Mustafa Kemal Üniversitesi Tarım Bilimleri Dergisi 24 (Özel Sayı):9-15, 2019
(*Mustafa Kemal University Journal of Agricultural Sciences* 24 (Special Issue):9-15, 2019)
e-ISSN: 2667-7733
http://dergipark.org.tr/mkutbd

1st Int. Congress on Biosystems Engineering (ICOBEN 2019) ARAŞTIRMA MAKALESİ/RESEARCH ARTICLE

Agricultural residues potential of Hatay

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MAKALE BİLGİSİ / ARTICLE INFO

Makale tarihçesi / Article history:
Geliş tarihi /Received:09.05.2019
Kabul tarihi/Accepted:09.10.2019

Keywords:
Biomass energy, agricultural residues, Hatay.

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ÖZET/ABSTRACT

Aims: The aim of this study was to determine the biomass potential and the energy value, being produced from agricultural residues in Hatay province.

Methods and Results: The amounts of residues from the agricultural crops cultivated in Hatay province were calculated using production data of crops with Turkish Statistical Institute for the 2018 seasonal years. The annual gross potential of agricultural residues was determined by using residue to product ratio or residue per tree or residue per area. The total amount of agricultural residues was approximately 652.8 kt.year^{-1}. The total heating value of the agricultural residues was around 13.36 PJ.year^{-1}. The top four districts of Hatay according to the amount of agricultural residues are Kırıkhan (181.6 kt), Center (158.8 kt), Reyhanlı (111.3 kt) and Kumlu (65.2 kt). The major crops included in the ratio of the total residues amount were cotton (65.5%), maize (14%), olive (13.3%) and citrus (10.9%).

Conclusions: The potential of agricultural residues concentrated in the Kırıkhan and Center districts. However, there are also significantly different crop residues in other districts. Hatay have a great agricultural residues potential for conversion to energy. Such a large potential necessarily has to be evaluated by establishing modern facilities.

Significance and Impact of the Study: In this paper, the produced maps were provided to see more clearly in the differences of data among the districts. The mapping can provide the rise of public awareness, policy-makers' reference and investor's guide about these subjects.

Atıf / Citation: Karaca C (2019) Agricultural Residues Potential of Hatay. *MKU. Tar. Bil. Derg.* 24 (Özel Sayı) :9-15

INTRODUCTION

Energy is central to economic development, and there is a clear correlation between energy consumption and living standards. Energy sources are split into three categories: fossil fuels, renewable sources and nuclear sources (Karaca, 2015). The valid global energy supply depends heavily on fossil sources (crude oil, lignite, hard coal, natural gas). The World's economies are dependent on crude oil. Fossil fuels are limited resources, collected in few regional areas of the world. This creates a permanent and insecure status of dependency on import of energy for the countries outside this region.

Conventional biomass plays a considerable role in energy production in Turkey. Wood is used as a major resource for direct cooking and heating in rural areas, but the use of modern biomass for energy production is a rather recent event. Turkey is an agricultural country; moreover, it has significant forestry potential, especially in the Central Anatolia, Çukurova, and Southern Anatolia regions. Even though the main goal is harvesting cereals and other seeds in agriculture, there is a strong wish to reclaim buried agricultural waste. Agricultural waste is a major source of biomass due to its high potential (Karaca and Başçetinçelik, 2014).

Turkey has always been one of the major agricultural countries in the world. The importance of agriculture is increasing for biomass energy is one of the major

resources in Turkey. Biomass waste materials can be used in Turkey to provide centralized, medium- and large-scale production of process heat for electricity generation. Electricity generation from biomass has been found to be a promising method in the near future in Turkey (Karaca, 2015).

Biomass energy includes agricultural residues, domestic waste, fuelwood, animal waste and other fuel derived from biological sources. Estimation is based on the recoverable energy potential from the main agricultural residues, livestock farming waste, forestry and wood processing residues and domestic waste as given in the literature. Biomass, which comprising mostly wood and dung for heating and cooking is mainly used in rural areas (Başçetinçelik et al. 2005)

Agricultural residues are defined as a biomass by-product from the agricultural system and include straws, husks, shells, and stalks. These residues can be divided into two groups: crop residues, which remain in the field after harvest, including the cotton stalk, and agricultural residues, which are the by-products of the industrial processing of crops such as rice husk. (Karaca, 2015)

This study aimed to determine the biomass potential and the energy value, being produced from agricultural residues in Hatay province. The major benefits are environmental and relate to the reduction of GHG emissions (since crops are considered CO_2 neutral), conservation of natural resources, and avoidance of fossil fuel consumption. They are complemented by economic benefits (reduction of imported fuel consumption), regional development and investment increase.

MATERIAL and METHODS

Hatay has a surface area of 5,524 km^2 located between the 35°52' - 37°4' northern latitudes and 35°40' - 36°35' east longitudes in the eastern part of the Mediterranean Sea. Hatay province is divided into 14 districts, two of which (Antakya and Defne) are included in the municipality of Center district. Other districts include Altınözü, Arsuz, Belen, Dörtyol, Erzin, Hassa, İskenderun, Kırıkhan, Kumlu, Reyhanlı, Samandağ and Yayladağı (Karaca, 2017).

Grains and industrial crops have the most important place regarding production area and amount of product in the production of agricultural products of Hatay. The province has 228,528 hectares of agricultural land. Field crops constitute 48.5% of the agricultural land and fruit, vegetable and fallow lands constitute the rest. Cotton, wheat, maize, olive and citrus are the prominent products in the province. (Anonymous, 2018a)

The amounts of residues of the crops cultivated in Hatay province were calculated using production data of crops with the Turkish Statistical Institute for the 2018 seasonal years (Anonymous, 2018b). The annual gross potential of agricultural residues was determined by using the residue to product ratio (RPR) (Table1).

The net potential of residues was determined by using the availability of residues. The availability of residues is unused and completely wastes part of residues (Table1). The available potential of the agricultural residues in each district of Hatay was calculated based on the Eq.1.

$$(AAR)_i = (AAP)_i \times (RPR)_i \times (A)_i \quad \text{Eq. (1)}$$

where $(AAR)_i$ is the available amount of agricultural residues of i^{th} crop in ton, $(AAP)_i$ the amount of agricultural product in tons or number of tree for pruning wastes, $(RPR)_i$ residue-to product ratio of the i^{th} crop and $(A)_i$ the availability of residues.

The residues are material left over the field after agricultural production. Some agricultural residues have already been used for domestic purposes, heating, animal fodder, bedding. Mainly residues from the production of industrial, agricultural products are left over the field. The species are cotton stalk, maize stalk, sunflower stalk, cereal straw, pruning, etc.

The energy potential of residues for each district was calculated by multiplication of the heating values of a selection of agricultural residues which was taken heating value per each residue (Table 1) with the available residue amount (Eq. 2).

$$(THV)_i = (AAR)_i \times (LHV)_i \quad \text{Eq. (2)}$$

where $(THV)_i$ the total heating value of agricultural residues of i^{th} crop in GJ, $(AAR)_i$ is the available amount of agricultural residues of i^{th} crop in tons and $(LHV)_i$ lower heating value of air-dry residues of i^{th} crop in MJ kg^{-1}.

The energy content of the selected products for each district was calculated using the above equations. For each district, the calculated values that the total amount and the total energy potential of agricultural crop residues were mapped using the GIS software. The produced maps were provided to see more clearly in the differences of data among the districts. The mapping can provide the rise of public awareness and policy-makers' reference about these subjects.

Table 1. The ratio of product to residue, availability and heating values of a selection of agricultural crop residues (Başçetinçelik et al., 2006; Bilandzija et al., 2012; Velázquez-Martí et al., 2013; Karaca, 2015)

Field Crops	Residues	Ratio of Product to Residue (*RPR*)	Availability (*A*) (%)	Heating Value (*LHV*) (MJ kg^{-1})
Wheat	Straw	1.00	15	17.9
Barley	Straw	0.75	15	17.5
Maize	Stalk	1.60	60	18.5
	Cob	0.30	60	18.4
Cotton	Stalks	2.30	60	18.2
	Ginning residues	0.30	80	15.7
Tobacco	Stalk	1.20	60	16.1
Sunflower	Stalk	2.50	60	14.2
Fruits Crops				
Apricot	Pruning	5.80*	80	19.3
Peach	Pruning	7.00*	80	19.4
Plum	Pruning	7.00*	80	17.3
Fig	Pruning	4.50*	80	15.8
Pomegranate	Pruning	9.00*	80	17.0
Walnut	Pruning	3.50*	50	19.0
Almond	Pruning	5.80*	80	18.4
Lemon	Pruning	13.00*	80	17.6
Orange	Pruning	15.00*	80	17.6
Mandarin	Pruning	13.00*	80	17.6
Grapefruits	Pruning	14.00*	80	17.6
Vineyard	Pruning	4,250**	80	18.0
Olive	Cake	0.40	90	19.7
	Pruning	9.00*	50	18.1

* RPR kg/tree

** RPR kg/ha

RESULTS and DISCUSSION

The total amount of agricultural residues, including annual crop residues (grains, maize, cotton, sunflower, tobacco), perennial residues (tree pruning) and agro-industrial residues (cotton-ginning, seed oil industries, olive oil industries), were calculated to be about 739.8 thousand tons in Hatay (Table 2). The share of sources in these residues is field crops 75.24% and fruit crops 27.76%. Major crops that included in the ratio of the total residue amount are cotton (57.8%), maize (12.41%), olive (11.76%), citrus (9.61%), wheat (4.74%) and vineyard (2.21%).

Table2. The amount of agricultural product and available residues of Hatay

Field Crops	**Amount of Agricultural Product (*AAP*) (tons)**	**Residues**	**Available Residues (*AAR*) (tons)**
Wheat	233,578	Straw	35,037
Barley	5,424	Straw	610
Maize	80,511	Stalk	77,291
		Cob	14,492
Cotton	263,901	Stalks	364,183
		Ginning residues	63,336
Tobacco	1,284	Stalk	924
Sunflower	522	Stalk	783
Fruits Crops			
Apricot	673,675*	Pruning	3,126
Peach	122,665*	Pruning	687
Plum	338,210*	Pruning	1,894
Fig	130,805*	Pruning	471
Pomegranate	732,554*	Pruning	5,274
Walnut	65,065*	Pruning	114
Almond	48,250*	Pruning	224
Lemon	341,191*	Pruning	3,548
Orange	1,935,968*	Pruning	23,232
Mandarin	4,179,458*	Pruning	43,466
Grapefruit	78,273*	Pruning	877
Vineyard	4,622**	Pruning	16,360
Olive	85,501	Cake (pomace)	30,780
	12,492,281*	Pruning	56,215
TOTAL		**Residues**	**739,800**

* Number of trees

** Planting Area (ha)

All districts of Hatay were put in order according to the amounts of residue in Table 3. Also, the distribution map of agricultural residues, which mapped using a GIS Software for each district, was given Fig 1.

It is determined that the most agricultural residue is in Kırıkhan (25.72%) and Center (23.54%) districts in Hatay. Apart from these, also the Reyhanlı district is seen to have a high agricultural residue potential (114.76 ktons). It is viewed that there will not be a shortage of raw materials for the investment and facilities to be made for obtaining energy from agricultural residues in these three districts.

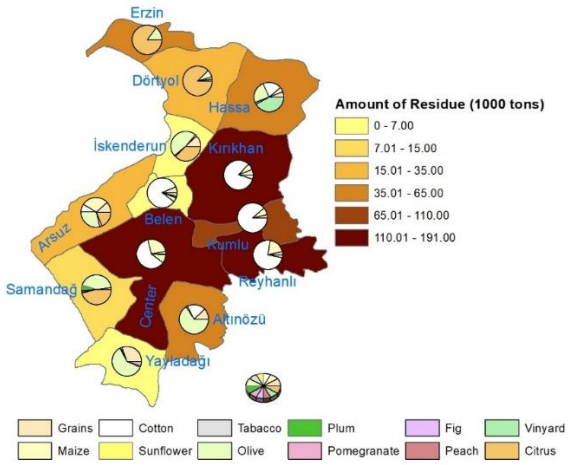

Fig 1. The distribution map of agricultural residues in Hatay

Table 3. The ranking of districts according to amount of agricultural residues

Districts	Field Crops Residues (tons)	Fruit Crops Residues (tons)	Total Residues (tons)	Share in Total Residues (%)
Center	154,789	19,344	174,133	23.54
Altınözü	14,518	26,910	41,428	5.60
Arsuz	10,405	13,763	24,168	3.27
Belen	5,377	762	6,139	0.83
Dörtyol	935	22,833	23,768	3.21
Erzin	1,041	38,672	39,713	5.37
Hassa	11,726	25,116	36,841	4.98
İskenderun	506	3,221	3,726	0.50
Kırıkhan	179,474	10,838	190,312	25.72
Kumlu	64,923	508	65,431	8.84
Reyhanlı	110,602	4,156	114,757	15.51
Samandağ	315	12,857	13,173	1.78
Yayladağı	2,046	4,165	6,211	0.84
TOTAL	**556,657**	**183,143**	**739,800**	100.00

It was calculated that the total heating value of the agricultural residues was about 13,362.8 TJ (319 ktoe) for the production period of 2018 in Hatay. The heating value of agricultural residues that calculated separately for each product is given in Table 4. The distribution map was given Fig 2.

Table 4. Total heating value of agricultural residues of Hatay

Field Crops	Residues	Total Heating Value (*THV*) (GJ)
Wheat	Straw	35,037
Barley	Straw	610
Maize	Stalk	77,291
	Cob	14,492
Cotton	Stalks	364,183
	Ginning residues	63,336
Tobacco	Stalk	924
Sunflower	Stalk	783
Fruits Crops		
Apricot	Pruning	3,126
Peach	Pruning	687
Plum	Pruning	1,894
Fig	Pruning	471
Pomegranate	Pruning	5,274
Walnut	Pruning	114
Almond	Pruning	224
Lemon	Pruning	3,548
Orange	Pruning	23,232
Mandarin	Pruning	43,466
Grapefruit	Pruning	877
Vineyard	Pruning	16,360
Olive	Cake (pomace)	30,780
	Pruning	56,215
TOTAL		**13,362,814**

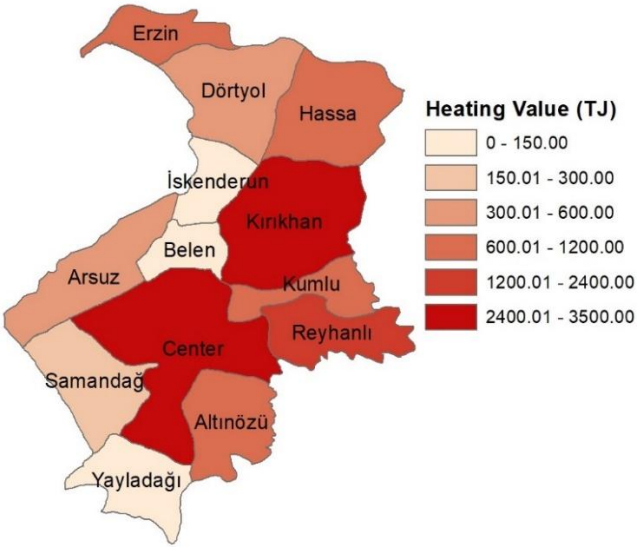

Fig 2. The distribution map of heating value based on agricultural residues in Hatay

These maps (Fig 1 and 2) showed that the potential of agricultural residues concentrated in the Kırıkhan and Center districts. Especially, it is observed that the type and distribution of residues in Kırıkhan district, the distribution of agricultural residues according to heating value are ranked as cotton (2,770 TJ), maize (229.8 TJ) and wheat (203 TJ) respectively. In Center, this ranking consists of cotton (1,885.4 TJ), maize (814.7 TJ), and olive wastes (286.5 TJ) respectively. However, different crop residues are remarkable in a certain district. Heating values of citrus pruning wastes are 585.9 TJ in Erzin, 368.6 TJ in Dörtyol, 110.1 TJ in Samandağ and 25.3 TJ in İskenderun, respectively. Furthermore, olive waste constitutes an important potential in Altınözü (492 TJ), Center (286.5 TJ), Kırıkhan (162.8 TJ) Hassa (160.3 TJ), Arsuz (114 TJ), Samandağ (101 TJ) and Erzin (101.4 TJ) districts. Moreover, it is seen that the vineyard pruning waste also creates a significant energy potential in Hassa (276.9 TJ).

The potential of biomass from agricultural residues was determined in Samsun province. The total biomass potential was determined as 366.6 ktons in the province. (Karaca et al., 2017).

A study carried out by Karaca and Öztürk (2017) in Osmaniye province indicated that the total biomass potential from agricultural residues was 491 ktons.

Karaca (2018) reported the amount of biomass from agricultural residues was about 380.8 ktons year^{-1}, equivalent to about 6,517.8 TJ of heating value in Balıkesir.

Despite these facts, until now, there has not been any investment in these areas related to agricultural residues, which have a great potential for conversion to energy. However, the results of this study show that such a large potential necessarily has to be evaluated by establishing modern facilities.

CONCLUSIONS

This study aimed to determine the distribution of agricultural residues in the districts of Hatay as given on the map. The importance of this paper is increasing more because Turkey is an energy importing country. Hatay is in the tenth place with a share of 2.57% in Turkey, especially regarding the potential for field crops residues (Karaca, 2015).

The total amount of agricultural residues was approximately 739.8 kt. It was found that the total heating value of the agricultural residues was around 13,362.8 TJ for the production period of 2018. It was determined that this potential concentrate in the Kırıkhan, Center and Reyhanlı districts. It was seen that the majority of agricultural residues originate from field crops. According to the amount of residues of agricultural products, it is listed as, cotton (57.8%), maize (12.41%), olive (11.76%), citrus (9.61%), wheat (4.74%) and vineyard (2.21%).

Although Hatay province has a large biomass energy potential, this potential cannot be adequately assessed. In this paper, the produced maps were provided to see more clearly in the differences of data among the districts. The mapping can provide the rise of public awareness, policy-makers' reference and investor's guide about these subjects.

Consequently, agricultural residues are a very attractive choice, since it is economical, sustainable, environmental friendly and a familiar energy source for Hatay.

DECLARATION OF CONFLICTING INTERESTS

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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