864428	13.36
Production (Tones) (*Üretim*)	109902	44288	154190	1500467	10.28

*South Marmara Development Region

Reduced tillage, conservation of natural vegetation, organic fertilization and use of olive oil residues are supported by the European Commission in olive groves. However, the environmental impact of applications related to olive tree pruning management is not taken into account, residues are considered useless and burned (Gomez-Munoz et al., 2016). Bellitürk et al. (2018) stated that these materials were used as firewood in many regions of Turkey. In recent years, the importance given to the recovery of organic residues in the world has increased rapidly and techniques that biomass can be utilized without direct burning have been introduced. In the Intergovernmental Panel on Climate Change, it was reported that the increase of greenhouse gases in the atmosphere is caused by the intensive use of fossil fuels (Acampora et al., 2013; Sümer et al., 2016a). Biomass is a renewable energy type that can be effectively used to reduce the effects of fossil fuels on the global environment in energy production and can be converted into useful energy forms using different processes (Amirante et al., 2016). Solid olive waste is also a source of biomass, which contains a significant amount (15.58–19.81 MJ kg^{-1}) of energy (Acampora et al., 2013; Christoforou and Fokaides, 2016). Although the use of agricultural waste as energy plays an important role in reducing the consumption of fossil fuels, this is not as common as expected in the regions where agricultural waste is abundant (Amirante et al., 2016).

Romero-García et al. (2014) reported that approximately 2.5 tons of olives and 1.5 tons of pruning residues were obtained from the 1 ha olive grove. Naturally, this value varies from country to region depending on the country. For example, pruning residues obtained from the pruning of the olive tree have been reported to vary between 1-5 tons ha^{-1} in Spain and 4-11 tons ha^{-1} in Italy (Spinelli and Picchi, 2010; Romero-García et al., 2014). This subject has been studied to some extent in Turkey as well. Demirbaş (1997) calculated the energy content of agricultural waste. Başçetinçelik et al. (2005) conducted studies on energy conversion from agricultural and animal waste. Melikoğlu (2013) has analyzed the feasibility of the renewable energy requirements in Turkey. Sümer et al. (2016a) determined the potential of olive residues in Çanakkale province by using the coefficient and rates reported by other researchers. Karaca and Öztürk (2017) determined the energy potential of agricultural waste in Osmaniye. Sümer et al. (2016b) determined the residual and energy potential of field crops in Çanakkale. Çiçek et al. (2019) determined the coefficient that could be used in the calculation of the potential of pruning peach trees. In Turkey, however, there is no study on how to determine a coefficient for the amount of oil tree pruning residues. Turkish researchers aiming to determine the potential of olive pruning residues used the coefficients that were calculated by different studies in other countries. Therefore, the objective of this study was to determine the coefficients that could be used to calculate the potential of olive pruning residues for SMDR of Turkey. By use of these coefficients, the amount and energy potential of olive pruning residues as well as the possibilities for different uses of these material in the region were investigated.

MATERIAL and METHOD

The plant material consisted of Ayvalık, Gemlik and Domat olive varieties, grown widely in the SMDR. Pruning was performed on 5 trees from young (0-25 years), full-yield (25-50 years) and old (over 50 years) trees (Kaleci, 2015) of these 3 varieties, according to a randomized plot design, totaling 45 trees. Shears and saws were utilized for pruning and the residues were weighed with a 10-gram precision digital hand scale. Based on the amount of the pruning residues produced, pruning residual coefficients (kg tree^{-1} year^{-1} and kg ha^{-1} year^{-1}) were determined. The availability of pruning residues was designated as 50%, in accordance with Blasi et al. (1997) and Başçetinçelik et al. (2005). The determined coefficients were adapted to the SMDR, and the amount of olive pruning residues and their annual energy potential value were calculated. The possibilities of using this material as an energy source in alternative energy production have been evaluated. Energy content of olive pruning residues was reported as 18.1 MJ kg^{-1} by Başçetinçelik et al. (2005), at least 16.91 MJ kg^{-1} by Blandzija et al. (2012) and at most 22 MJ kg^{-1} by Blasi et al. (1997). In the calculations made in this study, when calculating the energy content in this study, the value of 18.1 MJ kg^{-1} were used in accordance with Başçetinçelik et al. (2005).

The data obtained in the study were subjected to one-way analysis of variance (ANOVA) using the SPSS Statistical Package v.20.0 program and the significance control of the difference between the averages was made by Duncan test.

RESULTS and DISCUSSION

The amount of annual pruning per tree and per unit area belonging to varieties and age groups is given in Table 2. The highest pruning residual per tree was obtained from Ayvalık, while the lowest value was from Gemlik. There was no statistical difference between Ayvalık and Domat varieties. Similarly, Ayvalık and Gemlik varieties yielded the highest and the lowest pruning residuals per unit area, respectively. Domat variety sustained the highest number of trees per unit area and did not change the order of the residual amount obtained (Table 2).

Table 2. Annual pruning values of the investigated varieties
Çizelge 2. Çeşitlerin ağaç başına ve birim alanda yıllık budama miktarları

Variety *(Çeşit)*	Pruning amount for age groups, kg *(Yaş gruplarına göre budama miktarı, kg)*			Pruning amount Coefficients *(Budama miktarı katsayıları)*		Number of trees *(Ağaç sayısı)*
	0-25	25-50	>50	kg tree^{-1} year^{-1}	kg ha^{-1} year^{-1}	tree ha^{-1}
Ayvalık	53.03±14.87a	30.57±24.88ab	38.39±5.16ab	40.67±14.98 a	6913.9	170
Gemlik	18.30±6.31b	17.62±5.86b	38.12±13.91ab	24.68±8.49 b	3702	150
Domat	27.72±5.05b	39.80±5.12ab	39.00±2.17ab	35.5±4.11 a	6390	180
Average	33.02±8.74a	29.34±11.96a	38.5±7.08a	33.62±9.19	5668.63	166.67

The average amount of pruning residues from olive trees of trials was found as 33.62 kg tree^{-1}. The amount of pruning residues obtained from the unit area was determined as 5668.63 kg ha^{-1}year^{-1}.

Different values were obtained in various studies on olive pruning residue. Bilandzija et al. (2012) obtained 2524.2 kg ha^{-1} and 9.08 kg wood^{-1} pruning residue in Croatia. Cohen et al. (2018) obtained 5-20 tons of ha-1 residue in a 2-year intervals olive pruning in Sierra Magina region of France. In studies conducted in Italy; Pantaleo et al. (2009) reported an average value of 10-30 kg tree^{-1} year^{-1} depending on the structure and size of the tree, and Blasi et al. (1997) observed an average of 1.7 tonha^{-1}. Spinelli et al. (2011) found 2, 7.1, and 14.9 kg tree^{-1} in light, medium and heavy pruning applications, respectively. They reported 18.2 kg tree^{-1} in heavy pruning on a different variety.

In Spain; Toledano et al. (2012) found the same numbers (3000 kg ha^{-1}), while Vera et al. (2014) reported 2500-3000 kg ha^{-1} olive pruning residue. Similarly, Gomez-Munoz et al. (2016) found 1300-3000 kg ha^{-1} in Eastern Spain.

Romero-Garcia et al. (2014) reported 4-11 tons ha^{-1} for İtaly, and Spinelli and Picchi (2010) 1-5 ton ha^{-1} for Spain. It is seen that the coefficient values referred here agrees with these researchers' general ranges. The amount of pruning residues may vary depending on several factors (country, region, number of trees per unit area, frequency of pruning, variety, pruning worker etc.). In this study, an average of 5.7 tons ha^{-1} pruning residue was obtained. Although the amount of pruning per unit tree is higher compared to other countries, it is seen that the pruning residual amount obtained in the unit area is close to other countries, due to the fact that olive producers use fewer number of trees per unit area in Turkey. Oil growers prefer hard pruning, generally in every three years, because of lacking skilled pruners and expensive labor. Therefore, the amount of pruning obtained per unit tree is higher compared to other countries. Also, the high numbers for Ayvalık variety (53.03 kg) in young trees (0-25 years) could be explained with this hard pruning application. The difference among the varieties lost significance in older age groups (Table 2).

When the tree age groups were examined, the most pruning residue was obtained from the oldest trees, while the least amount was obtained from the trees between 25-50 years old. However, the statistical analysis revealed that these differences among the groups were not significant. It is necessary to do hard pruning for older trees to make new shoots (Dursun, 2019), which can be seen as a reason for having more residues from 50+ years old olives (Table 2).

In the olive groves evaluated for this study, spacing of the trees varied across the groves even for the same variety. It is observed that spacing was not a factor that the growers paid attention in older (25+ years) groves, whereas in those established in recent years, more conscious production is carried out from planting to harvest. New groves contain more trees per unit area, resulting in more pruning residues in 0-25 age group compared to 25-50 age group.

The energy potential of pruning residues was 304.26 MJ for a tree per year, while it was 50711.18 MJ for one hectare per year, as calculated by using the coefficients, energy value and availability ratio (Table 2 and 3). Bilandzija et al. (2012) reported these values as 153.5 MJ tree^{-1} year^{-1} and 42672 MJ ha^{-1} year^{-1}, respectively. Although the energy potential per tree from this research is about twice as big as Bilandzija et al's study, the energy values for unit area are close, as a result of the differences in the number of trees per unit area in olive groves.

The energy potential of olive pruning residues in the SMDR was determined as 5.16 PJ (Table 3).

Table 3. Energy potential of olive pruning residues in SMDR and Turkey
Çizelge 3. Güney Marmara Kalkınma Bölgesi ve Türkiye'de zeytin budama artıklarının enerji potansiyeli

	Number of trees *(Ağaç sayısı)*	Residue amount(kg tree^{-1}) *(Artık miktarı)*	Total residue amount (tons) *(Toplam artık miktarı)*	Availability ratio (%) *(Kullanılabilir oran)*	Amount of available residue (tons) *(Kullanılabilir artık miktarı)*	Unit heating value (MJkg^{-1}) *(Birim ısıl değer)*	Energy potential (PJ) *(Enerji potansiyeli)*
Ayvalık	15023887	40.67	611021	50	305511	18.1	5.53
Gemlik	1923853	24.68	47481	50	23740	18.1	0.43
Domat	23158	35.5	822	50	411	18.1	0.01
SMDR	16970898	33.62[1]	570562	50	285281	18.1	5.16
Turkey	177843966	33.62[1]	5979114	50	2989557	18.1	54.11

[1]the average coefficient

The 3 olive varieties discussed in this study constitute over 99% (Ayvalık 88.53%, Gemlik 11.34%, Domat 0.14%) of the region's olive production (Anonymous, 2020a; Anonymous, 2020b). A 13.57% difference was detected between the calculations using variety-based coefficients and the average coefficient (Tablo 3). The calculations based on varieties would give more realistic results. However, the use of the average coefficient to make estimations for the other regions and/or Turkey in general, will be able to provide reasonable numbers to make comparisons with other studies. The share of these 3 varieties in Turkey is about 76.97%; (Gemlik 48.71, Ayvalık 20.66%, Domat 7.56) (Özaltaş et al., 2016). For the coefficients representing Turkey in general, similar studies should be conducted for the other varieties. However, in order to provide a general approach, energy potential due to olive pruning residues in Turkey can be calculated as 54.11 PJ considering the coefficient calculated and total olive pruning olive trees for the country.

CONCLUSIONS

The results of this study suggest that Southern Marmara Development Region, which contain 9.54% of olive trees and 13.36% of olive growing areas in Turkey, has an important share in terms of energy potential from pruning residues. Literature contain a variety of reports on pruning residue values, which vary according to species, variety, country and region. With this study, olive pruning residue coefficients were determined that could represent certain regions and varieties. Since the distribution of olive tree per unit area varies depending on the country, region and variety, the use of the coefficient per tree will give more accurate and comparable results for determining the potential of olive pruning. Biomass is the most important renewable energy source in many countries. Olive pruning residues, an important source of biomass, are not utilized in any way and are usually burned and destroyed. Pruning residues obtained from olive trees in large areas have an important energy source potential. In order to determine the transportation and storage costs of olive pruning residues, an economic analysis should be made and the possibilities of using these residues for energy recovery should be investigated.

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Makaleye eşit oranda katkı sağladığımızı beyan ederiz.

Çıkar Çatışması Beyanı

Makale yazarları arasında herhangi bir çıkar çatışması olmadığını beyan ederiz

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