T.R.
ONDOKUZ MAYIS UNIVERSITY
INSTITUTE OF GRADUATE STUDIES
DEPARTMENT OF SOIL SCIENCE AND PLANT NUTRITION

IMPACTS OF DIFFERENT ORGANIC WASTE ON THE RHIZOSPHERE OF STRAWBERRY PLANTS

Master's Thesis

Mohammed Gamal Abdelaziz ALI

Supervisor
Prof. Dr. Rıdvan KIZILKAYA

II. Supervisor
Prof. Dr. Ivan MANOLOV

SAMSUN
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2023

ACCEPTANCE AND APPROVAL OF THE THESIS

The study entitled **"IMPACTS OF DIFFERENT ORGANIC WASTE ON THE RHIZOSPHERE OF STRAWBERRY PLANTS,"** prepared by **Mohammed Gamal Abdelaziz ALI** and supervised by **Prof. Dr. Rıdvan KIZILKAYA** and **Prof. Dr. Ivan MANOLOV** were found successful and unanimously accepted by committee members as Master thesis, following the examination on the date 15.8.2023.

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This thesis has been approved by the committee members that already stated above and determined by the Institute Executive Board.

Prof. Dr. Ahmet TABAK
Head of Institute of Graduate Studies

DECLARATION OF COMPLIANCE WITH SCIENTIFIC ETHIC

I hereby declare and undertake that I complied with scientific ethics and academic rules in all stages of my Master's Thesis, that I have referred to each quotation that I use directly or indirectly in the study, and that the works I have used consist of those shown in the sources, that it was written in accordance with the institute writing guide and that the situations stated in the article 3, section 9 of the Regulation for TÜBİTAK Research and Publication Ethics Board were not violated.

Is Ethics Committee Necessary?

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No ☒

15 / 08 / 2023
Mohammed Gamal Abdelaziz ALI

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Thesis Title: IMPACTS OF DIFFERENT ORGANIC WASTE ON THE RHIZOSPHERE OF STRAWBERRY PLANTS

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ÖZET

FARKLI ORGANİK ATIKLARIN ÇİLEK BİTKİSİNİN RİZOSFERİ ÜZERİNDEKİ ETKİLERİ

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Toprak Bilimi Ve Bitki Besleme Ana Bilim Dalı
Yüksek Lisans, Ağustos/2023
Danışman: Prof. Dr. Rıdvan KIZILKAYA
Danışman: Prof. Dr. Ivan MANOLOV

Çilek (*Fragaria x ananassa Duch*.), arzu edilen lezzeti ve çekici şekliyle en seçkin küçük meyveler arasında yer almaktadır. Bu çalışma, hayvansal ve bitkisel atıkların çilek bitkilerinin rizosfer bölgelerini geliştirmek için kullanılmasını araştırmayı amaçlamıştır. Özellikle, büyükbaş hayvan gübresi (CM), kanatlı gübresi (PM), koyun gübresi (SM) ve solucan gübresi (VC) gibi farklı hayvan atıkları ile buğday samanı (WS), çeltik kavuzu (RH), çay atığı (TW) ve fındık zurufu (HH) gibi bitkisel artıkların çilek bitkisinin rizosfer mikrobiyolojisi ve bitki büyümesi üzerindeki etkileri sera koşullarında incelenmiştir. Bu amaçla, her bir saksıda bulunan 150 gr toprak üzerine toprak ağırlığının %5'i olacak şekilde organik atıkların uygulamaların yapılmış, çilek fidelerinin dikimi gerçekleştirilmiştir. Saksı topraklarının nem içeriği, her gün yapılan tartımlar ile tarla kapasitesi seviyesinde tutulmuştur. Deneme, tesadüf parselleri deneme desenine göre kurulmuş ve 61 gün sürmüştür.Deneme sonunda, toprakların bazı mikrobiyolojik ve kimyasal özelliklerin belirlenmesi amacıyla saksılardan toprak örnekleri alınmıştır. Toprak örneklerinde; toprak solunumu (BSR), mikrobiyal biyomas C (MBC), dehidrogenaz aktivitesi (DHA), katalaz aktivitesi (CA) gibi mikrobiyolojik özellikler ile ve organik madde (OM), pH, elektriksel iletkenlik (EC), toplam azot (N), değişebilir kalsiyum (Ca) ve magnezyum (Mg) gibi toprak kimyasal özellikleri olarak incelenmiştir.

Elde edilen sonuçlara göre; TW, kontrol grubuna kıyasla BSR üzerinde en önemli etkiye sahip olduğunu göstermiştir. WS, kontrol grubuna kıyasla MBC üzerinde en yüksek etkiyi göstermiştir. SM, kontrol grubuna kıyasla DHA üzerinde en büyük etkiye sahip olmuş, PM ise CA üzerinde en önemli etkiyi göstermiştir. EC, PM, VC, CM, SM, TW, HH ve RH tarafından önemli ölçüde etkilenmiştir. Toprak pH değerinin, SM, HH, VC ve CM uygulamaları ile arttığı saptanıştır. Toprak organik madde içeriği ise tüm uygulamalarla artmıştır. Toplam N içeriği SM, CM ve VC ile artarken, TW, RH, WS, HH ve PM ile azalmıştır. Değiştirilebilir kalsiyum PM dışındaki tüm uygulamalarla azalmıştır. Değiştirilebilir magnezyum ise sırasıyla SM, WS, TW, HH, VC, CM ve RH tarafından arttırılırken, PM tarafından azaltılmıştır. Sonuç olarak, bitkisel ve hayvansal atıkların çilek yetiştiriciliğinde kullanımı, toprak özellikleri ve rizosferdeki mikrobiyel faaliyetleri değişik etkiler gösterdiği belirlenmiştir. Elde dilen bulgular, organik atık kullanımının toprak koşullarını iyileştirmek ve çilek bitkisinin büyümesini artırmak için potansiyel faydalarını gösterdiğini ortaya koymaktadır.

Anahtar Sözcükler: Organik atık, Çilek Rizosfer, Toprak solunumu, dehidrojenazlar, katalaz, Mikrobiyal biyokütle karbonu, Bazal toprak solunumu.

ABSTRACT

IMPACTS OF DIFFERENT ORGANIC WASTE ON THE RHIZOSPHERE OF STRAWBERRY PLANTS

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Strawberry (Fragaria x ananassa Duch.) is a highly esteemed small fruit species known for its desirable taste and appealing shape. This study aimed to investigate the utilization of animal and plant waste for enhancing the rhizosphere of strawberry plants. Specifically, the effects of various animal wastes, including cow manure (CM), poultry manure (PM), sheep manure (SM), and vermicompost (VC), as well as plant residues such as wheat straw (WS), rice husk (RH), tea waste (TW), and hazelnut husk (HH), on rhizosphere microbiology and strawberry plant growth were examined under greenhouse conditions. The organic waste application was set at 5% of the pot weight, equivalent to 150 grams per pot, followed by strawberry transplanting. Soil moisture content was maintained close to field capacity by daily monitoring and replenishing moisture as needed. The experimental period lasted 61 days, and a completely randomized design was employed. At the end of the experiment, soil samples were collected from the pots to assess various soil microbiological and chemical properties. Basal soil respiration (BSR), microbial biomass C (MBC), dehydrogenase activity (DHA), catalase activity (CA), and organic matter (OM) were analyzed as soil microbiological properties. Additionally, pH, electrical conductivity (EC), total nitrogen (N), exchangeable calcium (Ca), and magnesium (Mg) were examined as chemical properties.

The results revealed that tea waste (TW) had the most significant impact on BSR compared to the control group. Wheat straw (WS) exhibited the highest influence on MBC compared to the control. Sheep manure (SM) demonstrated the greatest effect on DHA compared to the control, while poultry manure (PM) had the most significant impact on CA. Soil EC was significantly affected by PM, VC, CM, SM, TW, HH, and RH. Soil pH was increased by SM, HH, VC, and CM treatments. Organic matter content increased across all treatments. Total nitrogen content was increased by SM, CM, and VC, while it was decreased by TW, RH, WS, HH, and PM. Exchangeable calcium was decreased by all treatments except PM. Exchangeable magnesium was increased by SM, WS, TW, HH, VC, CM, and RH, respectively, while it was decreased by PM. In conclusion, using plant and animal waste materials in strawberry cultivation influenced various soil properties and microbial activities in the rhizosphere. These findings provide valuable insights into the potential benefits of organic waste utilization for improving soil conditions and enhancing strawberry plant growth.

Keywords: Organic waste, Strawberry Rhizosphere, Soil respiration, dehydrogenases, catalase, Microbial biomass carbon, Basal soil respiration.

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SYMBOLS AND ABBREVIATIONS

Organic Matter	: (OM)
Poultry Manure	: (PM)
Cow Manure	: (CM)
Compost	: (CO)
Vermicompost	: (VC)
Sheep Manure	: (SM)
Tea Wastes	: (TW)
Wheat Straws	: (WS)
Rice Husk	: (RH)
Organic Waste	: (OW)
Soil Organic Carbon	: (SOC)
Greenhouse Gases	: GHGs
Ammonia	: (NH_3)
Methane	: (CH_4)
Nitrous Oxide	: (N_2O)
Nitric Oxide	: (NO)
Carbon Dioxide	: (CO_2)
Carbon	: (C)
Oxygen	: (O)
Hydrogen	: (H)
Nitrogen	: (N)
Sulfur	: (S)
Silicon	: (Si)
Iron	: (Fe)
Calcium	: (Ca)
Magnesium	: (Mg)
Sodium	: (Na)
Potassium	: (K)
Phosphorus	: (P)
Organic Carbon	: (OC)
2,3,5-triphenyltetrazoliumchlor	: (TTC)
1,3,5 triphenylformazan	: (TPF)

Control	: (C)
Microbial Biomass Carbon	: (MBC)
Basal Soil Respiration	: (BSR)
Dehydrogenase Enzyme Activi	: (DHA)
Catalase Activity	: (CA)
Soil Reactions	: (pH)
Electrical Conductivity	: (EC)
Oven Dry Soil	: (ODS)
Tea Seed Powder	: (TSP)

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1. INTRODUCTION

With its exceptional taste and appealing shape, the strawberry (*Fragaria x ananassa Duch.*) stands out as one of the extremely notable varieties amongst small fruits. It holds significant importance as a source of bioactive components, contributing to its popularity (Dzhanfezova et al., 2020). In particular, soil fertility, mineral fertilization, mineral ratios, and climate conditions affect strawberry output and quality (Tohidloo et al., 2018). To achieve high yields of quality fruits, it is essential to provide sufficient nutrients for optimal plant nutrition (Agehara and Nunes, 2021). With its nutritional value, delightful taste, and associated health benefits, the strawberry has earned the title "Queen of Fruits," driving global demand and economic profits for farmers (Lazcano et al., 2021). Strawberry is low in calories and high in bioactive substances such as flavonoids, antioxidants, anthocyanins, fiber, vitamin C, and folic acid (Kobi et al., 2018). Various types of cancer, including breast, lung, liver, colon, and colorectal, have been associated with the suppression and recovery from these bioactive substances (Afrin et al., 2017; Amatori, 2016; Cao et al., 2019; Chen et al., 2019; Giampieri et al., 2018).

In the soil ecosystem, soil microbes are essential for humus production, organic matter decomposition, and nutrient cycling and transformation (Baldock and Skjemstad, 2000). Previous research has shown that applying organic waste (OW) can enhance the soil's microecological environment, promoting crop growth (Zhang et al., 2019). Minerals and other substances included in organic waste improve soil fertility and promote crop development (Meng et al., 2020). Adding organic waste is crucial for preserving soil organic matter and increasing crop productivity, leading to increased nitrates, soil enzyme activity, and metabolic amounts, ultimately improving soil fertility (Piotrowska-Długosz et al., 2022). Additionally, using organic waste modifies physiological processes like lowering lipid peroxidation, enhancing osmotic regulation, and raising antioxidant enzyme activity, strengthening plant resilience to nutritional deficits (Anwar et al., 2018). Poultry manure (PM), cow manure (CM), compost (CO), and vermicompost (VC) are among the excellent organic waste materials that serve as soil amendments when properly applied, providing nutrients for crop growth and improving soil quality. Poultry manure strengthens the soil's physical properties by increasing aeration, water-holding capacity, nutrient retention, and infiltration (Sharma and Negi, 2019). Sheep manure (SM) exhibits desirable

characteristics, including good texture and a higher content of organic compounds than other animal manures. It is a neutral fertilizer excellent for sandy and clay soils (Li et al., 2020). Farm manure has long been employed in agricultural production as a useful plant nutrition resource since it is rich in macronutrients like N, P, K, Ca, and Mg (Apriyani et al., 2021). Because of its porous structure, Vermicompost provides ample plant nutrients while enhancing soil aeration and water retention. It encourages microbial activity on the soil surface, maintains ideal carbon levels, and gradually releases nutrients to plants, facilitating effective nutrient uptake (Pierre-Louis et al., 2021).

Organic waste increases the amount of organic matter in the soil, raises pH, and makes it easier for plants to absorb macro and micronutrients (Apriyani et al., 2021). Since it has been demonstrated that tea waste (TW) increases soil aggregate stability on degraded soils, it substantially impacts agriculture in many different regions (Turgut and Kose, 2016). Furthermore, the TW composition includes phenols and amino acids that can change the alkaline pH of saline soil, resulting in increased soil microbial activity. By mineralizing organic matter, hazelnut orchards have shown enhanced soil soluble nutrient contents, leading to better soil physical properties (Gülser et al., 2015). Wheat straw (WS) has demonstrated potential for improving soil structure, crop output, and soil organic carbon (Kalkhajeh et al., 2021). The amount of organic matter in the soil can be increased by adding plant residues like rice husk (RH), compost, and charcoal. RH is the abbreviation for the tough, dry outer layer of the rice kernel (Aderolu et al., 2007). Much research has looked at the use of agricultural wastes, microbes, and chemicals for soil stabilization, highlighting their low cost and high cementation reaction (Abdu et al., 2017; Adetoro and Dada, 2015; Akiije, 2016; Alhassan, 2008; Basha et al., 2005; Chiet et al., 2016; DeJong et al., 2010; Whiffin et al., 2007)

This research aims to measure the impact of different organic waste materials on the rhizosphere of Albion variety strawberry plants before planting and to assess the influence of these waste materials on the soil's biological and chemical properties.

2. LITERATURE REVIEW

2.1. Management of Organic Waste Use in Agriculture

In the globe, organic waste is between 44 and 46 percent (by mass) of the total municipal solid waste (Maharjan et al., 2022). Compost and Vermicompost are produced using organic waste as an essential raw source. However, it needs to be managed sustainably in many countries. A landfill is used to dispose of organic and other types of solid waste. In developing nations, this practice is widespread. Globally, about 70% of solid waste is dumped in landfills, 19% is recovered through recycling and composting, and 11% is treated using modern incineration (Sharma and Jain, 2020). Burning crop residue and dumping industrial waste into freshwater bodies are common practices involving agricultural waste everywhere. Burning crop residue causes significant emissions of gaseous and particulate pollutants, especially after harvesting, frequently worsening local and regional pollution (Wang et al., 2013). Animal manure, crop leftovers, waste from food processing, municipal biosolids, some industries, and by-products of agricultural, industrial, or municipal activities are all considered organic waste because they are not the main product. However, the objective is to transform the "waste" into a resource that can be used rather than thrown away.

Among the uses for organic waste are:

- Soil amendment or fertilizer.
- Energy restoration (heat, liquid fuels, electricity).
- Manufacturing of chemicals (volatile organic acids, ammonium products).

Animal manure has long been used in agriculture as a fertilizer and to enhance the physical and chemical properties of the soil. It has also used industrial OW and municipal biosolids for this purpose, albeit to a much lesser extent. Agriculture worldwide has used organic waste, such as crop residues and animal manure, to produce energy to varying degrees. The use of different OW in agriculture is influenced by several variables, including the waste's properties, such as its nutrient and heavy metal content, energy value, odor it produces, availability, transportation costs, benefits to agriculture, and regulatory considerations. These considerations can vary in importance depending on the type of OW, but most OW share many of the same considerations. In this thesis, we will discuss some OW of animal origin, such

as (CM, PM, SM, and VC). As well as some OW of plant origin, such as (RH, WS, TW, and HH). Agricultural wastes and products from these resources have a wide range of nutrient compositions influenced by several variables, including their sources, animal diets, waste storage and management, and production practices (Rayne and Aula, 2020). Figure. 2.1 shows typical agricultural by-products and the parts added to agricultural soils as fertilizers and amendments.

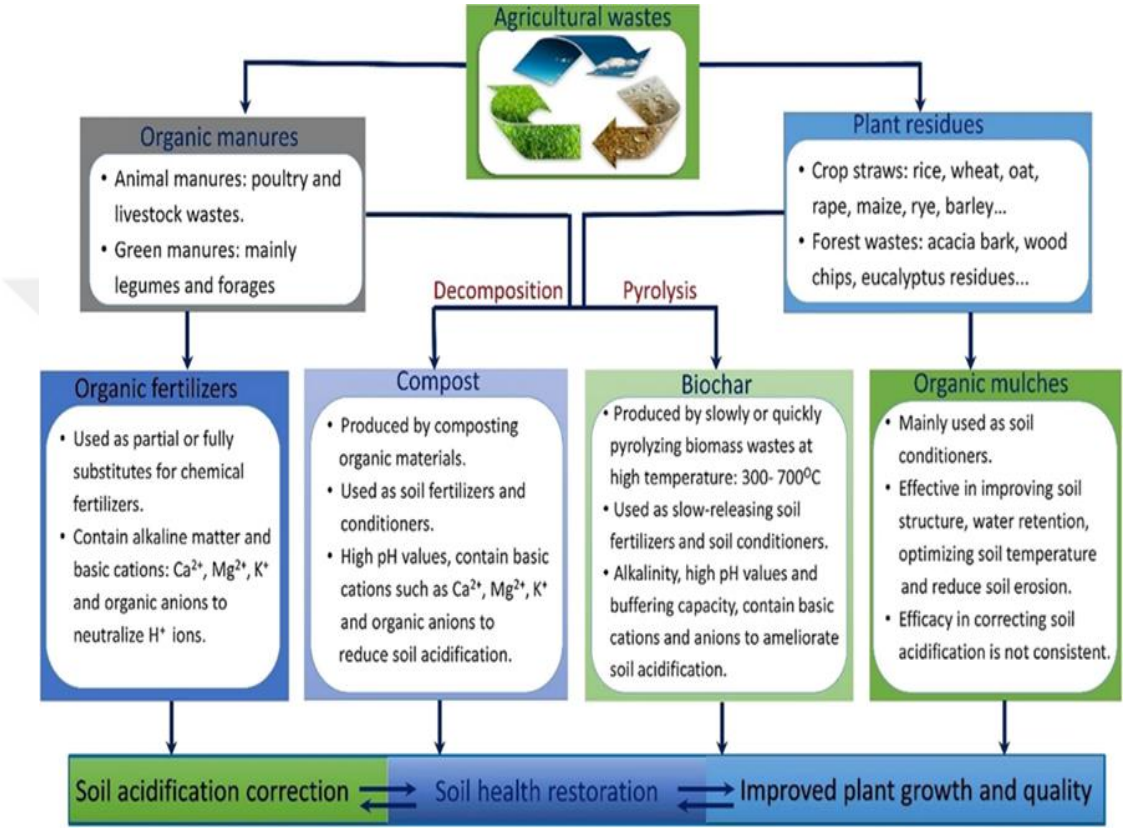

Figure 2.1. illustrates typical agricultural waste and products to reduce soil acidification and enhance soil health, crop growth, and crop quality (Le et al., 2021).

A variety of agricultural OW practices are used on croplands. Nevertheless, based on their common uses and places of origin, they can be divided into groups (Fig.2.1). Globally, croplands received about 35 million tons of nitrogen fertilizer in 2018, compared to more than 13 million tons from poultry (FAO, 2021). When organic waste (OW) decomposes naturally through various microbial species, it can be applied to soil or used as the primary component of compost (Bhatt et al., 2019). The nutrient makeup of some of the most common categories of agricultural wastes and the derived products used as soil amendments are shown in Table 2.1.

Table 2.1. Nutrient Composition of Some Major Agricultural Waste and Soil the Products Derived from It Used as Soil Amendments.

Waste category	Nutrition content									Source
1. Animals' waste	N	P	K	Na	Fe	Cu	Mn	Zn	Total C	
Cow Manure	18.6	7.89	17.6	5.38	3527	20	111	79	43.88	(de Mendonça Costa et al., 2015; Moreno-Caselles et al., 2002)
Poultry Manure	31.4	13.2	24.7	4.85	154	40	237	304	34	(Moreno-Caselles et al., 2002; Ravindran and Mnkeni, 2016)
Sheep Manure	18.7	5.67	34.3	6.94	3786	21	137	159	41.84	(Costa et al., 2015; Moreno-Caselles et al., 2002)
Vermicompost	8.7	< 0.1	1.3	26.3	-	181[c]	8.09	20.9	8.09	(Adhikary, 2012)
Note: N, P, K (g/kg, dry weight); Na, Fe, Cu, Mn, Zn (mg/kg, dry matter); total C (%, dry weight); [c] (g/kg)										
2. Plant waste	N	P	K	C	Ca	Mg	pH	C: N Ratio	Ash content	Source
Wheat straw	55	9	42	43.9	22.61	2.88	5.1	124.4	23.2	(Torma et al., 2018)
Rice straw	0.5-0.8[a]	0.07-0.12[a]	1.16-1.66[a]	41.25	7.03	3.96	-	-	33.6	(Chivenge et al., 2020)
Tea pruned foliage	252	30	72	2.9[b]	-	-	-	11	-	(Kamau, 2008)
Tea pruned twigs	85	10	21	1.4[b]	-	-	-	17	-	(Kamau, 2008)
Note: N content, P, K (kg/ ha); OM, C (%), [b] (t/ ha); Ca, Mg (cmol $_{(+)}$/kg); ash content: (%; dry weight); [a] (%)										

2.2. Animal Wastes

2.2.1. Cow Manure

As a natural resource that can replace manufactured fertilizers and increase soil fertility, animal manure is recognized as a valuable renewable energy source. However, if this organic waste is not managed, it can cause odors, soil and water depletion, and greenhouse gas emissions (Burg et al., 2018). Using cow manure as a co-substrate in anaerobic co-digestion increases methane production, among other advantages and benefits. It balances the C/N ratio, pH, low substrate characteristics, and nutritional content (Zhao et al., 2018). Currently, managing cow manure is regarded as one of the key issues. To manage CM issues, it is necessary to go into more detail about suitable approaches and treatments. Therefore, using biogas plant technology to produce renewable energy while decreasing greenhouse gas emissions is a good idea (Ali et al., 2019). Ruiz et al. (2018) Reported the total yearly animal manure production, with sewage sludge coming in first place with 7200 t/yr, followed by pig and CM with 6500 t/yr. Cow manure's characteristics make it an ideal substrate for anaerobic digestion. Although land spreading is the most prevalent application of CM, there is a surplus in amount, which can be elaborated through anaerobic digestion. Despite spreading CM across the land is its most prevalent usage, there is a surplus that can be refined by anaerobic digestion. With the use of this method, an appropriate digestate that is rich in vital nutrients for plants (C, K, N, and P) can be produced after the procedure. On the other hand, soluble OM is consumed by the microbial population. Therefore, in anaerobic digestion, solubility and humidity percentage are essential (Li et al., 2019).

2.2.2. Poultry Manure

Poultry manure is abundant in N, but it also has considerable amounts of P, and K Typically has N content ranging from 3-5%, P content of 0.9-3.5%, and K content of 1.5-3% (Jędrczak et al., 2014). Owing to its composition and the presence of certain nutrients, PM can be used as a fertilizer to enhance the fertility and physical characteristics of the soil. Additionally, calcium, magnesium, and sulfur concentrations are significantly higher than in cow manure (Bolan et al., 2010). Direct application of poultry manure to the soil is one option, as well as several processing steps that result in products with added value, including compost, digestate, and

biochar. When PM is applied to soil, chemical processes are triggered, including decomposition, hydrolysis, ammonia volatilization, nitrification, denitrification, and fermentation. The production of GHGs, including ammonia (NH_3), methane (CH_4), nitrous oxide (N_2O), nitric oxide (NO), and carbon dioxide (CO_2), can occur as a result of these processes, so it is crucial to keep that in mind (Li et al., 2012). Additionally, it may result in the heavy metals Zn and Cu contaminating the soil and groundwater (Liu et al., 2020). High nitrogen content 3-5 % dry weight in the form of urea 4-12 %, ammonium, feed protein 10-40 %, and uric acid 40-70 % can be found in poultry manure 4-20 % (Bhatnagar et al., 2022). Largely relies on the animal's age, kind, and food (Nahm, 2003). When organic N is stored in poultry manure, it turns into ammonia, which causes volatilization and N loss into the atmosphere. To be used by plants, poultry manure is applied to the soil, where it causes the mineralization process, which transforms organic N into mineral forms. This conversion enables the N to be changed into easily assimilated mineral forms, allowing plants to uptake and efficiently use the nutrient. This depends on the soil pH, temperature, and moisture content. (Fig.2.2.2).

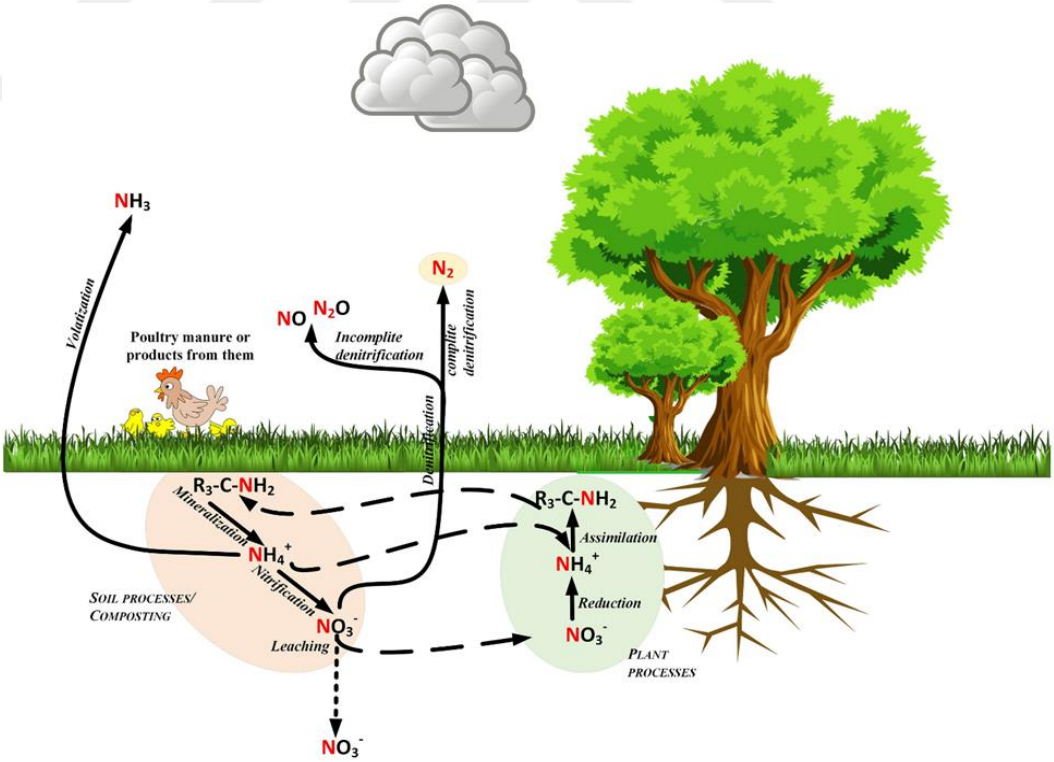

Figure 2.2.2. Shows nitrogen transformation in soil based on poultry manure, according to (Lesschen et al., 2021).

2.2.3. Sheep Manure

Fresh SM is an excellent source of OM, N, and P. Microorganisms can transform SM into superior organic fertilizers after decomposing under aerobic conditions. Many nations have effectively implemented this strategy to manage animal waste (Ravindran et al., 2019). Sheep manure, derived from nitrogen-rich organic materials, is readily accessible. Additionally, it contributes to the increased availability of carbon for soil microbes by releasing a substantial amount of exogenous carbon into the soil. Increasing microbial biomass raises microbial function and activity in the soil (Neufeld et al., 2017). Sheep excrement has no adverse environmental effects and can be used as plant fertilizer (Palani et al., 2022).

2.2.4. Vermicompost

Recent studies have found that Vermiculture applications boost soil restoration and improve agricultural productivity (Sinha, 2012). Vitamins, antibiotics, humic acid, and N, P, and K are all present in VC in good amounts. (Arancon et al., 2006; Bansal and Kapoor, 2000; Pramanik et al., 2007), in addition to microorganisms that fix N and P, enzymes like protease, amylase, lipase, cellulase, and chitinase, and chemicals that encourage development, such as auxins and gibberellins (Lazcano and Domínguez, 2011), Vermicompost also regulates the bacterial community and soil characteristics in plastic shed soil, which enhances plant development and nutrient uptake (Wang et al., 2018). Vermicompost regularly enhances soil aeration, drainage, structure, and infiltration (Arancon et al., 2008). Increased microbial activity from the injection of vermicompost into the soil can affect how much the soil aggregates, lower bulk density, and enhance overall porosity, moisture-holding capacity, cation-exchange capacity, and oxidation potential of the soil (Manivannan et al., 2009). Earthworm populations rise in vermicompost-rich soil, which promotes extensive burrowing and creates loose, porous soil with micropores that enhance water absorption, drainage, and aeration to the root rhizosphere. Water permeability in the soil is influenced by worm burrowing as well. It has been demonstrated that castings may store nine times their weight in water, enhancing soil fertility (Girde et al., 2016).

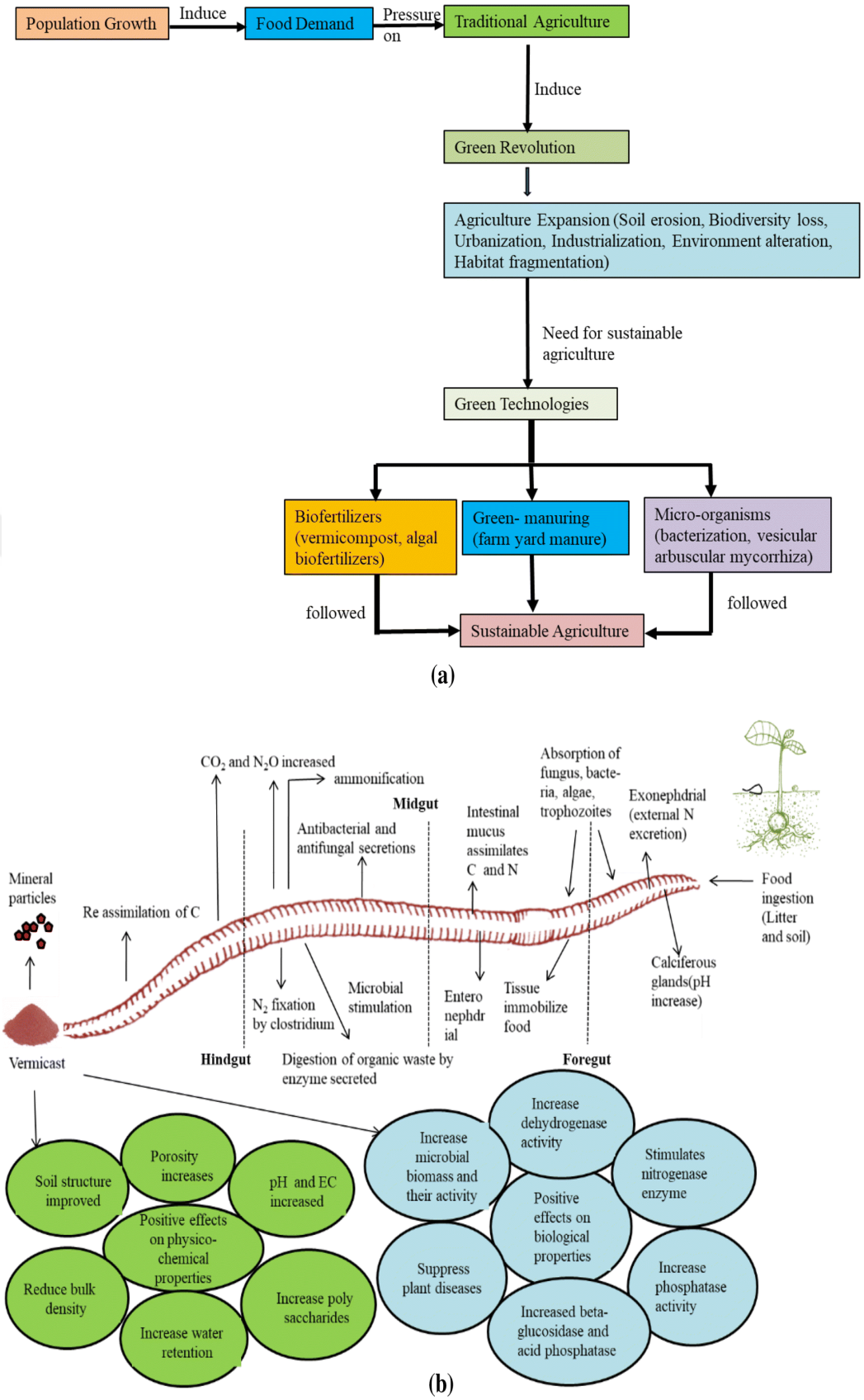

Figure 2.2.4. (a) illustration of The Anthropogenic Activities on Agriculture and Its Sustainable Options, and (b) process of vermicompost production and its consequences (Lemtiri et al., 2014).

2.3. Plant Residue

Crop residue management is a key technique for improving soil, water, and air quality, soil organic carbon (SOC) sequestration, and soil erosion control. The effects of long-term residue management on the linkages between SOC and soil structural characteristics differ, however, depending on the quantity, nature, and quality of the residue, the tillage system, the climate, and the inherent soil properties (such as clay content, drainage, slope), as well as the existence and activity of residue decomposers (such as earthworms and bacteria). For instance, adding WS could occasionally change the characteristics of the soil's strength and water transmission (Kelley and Sweeney, 1998). According to certain studies, tillage affects soil structural qualities more than residue management (Sharratt, 1996).

2.3.1. Rice Husk

Around the world, more than 75 countries produce rice husk (Natarajan et al., 1998). Only when processed appropriately, could rice husk be used as an eco-friendly source for soil amendment. Numerous elements, such as C, O, H, N, S, Si, Fe, Ca, Mg, Na, K, and P, are found in rice husk. These elements contribute to the overall chemical composition of rice husk and can have implications for its potential applications and utilization (Jenkins et al., 1998). Carbon and nitrogen are two of the main nutrients of RH, with magnitudes of 37.8–39.1 % and 0.5–0.6 %, respectively (Jenkins et al., 1998). Silica accounts for between 90 and 95 percent of the rice husk ash content, which ranges from 16 to 23 % (Jenkins et al., 1998). Rice husk is a byproduct of paddy mills, and countries that grow paddy produce enormous amounts of RH. Since RH hardly decomposes and disintegrates in soil due to its high C/N ratio, it cannot be used directly in agricultural practices. In order to lower the C/N ratio, the raw husk is composted, but unlike other organic wastes, it can still stay in the soil for a very long time. Omaliko and Agbim (1983) had previously established that using RH and other rice mill by-products in agricultural production would, among other things, solve the waste disposal problem without endangering the environment.

2.3.2. Wheat Straw

Reusing or retaining crop residues is a sustainable method of enhancing soil quality and crop production (Liu et al., 2014). Crop residue decomposition releases

nutrients that raise soil organic C content, particularly the active soil C fraction and mineral nutrient availability (Blanco-Canqui, 2012). Crop residue addition can sometimes impact soil nitrification and denitrification processes, which causes an increase in upland soil N_2O emission and a decrease in paddy soil N_2O emission (Hu et al., 2014). By increasing SOC sequestration and nutrient deposition, straw incorporation has the potential to enhance soil quality and maintain sustainable soil productivity. The global meta-analysis revealed that adding straw significantly increased SOC content by over 12% (Xia et al., 2018). Despite making up a small portion of straw, the nutrients can complement the soil and offer a steady supply of nutrients for crop growth. Straw incorporation increased soil total and available NPK primarily caused by the biochemical decomposition of soil microorganisms like bacteria, actinomycetes, and fungi (Zhao et al., 2016). It is possible to use soil enzyme activities as a useful indicator of soil quality and environmental stability because they are related to the soil microbe population (Garg and Bahl, 2008). The biochemical decomposition of the straw and nutrient turnover was catalyzed by soil enzymes, which were a significant soil component. Finding appropriate methods to handle crop residues is of great interest for sustainable agriculture and controlling C sequestration in agricultural ecosystems because crop residue is a crucial component of agricultural production systems and is produced in enormous quantities.

2.3.3. Hazelnut husk

Hazelnut husk, a renewable and unused natural resource, remains unexploited in industrial applications (Çöpür et al., 2007). As a result, research on using hazelnut shells and husks in the forest industry is scarce. After kernel harvesting, the husk remains in the field and is either burned or allowed to biodegrade for soil enrichment (Copur et al., 2008). Due to its high OM content, hazelnut husk can enhance the physical characteristics of soils, such as aggregate stability, hydraulic conductivity, and aeration. However, after composting, HH ought to be incorporated into the soil. After that, it can be applied to agriculture to promote plant growth (Zeytin and Baran, 2003). Large amounts of husk and shell waste are generated during the processing of hazelnuts. They contribute to pollution because they are burned in stoves to heat homes. It has been proposed that some form of cultivation might be possible using these agricultural wastes (Çöpür et al., 2007). Hazelnut is one of the most important agricultural products produced in Türkiye's Black Sea Region. The hazelnut orchards'

only method of soil management is the application of surface fertilizer. Türkiye is the world's largest hazelnut producer and exporter, producing 500,000–650,00 tons of hazelnuts annually, or 75% of global production. Up to 200.000 tons of hazelnut husk residue are thought to remain after harvest, which can either be burned or left in the field. Whichever is used will benefit the economy and the environment. As seen in Fig.2.3.4, the HH is green during the phases of growth and evolution, turning yellowish green before harvest and brown after harvest and drying. Applying organic waste to soils greatly impacts their OM content and nutrient values. It enhances their structure, water, air balance, and microbiological activities (Candemir and Gülser, 2010).

(a) Green samples

(b) Dried samples

(c) Hazelnut husk

(d) Husk extracted

Figure.2.3.3. The Husk of Hazelnut is in Different Stages (Guney, 2013).

2.3.4. Tea Waste

Although native to Asia, tea plants can adapt to a variety of climatic and soil conditions (Rana et al., 2021). According to Gebrewold (2018), For best growth and productivity, this perennial crop needs acidic soils; the ideal soil pH range for tea plants is between 4.5 and 6, and the plants themselves can acidify the soil Fig.2.3.3. In

various agricultural systems and regions, soil acidification has been a serious threat to soil health and environmental sustainability (Yan et al., 2020).

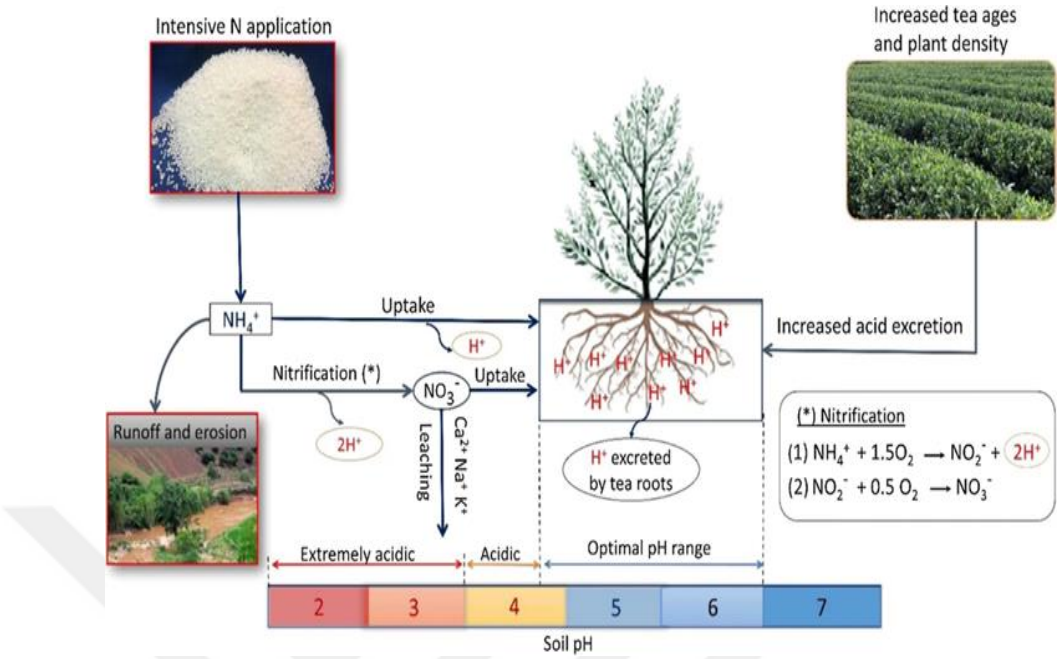

Figure 2.3.4. Shows the acidity produced by the tea plants roots (Le et al., 2021).

As they are woody perennials, tea plants have long-term interactions with soil organisms and physicochemical processes that affect the health of the soil and plant productivity (Arafat et al., 2020). Principal reasons why tea cultivation causes soil acidification. The frequent addition of N fertilizers is the main factor contributing to soil acidification. Additionally contributing to the acidification of soils is the buildup of organic and carbonic acids released by tea roots.

2.3.5. The Positive Effects of Waste on The Rhizosphere

Organic wastes such as CM, PM, SM, VC, RH, WS, TW, and HH are all excellent sources of organic matter that can positively impact the rhizosphere. This waste can improve soil structure, water infiltration, and nutrient retention, improving plant growth and yield. Many studies found that CM has positive effects on the rhizosphere. It has been shown to increase soil pH and improve oat growth in terms of increased biomass and nutrient absorption (Zhang et al., 2020). A variety of microorganisms that can produce a variety of metabolites are found in CM and may be advantageous to humans (Zhao et al., 2022). Additionally, the research examined the effects of fertilizing with CM on soil bacterial communities in tea plantations and found that CM fertilization significantly increased bacterial community diversity and

composition in soil (Gupta et al., 2016). These findings suggest that using CM as an organic fertilizer can be a sustainable and environmentally friendly alternative to chemical fertilizers while benefiting the rhizosphere's plant growth and soil health (Zhao et al., 2022).

Whereas a study carried out by Zhang et al. (2019) found a correlation between the diversity and abundance of beneficial bacteria in strawberry plants' rhizosphere and PM use. Additionally, wheat plants' rhizospheres contained more nitrogen-fixing bacteria due to PM, which may enhance plant growth and yield (SINGH et al., 2016).

In addition to a previous study that demonstrated the benefits of SM on the rhizosphere, which promoted plant growth and enhanced soil quality, it was discovered that SM also significantly increased tea production by enhancing soil pH and nutrition (Li et al., 2018). However, vermicomposting is thought to provide a method by which organic waste can be significantly stabilized, turning it into a finished fertilizer (Hussain and Abbasi, 2018).

According to a study conducted by Harun et al. (2021), RH biochar can boost soil fertility and water retention, crop growth and yields, and enhance plant growth. Incorporating RH into the soil can reduce toxic inorganic As in rice grain by 25–50% without affecting grain Cd in flooded and unflooded soils (Runkle et al., 2021). Furthermore, using RH biochar combined with arbuscular mycorrhizal fungi (AMF) has also been studied and has varied effects on soursop seedlings (Harun et al., 2021).

Another research found that adding WS to soil has been found to have positive effects on the rhizosphere. It increases the fungal community diversity and abundance of beneficial bacteria, decreasing the occurrence and severity of soil-borne diseases like Fusarium wilt; WS incorporation is a common practice in modern agriculture worldwide. Additionally, it is a successful method for reducing soil-borne diseases (Tang et al., 2020).

Moreover, it has been discovered that adding rice straw to soil improves the rhizosphere. This increases the amount of labile carbon in the soil, feeds the microbes, and boosts the activity of enzymes, nucleation centers, total carbohydrates, and total polysaccharides (Sharma et al., 2022). These studies suggest which soil organic amendments like wheat straw, rice straw, and rotten straw are effective management tools for improving soil nutrient availability and productivity in agriculture.

Numerous studies have examined the positive effects of tea plant waste on the rhizosphere. One study found that applying compost tea and inorganic fertilizers significantly increased the biomass of purslane shoots and some soil chemical properties such as pH (Carrascosa et al., 2023). Furthermore, tea plant waste has positively impacted tea plants' development and microbial diversity. For instance, high P input increased the tea biomass (Yang et al., 2022).

Hazelnut husk extracts have been found to possess great anti-microbial activity versus Gram-positive bacteria such as *Bacillus subtilis* and *Bacillus cereus* (Nicoletti et al., 2022). While there is limited research on the specific effects of hazelnut husk on the rhizosphere, it is known that plant biostimulants, which hazelnut husk extracts are a part of, have a good impact on plant development and biomass (Baltazar et al., 2021). Moreover, a recent review article discusses using integrated rhizosphere management strategies for plant drought stress mitigation (Zia et al., 2021). These organic fertilizers can promote sustainable agriculture and help growers produce healthier strawberry plants.

3. MATERIALS AND METHODS

3.1. Soil

The experimental soil was collected from the agricultural field at Ondokuz Mayis University in Samsun, Türkiye (41° 21' 49.9" N, 36° 11' 19.7" E). The site experiences a mean annual maximum temperature of 27.7°C, a relative humidity of 73%, and a minimum temperature of 5°C. In this area, there is 937.26 mm of annual precipitation.

Standard techniques were used to measure the physical and chemical properties of the soil: particle size distribution by hydrometer method according to Bouyoucos (1962), $CaCO_3$ content volumetric method, (Martin and Reeve, 1955), pH 1:1 soil-water suspension, pH-meter (Rowell, 2014), electrical conductivity (EC) 1:1 soil-water suspension, EC-meter (Rowell, 2014). Total soil organic matter (SOM) was determined using the Walkley-Black wet oxidation method with $K2Cr_2O_7$ (Rowell, 2014). Soil nutrient contents were analyzed: total nitrogen (Kjeldahl method, Bremner 1965), exchangeable calcium, and magnesium 1N NH_4OAc extraction, (Rowell, 2014).

3.2. Strawberry

The study utilized the *Fragaria × ananassa Duch* cultivar Albion, a day-neutral strawberry variety known for its sweetness, disease resistance, and fast growth. Albion has been widely cultivated commercially in various climates and cultivation modes (Gunness et al., 2009).

3.3. Organic Wastes

Various organic wastes were collected from Ondokuz Mayıs University Agricultural Faculty Farms in Samsun, Türkiye. The organic wastes included animal wastes [Cow Manure (CM), Poultry Manure (PM), Sheep Manure (SM), Vermicompost (VC) and plant residues [Wheat Straw (WS), Rice Husk (RH), Tea Waste (TW), Hazelnut Husk (HH)]. The chemical analysis of the organic wastes was conducted using standard methods: pH 1:10, w/v, waste-water suspension, pH-meter, (Rowell, 2014), electrical conductivity 1:10, w/v, waste-water suspension, EC-meter, (Rowell, 2014). Ash content was determined by dry ashing (Miller et al., 1996), and organic matter content was estimated by dry ashing and calculating the organic carbon

using a conversion factor of 1.724 (Rowell, 2014). The dry ashing method was used to determine the total phosphorus in organic wastes, and the Kjeldahl method was used to determine the total nitrogen content (Bremner, 1965).

3.4. Experimental Design

Approximately 200 kg of soil was collected, air-dried, crushed, and sieved through a 4 mm sieve to prepare homogeneous soil conditions for each treatment. The experiment involved 27 pots, each containing 3 kg of soil. The organic waste application was set at 5% of the pot weight (150 grams per pot), followed by transplanting the Albion strawberry plants and watering them with rainwater. Regular monitoring and adjustment-maintained Soil moisture content close to field capacity. Insecticides were applied twice during the experiment as recommended by the Plant Protection Department at Ondokuz Mayis University. The experiment spanned 61 days and followed a completely randomized design. It was conducted in a greenhouse with controlled environmental conditions, including temperature regulation.

3.5. Data Collection

Throughout the plant growth stages, data were collected for the height of the plant (cm), runners' number, leaves number, flowers number, and fresh and dry weight (g). Two images (Figure 5 and Figure 6) in Attachment Figures illustrate the data collection and measurement process.

3.6. Laboratory Analysis

After harvesting the strawberry plant, two soil samples were collected from each pot. The first sample was kept directly in the fridge at (+4°C) to be used in biological analysis. The other sample was left for 10 days to air dry for use in chemical and physical analysis.

Lab analysis involved the determination of soil pH 1:1 soil-water suspension, pH-meter, (Rowell, 2014), electrical conductivity 1:1 soil-water suspension, EC-meter, (Rowell, 2014), using the Walkley-Black wet oxidation method, soil organic matter (SOM) was determined with $K_2Cr_2O_7$ (Rowell, 2014), using the Kjeldahl method, total nitrogen content (Bremner, 1965), C/N ratio calculation, and exchangeable calcium and magnesium content using 1N NH_4OAc extraction (Rowell, 2014). The fumigation-extraction method was used to measure the microbial biomass

carbon (MBC) (Anderson and Domsch, 1978), The alkali absorption method was used to measure basal soil respiration (BSR) (Anderson, 1982), dehydrogenase enzyme activity (DHA) was determined using the reduction of 2,3,5-triphenyl tetrazolium chloride (TTC) (Pepper et al., 1995), and catalase activity (CA) was measured based on the decomposition of hydrogen peroxide (H_2O_2) (Beck, 1971).

3.7. Statistical Analyses

The mean values were calculated, and the least significant difference (LSD) test was used in statistical analyses to identify significant differences among treatments. The analysis was conducted using the statistical software CoStat 6.400. Figure 7 Shows Lab analysis in the process (Attachment Figures).

4. RESULTS AND DISCUSSION

4.1. Soil Analysis and Organic Wastes

The soil analysis revealed several important properties, according to Table 1. The pH indicated slight acidity soil, while the electrical conductivity (EC) suggested non-saline soil. The organic matter (OM) content indicated a moderate level, while the lime ($CaCO_3$) content was low. Additionally, the soil contained high levels of exchangeable calcium (Ca) and magnesium (Mg) cations.

Table 1. Pre-Treated Soil Physical and Chemical Analysis.

Soil Properties	Results
pH	6.89
EC	552.67 μs cm^{-1}
Soil Texture	Clay Soil
% Silt	21.68%
% Sand	29.91%
% Clay	48.41%
OM	2.176%
OC	1.26%
Lime ($CaCO_3$) Content	1.79%
Exchangeable Cations	
Ca	46.85 meq/100g
Mg	13.49 meq/100g
N	12.726 mg/100g
C/ N ratio	9.92

Table 2 demonstrates the findings of the chemical analysis of the organic wastes used in the experiment, including CM, PM, SM, VC, RH, WS, TW, and HH. Each sample was tested for various properties such as pH, EC, OM, organic carbon (OC), ash, phosphorus (P), nitrogen (N), and (C/N) ratio. The samples exhibited a pH range of 4.78 to 9.11, with TW being the most acidic and VC being the most alkaline. EC values varied from 1093 to 5662 μS/cm, with VC having the highest value. The samples also varied in their OM, OC, and ash percentages, with RH having the highest OM and ash content. Moreover, the samples contained different amounts of P and N, with CM having the highest P content and WS having the highest C/N ratio. This data

provides valuable information regarding these organic wastes' nutrient content and suitability for soil amendments or for composting.

Table 2. Chemical Properties of Organic Wastes.

Organic waste	pH	EC, $\mu S\ cm^{-1}$	OM, %	OC, %	Ash, %	P, $mg\ kg^{-1}$	N, %	C/N
Cow Manure	7.94	2141	57.62	33.42	42.38	5663	1.56	21.42
Poultry Manure	7.53	5441	65.53	38.01	34.47	4615	5.22	7.28
Sheep Manure	8.88	1244	60.03	34.82	39.97	3515	2.03	17.15
Vermicompost	9.11	5662	59.25	34.37	40.75	5361	2.17	15.84
Rice Husk	6.72	1093	82.04	47.58	17.96	905	0.40	118.96
Wheat Straw	6.80	1509	70.30	40.77	29.7	71	0.33	123.56
Tea Waste	4.78	3018	43.62	25.30	56.38	852	1.19	21.26
Hazelnut Husk	7.26	2024	80.51	46.70	19.49	1757	0.78	59.87

4.2. Effect of the Organic Wastes on Strawberry Properties

4.2.1. Strawberry Height

Figure 4.2.1 illustrates the impacts of various treatments on strawberry height. The CM, SM, VC, and TW treatments had a higher plant height than the control, while RH, PM, WS, and HH treatments decreased the height. The highest mean heights of (34.17, 33.67, 33.50, and 31.67 cm) were observed in the CM, SM, VC, and TW treatments, respectively, significantly higher than the control plant height of 30 cm. Conversely, the treatments RH, PM, WS, and HH reduced the strawberry height, with mean values of 27, 20, 18, and 17.13 cm, respectively.

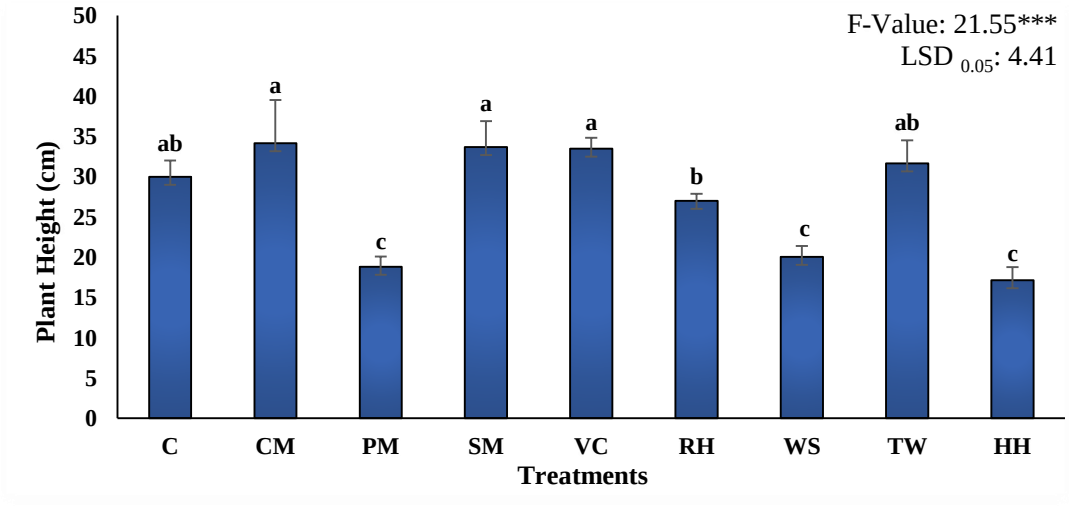

Figure 4.2.1. Effects of the different organic wastes on the strawberry height.

These results are consistent with earlier research showing the positive impacts of organic fertilizers, like CM and VC, on strawberry plant growth (Blouin et al., 2019; Rahman et al., 2018). Specifically, cow manure has been shown to significantly increase strawberry plant height, while vermicompost positively affects various growth parameters during the flowering period (Zuo et al., 2018).

4.2.2. Plant Weight

Different treatments influenced strawberry fresh weight. SM, CM, and VC treatments increased fresh weight, while TW, RH, WS, HH, and PM treatments decreased the fresh weight. The highest mean fresh weights of (34.08, 31.73, and 29.74 g) were observed in the SM, CM, and VC treatments, respectively, significantly higher than the control's fresh weight of 28.61 g (Figure 4.2.2a). Similarly, SM, CM, and VC treatments increased dry weight, while TW, RH, WS, HH, and PM decreased the dry weight (Figure 4.2.2b). The highest mean dry weights of (6.21, 5.76, and 5.42 g) were observed in the SM, CM, and VC treatments, respectively, significantly higher than the control's dry weight of 5.35 g.

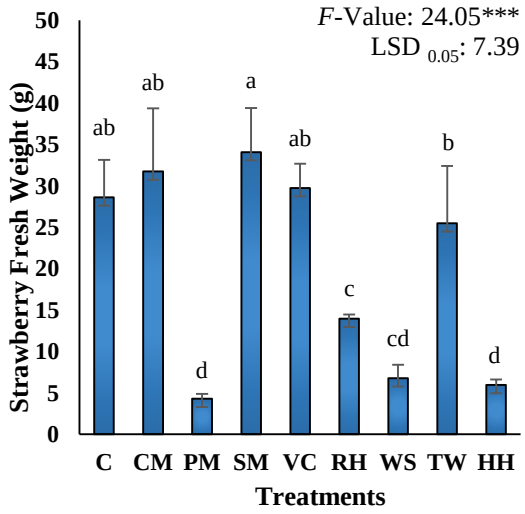

Figure 4.2.2.a. Effects of the different organic wastes on the strawberry fresh weight.

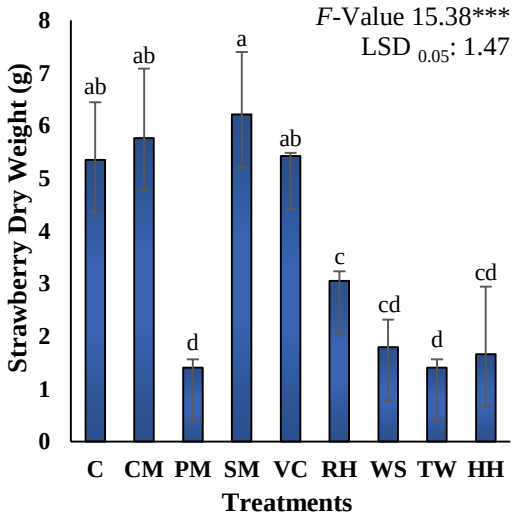

Figure 4.2.2.b. Effects of the different organic wastes on the strawberry dry weight.

These findings show that plant growth and yield are significantly impacted by the type of organic fertilizer used. Previous research has also shown that organic fertilizers, such as composted materials and vermicompost, can enhance strawberry plants' fresh and dry weight (Alvarado-Raya et al., 2021; Mufty and Taha, 2021).

4.2.3. Number of Leaves

The treatments SM and CM increased the number of leaves produced, while the treatments VC, PM, TW, HH, RH, and WS decreased the number of leaves (Figure 4.2.3). Statistical analysis and comparison of treatment means revealed that the highest mean number of leaves, 6.67 and 6.00, was observed in the SM and CM treatments, respectively, and were significantly higher. Previous research has found that organic fertilizers, such as farm manure and VC, positively affect strawberry quality, yield, and soil properties (Zuo et al., 2018). Therefore, using organic fertilizers may positively affect the number of leaves in strawberry plants.

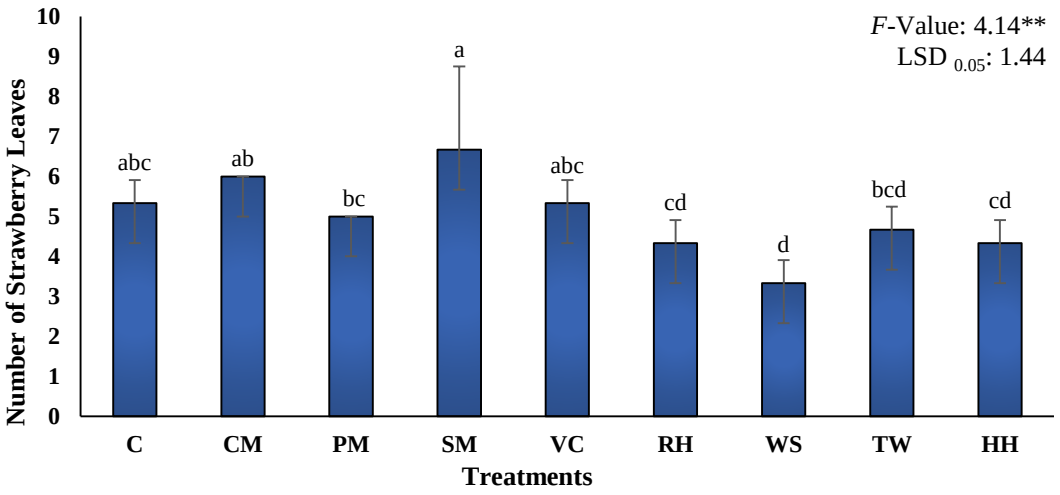

Figure 4.2.3. Effects of the different organic wastes on the number of strawberry leaves.

4.2.4. Number of Runners (Daughter Plants)

TW, VC, SM, CM, and RH treatments increased runner production in strawberry plants, while PM, WS, and HH decreased runner production (Figure 4.2.4). The highest mean number of runners was recorded for TW, VC, SM, CM, and RH, with a value of 2 runners. It has been demonstrated that TW, specifically dry waste of red tea leaves and rose petals, increase strawberry plants' salinity stress tolerance and positively impacts their growth and physiology (Alluqmani and Alabdallah, 2022). Tea seed powder (TSP), a waste product from tea seeds rich in saponins, has shown plant growth regulatory effects (Andresen and Cedergreen, 2010). These findings suggest that TW can have a beneficial impact on the growth and physiology of strawberry plants. Previous studies have also highlighted the positive effects of VC, CM, and SM as organic fertilizers in enhancing soil fertility and promoting plant growth (Arancon et al., 2004; Pathma and Sakthivel, 2012). However, more

investigation is required to pinpoint the precise effects on runner production (Garza-Alonso et al., 2022).

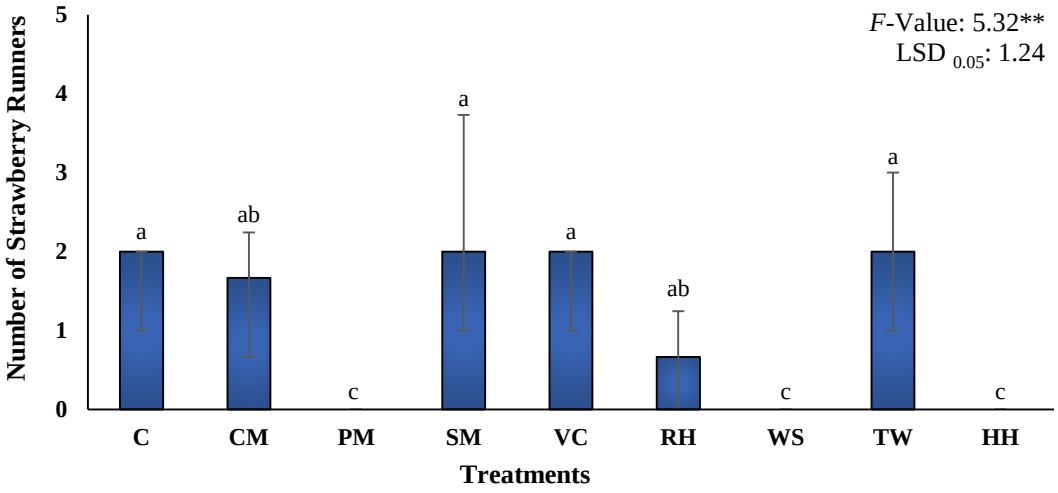

Figure 4.2.4. Effects of the different organic wastes on the number of strawberry runners.

4.2.5. Number of Flowers

The effects of the treatments on the number of strawberry flowers are shown in Figure 4.2.5. The CM treatment increased flower numbers, while RH, SM, VC, TW, PM, WS, and HH reduced the number of flowers compared to the control. The highest mean of 5.33 was noted for the CM treatment, while the lowest values of 0 were observed for the PM, WS, and HH treatments, respectively. The RH, SM, VC, and TW treatments had mean values of 3.67, 3.33, 3, and 1.67, respectively, significantly different.

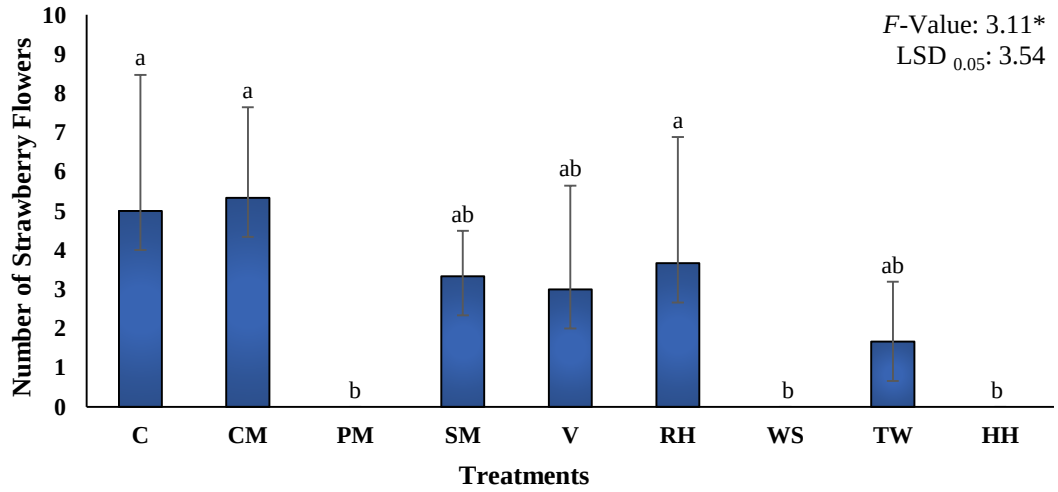

Figure 4.2.5. Effects of the different organic wastes on the number of strawberry flowers.

It is important to note that genetic factors primarily influence the number of flowers strawberry plants produce (Renfiyeni et al., 2020). Therefore, while CM may enhance overall plant growth, it may not necessarily increase the number of flowers. The decrease in flower numbers observed in treatments like RH can indicate the unsuitability of these organic substances for optimal plant growth, triggering a protective mechanism in the plant to produce flowers as a response to stress.

4.3. Impacts of the Organic Wastes on the Soil Chemical Characteristics

4.3.1. Electrical Conductivity (EC)

Applying organic wastes increased soil electrical conductivity (EC), except for WS (Figure 4.3.1). Different organic waste types can have different effects on the EC of the soil. Among the treatments, PM, VC, CM, SM, TW, HH, and RH showed the highest mean EC values of 5229.33, 2616, 1323.67, 1225.33, 1142, 708.6, and 681.4 µs cm^{-1}, respectively, and these values were significantly higher compared to the control (621.9 µs cm^{-1}). Conversely, the application of WS resulted in a decrease in EC, with a mean value of 591.47 µs cm^{-1}. Previous research has demonstrated that adding PM to inorganic fertilizers can significantly raise soil EC levels (Rayne and Aula, 2020). When evaluating the impacts of organic waste on soil properties and EC levels, it is crucial to consider several variables, including nutrient mineralization rates and the chemical, physical, and biological properties of the waste (Rayne and Aula, 2020).

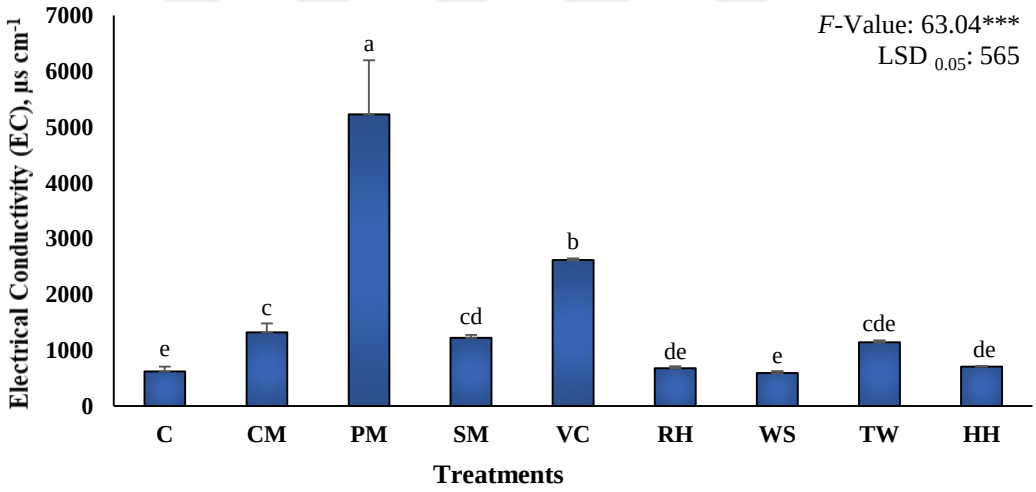

Figure 4.3.1. Effects of the different organic wastes on the soil electrical conductivity.

4.3.2. Soil Reactions (pH)

Among the treatments, SM, HH, VC, and CM increased soil pH, while WS, RH, TW, and PM decreased it (Figure 4.3.2). The application of organic waste influenced the pH value of the soil. SM, HH, VC, and CM had the highest pH mean values of 7.38, 7.15, 7.14, and 7.09, respectively, and these values were significantly higher. On the other hand, PM resulted in the lowest pH value of 6.13. Previous studies have shown that adding SM and VC can decrease soil pH and titratable acidity (Gutierrez-Miceli et al., 2007). The initial pH of the soil, the amount of mean annual

precipitation, and the climate zone all have an impact on how the soil pH changes (Wang et al., 2023), manure type, incubation period (Roy and Kashem, 2014), prolonged application fertilizers, both organic and chemical, over a long period of time (Wang et al., 2019), and the application of plant residues (Demir and Gülser, 2015; Thengane et al., 2020). Agricultural wastes like HH, WS, RH, and TW can be utilized to manage soil acidity (Chang and Li, 2019). Additionally, applying raw and torrefied biomasses can reduce soil pH, with pine shavings exhibiting a more pronounced decrease in pH (Thengane et al., 2020). Therefore, the choice of animal waste and plant residues can significantly impact soil pH levels.

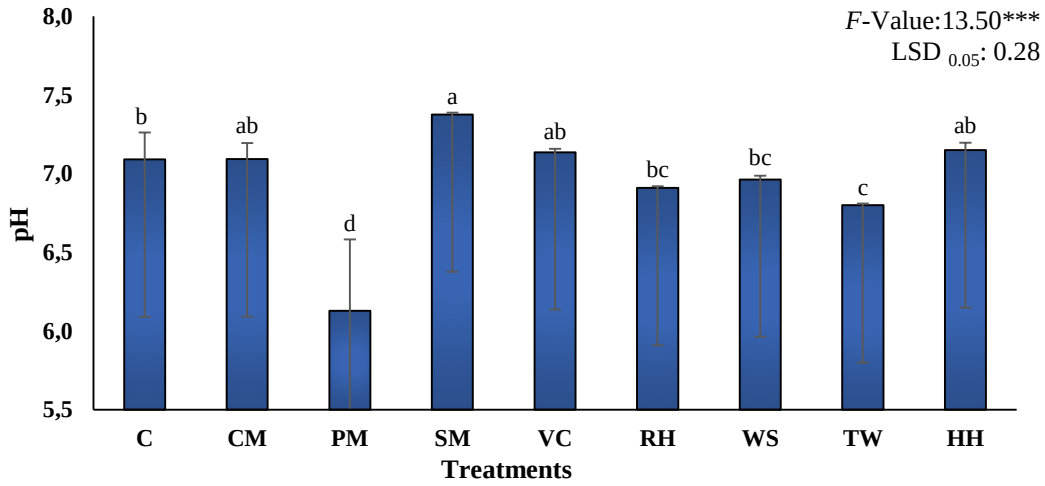

Figure 4.3.2. Effects of the different organic wastes on the soil pH.

4.3.3. Organic Matter (OM)

The percentage of soil OM increased due to applying all organic wastes. WS, RH, HH, TW, CM, PM, VC, and SM showed the highest mean OM values of 5.41, 5.38, 5.15, 4.60, 4.27, 3.63, 3.23, and 2.85%, respectively, which showed a significant improvement when compared to the average value of 2.21 % in the control group (Figure 4.3.3). Previous research has demonstrated the positive impact of rice straw mulching on soil organic matter content (Yang et al., 2009). Applying organic waste is a sustainable way to improve crop productivity and soil health. Cow manure, poultry manure, sheep manure, vermicompost, rice husk, wheat straw, tea plant waste, and hazelnut shells are valuable resources for soil management. These wastes provide essential nutrients and organic matter, improving soil fertility and promoting plant growth.

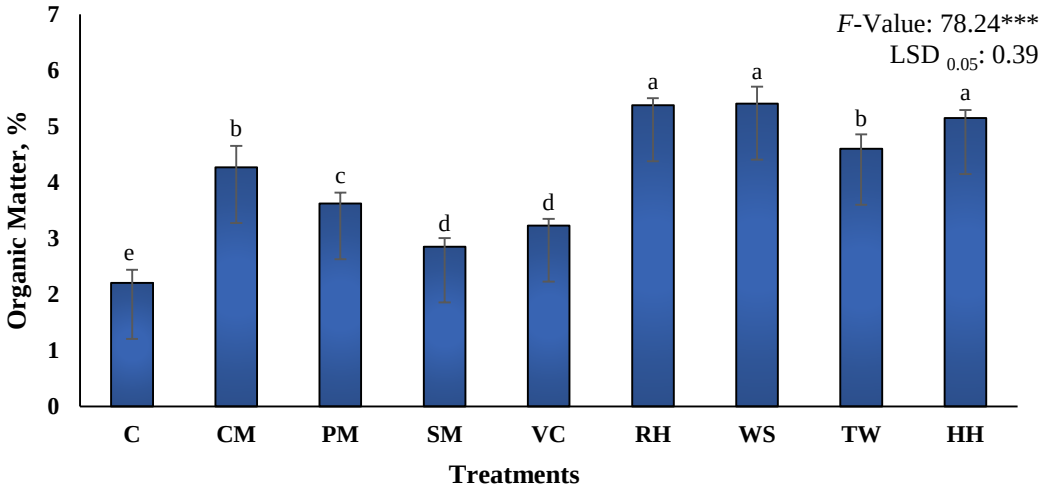

Figure 4.3.3. Effects of the different organic wastes on soil organic matter.

4.3.4. Total Nitrogen Content (N)

The total nitrogen content varied with different treatments. SM, CM, and VC applications increased the total nitrogen content, while TW, RH, WS, HH, and PM applications decreased it (Figure 4.3.4). The mean values of total nitrogen content were 231.42, 225.77, and 212.10 N mg $100g^{-1}$ for SM, CM, and VC, respectively, indicating a significant increase compared to the control mean value of 179.58 N mg/100g soil. Conversely, TW, RH, WS, HH, and PM treatments showed mean values of 170.15, 120.19, 117.36, 113.59, and 113.12 N mg $100g^{-1}$, respectively, significantly lower.

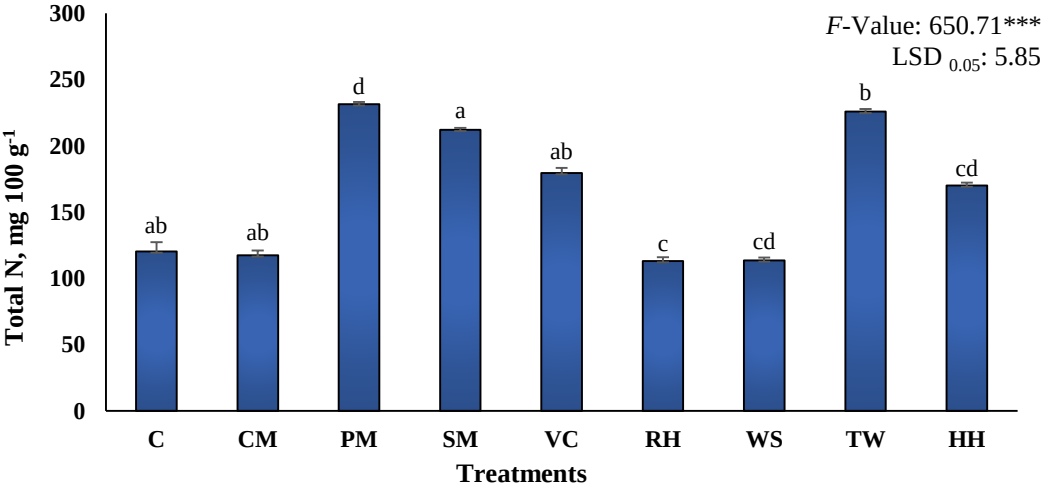

Figure 4.3.4. Effects of the different organic wastes on the total N content of the soil.

According to studies, organic fertilizers contain a higher concentration of nitrogen, and their ability to improve soil structure and promote microbial activity contributes to the increase in total nitrogen content (Aslam, 2020; Jacoby et al., 2017). According to van der Waal et al. (2011), Applying animal manure correctly and

subsequent decomposition produces nutrients that encourage plant growth. Additionally, VC has been found to have a higher total nitrogen content than the raw material from which it was derived. These findings highlight using organic fertilizers as a sustainable and effective approach to enhance soil fertility and crop production.

4.3.5. C/N Ratio

Figure 4.3.5 shows that the C/N ratio increased across all plant residue treatments, while animal waste treatments, except for CM, decreased the C/N ratio. The mean C/N ratio values were 27.64, 27.61, 21.10, 17.55, and 11.82 for WS, RH, CM, HH, and TW, respectively, indicating a significant increase compared to the control mean value of 10.64. On the other hand, VC, PM, and SM treatments showed mean values of 10.43, 9.09, and 7.81, respectively, which were significantly lower. The amount of resistant materials also impacts the C/N ratio, which is used as a measurement for the decomposition of organic matter (Hadas et al., 2004). Previous studies have reported differences in the C/N ratio among various plant and animal residues, which can be attributed to their biochemical composition (Walton et al., 2010).

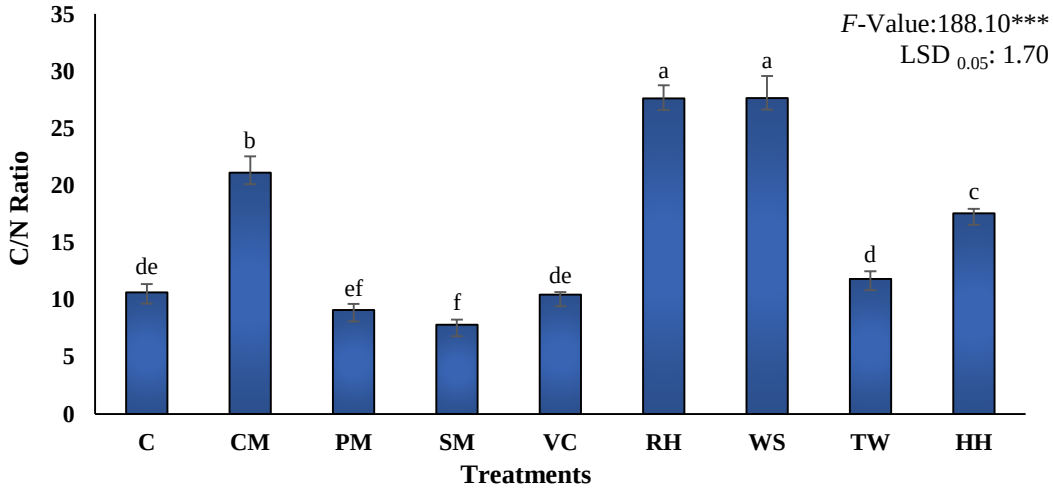

Figure 4.3.5. Effects of the different organic wastes on the C/N ratio of soil.

4.3.6. Exchangeable Calcium (Ca) and Magnesium (Mg) Content

All the treatments decreased exchangeable Ca content except for the PM treatment (Figure 4.3.6 a). The mean values of exchangeable Ca content were 43.67, 43.17, 43.09, 42.93, 42, 42, and 36.62 meq Ca 100 g^{-1} for HH, RH, VC, CM, TW, SM, and WS, respectively, indicating a significant decrease compared to the control mean value of 46.28 meq Ca 100 g^{-1}. Conversely, PM treatment showed a mean value of

47.22 meq Ca 100 g^{-1}, significantly higher. Previous research has demonstrated that increasing soil organic matter content can increase the total soil and exchangeable calcium content (Luo et al., 2023). Various treatments changed exchangeable magnesium (Mg) content (Figure 4.3.6 b). The mean values of exchangeable Mg content were 17.99, 17.95, 15.30, 14.96, 14.60, 14.55, and 14.39 meq Mg 100 g^{-1} for SM, WS, TW, HH, VC, CM, and RH, respectively, indicating a significant increasement compared to the control mean value of 11.09 meq Mg 100 g^{-1}. Conversely, PM treatment showed a mean value of 11.09 meq Mg 100 g^{-1}, which was significantly lower. Studies have shown that applying organic amendments, such as VC, CM, RH, SM, and WS, can raise the soil's exchangeable magnesium content (Adekiya et al., 2020; Arancon et al., 2004; Osman et al., 2022; Yang et al., 2009).

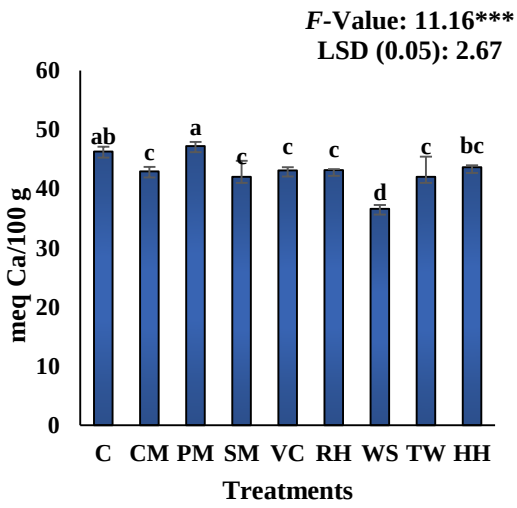

Figure 4.3.6. (a) Effects of the different organic wastes on exchangeable Ca of the soil.

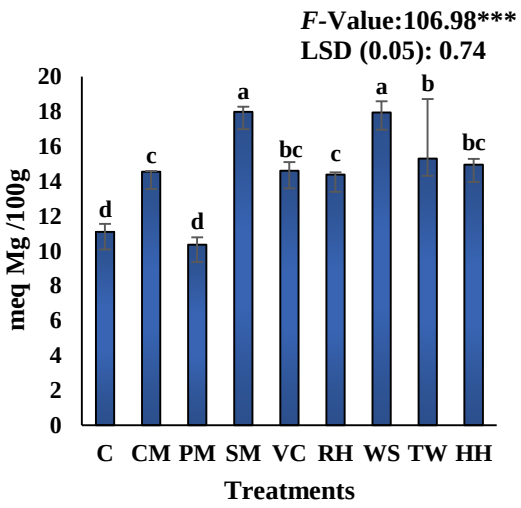

Figure 4.3.6. (b) Effects of the different organic wastes on exchangeable Mg of the soil.

4.4. Impacts of Organic Wastes on Soil Biological Characteristics.

4.4.1. Microbial Biomass Carbon

Microbial biomass carbon (MBC) values across all treatments increased due to organic waste treatments (Figure 4.4.1). The highest mean MBC values of 6.89, 15.80, 14.50, 13.35, 12.67, 7.42, 7.23, and 4.42 mg CO_2-C g^{-1} $24h^{-1}$ were observed in WS, SM, TW, PM, HH, VC, RH, and CM treatments, respectively. Compared to the control treatment, these values were significantly higher, with a mean MBC value of 3.65 mg CO_2-C g^{-1} $24h^{-1}$. It has been reported in numerous studies that the application of manure in agricultural systems typically increases MBC. However, microbial biomass response can vary based on management practices, weather conditions, and soil types (Lentendu et al., 2014). Additionally, research has demonstrated that adding straw can boost soil microbial diversity, resulting in higher urease, phosphatase, and invertase activity (Zhang et al., 2016). Furthermore, Ren et al. (2019) suggested that the recovery of microbial communities in conventional agricultural systems subjected to long-term and intensive mineral fertilizer applications can benefit, especially from manure amendment.

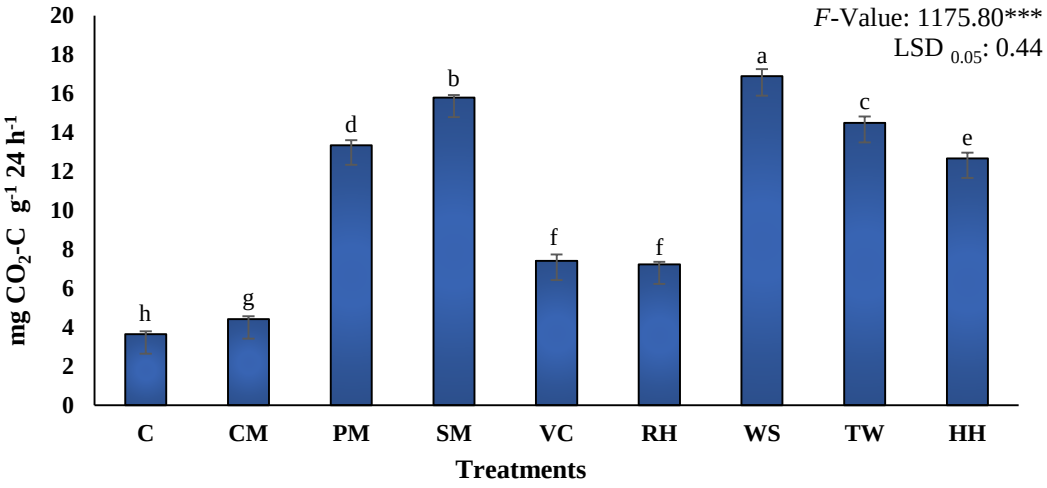

Figure 4.4.1. Effects of the different organic wastes on the Microbial Biomass C of soil.

4.4.2. MBC/ OC ratio

Most treatments increased the MBC/OC ratio, except for CM and RH treatments, which decreased the ratio. The highest mean MBC/OC ratios of 9.56, 6.36, 5.45, 5.40, 4.24, and 3.97 were observed in SM, PM, TW, WS, HH, and VC treatments, respectively, and were significantly higher than the MBC/OC ratio in the control treatment 2.87 (Figure 4.4.2). The proportion of microbial biomass to the amount of

organic carbon in the soil is reflected by the MBC/OC ratio, which is a crucial indicator for determining the health of the soil (Anderson and Domsch, 1989). Monitoring and interpreting MBC results in agricultural experiments can provide insights into soil health assessments, nutrient management strategies, and carbon sequestration efforts, leading to improved agricultural practices and sustainability.

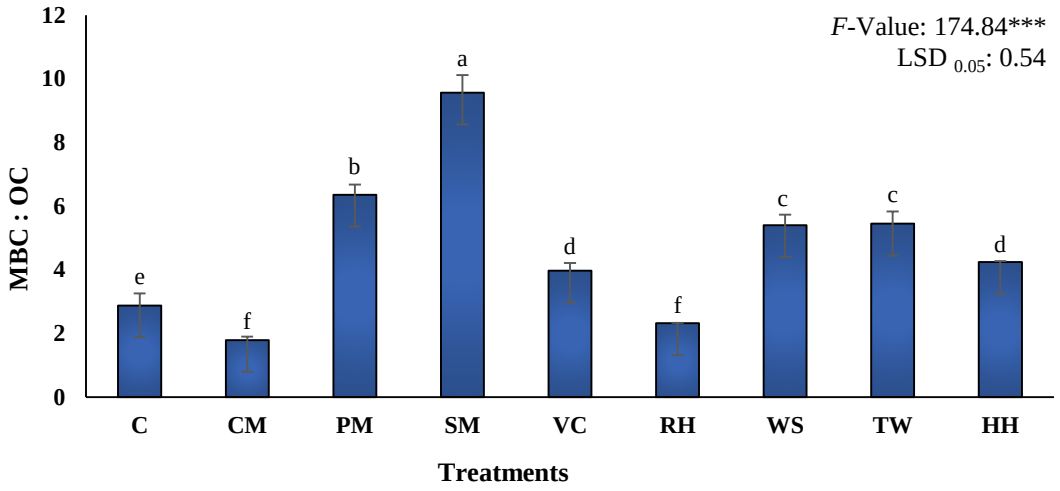

Figure 4.4.2. Effects of the different organic wastes on the MBC/OC ratio of soil.

4.4.3. Basal Soil Respiration (BSR)

Basal Soil Respiration increased with TW, PM, SM, HH, WS, and RH treatments, with mean values of 2.04, 1.40, 1.23, 1.57, 1.08, and 0.93 mg CO_2-C g^{-1} $24h^{-1}$, respectively. In contrast, the treatments CM and VC led to a decrease in basal soil respiration, with mean values of 0.81 and 0.69 mg CO_2-C g^{-1} $24h^{-1}$, respectively, compared to the control treatment with a mean value of 0.84 mg CO_2-C g^{-1} $24h^{-1}$ (Figure 4.4.3). These findings imply that applying tea plant waste can enhance soil health by positively affecting basal soil respiration.

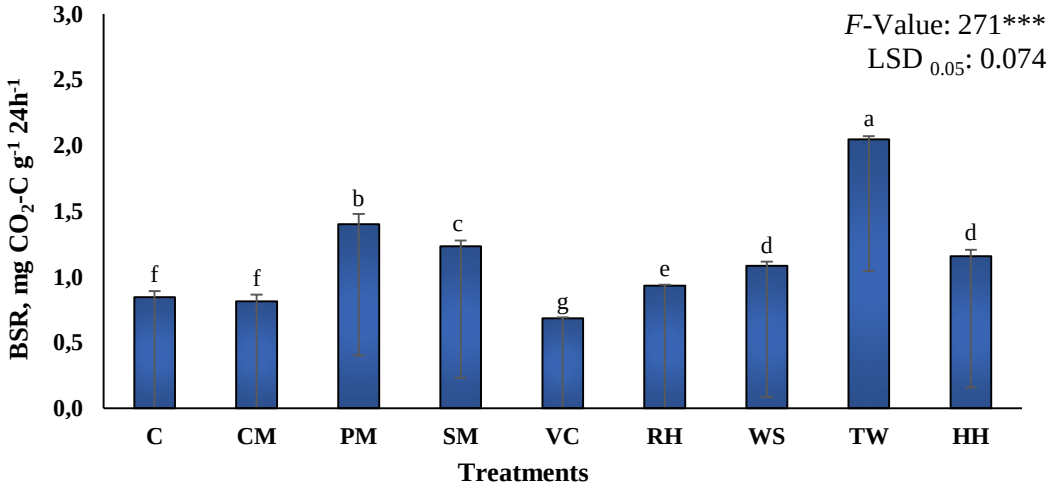

Figure 4.4.3. Effects of the different organic wastes on the Basal Soil Respiration.

Wu et al. (2021) found similar results in their research, where adding manure increased soil basal respiration and microbial activities, while biochar-treated soils showed a significant decrease in these parameters. Additionally, Yu et al. (2003) reported that soil basal respiration potential and enzyme activities were closely related to soil pH and significantly increased with the age of tea bushes. Furthermore, Iovieno et al. (2009) found that compost-treated soils exhibited increased soil respiration and enzyme activities attributed to microbial growth, enhanced resource availability, and changes in microbial community composition.

4.4.4. Dehydrogenase Enzyme Activity (DHA)

Dehydrogenase enzyme activity (DHA) values increased with all treatments (Figure 4.4.4). In this study, the highest mean DHA values of 135.42, 78.75, 69.13, 64.81, 52.61, 52.21, 51.77, and 49.93 µg TPF g^{-1} $24h^{-1}$ were observed in PM, SM, TW, VC, CM, WS, HH, and RH treatments, respectively. These values were significantly higher than the DHA in the control treatment (37.69 µg TPF g^{-1} $24h^{-1}$).

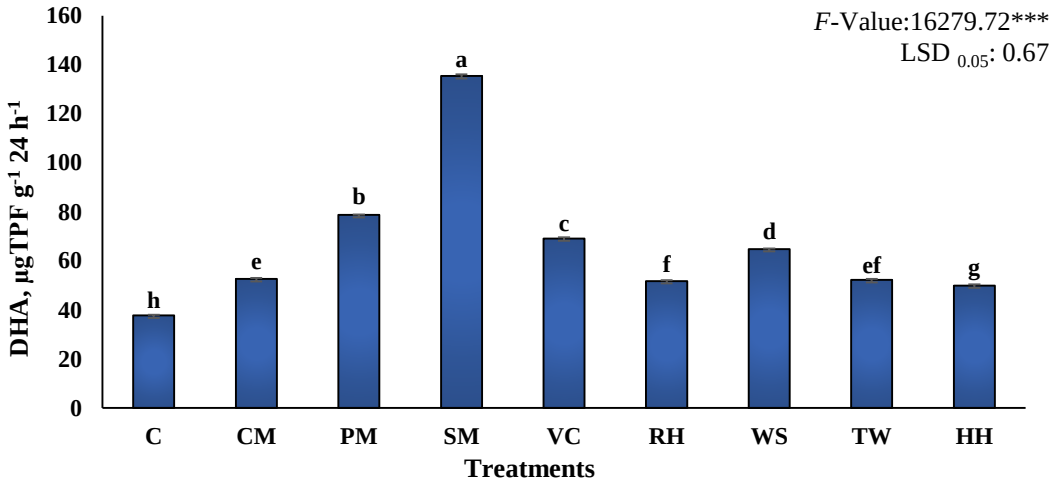

Figure 4.4.4. Effects of the different organic wastes on the dehydrogenase enzyme activity.

Various factors, including soil moisture, temperature, nutrient availability, and pollutants or contaminants, can influence changes in DHA. In Northern Türkiye, an experiment showed Organic waste from agriculture, such as bio-solids and tea waste, positively influenced DHA in eroded soils the study suggested that adding organic wastes can increase DHA levels in eroded soils also showed that the effects of organic wastes on DHA varied depending on the application dose, with wastes from tea production increasing DHA at all erosion levels. In contrast, wastes from biosolids increased DHA at 2% but decreased it at 4% and 6% (Yakupoglu et al., 2009).

according to Skujinš (1973), DHA, reflects the oxidative activity of soil microflora, functions as an indicator of soil microbial activity and overall soil health.

4.4.5. Catalase Activity (CA)

Catalase activity (CA) values increased with all treatments (Figure 4.4.5). The highest mean CA values of 251.18, 225.41, 209.41, 131.12, 129.33, 122.27, 105.21, and 97.11 ml O_2 g^{-1} 3 min^{-1} were observed in PM, SM, TW, VC, CM, WS, HH, and RH treatments, respectively, when compared to the CA in the control treatment 90.51 ml O_2 g^{-1} 3 min^{-1} and were significantly higher.

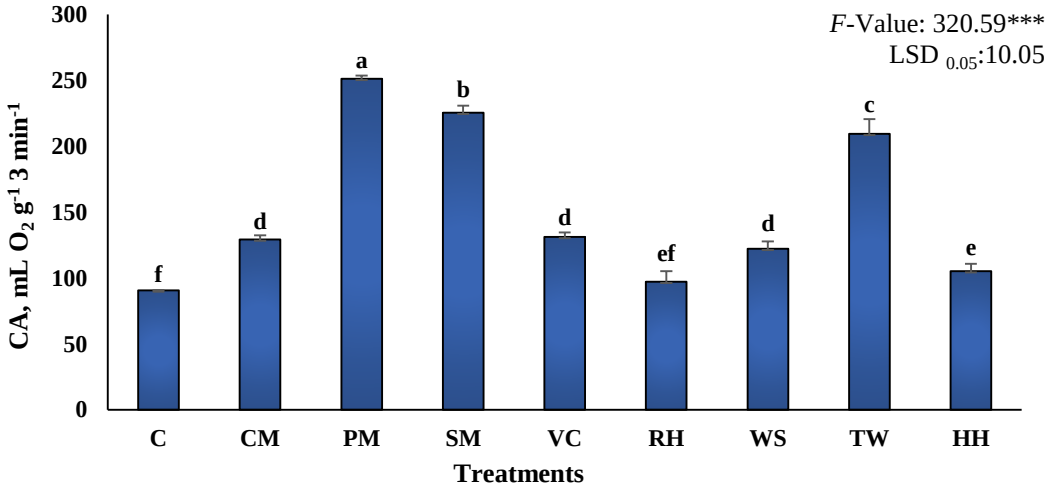

Figure 4.4.5. Effects of the different organic wastes on the soil catalase enzyme activity.

Based on the oxygen release rates from additional hydrogen peroxide, catalase activity is directly correlated with the metabolic activity of aerobic organisms (Kızılkaya et al., 2004). Municipal solid waste, bio-waste, food waste, sewage sludge, and manure are examples of different organic wastes that have been found to improve soil's physical, chemical, and biological characteristics, including the number of soil microorganisms (Sun et al., 2021). According to Lalande et al. (1998), It has been hypothesized that soil's organic matter content, rather than its quality, has a greater impact on enzyme activity. Vermicompost, recommended as an organic fertilizer for sustainable nursery substrate production, contains many beneficial microorganisms (Zhao et al., 2019). The study's findings showed that organic amendments enhance the biological characteristics of the soil and crop yield and lessen the need for significant amounts of mineral N fertilizer. Sulfatase, catalase, phosphodiesterase, phosphomonoesterase, sucrase, and urease were among the soil enzymes whose activity was increased by applying VC (Zuo et al., 2018).

5. CONCLUSION

In conclusion, the findings of this study highlight the significant impacts of organic fertilizers and waste materials on strawberry plant growth, soil fertility, and overall soil health. The results indicate that organic fertilizers such as SM, CM, and VC have the potential to serve as viable alternatives to chemical fertilizers, promoting plant growing and enhancing nutrient content. However, it is crucial to consider various factors, including plant species, environmental conditions, and genetic factors, when selecting and applying organic fertilizers to optimize their effectiveness in strawberry cultivation. More investigation is required to delve into the underlying mechanisms behind these observed effects and determine the optimal application rates and timings for different organic fertilizers in strawberry production.

Furthermore, the application of organic wastes has demonstrated significant impacts on the chemical characteristics of the soil. Various organic wastes, including tea plant waste, straw, and manure, have been shown to increase electrical conductivity (EC), organic matter (OM) content, and nutrient availability, while also inducing changes in soil pH, total nitrogen content (N), C/N ratio, and exchangeable calcium (Ca) and magnesium (Mg) content. These alterations improve soil fertility, nutrient availability, and overall soil health, enhancing plant growth and crop productivity. It is important to consider factors such as soil types, management practices, climate conditions, and the type and dosage of the organic waste applied to better understand and harness the potential benefits of the organic waste application.

Moreover, the addition of organic wastes has positive effects on soil biological characteristics. The incorporation of organic amendments, including tea plant waste, straw, and manure, has been found to increase microbial biomass carbon (MBC), the MBC/OC ratio, basal soil respiration (BSR), dehydrogenase enzyme activity (DHA), and catalase activity (CA). However, the effects of organic waste on soil biological characteristics can vary depending on several factors, such as soil types, management practices, climate conditions, and the specific type and dosage of the organic waste used. Monitoring and interpreting soil biological characteristics can provide valuable insights for soil health assessments, nutrient management strategies, and carbon sequestration efforts, leading to improved agricultural practices and long-term sustainability.

In summary, this study highlights the potential benefits of utilizing organic fertilizers and waste materials in strawberry cultivation. The findings emphasize their positive impacts on plant growth, soil fertility, and soil biological characteristics. Incorporating organic wastes in agricultural practices can contribute to sustainable soil management, improved crop productivity, and environmental conservation. Future research should continue to explore the specific mechanisms underlying these effects, optimize application methods, and evaluate long-term impacts on soil health and plant performance. By harnessing the potential of organic wastes, we can promote more sustainable and ecologically friendly agricultural practices, fostering the long-term viability of strawberry cultivation and contributing to global food security.

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Attachment Tables

1. Impacts of the Organic Wastes on the Strawberry Properties

1.1. ANOVA Effects of the Treatments on the Strawberry Height.

Source	df	Type I SS	MS	F	P	
Main Effects						
Treatments	8	1141.24	142.655	21.545477	0.0000	***
Error	18	119.18	6.6211111<-			
Total	26	1260.42				

R^2 = 0.90544421701

Root MS error = 2.57315197979

Mean Y = 27.3333333333

Coefficient of Variation = 9.4139707%

Significance Level: 0.05

Variance: 6.62111111111

LSD 0.05 = 4.41397374548

Treatment Name	Mean	STD	Non-significant ranges
Cow Manure	34.17	5.35	a
Sheep Manure	33.67	3.21	a
Vermicompost	33.50	1.32	a
Tea Waste	31.67	2.84	ab
Control	30.00	2.00	ab
Rice Husk	27.00	0.87	b
Wheat Straw	20.03	1.36	c
Poultry Manure	18.83	1.26	c
hazelnut Husk	17.13	1.63	c

1.2. ANOVA Effects of the Treatments on the Strawberry Fresh Weight.

Source	df	Type I SS	MS	F	P	
Main Effects						
Treatments	8	3568.467262	446.05841	24.051836	0.0000	***
Error	18	333.8228	18.545711<-			
Total	26	3902.290062				

R^2 = 0.9144546421

Root MS error = 4.30647316387

Mean Y = 20.0708148148

Coefficient of Variation = 21.456394%

Compare Means

Significance Level: 0.05

Variance: 18.5457111111

LSD 0.05 = 7.38730538663

Treatment Name	Mean	STD	Non-significant ranges
Sheep Manure	34.08	5.31	a
Cow Manure	31.73	7.63	ab
Vermicompost	29.74	2.92	ab
Control	28.61	4.51	ab
Tea Waste	25.47	6.92	b
Rice Husk	13.96	0.51	c
Wheat Straw	6.79	1.63	cd
hazelnut Husk	5.96	0.67	d
Poultry Manure	4.3	0.59	d

1.3. ANOVA Effects of the Treatments on the Strawberry Dry Weight.

Source	df	Type I SS	MS	F	P	
Main Effects						
Treatments	8	90.20421563	11.275527	15.387361	0.0000	***
Error	18	13.19001267	0.7327785<-			
Total	26	103.3942283				

R^2 = 0.87242989397

Root MS error = 0.85602481359

Mean Y = 3.91062962963

Coefficient of Variation = 21.889693%

Compare Means

Significance Level: 0.05

Variance: 0.73277848148

LSD 0.05 = 1.46842125235

Treatment Name	Mean	STD	Non-significant ranges
Sheep Manure	6.21	1.18	a
Cow Manure	5.76	1.32	ab
Vermicompost	5.42	0.06	ab
Control	5.35	1.10	ab
Tea Waste	4.56	0.53	b
Rice Husk	3.05	0.18	c
Wheat Straw	1.79	0.53	cd
hazelnut Husk	1.66	1.28	cd
Poultry Manure	1.40	0.16	d

1.4. ANOVA Effects of the Treatments on the Number of Leaves.

Source	df	Type I SS	MS	F	P	
Main Effects						
Treatments	8	23.33333333	2.9166667	4.1447368	0.0058	**
Error	18	12.66666667	0.7037037<-			
Total	26	36				

R^2 = 0.64814814815

Root MS error = 0.83887049281

Mean Y = 5

Coefficient of Variation = 16.77741%

Compare Means

Significance Level: 0.05

Variance: 0.7037037037

LSD 0.05 = 1.43899480489

Treatment Name	Mean	STD	Non-significant ranges
Sheep Manure	6.67	2.08	a
Cow Manure	6.00	0.00	ab
Control	5.33	0.58	abc
Vermicompost	5.33	0.58	abc
Poultry Manure	5.00	0.00	bc
Tea Waste	4.67	0.58	bcd
Hazelnut Husk	4.33	0.58	cd
Rice Husk	4.33	0.58	cd
Wheat Straw	3.33	0.58	d

1.5. ANOVA Effects of the Treatments on the Number of the Plant's Runners.

Source	df	Type I SS	MS	F	P	
Main Effects						
Treatments	8	22.07407407	2.7592593	5.3214286	0.0016	**
Error	18	9.333333333	0.5185185<-			
Total	26	31.40740741				

R^2 = 0.70283018868

Root MS error = 0.72008229982

Mean Y = 1.14814814815

Coefficient of Variation = 62.716845%

Compare Means

Significance Level: 0.05

Variance: 0.51851851852

LSD 0.05 = 1.23522605387

Treatment Name	Mean	STD	Non-significant ranges
Tea Waste	2.00	1.00	a
Vermicompost	2.00	0.00	a
Control	2.00	0.00	a
Sheep Manure	2.00	1.73	a
Cow Manure	1.67	0.58	ab
Rice Husk	0.67	0.58	ab
Poultry Manure	0.00	0.00	c
Wheat Straw	0.00	0.00	c
Hazelnut Husk	0.00	0.00	c

1.6. ANOVA Effects of the Treatments on the Number of Flowers.

Source	df	Type I SS	MS	F	P	
Main Effects						
Treatments	8	106.0740741	13.259259	3.1130435	0.0216	*
Error	18	76.66666667	4.2592593<-			
Total	26	182.7407407				

R^2 = 0.58046209972

Root MS error = 2.06379729122

Mean Y = 2.51851851852

Coefficient of Variation = 81.944892%

Compare Means

Significance Level: 0.05

Variance: 4.25925925926

LSD 0.05 = 3.54022892196

Treatment Name	Mean	STD	Non-significant ranges
Cow Manure	5.33	2.31	a
Control	5.00	3.46	a
Rice Husk	3.67	3.21	a
Sheep Manure	3.33	1.15	ab
Vermicompost	3.00	2.65	ab
Tea Waste	1.67	1.53	ab
Poultry Manure	0.00	0.00	b
Wheat Straw	0.00	0.00	b
Hazelnut Husk	0.00	0.00	b

2. Impacts of The Organic Wastes on the Soil Chemical Characteristics

2.1. ANOVA Effects of the Treatments on the Soil EC.

Source	df	Type I SS	MS	F	P	
Main Effects						
Treatments	8	54706578.68	6838322.3	63.035341	0.0000	***
Error	18	1952710.987	108483.94<-			
Total	26	56659289.67				

R^2 = 0.96553590774

Root MS error = 329.369008414

Mean Y = 1571.07777778

Coefficient of Variation = 20.964526%

Compare Means

Significance Level: 0.05

Variance: 108483.943704

LSD 0.05 = 564.998168446

Treatment Name	Mean	STD	Non-significant ranges
Poultry Manure	5229.3	967.45	a
Vermicompost	2616	33.05	b
Cow Manure	1323.6	158.45	c
Sheep Manure	1225.3	51.40	cd
Tea Waste	1142	36.09	cde
Hazelnut Husk	708.6	10.55	de
Rice Husk	681.4	32.58	de
Control	621.9	88.67	e
Wheat Straw	591.4	34.85	e

2.2. ANOVA Effects of the Treatments on the Soil pH.

Source	df	Type I SS	MS	F	P	
Main Effects						
Treatments	8	2.9778	0.372225	13.500907	0.0000	***
Error	18	0.496266667	0.0275704<-			
Total	26	3.474066667				

R^2 = 0.85715108135

Root MS error = 0.16604327861

Mean Y = 6.96111111111

Coefficient of Variation = 2.3852985%

Compare Means

Significance Level: 0.05

Variance: 0.02757037037

LSD 0.05 = 0.28482991993

Treatment Name	Mean	STD	Non-significant ranges
Sheep Manure	7.38	0.01	a
Hazelnut Husk	7.15	0.05	ab
Vermicompost	7.14	0.02	ab
Cow Manure	7.09	0.10	ab
Control	7.09	0.17	b
Wheat Straw	6.96	0.02	bc
Rice Husk	6.91	0.01	bc
Tea Waste	6.80	0.01	c
Poultry Manure	6.13	0.4	d

2.3. ANOVA Effects of the Treatments on the Soil OM.

Source	df	Type I SS	MS	F	P	
Main Effects						
Treatments	8	32.52973933	4.0662174	78.237168	0.0000	***
Error	18	0.935513333	0.051973<-			
Total	26	33.46525267				

R^2 = 0.97204523323

Root MS error = 0.22797579469

Mean Y = 4.08088888889

Coefficient of Variation = 5.5864249%

Compare Means

Significance Level: 0.05

Variance: 0.05197296296

LSD 0.05 = 0.3910686894

Treatment Name	Mean	STD	Non-significant ranges
Wheat Straw	5.41	0.30	a
Rice Husk	5.38	0.12	a
Hazelnut Husk	5.15	0.15	a
Tea Waste	4.60	0.26	b
Cow Manure	4.27	0.38	b
Poultry Manure	3.63	0.19	c
Vermicompost	3.23	0.12	d
Sheep Manure	2.85	0.15	d
Control	2.21	0.23	e

2.4. ANOVA Effects of the Treatments on the Nitrogen Content.

Source	df	Type I SS	MS	F	P	
Main Effects						
Treatments	8	60521.71692	7565.2146	650.7086	0.0000	***
Error	18	209.2701147	11.626117<-			
Total	26	60730.98703				

R^2 = 0.996554146

Root MS error = 3.40970929574

Mean Y = 164.809555556

Coefficient of Variation = 2.0688784%

Compare Means

Significance Level: 0.05

Variance: 11.6261174815

LSD 0.05 = 5.84900053682

Treatment Name	Mean	STD	Non-significant ranges
Sheep Manure	231.42	1.41	a
Cow Manure	225.77	3.74	ab
Vermicompost	212.10	3.74	ab
Control	179.58	7.07	ab
Tea Waste	170.15	2.16	b
Rice Husk	120.19	2.83	c
Wheat Straw	117.36	2.16	cd
Hazelnut Husk	113.59	2.16	cd
Poultry Manure	113.12	1.63	d

2.5. ANOVA Effects of the Treatments on the Soil C/N Ratio.

Source	df	Type I SS	MS	F	P	
Main Effects						
Treatments	8	1471.553377	183.94417	188.10259	0.0000	***
Error	18	17.60207067	0.9778928<-			
Total	26	1489.155448				

R^2 = 0.98817982992

Root MS error = 0.9888846317

Mean Y = 15.9651851852

Coefficient of Variation = 6.1940066%

Compare Means

Significance Level: 0.05

Variance: 0.97789281481

LSD 0.05 = 1.69632840808

Treatment Name	Mean	STD	Non-significant ranges
Wheat Straw	27.64	1.94	a
Rice Husk	27.61	1.14	a
Cow Manure	21.10	1.43	b
Hazelnut Husk	17.55	0.40	c
Tea Waste	11.82	0.67	d
Control	10.64	0.73	de
Vermicompost	10.43	0.24	de
Poultry Manure	9.09	0.54	ef
Sheep Manure	7.81	0.45	f

2.6. ANOVA Effects of the Treatments on the Exchangeable Mg.

Source	df	Type I SS	MS	F	P	
Main Effects						
Treatments	8	161.1156963	20.139462	106.98148	0.0000	***
Error	18	3.388533333	0.1882519<-			
Total	26	164.5042296				

R^2 = 0.9794015428

Root MS error = 0.43387999706

Mean Y = 14.5762962963

Coefficient of Variation = 2.9766135%

Compare Means

Significance Level: 0.05

Variance: 0.18825185185

LSD 0.05 = 0.74427586507

Treatment Name	Mean	STD	Non-significant ranges
Sheep Manure	17.99	0.288	a
Wheat Straw	17.95	0.363	a
Tea Waste	15.3	0.807	b
Hazelnut Husk	14.96	0.430	bc
Vermicompost	14.60	0.506	bc
Cow Manure	14.55	0.043	c
Rice Husk	14.39	0.042	c
Control	11.09	0.466	d
Poultry Manure	10.36	0.419	d

2.7. ANOVA Effects of the Treatments on the Exchangeable Ca.

Source	df	Type I SS	MS	F	P	
Main Effects						
Treatments	8	215.0648667	26.883108	11.162039	0.0000	***
Error	18	43.35193333	2.4084407<-			
Total	26	258.4168				

R^2 = 0.83224026714

Root MS error = 1.55191518478

Mean Y = 42.9966666667

Coefficient of Variation = 3.6093849%

Compare Means

Significance Level: 0.05

Variance: 2.40844074074

LSD 0.05 = 2.66214857677

Treatment Name	Mean	STD	Non-significant ranges
Poultry Manure	47.21	0.730	a
Control	46.28	0.838	ab
Hazelnut Husk	43.67	0.319	bc
Rice Husk	43.17	0.127	c
Vermicompost	43.09	0.547	c
Cow Manure	42.93	0.754	c
Tea Waste	42	3.416	c
Sheep Manure	42	2.713	c
Wheat Straw	36.67	0.646	d

3. Impacts of Different Organic Wastes on the Soil Biological Characteristics.

3.1. ANOVA Effects of the Treatments on the MBC.

Source	df	Type I SS	MS	F	P	
Main Effects						
Treatments	8	605.0386667	75.629833	1175.7963	0.0000	***
Error	18	1.1578	0.0643222<-			
Total	26	606.1964667				

R^2 = 0.99809005815

Root MS error = 0.25361826082

Mean Y = 10.6588888889

Coefficient of Variation = 2.3794062%

Compare Means

Significance Level: 0.05

Variance: 0.06432222222

LSD 0.05 = 0.43505566458

Treatment Name	Mean	STD	Non-significant ranges
Wheat Straw	16.89	0.36	a
Sheep Manure	15.80	0.14	b
Tea Waste	14.50	0.33	c
Poultry Manure	13.35	0.26	d
Hazelnut Husk	12.67	0.29	e
Vermicompost	7.42	0.32	f
Rice Husk	7.23	0.14	f
Cow Manure	4.42	0.15	g
Control	3.65	0.16	h

3.2. ANOVA MBC/ OC Ratio

Source	df	Type I SS	MS	F	P	
Main Effects						
Treatments	8	136.9265404	17.115818	174.84066	0.0000	***
Error	18	1.762088459	0.0978938<-			
Total	26	138.6886288				

R^2 = 0.9872946436

Root MS error = 0.31287985436

Mean Y = 4.66136135496

Coefficient of Variation = 6.7121991%

Compare Means

Significance Level: 0.05

Variance: 0.09789380326

LSD 0.05 = 0.53671274509

Treatment Name	Mean	STD	Non-significant ranges
Control	2.87	0.38	e
Cow Manure	1.79	0.10	f
Poultry Manure	6.36	0.32	b
Sheep Manure	9.56	0.55	a
Vermicompost	3.97	0.25	d
Rice Husk	2.32	0.01	f
Wheat Straw	5.40	0.33	c
Tea Waste	5.45	0.39	c
hazelnut Husk	4.24	0.02	d

3.3. ANOVA Effects of the Treatments on the BSR.

Source	df	Type I SS	MS	F	P	
Main Effects						
Treatments	8	4.026137333	0.5032672	270.09508	0.0000	***
Error	18	0.033539333	0.0018633<-			
Total	26	4.059676667				

R^2 = 0.99173842252

Root MS error = 0.04316591591

Mean Y = 1.13222222222

Coefficient of Variation = 3.812495%

Compare Means

Significance Level: 0.05

Variance: 0.0018632963

LSD 0.05 = 0.07404662493

Treatment Name	Mean	STD	Non-significant ranges
Tea Waste	2.04	0.03	a
Poultry Manure	1.40	0.08	b
Sheep Manure	1.23	0.04	c
Hazelnut Husk	1.16	0.05	d
Wheat Straw	1.08	0.03	d
Rice Husk	0.93	0.01	e
Control	0.84	0.05	f
Cow Manure	0.81	0.05	f
Vermicompost	0.68	0.01	g

3.4. ANOVA Effects of the Treatments on the DHA.

Source	df	Type I SS	MS	F	P	
Main Effects						
Treatments	8	19875.24427	2484.4055	16279.718	0.0000	***
Error	18	2.746933333	0.1526074<-			
Total	26	19877.99121				

R^2 = 0.99986181032

Root MS error = 0.39064998068

Mean Y = 65.8118518519

Coefficient of Variation = 0.5935861%

Compare Means

Significance Level: 0.05

Variance: 0.15260740741

LSD 0.05 = 0.67011928248

Treatment Name	Mean	STD	Non-significant ranges
Sheep Manure	135.42	0.61	a
Poultry Manure	78.75	0.16	b
Vermicompost	69.13	0.52	c
Wheat Straw	64.81	0.22	d
Cow Manure	52.61	0.43	e
Tea Waste	52.21	0.38	ef
Rice Husk	51.77	0.29	f
Hazelnut Husk	49.93	0.44	g
Control	37.69	0.24	h

3.5. ANOVA Effects of the Treatments on the CA.

Source	df	Type I SS	MS	F	P	
Main Effects						
Treatments	8	88007.38967	11000.924	320.5919	0.0000	***
Error	18	617.6594753	34.314415<-			
Total	26	88625.04915				

R^2 = 0.99303064448

Root MS error = 5.85785074036

Mean Y = 151.281962963

Coefficient of Variation = 3.8721409%

Compare Means

Significance Level: 0.05

Variance: 34.3144152963

LSD 0.05 = 10.0485317525

Treatment Name	Mean	STD	Non-significant ranges
Poultry Manure	251.18	2.52	a
Sheep Manure	225.41	5.39	b
Tea Waste	209.41	11.17	c
Vermicompost	131.12	3.35	d
Cow Manure	129.33	3.08	d
Wheat Straw	122.26	5.57	d
Hazelnut Husk	105.21	5.54	e
Rice Husk	97.11	8.13	ef
Control	90.51	0.43	f

Attachment Figures

Figure 1. Plant and Animal Wastes Before Processing.

Tea Waste

Rice Husk

Cow Manure

Poultry Manure

Hazelnut Husk

Wheat Straw

Vermicompost

Sheep Manure

(a) Plant Waste Before Grinding and Sieving.

(b) Animal Waste Before Crushing and Sieving.

Figure 2. Plant and Animal Wastes After Processing.

Tea Waste

Rice Husk

Cow Manure

Poultry Manure

Hazelnut Husk

Wheat Straw

Vermicompost

Sheep Manure

(a) Plant Waste After Grinding and Sieving.

(b) Animal Waste After Crushing and Sieving.

Figure 3. Soil is Kept for Air Drying Before the Experiment.

Figure 4. Preparing the Pots for Planting.

Preparing Empty Pots and Writing Labels

Weight of 3kg of Soil in Each Pot

Control

Cow Manure

Poultry Manure

Sheep Manure

Vermicompost

Rice Husk

Wheat Straw

Tea Waste

Hazelnut Husk

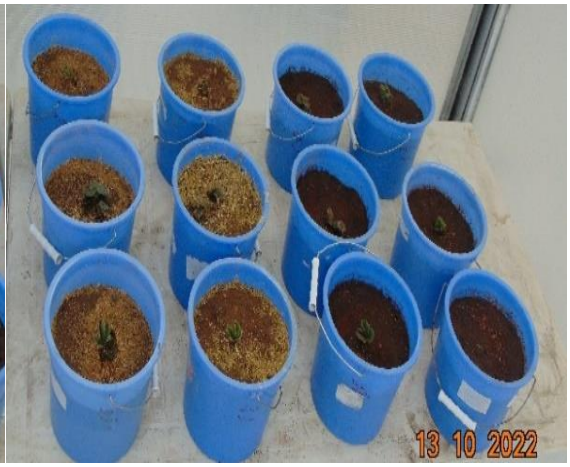

Figure 5. Track the Plants During Their Growth Period.

19.10.2022

25.10.2022

31.10.2022

7.11.2022

14.11.2022

30.11.2022

9.12.2022

12.12.2022

Figure 6. Soil Kept for Air Drying.

Figure 7. Lab Analysis in the Process.

CURRICULUM VITEA

Mohammed Gamal Abdelaziz Ali graduated in 2016 from the Faculty of Agriculture, Saba Basha, Alexandria University, and obtained a Bachelor of Agricultural Sciences with a major in Reclamation and Cultivation of Desert Land, with an overall excellent grade and honors. In 2018, was appointed to the same Faculty in the Department of Soil and Agricultural Chemistry as a Demonstrator (Teaching Assistant). In 2021, was awarded the ERASMUS+ Mundus Joint master's degree in Soil Science (emiSS) scholarship and studied at two universities, Ondokuz Mayıs University in Turkey-Samsun and Agricultural University Plovdiv in Bulgaria.

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Publications:

1. Gamal, M., Kızılkaya, R. (2022). Effects of rhizosphere microbiome on alleviate environmental stress on strawberry crop: A review International Soil Science Symposium on "Soıl Scıence and Plant Nutrıtıon" 2 – 3 December 2022, Samsun, Türkiye, Book of Proceedings, pp.107-117.

Won Awards, Incentives, and Scholarships:

1. MSc Chinese Scholarship Council (CSC) 2020.

2. ERASMUS+ Mundus Joint master's degree in Soil Science (emiSS) 2021.

3. Ph.D. Chinese Scholarship Council (CSC) 2023.