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AGRO-ECONOMIC ANALYSIS OF COMPOST DERIVED FROM ORGANIC KITCHEN WASTES

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Abstract

In this research, it was aimed to determine the amount of compost obtained from organic kitchen waste in Isparta province and the resulting economic loss when these wastes were not recycled as compost. Composting of organic kitchen wastes collected from the selected households was carried out in a home composter in the Laboratory of Composting and Biogas, Department of Agricultural Machinery and Technology Engineering, Süleyman Demirel University. The results showed that the concentrations of N, P_2O_5, K_2O, MgO, and CaO of the finished compost were determined as 1.73%, 1.00%, 1.91%, 1.00%, and 3.72%, respectively. Results revealed that kitchen organic waste corresponding to 0.66 kg N, 0.38 kg P_2O_5, 0.73 kg K_2O, 0.38 kg MgO, and 1.41 kg CaO kitchen waste per household per year was wasted without utilization.

In the study, the economic value of the wastes when not recycled as compost was determined as 54658$, 29389$, and 111237$ per year corresponding urea, triple superphosphate, and potassium sulphate, respectively based on the commercial fertilizer price. It was determined that compost obtained from organic kitchen wastes was found to be 386164$ per year when economic value was calculated directly as compost rather than as equivalent commercial fertilizer.

Keywords: organic kitchen wastes, compost, economic loss, equivalent commercial fertilizer

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INTRODUCTION

Organic matter plays many roles on physical, chemical and biological properties of the soils thereby on soil fertility directly and indirectly. There are occasions where these effects occur at the same time. Organic matter improves the physical properties of the heavy soils. Adding organic matter into soils provides good aerations leading to good condition for better plant and microorganism growth. Furthermore, increase of organic matter in the soil leads to aggregations of soil particles. Soil organic matter has positive effects on soil pH, cation exchange capacity, heat and water holding capacity. From one side, decomposition products of organic matters increase the availability of unavailable nutrients in the soils, on the other side, releases of nutrients with mineralization processes from the organic matter have direct effect on soil fertility and plant mineral nutrition. Additionally, as being a reserve of the many macro and micro nutrients, organic matter is one of the most important soil components (Havlin *et al*., 2005; Marschner, 2011; Doan *et al*., 2013; Doan *et al*. 2014; Aynacı and Erdal, 2016). Although chemical fertilizers are the most effective sources for solving the nutritional problems in the soils and plants, organic matter additions can play a key role next to inorganic fertilizers. Soil organic matter is subjected to decrease due to continuous cultivation of soil in case of no replacement occurs. Therefore, some precautions should be taken to keep the amount of organic matter in the soil at the certain level. There are several ways to maintain the certain level of organic matter, one of which is the addition of compost to soil. Composting is a decomposition of organic materials and a process of which physical, chemical, and biological factors interact simultaneously (Keener *et al*., 1993). At the end of composting process, the new and economic products (humus like materials) are produced. Many organic materials such as manure, plant residues, pruning materials, leaves, straws, roots, tubers, municipal open market wastes, agricultural industry wastes, etc. can be used as compost material (Jaya *et al*., 2006; Haydar and Masood 2011; Ekinci *et al*., 2016). Additionally, home-originated wastes (kitchen wastes) are being used widely for compost production in the world (Nair *et al*. 2006; Kibria 2013; Skadborg *et al*. 2016; Mousavi and Faraji 2016). However, the amount of wastes collected for composting is at very low level since the number of municipal composting facility is limited in Turkey. According to the report published by the Ministry of Environment and Urbanism, there are only four plants where organic kitchen wastes are regularly collected and composted in Turkey (Anonymous, 2017).

In this study, it was aimed to determine the amount of compost obtained from organic kitchen waste in Isparta province and the resulting economic loss when these wastes were not recycled as compost in the province of Isparta.

MATERIALS AND METHODS

The composting process was carried out in the 150 dm^3 home composter in Compost and Biogas laboratory of Department of Agricultural Machinery and Technology Engineering, Süleyman Demirel University. Total 296 kg of organic kitchen wastes were collected from ten households for one month and were left for composting without any other addition. There were not any other contaminants or non-organic materials in the wastes. Composting was carried out in an open type home composting bin with naturel aeration. Composting took almost 4.5 months and 39.6 kg compost was obtained from 10 households for one month. Maximum temperature was measured as 65 C^o during the composting period. At the end of the composting period, C/N ratio was about 25. The compost amount decreased 20.5% due to drying for nutrient analysis and the dried compost was recorded as 31.5 kg. This equals to 3.15 kg dried compost for each household in a month and 38 kg in a year. In order to find the commercial chemical fertilizer equivalency of compost, N, P, K, Ca, and Mg concentrations of the finished composts were analyzed. In order to determine N concentration, 0.5 g grounded sample was weighted in to the 250 ml macro-Kjeldahl tubes then 5 g of salt mixture and 10 ml concentrated H_2SO_4 was added and tubes were placed in the digesting block at 350-400 C^o. After digesting, samples were distilled with NaOH (40%). The ammonium N was fixed in H_3BO_3 (2%) and titrated with 0.1N H_2SO_4. For other analyses, 0.5 g of dried compost sample was wet digested using microwave digestion unit and filled up to 100 ml with pure water. Phosphorus measurement was done using spectrophotometer; K, Ca and Mg were measured with Atomic Absorption Spectrophotometer. The total compost obtained within a year in Isparta Province was calculated based on the number of households and the amount of compost which could be produced per household. Afterwards, the commercial chemical fertilizer equivalency of compost was obtained by multiplication of the total compost produced by chemical contents of compost. Then, the economic value of total compost material corresponding to N, P, K, Ca and Mg contents of chemical fertilizers was determined from the current commercial fertilizer prices. For the nutrient calculation, commercial fertilizers such as urea, ammonium nitrate, triple superphosphate, potassium sulphate, calcium sulphate and magnesium sulphate were used. For the sake of economic analysis, ammonium nitrate as commercial fertilizer was not considered because of the legal sales prohibition.

RESULTS AND DISCUSSION

The nutrient content of the finished compost is given in Table 1 while the total plant nutrient (per year) obtained from organic kitchen waste in Isparta

province presented in Table 2. Calculation is based on the fact that approximately 1 kg of organic kitchen wastes per day per person is produced in a family of four. This value is close to the values reported by Yaman (2012). The concentrations of N, P_2O_5, K_2O, MgO, and CaO, which are plant nutrients in compost material, were determined as 1.73 %, 1.00 %, 1.91 %, 1.00 %, and 3.72 %, respectively. The similar values were determined from the study carried out by Ekinci *et al*. (2016) for the composts obtained from market wastes. It was found that the CaO content of compost material in particular was higher than that of other nutrients. Nitrogen was followed by potassium. It was stated that compost products were rich in soluble cations (Ca and Mg) in a study (Güler, 2001). Similar results were obtained in the study conducted by Adediran *et al*. (2003). The compost mineral content varies depending on the raw materials used. For example, Alburquerque *et al*. (2007) found the compost P, K, and Ca content from various mixtures as 1.4, 2.75, and 1.25%, respectively, while Baldi *et al*. (2014) determined the contents of P and K of the compost material as 0.58 and 0.91%, respectively.

Table 1. Nutrient concentration of the finished compost obtained from organic kitchen waste (%) in the study

Nutrients	%
N	1.73
P_2O_5	1.00
K_2O	1.91
MgO	1.00
CaO	3.72

Table 2. The amount of plant nutrition of compost (kg)

Nutrients	Nutrient amounts		The number of households	Total plant nutrient (Kg year^{-1})
	(Kg 10 households^{-1} month^{-1})	(Kg households^{-1} year^{-1})		
N	0.55	0.66	76696	50619
P_2O_5	0.32	0.38	76696	29144
K_2O	0.61	0.73	76696	55988
MgO	0.32	0.38	76696	29144
CaO	1.18	1.41	76696	108141

The amount of plant nutrients in the finished compost are given in Table 2. It was determined that 0.66 kg of N, 0.38 kg of P_2O_5, 0.73 kg of K_2O, 0.38 kg of

MgO and 1.41 kg of CaO per household per year were wasted without utilization of organic kitchen wastes. The total amount of wasted plant nutrients per year was calculated by multiplication of the total number of households in the study area with the amount of plant nutrient wasted per household per year. According to this study, 50619 kg N, 29144 kg P_2O_5, 55988 kg K_2O, 291144 kg MgO and 108141 kg MgO per year in Isparta province were thrown away without utilization as compost.

Table 3. Chemical fertilizer equivalency of compost (kg)

Nutrients	Nutrient amount	Urea	Ammonium nitrate (33%)	Triple superphosphate (44%)	Potassium sulphate (50%)	Calcium sulphate (32%)	Magnesium sulphate (15%)
N	50619	110042	153392	-	-	-	-
P_2O_5	29144	-	-	66237	-	-	-
K_2O	55988	-	-	-	111976	-	-
MgO	29144	-	-	-	-	-	194297
CaO	108141	-	-	-	-	337942	-

The amount of commercial fertilizer equivalent to the amount of plant nutrients in compost obtained from organic kitchen wastes is given in Table 3. Urea and ammonium nitrate for nitrogen, triple superphosphate for phosphorus, potassium sulphate for potassium, calcium sulphate for calcium and magnesium sulphate for magnesium have been considered as equivalent fertilizers. The corresponding equivalency of commercial fertilizer of 110042 kg of urea and 153392 kg of ammonium nitrate, 66237 kg of triple superphosphate of potassium phosphate, 111976 kg of potassium sulfate, 337942 kg of calcium sulfate and 194297 kg of magnesium sulfate as calcium fertilizer were calculated (Table 3).

Table 4. Economic value of compost as a commercial fertilizer

Commercial chemical fertilizers	Amount (Kg)	Price (USD kg^{-1})	Value (USD)
N (Urea)	110042	0.4967	54658
P_2O_5 (Triple Superphospate, 44%)	66237	0.4437	29389
K_2O (Potassium sulphate, 50%)	111976	0.9934	111237
CaO (Calcium sulphate, 32%)	337942	0.4967	167856
MgO (Magnesium sulphate, 15%)	194297	0.3311	64332

Economic value of the finished compost based on commercial fertilizer is given in Table 4. The amount of commercial fertilizer and corresponding market prices were multiplied to determine economic value of compost. This value based on the commercial fertilizer price was determined as 54658$, 29389$, and 111237$ corresponding urea, triple superphosphate, and potassium sulphate, respectively.

The annual amount of the finished compost and the economic value in Isparta province calculated from the compost material obtained from the study are given in Table 5. According to the calculations, approximately 1 kg of kitchen wastes per day per person was produced in a family of four. This value is close to the values stated in the report (Yaman, 2012). Compost obtained from organic kitchen wastes was found to be 386164 $ when economic value was calculated directly as compost rather than as equivalent commercial fertilizer. Furthermore, it was determined that Isparta province had a significant economic value of organic kitchen wastes which cannot be recycled in urban area. Especially, local authorities have important duties to prevent this economic loss. Organic kitchen wastes can be valorized by local governments' investment in compost production. If only 1.1% of the collected waste in Turkey is considered to be used for compost production, the size of the economic loss can be seen clearly (Yaman 2012).

Table 5. The value of kitchen wastes as a compost

	Value
Amount of compost per household (Kg household^{-1}year^{-1})	38
Total household number	76696
Total compost amount (Kg year^{-1})	2914448
Compost price (USD Kg^{-1})	0.1325
Compost value (USD)	386164

CONCLUSIONS

Organic kitchen wastes collected from ten households for one month were composted in home composters. Composting took almost 4.5 months. In order to find the chemical fertilizer equivalency of compost, N, P, K, Ca, and Mg contents of the finished composts were analyzed. Results showed that kitchen organic wastes corresponding to 0.66 kg N, 0.38 kg P_2O_5, 0.73 kg K_2O, 0.38 kg MgO and 1.41 kg CaO per household per year were wasted without utilization. Taking into account of the total number of households in Isparta, it was estimated that 50441 kg N, 29157 kg P_2O_5, 55689 kg K_2O, 29157 kg MgO, and 108463 kg

MgO per year were wasted. In the study, the economic value of the wastes when not recycled as compost was determined as 54658$, 29389$ and 111237$ per year corresponding urea, triple superphosphate, and potassium sulphate, respectively based on the commercial fertilizer price. It was determined that compost obtained from organic kitchen wastes was found to be 386164$ per year when economic value was calculated directly as compost rather than as equivalent commercial fertilizer. In conclusion, the results of this study will help local authorities and policy makers for the development of alternative technologies/practices for utilization of organic kitchen wastes.

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