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EXPLOITABLE ENERGY POTENTIAL BASED ON AGRICULTURAL BIOMASS RESIDUES IN TURKEY

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ABSTRACT

Agricultural crops are grown in large quantities and agricultural biomass residues are remained from this production in Turkey. In this study, biomass residues amount was calculated from the arable field crops and horticultural fruit production in Turkey and its spatial distribution map was developed according to provinces in Turkey. The potential energy values of these biomass residues was also calculated for Turkey. With the study, the potential provinces that could establish a biomass energy plant were identified.

According to TUİK [13], theoretical biomass potential which was obtained from arable field crop production waste was about 50.9 Mton.dm, while theoretical energy potential was 853.3 PJ and available energy potential was about 291.8 PJ, respectively. Theoretical biomass potential obtained from pruning residues in horticultural fruit production was about 4.7 Mton.dm, and theoretical energy potential were 85.7 PJ, and available energy potential was about 68.5 PJ. The total theoretical biomass potential which was obtained from both field crop and horticultural fruit was 55.6 Mton.dm, theoretical energy potential was 939.0 PJ (22,425.5 ktoe), available energy potential was 360.3 PJ (8,604.8 ktoe).

When the biomass residue map and the energy values that can be obtained from biomass waste observed, the provinces which have over to 1 million tons solid waste biomass potential were Konya, Şanlıurfa, Adana, Diyarbakır, Mardin, Ankara, Manisa, Hatay, Tekirdağ, Edirne, Mersin, Aydın, Osmaniye, İzmir, Eskişehir and Kahramanmaraş respectively.

KEYWORDS:
Biomass, Waste Biomass, Waste Biomass Energy Potential

INTRODUCTION

Biomass energy resources, which can exist in every region of the world, are important renewable and sustainable energy resources for sustainable development. At the same time, many studies were carried out to determine the biomass potential and policies about biomass, which is regarded as a clean energy source, and stabilize greenhouse gas emissions.

Sakellariou et al. [1] studied the biomass production and economic results of sorghum. They indicated optimization of economic results could be achieved by a better management of production resources. Iqbal et al. [2] reviewed the way of promotion green agriculture and controlling pollution in their study indicating plants are sources of diverse classes of natural products. Status of bio-energy and requirements in biogas production was examined in Turkey by Denli et al. [3] which was revealed the potential sources such as raw material from agricultural areas and the importance of energy production via biogas in Turkey. Yücel et al. [4] carried out a study to asssess the potential of sweet sorghum as a source of biofuel production. According to results from their work, 21 genotypes had greater biomass and ethanol potentials than others. The biomass resources include crops, crop residues, forest resources, special energy crops, animal waste, industrial and urban waste. As a source of biomass energy, forestry, wastes, and residues derived from animal and agricultural sources, domestic and urban waste spread to all regions in Turkey. The amount of crop residue produced in agriculture is directly related to crop productivity. Crop productivity depends not only on agronomic processes but also on environmental factors such as climate and soil [5]. Also, differences in agricultural practices (such as the mowing height), the type of crop, and the production values of crops are also influencing the residual amount [6,7,8]. It is important to know the potential of biomass resources to develop and plan biomass-based policies. There are many studies on the potential of biomass resources at global scale [9,10,11].

Biomass wastes firstly should be considered for sustainable energy production. In agricultural production, many wastes have been occured from both crop production and fruit growing. Agriculture is very important in terms of climate characteristics and biological diversity in Turkey so, it is of great

importance to evaluate the wastes generated both field crops and horticulture growing.

Research on energy production based on biomass sources in Turkey, with contributions from the private sector, started with the entry of the Renewable Energy Law, then began to develop rapidly in the begining of 2000's. The incentives defined in the Renewable Energy Law No. 5346 include biomass investments. Biomass investments are supported by the highest purchase price guarantee level of 13.3 US cents/kWh, with an additional incentive under the name of "domestic contribution" in the case of domestic equipment use, reaching 18.1 US cents/kWh [19]. As of January 2018, located in Turkey 100 units Biogas, Biomass, Waste Heat and Power Plants Oil pyrolytic have total installed capacity of 530 MWe. The total installed base power rate is 0.64%, and about 2.277 GWh of electricity is produced annually from biomass energy [12].

In this study; the city-based map was developed according to the amount of waste, which was occured from both crop production and fruit growing value in Turkey. For this aim, the theoretical and available energy potential values were calculated by using values of crops and fruit production in each city of Turkey. Processes and technologies were interpreted for energy generation in waste for potentially high cities.

MATERIALS AND METHODS

Materials. The main data source was agricultural crop production statistics to calculate Turkey's and 81 provinces of agricultural biomass waste potential [13]. Totally 30 different crops were selected with high annual production, 14 for field crops and 16 for fruit. These are; wheat, sugar beet, barley, corn, cotton, sunflower, rice, rye, oats, beans, soybean, groundnut, rapeseed, tobacco, grape, apple, orange, olive, mandarin, lemon, apricot, hazelnut, peach, cherry, pear, fig, banana, grapefruit, pistachio, almond.

Methods. In this study, structural and physical properties of agricultural waste were evaluated for biomass as an energy source in the world's different countries, primarily Turkey. Taking into consideration the types of crops (straw, stem, crust, stem-leaf, cob, pruning, etc.), their relative humidity contents, residue/product ratio and lower heat collected data of the agricultural crop production patterns of the different countries based on the global scale were analyzed. Mean values were calculated according to various literature based on the values of the physical properties of field crops and fruit growing. The waste type (i), waste moisture content (M), Residue-Production-Ratio (RPR), the lower heating value (LHV) and availability rates (A) of the products were used in the study. The values were given in Table 1 and Table 2.

Theoretical biomass, theoretical energy and available energy potential were calculated in three stages based on field crops and horticultural products belonging to 81 provinces in Turkey [14]. Theoretical Biomass Potential (TBP) shows the total annual production of biomass obtained as waste.

The TBP can be calculated using the data in Tables 1 and 2 with the following equation:

$$(TBP = \sum_{i=1}^{n} CP(i) \times RPR(i) \times \left[\frac{100 - M(i)}{100}\right]) \quad (1)$$

TABLE 1
Selected field crop productions, waste types, moisture rates, waste-product rates, sub-thermal values and availability rates

Agricultural Products (i)	Type of residue	M[1](%)	RPR[1]	LHV[1](MJ/kg.dm)	A[2] (%)
Wheat	Straw	13	1.13	16.7	15
Sugar beet	Leaf	75	0.13	16.6	15
Barley	Straw	13	1.22	18.5	15
Corn	Stem	16	1.88	17.0	60
	Corncob	8	0.57	15.5	60
Cotton	Stem	9	2.30	16.4	60
Sunflower	Root- leaf	27	2.10	15.6	60
Rice	Straw	18	1.10	12.4	60
	Shell	12	0.24	16.4	80
Rye	Straw	15	0.99	17.4	15
Oat	Straw	12	0.37	18.5	15
Beans	Root- Leaf	5	1.45	14.7	15
Soybean	Straw	15	2.13	17.2	60
Groundnut	Shell	8	0.36	14.1	80
	Straw -stalk	15	2.20	14.8	80
Rapeseed	Stem	45	1.70	17.1	15
Tobacco	Root	85	2.27	16.1	60

(1) Numerical datas were calculated as average from the upper and lower values given in various literatures. [1,2,5,6,7,9,11,14,15,16,17,18,20,21,22,23,24,25,26,27,28,29,30].
(2) Available rates were taken from Ozturk & Bascetincelik [11].

TABLE 2
Selected horticulture productions, waste types, moisture rates, waste-product rates, sub-thermal values availability rates

Agricultural Products (i)	Type of residue	M[1] (%)	RPR[1]	LHV[1] (MJ/kgkm)	A[2] (%)
Grape	Pruning	45	0.42	18.0	80
Apple	Pruning	40	0.19	17.8	80
Orange	Pruning	40	0.35	18.1	80
Olive	Pruning	40	1.20	18.5	50
Mandarin	Pruning	40	0.28	17.6	80
Lemon	Pruning	40	0.30	17.6	80
Apricot	Pruning	40	0.19	20.0	80
Hazelnut	Pruning	40	3.34	19.0	80
Peach	Pruning	40	0.40	18.2	80
Cherry	Pruning	40	0.19	21.7	80
Pear	Pruning	37	0.22	18.2	80
Fig	Pruning	55	0.21	18.2	80
Banana	Stem-shell	85	2.00	13.1	80
Grapefruit	Pruning	40	0.11	17.6	80
Pistachio	Pruning	35	0.44	18.5	80
Almond	Pruning	37	0.60	18.2	80

1) Numerical datas were calculated as average from the upper and lower values given in various literature [1,6,10,11,14,15,19,21].
(2) Available rates were taken from Ozturk & Bascetincelik [11].

CP (i) shows the amount of agricultural crop production in tonnes per year, RPR(i) is waste-product rate, and M (i) is the relative humidity content as a percentage of waste. TBP_i is used to calculate the amount of annual waste, which was obtained as a dry matter. Additionally, following equation is used to calculate TEP- the energy potential of the calculated theoretical dry biomass.

$$(TEP = \sum_{i=1}^{n} TBP(i) \times LHV(i)) \qquad (2)$$

LHV (i) shows the lower heating value of the crop in MJ/kg.dm.

The following equation can be used to calculate in the AEP of field crops and horticulture waste:

$$(AEP = \sum_{i=1}^{n} TEP(i) \times A(i)) \qquad (3)$$

In this equation, A (i) is the percentage of availability of the waste.

RESULTS AND DISCUSSION

Utilizing the data of TUIK [13], amount of waste biomass, which obtained from field crops and fruit growing were calculated for 81 cities of Turkey. Theoretical and available energy potential values of the wastes were given Table 3, which was calculated from the data of Table 1 and Table 2.

The total waste was given as biomass potential (TBP_f and TBP_h), obtained from the field crops and fruit growing areas were separated two different sections at the table. Also, the theoretical energy potentials of these wastes (TEP_f and TEP_h) and the available energy potential values (AEP_f and AEP_h) was given. In the third sections, there are total waste biomass potential (TBP_T), total theoretical potential energy (TEP_T) and available energy potential (AEP_T) values obtained from both crop productions and fruit growing production.

According to the calculations made using data from TUİK [13] in Turkey;

Cultivation of arable field crops:

- Theoretical waste biomass potential is about 50.9 Mton dry matter,
- Theoretical energy potential is 853.3 PJ,
- Available energy potential is 291.8 PJ.

Obtained from fruit growing by pruning;

- Theoretical waste biomass potential is about 4.7 Mton dry matter,
- Theoretical energy potential is 85.7 PJ,
- Available energy potential is 68.5 PJ'dur.

Total obtained from field and horticultural cultivation;

- Theoretical waste biomass potential is 55.6 Mton dry matter,
- Theoretical energy potential is 939.0 PJ (22,425.5 ktoe) and
- Available energy potential is 360.3 PJ (8,604.8 ktoe).

It was found that the total calorific value of the field crop residues was around 228 PJ for the production period of 2002–2003 in Turkey. The total calorific value of the fruit residue was 75 PJ [11]. The total biomass energy potential of Turkey is about 33 million tons of oil equivalents (Mtoe). The amount of usable biomass potential of Turkey is approximately 17 Mtoe [15].

Given in the Table 3, when the total amount of waste is examined; it is possible to distinguish into five groups. These are;

1. Cities which are total waste biomass potential of more than 4 million tonnes / year: Konya, Şanlıurfa and Adana,
2. Cities which are total waste biomass potential of more than 2-3 million tonnes/year: Diyarbakır, Mardin, and Ankara,
3. Cities which are total waste biomass potential of more than 1-2 million tonnes/year: Manisa, Hatay, Tekirdağ, Edirne, Mersin, Aydın, Osmaniye, İzmir, Eskişehir and Kahramanmaraş,
4. Cities which are total waste biomass potential of more than 0.5-1 million tonnes/year: Adıyaman, Afyonkarahisar, Aksaray, Amasya, Antalya, Balıkesir, Bursa, Çanakkale, Çorum, Denizli, Karaman, Kayseri, Kırklareli, Kırşehir, Nevşehir, Sakarya, Samsun, Sivas, Tokat and Yozgat,
5. Cities which are total waste biomass potential of less than 0.5 million tonnes / year: Ağrı, Ardahan, Artvin, Bartın, Batman, Bayburt, Bilecik, Bingöl, Bitlis, Bolu, Burdur, Çankırı, Düzce, Elazığ, Erzincan, Erzurum, Gaziantep, Giresun, Gümüşhane, Hakkâri, Iğdır, Isparta, İstanbul, Karabük, Kars, Kastamonu, Kırıkkale, Kilis, Kocaeli, Kütahya, Malatya, Muğla, Muş, Niğde, Ordu, Rize, Siirt, Sinop, Şırnak, Trabzon, Tunceli, Uşak, Van, Yalova and Zonguldak.

Field crop and fruit products were determined based on the value of production in Turkey's cities for 2017 year and the map was given in Figure 1, which indicates the total waste biomass values. When the map is examined; areas with high waste potential were Thrace, Aegean, Mediterranean and Southeastern Anatolia regions where field crop and fruit growing were done intensely.

The theoretical energy potentials for the areas with the highest waste potential was 82.5 PJ for Konya, 69.3 PJ for Şanlıurfa, 68.3 PJ for Diyarbakır, 41.0 PJ for Mardin and 34.9 for Ankara. In Turkey, agricultural waste largely is used for animal feed and also, used for heat energy by direct burning. For this reason, the potential of available agricultural waste energy is decreasing. As a result of the calculations, which were made by considering the avaliable rates given by Öztürk & Başçetinçelik [10]. The available energy potentials were calculated as 25.1 PJ for Konya, 32.8 PJ for Şanlıurfa, 37.7 PJ for Adana, 14.8 PJ for Diyarbakır, 14.9 PJ for Mardin and 5.9 for Ankara.

CONCLUSIONS

Turkey due to the climatic conditions, agricultural biodiversity features that are quite high and the country is an agricultural crop production can be made in every region. Crop residues are obtained in large quantities during both field cultivation and fruit growing.

Wastes from field crops and fruit growing are mapped separately calculated for 81 provinces in Turkey using TUIK data [13]. The total theoretical potential of biomass waste of Turkey's arable and horticultural farming in the emerging waste (straw, leaves, pruning etc.) was calculated approximately 55.6 Mtoe of dry matter, theoretical energy potential was calculated as 939.0 PJ (22,425.5 kToE) and the usable energy potential was calculated as 360.3 PJ (8,604.8 kToE) respectively. Cities that has over 1 million tons of waste biomass potential on dry matter are listed as; Konya, Sanliurfa, Adana, Diyarbakir, Mardin, Ankara, Manisa, Hatay, Tekirdag, Edirne, Mersin, Aydın, Osmaniye, İzmir, Eskişehir and Kahramanmaraş. These plans need to be taken into account in planning for the establishment of waste biomass heat and electricity generation facilities.

Moisture content has a great importance, as well as various criteria for selecting the most suitable method for energy conversion of residues from field crops and fruit growing. Residues of less than 50% moisture content are better suited to, while a moisture content higher than 50% is suitable for Biomass residues containing more than 35% moisture are not economical for electricity generation [10].

Biomass energy conversion methods, biomass evaluation technologies are used to produce biomaterials such as composite material, organic fertilizer, compost production material, chipboard, bioplastic with biorefinery systems it is possible to obtain both high energy and high value at bio products with very little waste.

Biomass energy is used for the management of agricultural waste management and as alternative source of energy is also very important in terms of solving environmental problems. Biomass energy and electricity generation has significant value in terms of the agricultural sector and rural development, although currently installed capacity is low value in Turkey.

Legal regimes and investment potential for biomass energy resources need to be increase in order to ensure sustainability both economically and environmentally for Turkey, where imports the vast majority of energy. chemical processes such as gasification while a moisture content higher than 50% is suitable for biochemical conversion processes. Biomass residues containing more than 35% moisture are not economical for electricity generation.

TABLE 3

According to TUIK [13], theoretical biomass potential, theoretical energy potential, and available energy potential values, which are obtained from both field crop and fruit growing wastes

Provinces (Cities)	Field Crops			Horticulture			Total		
	TBP_f (tdm)	TEP_f (GJ)	AEP_f (GJ)	TBP_h (tdm)	TEP_h (GJ)	AEP_h (GJ)	TBP_T (tdm)	TEP_T (GJ)	AEP_T (GJ)
Turkey	**50,8954**	**853,3044**	**291,7890**	**4,6867**	**85,6860**	**68,5490**	**55,5820**	**938,9901**	**360,3371**
Adana	3,886,688	64,033,352	34,340,422	236,815	4,252,075	3,401,660	**4,123,503**	68,285,427	37,742,082
Adıyaman	619,472	10,713,369	2,786,211	25,640	465,896	372,716	**645,111**	11,179,265	3,158,928
Afyon	757,022	13,190,135	2,117,857	11,190	219,328	175,462	**768,212**	13,409,463	2,293,319
Ağrı	246,512	4,281,355	654,794	14	268	214,051	**246,526**	4,281,623	655,008
Aksaray	772,130	13,340,266	3,460,364	3,367	60,890	48,712	**775,499**	13,401,156	3,509,076
Amasya	602,195	10,129,819	2,926,110	9,426	180,163	144,130	**611,622**	10,309,982	3,070,240
Ankara	1,999,587	34,615,182	5,702,860	14,093	256,910	205,528	**2,013,680**	34,872,091	5,908,388
Antalya	453,418	7,683,206	2,384,012	251,399	4,440,599	3,552,479	**704,816**	12,123,804	5,936,491
Ardahan	23,551	422,257	63,527	302	5,676	4,541	**23,853**	427,932	68,068
Artvin	8,904	145,424	69,958	11,822	223,969	179,175	**20,726**	369,393	249,133
Aydın	1,034,968	17,095,395	9,500,302	232,592	4,285,591	3,428,473	**1,267,560**	21,380,986	12,928,774
Balıkesir	663,441	10,672,285	3,124,412	140,652	2,599,380	2,079,504	**804,093**	13,271,665	5,203,916
Bartın	41,935	700,805	261,586	15,766	298,609	238,887	**57,701**	999,414	500,474
Batman	297,322	4,978,241	1,515,895	8,074	145,687	116,549	**305,396**	5,123,928	1,632,444
Bayburt	79,851	1,376,055	206,424	182	3,306	2,644,685	**80,033**	1,379,361	209,069
Bilecik	95,602	1,626,149	299,407	10,226	189,182	151,346	**105,828**	1,815,332	450,753
Bingöl	33,060	551,919	98,721	1,955	35,247	28,198	**35,015**	587,166	126,919
Bitlis	90,487	1,472,023	274,560	3,215	59,100	47,280	**93,702**	1,531,123	321,840
Bolu	165,892	2,833,547	460,035	4,028	72,924	58,339	**169,920**	2,906,472	518,374
Burdur	235,531	4,078,842	626,733	11,255	204,293	163,434	**246,786**	4,283,135	790,168
Bursa	601,449	9,920,906	4,231,860	107,071	1,970,632	1,576,506	**708,520**	11,891,538	5,808,366
Çanakkale	583,297	9,513,850	2,938,414	127,698	2,348,375	1,878,700	**710,995**	11,862,224	4,817,114
Çankırı	336,841	5,676,844	980,303	1,929	35,186	28,149	**338,770**	5,712,030	1,008,452
Çorum	974,489	16,360,538	3,494,803	5,314	97,533	78,027	**979,803**	16,458,071	3,572,830
Denizli	709,248	12,036,788	4,202,499	143,273	2,590,914	2,072,731	**852,521**	14,627,702	6,275,230
Diyarbakır	2,414,650	40,448,523	14,307,705	31,284	564,025	451,220	**2,445,934**	41,012,548	14,758,925
Düzce	70,081	1,158,955	679,325	109,844	2,086,519	1,669,215	**179,925**	3,245,474	2,348,540
Edirne	1,342,137	20,606,483	8,464,020	4,755	85,974	68,779	**1,346,892**	20,692,457	8,532,799
Elazığ	217,658	3,852,570	577,885	28,253	523,702	418,961	**245,911**	4,376,271	996,847
Erzincan	161,947	2,767,192	424,560	3,878	71,444	57,155	**165,825**	2,838,636	481,715
Erzurum	283,379	4,844,791	779,062	1,031	19,145	15,316	**284,410**	4,863,936	794,378
Eskişehir	1,063,714	18,287,595	3,583,255	2,390	47,076	37,661	**1,066,104**	18,334,671	3,620,916
Gaziantep	373,526	6,263,283	1,985,995	58,875	1,076,090	860,872	**432,401**	7,339,373	2,846,868
Giresun	37,906	656,588	153,982	77,117	1,464,489	1,171,591	**115,023**	2,121,076	1,325,573
Gümüşhane	62,849	1,074,936	162,232	1,820	34,038	27,230	**64,670**	1,108,974	189,462
Hakkâri	13,045	215,731	36,211	2,109	38,154	30,523	**15,154**	253,885	66,734
Hatay	1,190,502	19,693,001	9,901,001	275,685	4,977,703	3,982,162	**1,466,187**	24,670,704	13,883,163
Iğdır	111,337	1,877,719	672,239	7,145	135,662	108,530	**118,482**	2,013,381	780,769
Isparta	220,150	3,863,334	582,394	94,100	1,707,759	1,366,207	**314,250**	5,571,094	1,948,601
İstanbul	246,536	4,105,011	1,038,055	2,203	41,525	33,220	**248,739**	4,146,536	1,071,275
İzmir	831,550	13,856,054	7,082,039	263,678	4,844,508	3,875,607	**1,095,228**	18,700	10,957,646
K.maraş	1,011,873	16,943,960	6,427,635	33,129	612,177	489,742	**1,045,002**	17,556,137	6,917,377
Karabük	38,153	659,939	104,532	758	13,975	11,180	**38,911**	673,914	115,712
Karaman	887,514	14,926,850	6,147,891	60,791	1,092,509	874,007	**948,305**	16,019,359	7,021,898
Kars	146,326	2,591,930	388,790	894	17,548	14,039	**147,220**	2,609,479	402,828
Kastamonu	143,007	2,421,775	441,584	14,994	282,670	226,136	**158,001**	2,704,445	667,720
Kayseri	810,658	14,066,042	2,366,215	20,279	365,708	292,566	**830,938**	14,431,749	2,658,781
Kırıkkale	392,991	6,738,892	1,311,861	3,111	56,242	44,993	**396,103**	6,795,134	1,356,854
Kırklareli	847,001	13,804,596	4,529,632	1,817	33,280	26,624	**848,818**	13,837,876	4,556,256
Kırşehir	536,512	9,447,500	1,549,134	1,545	27,903	22,322	**538,056**	9,475,403	1,571,457
Kilis	74,700	1,257,826	488,557	37,530	683,639	546,911	**112,230**	1,941,466	1,035,469
Kocaeli	121,249	2,065,169	624,772	17,882	338,598	270,879	**139,131**	2,403,767	895,651
Konya	4,843,268	81,855,035	24,610,513	36,853	685,753	548,602	**4,880,121**	82,540,788	25,159,116
Kütahya	363,841	6,263,666	981,307	6,889	138,739	110,991	**370,730**	6,402,405	1,092,298
Malatya	164,620	2,854,194	449,246	52,366	1,030,196	824,156	**216,987**	3,884,390	1,273,403
Manisa	1,125,071	18,849,769	8,689,460	461,004	8,385,546	6,708,437	**1,586,074**	27,235,316	15,397,897
Mardin	2,006,320	33,523,142	14,329,818	42,202	762,047	609,638	**2,048,522**	34,285,189	14,939,456
Mersin	826,841	13,778,836	6,424,916	481,118	8,372,305	6,697,844	**1,307,959**	22,151,140	13,122,760
Muğla	166,703	2,817,533	741,514	209,297	3,838,655	3,070,924	**371,000**	6,656,188	3,812,438
Muş	248,378	4,195,123	666,884	743	13,393	10,714	**249,121**	4,208,516	677,598
Nevşehir	488,357	8,404,519	1,264,025	25,209	454,040	363,232	**513,565**	8,858,559	1,627,257
Niğde	300,141	5,115,470	767,385	52,625	949,339	759,471	**352,767**	6,064,809	1,526,856
Ordu	18,109	305,476	141,653	188,043	3,571,642	2,857,313	**206,152**	3,877,117	2,998,967
Osmaniye	1,125,195	18,523,098	10,096,194	46,725	862,603	690,082	**1,171,921**	19,385,701	10,786,277
Rize	532	8,812	5,178	2,506	46,854	37,483	**3,038**	55,666	42,661
Sakarya	692,129	11,520,699	6,570,070	182,939	3,456,928	2,765,542	**875,068**	14,977,627	9,335,612
Samsun	721,545	11,518,548	4,378,191	144,439	2,737,547	2,190,037	**865,984**	14,256,094	6,568,228
Siirt	147,029	2,460,493	639,665	6,824	124,875	99,900	**153,853**	2,585,368	739,565
Sinop	106,624	1,658,095	659,954	3,753	70,553	56,443	**110,377**	1,728,649	716,396
Sivas	796,412	13,662,314	2,054,201	790	14,361	11,489	**797,201**	13,676,675	2,065,690
Şanlıurfa	4,124,521	68,697,143	32,267,355	32,904	601,400	481,121	**4,157,425**	69,298,543	32,748,475
Şırnak	262,208	4,372,728	1,269,020	1,766	31,817	25,454	**263,974**	4,404,545	1,294,474
Tekirdağ	1,422,940	23,317,008	6,798,203	15,466	281,572	225,257	**1,438,405**	23,598,580	7,023,461
Tokat	546,695	9,194,071	2,283,742	19,735	362,278	289,823	**566,430**	9,556,349	2,573,565
Trabzon	37,986	629,485	370,556	59,767	1,134,383	907,507	**97,753**	1,763,868	1,278,062
Tunceli	40,824	717,812	107,672	1,063	19,263	15,411	**41,887**	737,075	123,083
Uşak	321,179	5,655,596	893,067	8,660	157,347	125,877	**329,838**	5,812,943	1,018,945

Van	118,889	2,011,313	301,697	1,901	34,934	27,947	**120,789**	2,046,247	329,644
Yalova	5,219	90,666	14,837	4,148	76,448	61,158	**9,367**	167,113	75,996
Yozgat	887,966	14,991,272	2,356,931	4,764	86,391	69,113	**892,730**	15,077,663	2,426,043
Zonguldak	22,022	367,664	122,710	57,941	1,100,675	880,540	**79,963**	1,468,338	1,003,250

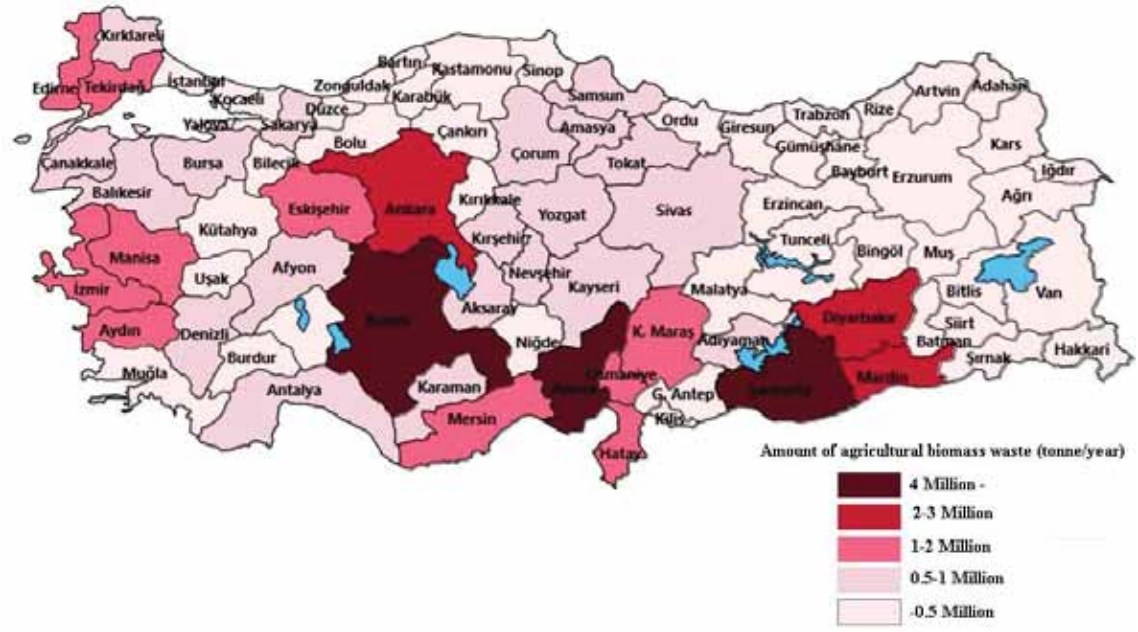


FIGURE 1
Distribution of potential waste amount map which was obtained from field crops and fruit growing, according to the cities of Turkey

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