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Composting and its Role in Mitigating Climate Change Through the Sequestration of Organic Carbon in the Soil

ADRI EREBARA[1*], ALBERT KOPALI[1], ADRIAN DOKO[1]

[1] Department of Environment and Natural Resources, Agricultural University of Tirana, Street "Pajsi Vodica", 1029 Tirana, Albania

* Corresponding author: E-mail: aerebara@ubt.edu.al

Abstract

Climate change is a major concern all over the world today. The current climate changes is not due to natural factors but to human activities, mainly through the release of greenhouse gases into the atmosphere such as CO_2, CH_4, NO_x, HFC, PFC, SF_6, which are significantly increasing their concentration in the atmosphere and consequently changing the climate. These gases, where the main role is played by CO_2, have intensified the activity of the greenhouse effect by keeping more heat inside the Earth's atmosphere and consequently changing the climate systems. All sectors of human economic activity influence negatively in the climate changes, where agriculture occupies an important place (with about 24%). The negative effects of climate change are very large. For this reason, the international scientific community is concerned and demands that all countries of the world act to solve this problem through mitigating and adaptive strategies to slow down climate change and its negative effects. The solution to the problem of climate change is to deposit the carbon that is used and circulated in ecological systems back into the soil, so that it is not released as a gas into the atmosphere. An important mitigation measure of greenhouse gas emissions is the practice of composting solid organic waste, especially those with agricultural origin. The use of compost in many types of soil increases their capacity to sequester organic C in soil. A great source of organic waste that can be used for this purpose in Albania is the olive pruning and post-processing waste.

Keywords: climate change, greenhouse gases, mitigation, compost, organic C

1. Introduction

The Earth's climate systems are dynamic systems and change continuously under the influence of natural causes, but the rapid climate changes verified in recent decades are dedicated to increased human activity in all economic sectors, but not only. Refer to many recent studies worldwide that have examined the problem of global warming, about 97% of them agree that climate change is real and caused by human activity [1]. Climate change has significantly increased vulnerability, affecting all ecological systems and millions of people around the world. Their consequences are already an evident phenomenon in action at the global level [2]. Climate changes are at global level and have also affected Albania [3]. The IPCC mentioned that global warming in the second half of this century and climate change is attributable to the release of greenhouse gases (GHG) into the atmosphere by human activities with an increase from 66% to 90% [4]. The main gas responsible for modifying the greenhouse effect of the atmosphere in the last 100 years is CO_2, whose concentration has increased by 40% [5]. These gases released into the atmosphere in 89% or 34.8 $GtCO_2$/year come from fossil fuels and 11% or 4.1 $GtCO_2$/year from land use changes. Under these conditions, the way to solve the problem of climate change is the implementation of mitigation and adaptation strategies at all local, regional and global levels. Mitigation strategies relate to interventions to reduce greenhouse gas emissions (GHG). One way to reduce GHG emissions, especially CO2 as one of the main gases responsible for climate change, is its deposition in the soil in the form of *organic* C. The soil has the ability to sequester carbon from the atmosphere and store it as organic carbon. One of the ways to deposit organic C in the soil is the *practice of composting* solid organic waste, especially those of agricultural origin. The composting process promotes the recycling of organic waste and increases the rate of carbon sequestration by the soil's organic matter. [6]. From an agronomic point of view, composting plays an important role as it returns to the soil the mostly carbon-based nutrients that are used by plants during the photosynthesis process. From an environmental point of view, the practice of composting reduces the impacts of climate change, through the sequestration of

*Corresponding author: Adri Erebara; E-mail: aerebara@ubt.edu.al
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carbon and its return to the soil, reducing its release into the atmosphere. The use of compost enhances the storage capacity of soil organic C. From the assessments that have been made in agriculture, in those lands where compost has been used for a period of over 20 years, the level of carbon sequestration has been 1.1 to 1.8 tons of CO_2-eq/ha/year. One of the agricultural organic wastes, which is widely found in rural territories, *are the wastes of olive cultivation (pruning residues) and the wastes of the agro-industrial post-processing of olives* for oil extraction from the processing factories as solid by-products (pomace). Olive pruning residues fix a large amount of CO_2 during their plant cycle. Thus, they comprise about 1.03 t/ha/year of dry matter, fix 1.89 t/ha/year of CO_2; have an isohumic coefficient of 0.35 and bring 0.36 t/ha/year of humus [7]. The main purpose of this study has been that through an analysis of the various researches carried out (review), to evaluate the residues of pruning and olive pomace in the conditions of Albania and their potential to be composted and used as additives in agriculture, making possible the sequestration of organic C and its return to the soil, thus contributing to the reduction of GHG emissions.

2. Material and method

The study is an investigation into climate change mitigation strategies for reducing GHG emissions. The methodology of the study consisted in examining a large number of bibliographic sources for the possibility of composting olive cultivation residues (pruning residues) and post-processing of olives for oil (pomace) in order to sequester organic C and return it to soil. For the realization of this study were used different studies and research on climate change and mitigation strategies from the IPCC (Intergovernmental Panel on Climate Change); Environmental European Agency (EEA); Joint Research Center (JRC), statistical data on the level of olive production in Albania in recent years [9]. The assessment of the potential of olive biomass for composting purposes is based on the analytical method, referring to the methodology of the studies carried out [10,7,11] for the conditions of Albania.

3. Results and Discussions

In Albania, olive cultivation occupies about 41,000 ha or over 10.5 million plants distributed in about 90,000 small farms, but a small number of them, less than 1% have farms with an area of more than 0.5 ha. Olive trees occupy about 6.3% of the arable land. According to the estimates made by the olive trees that are in production, around 130,000 tons of pruning residues and olive post-processing residues are generated. Olive pruning residues are usually used by farmers for heating, olive pomace is partially used as fertilizer or disposed of as waste in the environment, constituting a potential source of greenhouse gas emissions and pollution, despite legal requirements [12].

Table no. 1. The number of olive plants and production in Albania[9].

No.	Denomination	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	Total olives (root)	6,255,000	7,443,000	8,000,000	8,620,000	8,994,000	9,225,000	9,608,000	9,786,000	10,008,000	10,288,000	10,532,000	10,746,000
2	Olives in production (root)	4,298,000	4,576,000	4,829,000	5,277,000	5,803,000	6,332,000	6,643,000	7,442,000	7,798,000	8,226,000	8,616,000	8,827,000
3	Olive production (tons)	70,000	65,400	108,000	92,000	98,000	96,000	99,000	108,000	118,000	98,300	132,000	110,164
4	Olive oil production (tons)	7,816	6,939	13,745	10,597	8,900	9,500	18,320	20,154	19,624	20,038	21,500	>18,000

Potential assessment of olive pruning residues, compost production and CO_2 calculation from the waste humification process in Albania

In order to make it possible to evaluate the biomass that is created from the residues of olive pruning, there are different methods, since in cultivation there is a great variety of olive cultivars which differ in age, crown size and the shape of pruning. If we refer to a grown plant from its pruning, 10-30 kg of plant waste is created. According to some estimates, the annual average amount of biomass of olive pruning residues is 1.3-1.7 t/ha. In the conditions of Albania, where about 41,000 ha are cultivated, from the olive pruning residues, with a coefficient of 1.7 t/ha, 69,700 tons of biomass with a moisture content of about 50% would be obtained, which could potentially be composted and used as organic additive in agriculture. According to some other studies [13], from a grown olive plant, when we do a light or medium pruning, 7-15 kg of waste (branches) are obtained. If we evaluate an olive grove

in which 300 plants are planted, we will receive from 2,100 – 4,500 kg of pruning residues. On average, for 41,000 ha of olive groves, 86,100 tons of biomass would be obtained. According to another study [14], the pruning residues from the olive plant in production bring about 4.35 t/ha/year, with a moisture content of 45% or about 2.39 t/ha/year dry matter. Based on dry matter (t/ha/year) from olive tree pruning residues and the amount of carbon dioxide (in tons) fixed in photosynthesis during the annual life cycle and then re-released into the atmosphere after burning , the amount of carbon released by the method is calculated [7]: 1 g dry matter = 0,5 g C = 1,83 g CO_2 fixed in the atmosphere. For olive, pruning residues with a coefficient of 4.35 t/ha/year, with a humidity of about 45%, with 2.39 t/ha/year of dry matter and release +4.37 t/ha/year CO_2.

To calculate the amount of humus produced from the pruning material, we multiply the dry matter by the isohumic coefficient of the material that will be turned into the soil. Knowing that C is found in humus at 50% of its weight, we calculate the amount of CO_2 fixed as C in humified pruning residues [7]. According to the calculations for CO_2 fixed with the burial of the pruning residues for the olive plant, the dry matter is 2.39 t/ha/year, the isohumic coefficient 0.35, the humus 0.84 t/ha/year, the carbon content in the humus 0.42 t/ha/year and CO_2 fixed in humus -1.54 t/ha/year [7]. In the conditions of our country, the dry matter from the residues of olive pruning is about 97,990 t/ha/year, the amount of humus that can be obtained is about 33,946 t/ha/year, the content of C in humus is about 16,973 t/year ha/year and the content of CO_2 fixed in the atmosphere about 62,121 t/ha/year. Practices so far have shown that this large amount of plant material of pruning residues is mostly burned and a small part is used for other purposes.

Potential evaluation of olive post-processing residues in Albania

Referring to literature sources [15], the amount of pomace that comes out of olive oil extraction corresponds to 44% of the weight of processed olives. The amount of olives processed at the national level in 2021 was 96,500 tons. In average values, the extraction of this amount of olives entered into the processing results in an amount equal to 42,459 tons. Other authors [9], calculate the amount of profit obtained from the extraction of olive oil referred to in terms of the surface planted with olives, considering a production of processing residues equal to 1.84 tons/ha, in the conditions of our country, they result in about 75,440 tons residue.

4. Conclusions

The practice of composting olive pruning residues and olive post-processing residues for oil and the use of compost as an organic additive in agriculture is part of climate change mitigation strategies through the reduction of CO_2, N and N_2O emissions. The use of compost in agriculture has environmental effects by increasing the level of sequestration of organic C in the soil and agronomic effects since it affects the increase of soil fertility and the ecological functions of the soil. The study highlights the great potential of agricultural residues of olive pruning and post-products of olive oil extraction (olive pomace) from the oil industry in rural areas of Albania, which can be used as material for composting.

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