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

THE EFFECTS OF VERMICOMPOST ON THE YEILD AND YEILD COMPONANTS OF SOYBEAN AND LINEN

Master's Thesis

Maia Nabil Hafez AZAB

I. Supervisor
Prof. Dr. Ridvan KIZILKAYA
II. Supervisor
Prof. Dr. Agnieszka JÓZEFOWSKA

SAMSUN
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SAMSUN
2023

ACCEPTANCE AND APPROVAL OF THE THESIS

The study entitled **"THE EFFECTS OF VERMICOMPOST ON THE YEILD AND YEILD COMPONANTS OF SOYBEAN AND LINEN"** prepared by **Maia Nabil Hafez AZAB**, and supervised by **Prof. Dr. Ridvan KIZILKAYA** and **Prof. Dr. Agnieszka JÓZEFOWSKA** was found successful and unanimously accepted by committee members as Master thesis, following the examination on the date 15/08/2023 .

	Title Name SURNAME **University** **Department/Art**	**Final Decision**
Chairman	Prof. Dr. Ridvan KIZILKAYA Ondokuz Mayıs University Department of Soil Science and Plant Nutrition	☒ Accept ☐ Reject
Member	Prof. Dr. Violina ANGELOVA Agricultural University Plovdiv Department of General Chemistry	☒ Accept ☐ Reject
Member	Prof. Dr. Coskun GULSER Ondokuz Mayıs University Department of Soil Science and Plant Nutrition	☒ Accept ☐ Reject

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?

Yes ☐ (If it necessary, please add appendices.)

No ☒

13 /07 / 2023
Maia Nabil Hafez AZAB

DECLARATION OF THE THESIS STUDY ORIGINALITY REPORT

Thesis Title : THE EFFECTS OF VERMICOMPOST ON THE YEILD AND YEILD COMPONANTS OF SOYBEAN AND LINEN

As a result of the originality report taken by me from the plagiarism detection program on 14/07 /2023 for the thesis titled above;

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14 /07 / 2023
Prof. Dr. Rıdvan KIZILKAYA

ÖZET

VERMİKOMPOSTUN SOYA FASÜLYESİ VE KETENİN VERİMİ VE VERİM UNSURLARI ÜZERİNDEKİ ETKİLERİ

Maia Nabil Hafez AZAB
Ondokuz Mayıs Üniversitesi
Lisansüstü Eğitim Enstitüsü
Toprak Bilimi ve Bitki Besleme Bölümü
Yüksek Lisans, Haziran/2023
Danışman I: Prof. Dr. Rıdvan KIZILKAYA
Danışman II: Doç. Dr. Agnieszka JÓZEFOWSKA

Bu çalışmada, farklı dozlarda vermikompost uygulamalarının soya ve keten bitkilerinin verimine, toprakların kimyasal ve mikrobiyolojik özelliklerine olan etkisini araştırılmıştır. Deneme, tesadüf parselleri deneme desenine göre, 30 saksıda yürütülmüştür. Saksılar toprakla doldurulmuş ve farklı dozlarda solucan gübresi (0%, 0.5%, 1%, 2%, 4% w/w) ile muamele edilmiştir. Deneme, kontrollü koşullar altında 195 gün boyunca sürmüştür. Elde edilen sonuçlara göre, vermicompost uygulamasının her iki bitki türünde de bitki taze ağırlığı (PFW), bitki boyu (PH) ve dolu kapsül ağırlığı (FPW) üzerinde önemli bir etkisi olmadığını göstermiştir. Ancak, keten bitkisi için, vermikompost uygulamasıyla bitki kuru ağırlığı (PDW) önemli ölçüde artmışken, soya bitkisinde anlamlı bir fark gözlenmemiştir. Toprak özellikleri açısından, vermikompost uygulamasının toprak elektriksel iletkenliğini (EC) artırdığı, ancak toprak pH değeri üzerinde anlamlı bir etkisi olmadığı, toprak organik madde (SOM) ve azot (N) içeriğinin ise daha yüksek vermikompost dozlarında önemli ölçüde arttığı belirlenmiştir. Toprak mikrobiyal özellikleri açısından, vermikompostun soya bitkisinde dehidrojenaz enzim aktivitesi (DHA) ve toprak solunumu (BSR) üzerinde önemli bir olumlu etkisi olmuşken, keten bitkisinde anlamlı farklılıklar saptanmamıştır. Genel olarak, bu çalışma, vermikompostun, özellikle keten bitkisinde, toprak verimliliğini ve bitki büyümesini artırmak için organik bir toprak düzenleyici olarak kullanılabileceğini ortaya koymaktadır. Ancak, bu etkilerin temel mekanizmalarını tam anlamı ile ortaya koymak ve vermikompost uygulama stratejilerini optimize etmek için daha fazla araştırmaya da ihtiyaç vardır.

Anahtar Sözcükler: Solucan gübresi, soya, keten, bitki verimi, toprak kimyasal özellikleri, toprak mikrobiyal özellikleri.

ABSTRACT

THE EFFECTS OF VERMICOMPOST ON THE YEILD AND YEILD COMPONANTS OF SOYBEAN AND LINEN

Maia Nabil Hafez AZAB
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Institute of Graduate Studies
Department of Soil Science and Plant Nutrition
Master, June/2023
Supervisor I: Prof. Dr. Rıdvan KIZILKAYA
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This study aimed to assess the impact of different dose of vermicompost treatments on plant yield, soil chemical and microbiological properties in soybean and linen crops. A completely randomized design was employed, with 30 pots used for the experiment. The pots were filled with soil and treated with vermicompost at various dosage levels (0%, 0.5%, 1%, 2%, 4% w/w). The experiment lasted for 195 days under controlled environmental conditions. Results showed that the application of vermicompost did not significantly affect plant fresh weight (PFW), plant height (PH), and filled pod weight (FPW) in both crops. However, for linen, the plant dry weight (PDW) significantly increased with vermicompost treatment, while soybean showed no significant difference. Regarding soil properties, vermicompost application led to an increase in soil electrical conductivity (EC) but had no significant effect on soil pH. Soil organic matter (SOM) and nitrogen (N) content significantly increased with higher vermicompost dosage levels. In terms of soil microbial characteristics, vermicompost had a significant positive effect on dehydrogenase enzyme activity (DHA) and basal soil respiration (BSR) in soybean, while no significant differences were observed in linen. Overall, this study highlights the potential benefits of vermicompost as an organic soil amendment for improving soil fertility and plant growth, particularly in linen crops. Further research is needed to explore the underlying mechanisms of these effects and optimize vermicompost application strategies.

Keywords: Vermicompost, soybean, linen, plant yield, soil chemical properties, soil microbial characteristics.

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My appreciation extends to my family, especially my parents Mr. Nabil Azab and Mrs. Sally Abu Safieh, for their unconditional love, support, and understanding. Their unwavering belief in my abilities and sacrifices have been the driving force behind my success. I am forever grateful for their constant encouragement and for being the main reason of my strength. Also, I would like to extend my heartfelt thanks to MSc. Sinan Abu Al Hayja for his continuous help and support throughout this entire period. His guidance, patience, wisdom and understanding during challenging times have been invaluable, and I am truly grateful for his presence in my life.

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ALHAMDULILAH, I did it!

Maia Nabil Hafez AZAB

CONTENTS

SYMBOLS AND ABBREVIATIONS

BEUs	: Bushel Equivalent Units.
VC	: Vermicompost.
OM	: Organic Matter.
SOM	: Soil Organic Matter.
EC	: Electrical Conductivity.
W/v	: Weight/Volume.
W/w	: Weight/Weight.
BSR	: Basal Soil Respiration.
DHA	: Dehydrogenase Enzyme Activity.
CA	: Catalase Activity.
MBC	: Microbial Biomass Carbon.
PFW	: Plant Fresh Weight.
PDW	: Plant Dry Weight.
P.H	: Plant Height.
FPW	: Filled Pod Weight.
RFW	: Root Fresh Weight.

FIGURES LEGENDS

TABLES LEGENDS

1. INTRODUCTION

Intensive farming is a prevalent global issue, characterized by the pursuit of maximizing agricultural outputs while minimizing inputs such as labor and resources within a limited land area. This approach, also known as industrial agriculture, heavily relies on the excessive use of chemicals, fertilizers, and pesticides, posing significant threats to human health, including increased cancer risk and various allergies. Moreover, it negatively impacts soil microbes and organisms, leading to a decline in soil quality and reduced crop production. The sole reliance on chemical fertilizers diminishes microbial activity within the cropping system. Continuous usage of chemical fertilizers can alter soil pH, increase the prevalence of pests, result in acidification and soil crust formation, and ultimately lead to a decrease in organic matter and humus load, beneficial organisms, and hinder plant growth. Furthermore, it can even contribute to the emission of greenhouse gases, significantly impacting soil biodiversity and long-term soil health (Pahalyi et al., 2021). Intensive farming practices are predominantly adopted for commercial purposes or to meet the growing food demands of an expanding population.

Another pressing global issue is the generation of semi-solid and solid wastes, such as food waste, sludge waste, and disposable goods. Population growth, economic activities, and the escalating demand for natural resources are among the primary drivers of this problem. According to the latest available data, approximately 2.01 billion tonnes of municipal solid waste were generated in 2016, and this number is projected to increase to 3.40 billion tonnes by 2050 under a business-as-usual scenario (Kaza et al., 2018). Once waste is generated, it needs to be managed through recycling, reuse, treatment, or waste-to-energy technologies. Most municipal solid wastes are currently managed in land disposal units under careful conditions.

Improper waste management practices can lead to environmental contamination, posing threats to human health, aquatic life, and wildlife. An analysis of the physical composition of waste indicates that the compostable fraction ranges from 40% to 60%, while the recyclable fraction is observed between 10% and 25% (Ganeshwaran & Shri, 2015). Organic waste refers to waste originating from biological sources or previously being part of living organisms. Composting, a controlled biological breakdown process, plays a crucial role in the management of organic waste (Raza & Ahmad, 2016). Composting produces four primary products: compost, farmyard manure, green manure, and vermicompost. These products offer promising solutions to address both intensive farming and waste generation issues. The maintenance of soil organic matter is vital for the long-term productivity of agroecosystems (González et al., 2010). The application of alternative sources of organic amendments directly or indirectly improves soil health by influencing various soil properties (physical and chemical) and enzyme activities (biological) that regulate nutrient dynamics (Indoria et al., 2018).

Vermicomposting is a specialized method of composting that involves the use of specific earthworm species, namely Eisenia foetida and Lumbricus rubellis, to accelerate the composting process and reduce degradation time (Varshney, 2021). It is a process that converts biodegradable waste into organic matter.

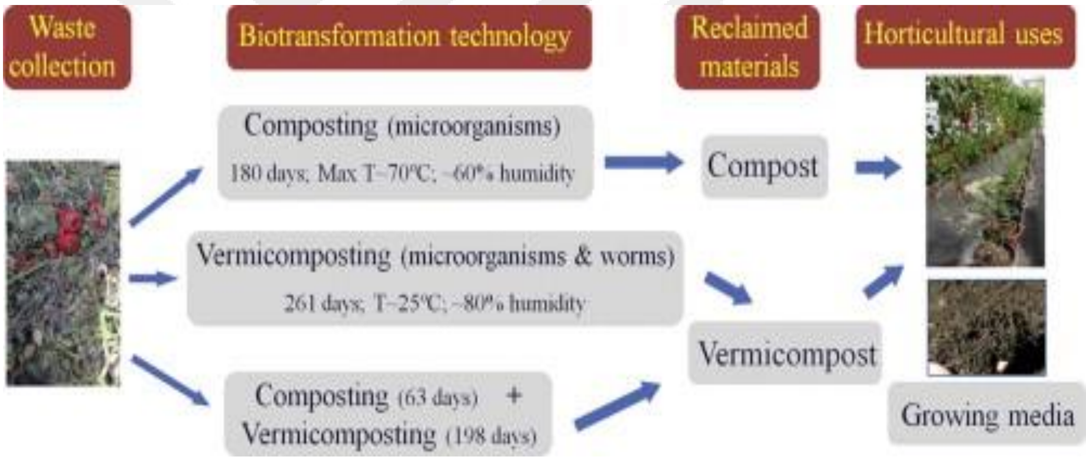

Figure 1.1. Differences between compost and vermicompost (Fornes et al. 2012).

Some distinctions between compost and vermicompost can be elucidated. While composting relies on microorganisms for organic matter transformation, vermicomposting involves the participation of both microorganisms and worms. Composting undergoes a thermophilic phase to ensure material sanitation, whereas vermicomposting occurs at ambient temperatures. Vermicomposting requires high humidity (around 80%), whereas composting requires less water. These factors likely influence the rate of organic matter transformation and the quality of the final products, compost and vermicompost (Fornes et al., 2012).

Based on the aforementioned issues, this research aims to:

- Assess the feasibility of utilizing vermicompost as a source of organic matter in soil.
- Analyze various parameters of microbial activity after adding different doses of vermicompost to two different plant types.
- Evaluate the variations in plant properties (specifically soybean and linen) in response to different doses of vermicompost added to the soil.
- Investigate the effects of vermicompost application on selected chemical properties and characteristics of the soil.

2. LITRETURE REVIEW

2.1. Vermicomposting Process

Vermicomposting is the process of using earthworms to convert organic waste into nutrient-rich compost. It is a sustainable and environmentally friendly method of composting.

Vermicomposting requires the use of the proper type of earthworm—a species whose niche in nature is to process large amounts of organic material. These are known as epigeic species. Redworms (E. fetida) are the most suitable, known variously as manure worms, red wigglers, tiger worms, and other common names (Edwards et al., 2010). Lumbricus rubellus can also be used. Choosing the suitable type of earthworms is the first step in producing vermicompost.

The second step is to prepare a suitable container. Vermicomposting can be done in various types of containers such as bins, boxes, or even barrels. The bed size may vary but it must be freely drained and covered. The cover is only removed when water or new feed is added (Savala 2003).

Following step is create bedding material; any material that provides the worms with a relatively stable habitat is called bedding. This habitat must have the following characteristics such as high absorbency, good bulking potential and low protein and/or nitrogen content (high Carbon: Nitrogen ratio). Worms need bedding in addition to food. Shredded paper or newspaper, coir (coconut husk fiber), and shredded cardboard are common bedding materials used for worm composting (Abd Manaf et al., 2009).

After this, adding the organic wastes as a food for earthworms (e.g. tea leaves, wheat husk, agricultural wastes, etc.), avoiding adding meat, dairy products , oily products or high acidic substances.

Temperature and moisture should be adjusted. The vermicomposting processes must be maintained at temperatures below 35°C. Exposure of worms to temperatures above this will kill them (Ndegwa & Thampson 2001). It is observed that the moisture content 75 ± 5% is the optimal at which the vermicomposting is fastest (Palsania et al., 2008)

Many studies has been done on vermicomposting, The period required for vermicomposting can vary depending on various factors such as the type and quantity of organic waste, environmental conditions, worm population, and management practices. Vermicomposting periods ranging from 28–120 days using these earthworms (Manyuchi & Phiri 2013).

2.2. Chemical Properties for Vermicompost

Vermicompositing appears to be the most promising as high value bio-fertilizer which not only increases the plant growth and productivity by nutrient supply but also is cost effective and pollution free. It was found that the vermicompost was rich in nutrients like Potassium, Nitrate, Sodium, Calcium, Magnesium, and Chloride and have the potential for improving plant growth than pit compost and garden soil (control) (Khan &Ishaq 2011). which plays an important role in enhancing plant growth in specific amounts, as it serves a rich source of plant nutrients (Azab et al., 2022). Table 1 shows the chemical composition of vermi-compost (Garg, Gupta, 2009).

Table 2.1. The chemical composition of vermi-compost (Garg, Gupta, 2009).

Characteristics	Value
Organic carbon %	9.15 to 17.88
Total Nitrogen %	0.5 to 0.9
Phosphorus %	0.1 to 0.26
Potassium %	0.15 to 0.256
Sodium %	0.055 to 0.3
Calcium & magnesium (Meq/100g)	22.67 to 47.6
Copper; mg kg^{-1}	2.0 to 9.5
Iron, mg kg^{-1}	20. to 9.3
Zinc, mg kg^{-1}	5.7 to 9.3
Sulphur, mg kg^{-1}	128.0 to 548.0

2.3. Vermicompost as Soil Amendment

The advantages of Vermicompost as a soil amendment include its potential to maintain soil organic matter, foster nutrient availability, suppress plant diseases, and increase soil microbial abundance and activity. Some recent findings contribute to better descriptions of whether and to what extent Vermicompost amendments affect soil microbial biomass, activity and community structure (Gómez-Brandón & Domínguez 2014). The results in (Azarmi et al, 2008) study on tomato (*Lycopersicum esculentum*) showed that addition of vermicompost, increased contents of soil total organic carbon, total N, P, K, Ca, Zn and Mn substantially compared with control plots. In addition, the physical properties such as bulk density and total porosity in soil amended with vermicompost were improved.

2.4. Vermicompost as biological soil amendment.

Vermicomposting is a biological process. Microorganisms play a key role in the evolution of organic material and in its transformation from waste to safe organic amendments or fertilizers (Vermicompost) (Gómez-Brandón & Domínguez 2014). (Arancon et al., 2006) found that there is an increases in dehydrogenase activity and microbial biomass in soil as an result to vermicompost application on strawberry plant regardless the dosage, which influence the nutrient cycling, production of plant growth-regulating materials, and the build-up of plant resistance or tolerance to crop pathogen and nematode attacks. (Tejada & Benítez 2011) found that the soil microbial biomass and dehydrogenase, urease, β-glucosidase, phosphatase and arylsulfatase activities increased more significantly in the vermicompost-amended soils with different doses respect to the control soil while maize (Zea mays cv. Tundra) planting.

2.5. Influence of vermicompost on plant yield.

Most investigations have confirmed that Vermicompost could increase yield production in some situations (Azab et al., 2022). (Jat & Ahlawat 2006) found that the Application of vermicompost at 3t/ha had a positive effect on dry matter production, grain yield and protein content of chickpea, dry fodder yield of succeeding maize as shown in Table 2 an enhancement of grain yield occurred by 28.3 and 28.0% in two years (Y1, Y2).

Table 2.1. Effect of vermicompost on dry matter (DM) accumulation, grain yield and protein content of chickpea, dry fodder yield of maize.

Treatment	DM of chickpea (g/plant)		Grain yield of chickpea (t/ha)		Protein content in chickpea seed (%)		Dry fodder yield of maize (t/ha)	
	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2
Vermicompost								
No vermicompost	17.44	19.62	1.91	2.05	19.2	19.5	6.66	7.05
Vermicompost 3t/ha	18.60	20.95	2.26	2.44	19.8	20.1	7.43	7.58

On the other hand, some research indicates that vermicompost has a negative effect on lentil pods number per plant in high concentrations (CERİTOĞLU and Erman, 2020). Other experiments have a linear relationship between applied vermicompost levels, plant growth and seed yield. Higher doses of vermicompost did not vary significantly from lowest dose (Joshi et al, 2015).

2.6. Soybean (Glycine max (L.)):

Soybean, (*Glycine max*), also called soja bean or soya bean, annual legume of the pea family (Fabaceae) and its edible seed. The soybean is economically the most important bean in the world, providing vegetable protein for millions of people and ingredients for hundreds of chemical products. The soybean may be cultivated in most types of soil, but it thrives in warm, fertile, well-drained, sandy loam. The crop is planted after all danger of frost is past. Like other legumes, the plant adds nitrogen to the soil by means of nitrogen-fixing bacteria and historically has been an important soil-enriching crop, though this practice is not common in most industrial agriculture systems. (https://www.britannica.com/plant/soybean).

Soybean, (Glycine max) is the most commercial species among the grain legume and oil seed crops according to (FAO 1982) that is shown in table (3).

Table 2.2**.** World production, area and average yield of the major grain legumes and oil seed crops in 1981 (FAO 1982b).

Grain legume	Production 10^6 mt	Area 10^6 ha	Average yield kg ha^{-1}
Soybeans (Glycine max)	87,941	50,219	1,751
Ground nuts (Arachis hypogaea)	19,368	19,329	1,002
Dry beans (phaseolus vulgaris)	14,053	24,805	567
Dry Peas (Pisum sativum)	8,215	7,890	1,041
Chick peas (Cicer arietinum)	6,292	10,104	632
Broad beans (Vicia faba	4,178	3,619	1,154
Lentils (Lens culinaris)	1,128	1,953	577

Figure 2, which displays the Global Vegetable Oil Consumption by Type according to USDA/FAS (Foreign Agricultural Service) shows that soybean oil, is the second consumed oil in the world since market year 1990 until 2018 in bushel equivalent units (BEUs).

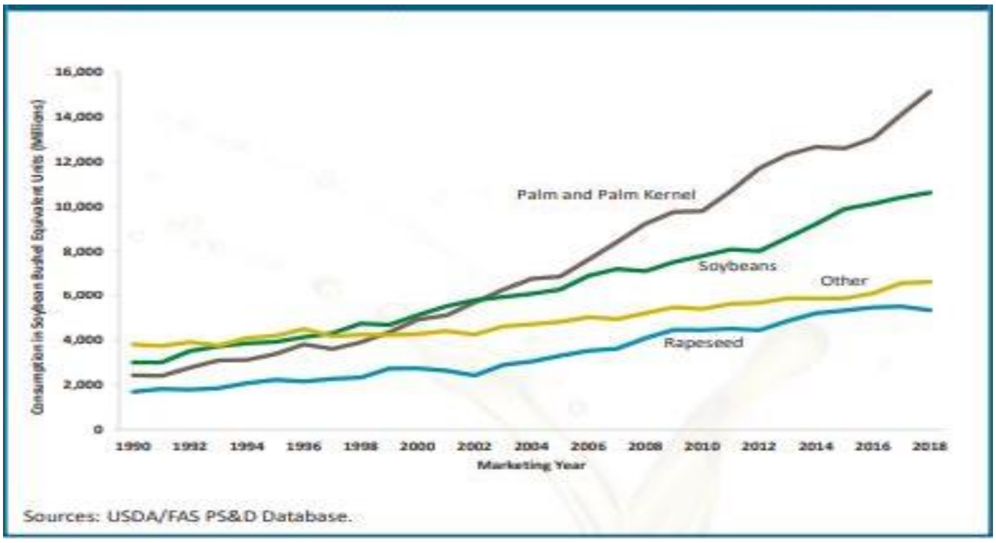

Figure 2.1. Global Vegetable Oil Consumption by Type (USDA Foreign Agricultural Service 2018).

2.7. Linen (Linum usitatissimum).

Plant of the family Linaceae, cultivated both for its fibre, from which linen yarn and fabric are made, and for its nutritious seeds, called flaxseed or linseed, from which linseed oil is obtained. Flax remains economically significant in a number of countries around the world, including China, Russia, and Canada. The plant is adaptable to a variety of soils and climates but grows best in well-drained sandy loam and in temperate climates. In most areas, planting of the same land with flax is limited to once in six years to avoid soil exhaustion. Cool moist growing seasons produce the most-desirable fibre.

Flaxseed is a rich source of the omega-3 fatty acid alpha-linolenic acid (ALA) and is high in a class of phytoestrogens known as lignans. It is also high in dietary fibre, protein, iron, calcium, manganese, thiamin, magnesium, phosphorus, and copper. The seeds can be eaten raw or toasted; added ground or whole seed. Linseed oil, derived from the seeds, is used in the production of paints, printing inks, linoleum, varnish, and oilcloth. (https://www.britannica.com/plant/flax).

3. MATERIAL AND METHODS

3.1. Soil

The experimental soil was collected from an agricultural field at Ondokuz Mayis University in Samsun, Turkey (41°21'49.9"N 36°11'19.7"E). The climate at the site is characterized by a mean annual maximum and minimum temperature range of 5°C to 27.7°C, a relative humidity of 73%, and an average annual precipitation of 937.26 mm.

The physical and chemical properties of the soil were determined using the following standard methods: particle size distribution was determined using the hydrometer method (Bouyoucos, 1962), CaCO3 content was measured using the volumetric method (Martin & Reeve, 1955), pH was determined in a 1:1 (w/v) soil-water suspension using a pH-meter (Rowell, 2014), electrical conductivity (EC) was measured in the same soil-water suspension using an EC-meter (Rowell, 2014). Total soil organic matter (SOM) was determined by the wet oxidation method (Walkley-Black) with K2Cr2O7 (Rowell, 2014). Total nitrogen (N) content was determined by digestion and subsequent measurement using the Kjeldahl method (Bremner, 1965).

3.2. Soybean (*Glycine max* (L.) samsoy)

In this study, the Samsoy variety of Soybean (Glycine max (L.) Merr.) was used as the indicator plant. Samsoy is a variety developed by the Black Sea Agricultural Research Institute in Samsun, Turkey, and registered in 2019. It exhibits determinate plant growth, a semi-upright growth habit, medium early maturity (143 days), and white flowers. Under favorable conditions, it can reach a height of 90-115 cm, with the first pod appearing at a height of 15 cm. Samsoy seeds are round, flat, and light brown, and the variety is known for its resistance to grain cracking and lodging.

3.3. Linen (Linum usitatissimum rolin).

The Rolin variety of Romanian flax fiber (Linum usitatissimum rolin) was used as the indicator plant in this experiment. It is a spring cultivar characterized by a plant height exceeding 80 cm, blue flowers, and moderate lodging resistance. However, it is susceptible (60-79%) to wilt disease.

3.4. Vermicompost.

Vermicompost used in the experiment was collected from Ondokuz Mayıs University Agricultural Faculty Farms in Samsun, located in the Black Sea region of Turkey. The chemical properties of the vermicompost were determined using the following standard methods: pH was measured in a 1:1 (w/v) vermicompost-water suspension using a pH-meter (Rowell, 2014), electrical conductivity (EC) was measured in the same vermicompost suspension using an 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).

3.5. Experimental Design

A completely randomized design was used for this experiment, where similar experimental units were grouped into plots. Approximately 200 kg of soil was collected, placed in the shade, and allowed to dry naturally for 15 days. Subsequently, it was crushed with a wooden hammer and manually sieved through a 4.7 mm sieve to achieve homogenized soil conditions for each treatment.

The experiment consisted of 30 pots, including 6 pots used as controls. Each pot was filled with 3 kg of soil to prepare the planting beds. Vermicompost was sieved using a 2 mm sieve. Vermicompost application was carried out at different doses (%w/w) (0%, 0.5%, 1%, 2%, 4%) relative to the pot weight, corresponding to (0, 15, 30, 60, 120) grams for each pot of each plant type. The seeds were sown, and the pots were watered with rainwater. Soil moisture content was maintained close to field capacity by weighing the pots daily to determine moisture depletion and replenishing the moisture to field capacity. The experiment spanned a period of 195 days and employed a completely randomized design.

The experiment was conducted under controlled environmental conditions, with temperature being maintained at a constant level.

3.6. Data Collection

3.6.1. Growth Stage

Throughout the plant growth phase, data were collected from each plant. This included measuring the initial weight of the pots (in grams) at the beginning of the experiment and calculating the soil's field capacity during the initial stages to determine the final weight of the pots. This final weight was used as a reference for irrigating the plants, ensuring they were neither over- nor under-irrigated. The amount of water lost from the pots due to plant evaporation was measured by comparing the weight of the pots before and after irrigation during the experimental period. The plants were monitored throughout their growth period.

3.6.2. Maturation Stage

After 6 months and 13 days, the plants were harvested by cutting the shoots at soil level, and the roots were extracted from the soil. To obtain a representative sample, the roots were gently watered using a sieve to collect any broken fragments. Prior to harvesting, various agronomic factors of the plants were recorded, including plant height, filled pod weight, plant fresh and dry weights, and root fresh weight.

3.7. Lab- Analysis

After harvesting the plants, soil samples were collected in two batches from each pot. The first batch of soil samples was collected and immediately sealed in plastic bags, then stored in a refrigerator at (+4°C). These soil samples were used for soil biological analysis. The second batch of soil samples was collected and air-dried for 10 days, and then used for chemical soil analysis.

3.7.1. Soil Chemical Analyses

3.7.1.1. pH and EC

pH and EC were measured in 1:1 (w/v) soil: water suspension with pH and EC meter (Rowell, 2014).

3.7.1.2. Soil Organic Matter (SOM)

Soil organic matter (SOM) was determined using the 'Walkley-Black' chromic acid wet oxidation method with K2Cr2O7 (Rowell, 2014), and the organic matter content was calculated using the conversion factor of 1.724 as described by Nelson and Sommers (1983).

3.7.1.3. Total Nitrogen

Total nitrogen (N) content was determined by digestion and subsequent measurement using the Kjeldahl method (Bremner, 1965).

3.7.2. Biological Soil Analysis

3.7.2.1. Microbial Biomass Carbon (MBC)

Substrate Induced Respiration (SIR) method, according to (Anderson & Domsch, 1978). A moist soil sample is equivalent to 5 g oven-dry soil was amended with a solution containing 0.5% glucose. The CO_2 production rate was measured hourly using the method described by (Anderson, 1982). Microbial biomass carbon was calculated from the maximum initial respiratory response of mg C g^{-1} soil as 40.04 mg CO_2 g^{-1} + 0.37. Three replicates of each soil sample were tested. Data were expressed as mg CO_2-C g^{-1} oven-dry soil 24 h^{-1}.

3.7.2.2. Basal Soil Respiration (BSR)

Basal soil respiration was measured, as reported by (Anderson, 1982) by alkali (Ba $(OH)_2.8H_2O$ + $BaCI_2$) absorption of the CO_2 produced during the 24h incubation period, followed by titration of the residual OH- with standardized hydrochloric acid, after adding three drops of phenolphthalein as an indicator. Three replicates of each sample were tested. Data were expressed as mg CO_2-C g^{-1} oven-dry soil 24 h^{-1}.

3.7.2.3. Dehydrogenase Enzyme Activity (DHA)

Dehydrogenase activity (DHA) was determined according to (Pepper et al., 1995). 1 g soil, 2.5 ml glucose, 1 ml of 3% 2,3,5-triphenyltetrazoliumchlorid (TTC) solution and 2.5 ml distilled water was added. The samples were incubated for 24 h at 25°C. The formation of 1,3,5 triphenylformazan (TPF) was determined spectrophotometrically at 485 nm, and the results were expressed as µg TPF g^{-1} oven-dry soil 24 h^{-1}.

3.7.2.4. Catalase Activity (CA)

Catalase activity (CA) was measured by (Beck, 1971) method. 10 ml of phosphate buffer (pH 7) and 5 ml of a 3% H_2O_2 substrate solution were added to 5 g of soil. The volume (ml) of O_2 released within 3 minutes at 20°C was determined. Three replicates of each sample were tested, and controls were tested in the same way but with the addition of 2 ml of 6.5% (w/v) NaN_3. Results were expressed as ml O_2 g^{-1} oven-dry soil 3 min^{-1}.

3.8. Statistical Analyses

The outcomes of this experiment were statistically evaluated using JMP Pro 14.0.0 software. The means of the results were compared using the Duncan test at the 0.01 and 0.05 significance levels, and the F-values of significant applications were indicated with ** at the 0.01 level and * at the 0.05 level. Each plant was analyzed separately in the statistical analysis.

4. RESULTS AND DISCUSSION

4.1. Soil Analysis

The analysis of the soil revealed several important properties, as shown in Table 4.1. The pH value indicated slightly acidic 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.

Table 3.1. Physical and chemical analysis for pre-treated soil.

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%
Organic matter	2.176%
Organic C	1.26%
Lime ($CaCO_3$) Content	1.79%
Nitrogen,	0.127%
C/ N ratio	9.92

4.2. Assessing The Impact of Different Dose of Vermicompost Treatments on Plant Yield and Properties in Soybean and Linen

4.2.1. Plant Fresh Weight

According to the statistical analysis, there was no significant difference in plant fresh weight (PFW) among the treated soil conditions for both Soybean and Linen ($p>0.05$). The results are presented in Figure 4.1. It can be observed that the PFW is similar across different treatments for each plant. However, the highest value was observed for a 2% vermicompost dosage in Linen, while the highest value was observed for a 4% vermicompost dosage in Soybean. Although there were no statistical differences, it is worth noting that the 2% and 4% vermicompost dosages resulted in higher biomass compared to other treatments and the control group. In a similar study conducted by Van Cuong and Van Chuong (2022), it was found that the addition of vermicompost to the treatment increased the fresh biomass of Soybean (Glycine max (L.) Merr.). However, it should be noted that in their study, the application of the highest proportions of vermicompost did not lead to an improvement in PFW. This finding is consistent with a study by Makkar et al. (2017), who observed detrimental effects on Linen plants with higher doses of vermicompost.

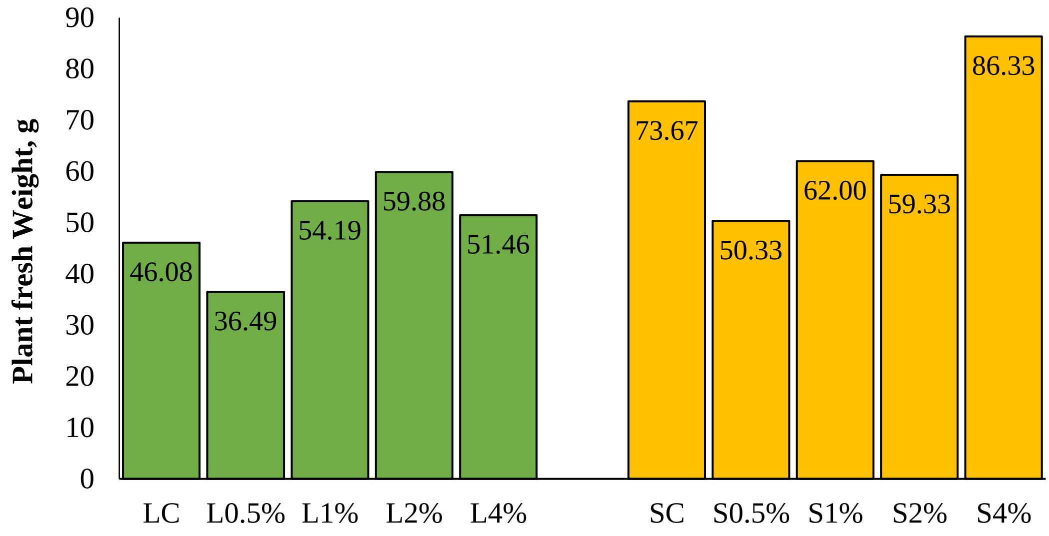

Figure 4.1. The influence of different vermicompost application doses on the plant fresh weight (PFW) of linen and soybean plants. The abbreviations used in the figure are as follows:

LC	: Linen control (without vermicompost)	SC	: Soybean control (without vermicompost)
L0.5%	: Linen with 0.5% vermicompost dose	S0.5%	: Soybean with 0.5% vermicompost dose
L1%	: Linen with 1% vermicompost dose	S1%	: Soybean with 1% vermicompost dose
L2%	: Linen with 2% vermicompost dose	S2%	: Soybean with 2% vermicompost dose
L4%	: Linen with 4% vermicompost dose	S4%	: Soybean with 4% vermicompost dose

4.2.2. Plant dry weight

According to the statistical analysis, there was no significant difference in plant dry weight (PDW) among the treated soil conditions for Soybean ($p>0.05$). However, for Linen, the dry weight of the treated plants with vermicompost at different dosage levels showed a significant increase ($p<0.01$). The results are illustrated in Figure 4.2. The highest PDW was observed in both Soybean and Linen for the vermicompost treatment with a dosage level of 4%, with PDW values of 23.95g and 33.17g, respectively. On the other hand, the smallest PDW values for Soybean and Linen were recorded for the 0.5% vermicompost treatment, with PDW values of 15.52g and 14.49g, respectively. In a study conducted by Mathenge et al. (2019) on

Soybean (Glycine max L. Merr), it was found that shoot dry biomass was greater in the treatment amended with vermicompost compared to other treatments and the control group. Similarly, Makkar et al. (2017) observed an increase in Linen shoot dry weight with the application of vermicompost in addition to vermiwash.

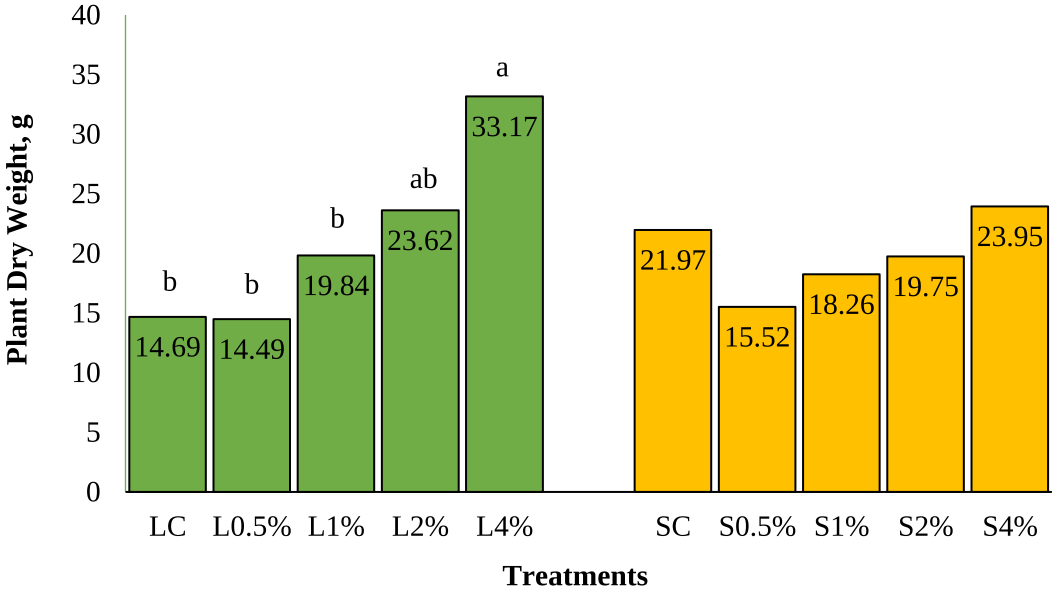

Figure 4.2. The influence of different vermicompost application doses on the fresh dry weight (PDW) of linen and soybean plants. The abbreviations used in the figure are as follows:

LC	: Linen control (without vermicompost)	SC	: Soybean control (without vermicompost)
L0.5%	: Linen with 0.5% vermicompost dose	S0.5%	: Soybean with 0.5% vermicompost dose
L1%	: Linen with 1% vermicompost dose	S1%	: Soybean with 1% vermicompost dose
L2%	: Linen with 2% vermicompost dose	S2%	: Soybean with 2% vermicompost dose
L4%	: Linen with 4% vermicompost dose	S4%	: Soybean with 4% vermicompost dose

F-value for Linen : 6.4668**

4.2.3. Plant Height

According to the statistical analysis, there was no significant difference in plant height (PH) among the treated soil conditions for both Soybean and Linen ($p>0.05$). The results are presented in Figure 4.3. PH was generally similar for both Soybean and Linen, regardless of the treatment. However, the highest PH value was observed for the 1% vermicompost dosage in Linen, with a height of 105.3cm. In contrast, the highest PH value was recorded for the control group in Soybean, with a height of 63.9cm. On the other hand, the lowest PH values were observed for the 4% vermicompost dosage in Linen (95.7cm) and the 0.5% vermicompost dosage in Soybean (49.1cm). In a study conducted by Kumar et al. (2019) on Linen, it was noticed that lower doses of vermicompost increased the growth attributes compared to higher doses. Additionally, Aritonang (2020) confirmed that the interaction dose of vermicompost had no significant effect on soybean PH.

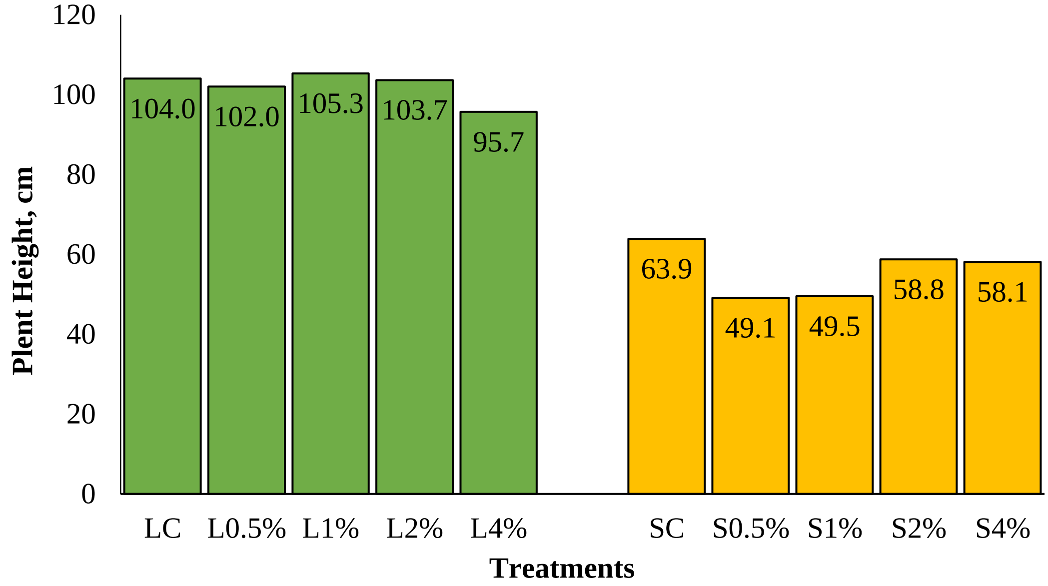

Figure 4.3. The influence of different vermicompost application doses on the plant height (PH) of linen and soybean plants. The abbreviations used in the figure are as follows:

LC	: Linen control (without vermicompost)	SC	: Soybean control (without vermicompost)
L0.5%	: Linen with 0.5% vermicompost dose	S0.5%	: Soybean with 0.5% vermicompost dose
L1%	: Linen with 1% vermicompost dose	S1%	: Soybean with 1% vermicompost dose
L2%	: Linen with 2% vermicompost dose	S2%	: Soybean with 2% vermicompost dose
L4%	: Linen with 4% vermicompost dose	S4%	: Soybean with 4% vermicompost dose

4.2.4. Filled Pod Weight

Based on the statistical analysis, there was no significant difference in the filled pod weight (FPW) among the treated soil conditions for both Soybean and Linen ($p>0.05$). The results are presented in Figure 4.4. In Linen, the FPW were similar across different treatments. The highest FPW was recorded for the 4% vermicompost dosage, with 5.4g per pot. On the other hand, the lowest weight was observed for the 0.5% vermicompost dosage, with 3.4g per pot. In contrast, the application of vermicompost had a negative effect on FPW in Soybean. The control treatment in Soybean recorded the highest FPW per pot, with 19.9g. The lowest soybean FPW was observed for the 4% vermicompost dosage, with 11.2g per pot. This suggests that higher vermicompost dosages decrease the FPW in Soybean. In a study conducted by Makkar et al. (2017) on Linen, it was found that improved plant growth parameters and higher yield were obtained with vermicompost alone. However, Aritonang (2020) confirmed that there was no significant effect of vermicompost treatment on the number of pods and number of filled pods in Soybean.

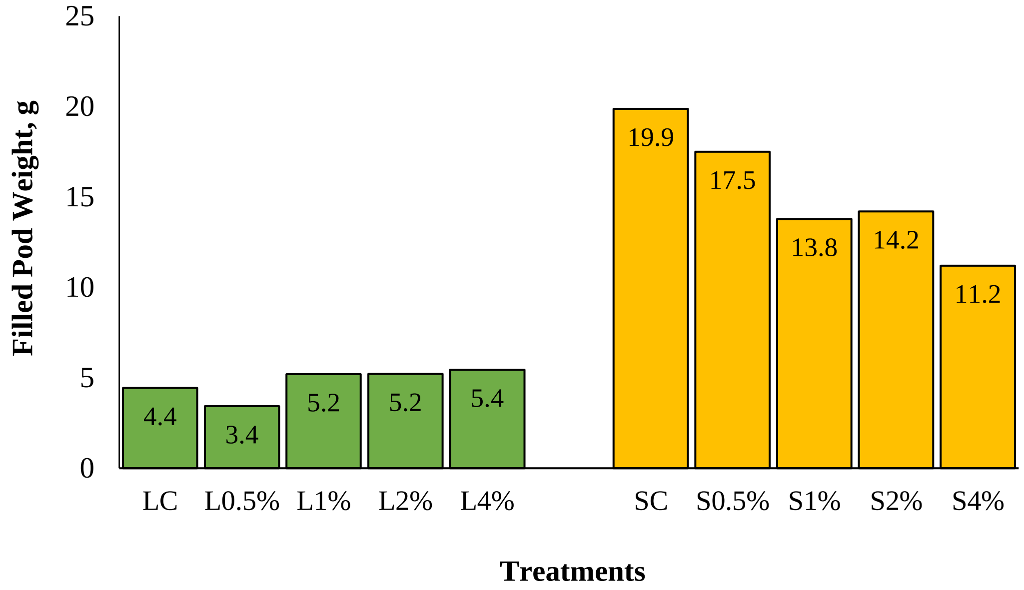

Figure 4.4. The influence of different vermicompost application doses on the filled pod weight (FPW) of linen and soybean plants. The abbreviations used in the figure are as follows:

LC	: Linen control (without vermicompost)	SC	: Soybean control (without vermicompost)
L0.5%	: Linen with 0.5% vermicompost dose	S0.5%	: Soybean with 0.5% vermicompost dose
L1%	: Linen with 1% vermicompost dose	S1%	: Soybean with 1% vermicompost dose
L2%	: Linen with 2% vermicompost dose	S2%	: Soybean with 2% vermicompost dose
L4%	: Linen with 4% vermicompost dose	S4%	: Soybean with 4% vermicompost dose

4.2.5. Root Fresh Weight

According to the results of the statistical analysis, the application of vermicompost at different dose levels has a significant effect on the Root Fresh Weight (RFW) of Linen ($p<0.05$). In Soybean, the RFW shows a statistically significant increase with the increase in Vermicompost dose level ($p<0.01$). These effects can be observed in Figure 4.5. In Linen, the highest Root biomass is recorded at the 2% vermicompost dose level and the control treatment, respectively. However, as the vermicompost dosage increases, the Root biomass decreases, reaching the lowest weight at the 4% vermicompost dose level. Generally, the Root biomass of Linen exhibits an increasing trend at low and medium vermicompost dosages. In contrast, in Soybean, the Root biomass shows a significant increase with the increase in vermicompost dosage. The highest weight is recorded at the 4% vermicompost dose level, while the lowest weight is observed at the 0.5% vermicompost dose level. These findings suggest that the dose level of vermicompost has a significant impact on the RFW in both Linen and Soybean. In Linen, lower and medium vermicompost dosages tend to increase the RFW, while in Soybean, the RFW shows a significant increase with higher vermicompost dosages. It is worth noting that a study conducted by Chan and Griffiths (1988) found that vermicompost had a stimulating effect on the growth of Glycine max (soybean), resulting in increased root length and lateral root number. Their findings align with the observed increase in Root biomass with the increase in vermicompost dosage in Soybean.

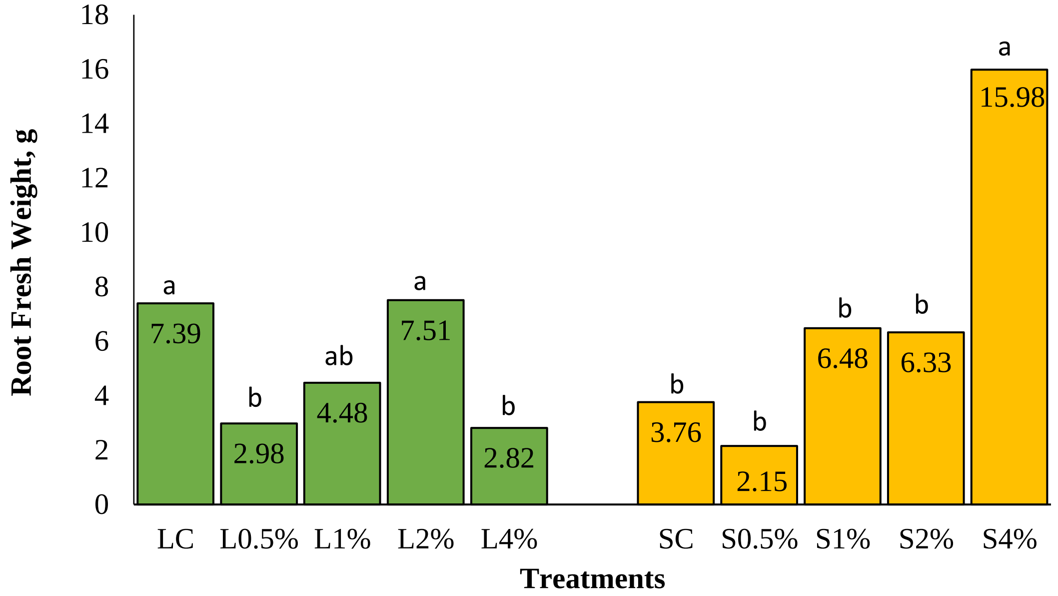

Figure 4.5. The influence of different vermicompost application doses on the root fresh weight (RFW) of linen and soybean plants. The abbreviations used in the figure are as follows:

LC	: Linen control (without vermicompost)	SC	: Soybean control (without vermicompost)
L0.5%	: Linen with 0.5% vermicompost dose	S0.5%	: Soybean with 0.5% vermicompost dose
L1%	: Linen with 1% vermicompost dose	S1%	: Soybean with 1% vermicompost dose
L2%	: Linen with 2% vermicompost dose	S2%	: Soybean with 2% vermicompost dose
L4%	: Linen with 4% vermicompost dose	S4%	: Soybean with 4% vermicompost dose
F-value for Linen : 4.837*		*F*-value for Soybean : 7.6368**	

4.3. Assessing the Impact of Different Dose of Vermicompost Treatments on Chemical properties in Soybean and Linen Soil

4.3.1. Soil pH and Electrical conductivity (EC)

According to the statistical analysis, there is no significant difference in Soil pH of treated soil ($p>0.05$) in both Soybean and Linen. This indicates that Vermicompost application at different dose levels does not have a significant effect on Soil pH. The effects of treatment application on Soil pH and Soil EC are presented in Table 4.2. However, Vermicompost application leads to an increase in Soil EC (Electrical Conductivity) in both Linen and Soybean. The increase in Soil EC is statistically significant at $p<0.01$ in Linen and $p<0.05$ in Soybean. It is important to note that previous studies have reported conflicting findings regarding the effect of Vermicompost on Soil pH. Some studies, such as those conducted by Gutiérrez-Miceli et al. (2007) and Azarmi et al. (2008), have found that the addition of vermicompost decreases soil pH. On the other hand, Romaniuk et al. (2011) reported slight but significant increases in soil pH due to Vermicompost addition. Regarding Soil EC, the findings align with the observations of Romaniuk et al. (2011), who reported a slight increase in soil EC with Vermicompost addition. Additionally, Argüello et al. (2006) confirmed that the application of Vermicompost to the soil increased electrical conductivity without causing salinity effects. In summary, Vermicompost application at different dose levels does not significantly affect Soil pH in both Soybean and Linen. However, it leads to a significant increase in Soil EC in both crops. The observed increase in Soil EC aligns with previous studies, while the lack of significant effect on Soil pH may be attributed to variations in experimental conditions and soil properties.

Table 4.2. The influence of different vermicompost application doses on pH and EC in Soybean and Linen soil.

Treatment	pH	EC, µS m^{-1}	Treatment	pH	EC, µS m^{-1}
LC	7.50	603.0 d	SC	7.50	522.1c
L0.5%	7.40	801.3 c	S0.5%	7.50	715.7 c
L1%	7.40	905.4 c	S1%	7.30	818.8 bc
L2%	7.40	1279.0 b	S2%	7.30	1110.0 ab
L4%	7.40	1607.0 a	S4%	7.40	1194.8 a
F-Value	1.821	143.7917**	F-Value	1.6001	5.7934*

The abbreviations used in the figure are as follows:

LC	: Linen control (without vermicompost)	SC	: Soybean control (without vermicompost)
L0.5%	: Linen with 0.5% vermicompost dose	S0.5%	: Soybean with 0.5% vermicompost dose
L1%	: Linen with 1% vermicompost dose	S1%	: Soybean with 1% vermicompost dose
L2%	: Linen with 2% vermicompost dose	S2%	: Soybean with 2% vermicompost dose
L4%	: Linen with 4% vermicompost dose	S4%	: Soybean with 4% vermicompost dose

4.3.2. Soil organic matter

According to the statistical analysis, Vermicompost application at different dose levels has a significant effect on Soil Organic Matter (SOM) in both Soybean and Linen ($p<0.01$). The effects of treatment application on SOM are depicted in Figure 4.6. Vermicompost, as an organic soil amendment, exhibits a positive effect on the percentage of SOM. As the dosage level of Vermicompost increases, the SOM content also increases. The highest SOM values are observed in the 4% vermicompost dose level for both Soybean and Linen. Conversely, the lowest values are found in the control groups of both crops. This observation is in line with the findings of Durak et al. (2017) who confirmed the positive effect of vermicompost on SOM. The addition of vermicompost, which is rich in organic materials, enhances the organic matter content in the soil. The increase in SOM is beneficial for soil fertility, nutrient retention, and overall soil health. In summary, Vermicompost application at different dose levels significantly increases SOM in both Soybean and Linen. The highest values are observed in the 4% vermicompost dose level, while the lowest values are found in the control groups. These findings are consistent with previous studies, such as the research conducted by Durak et al. (2017).

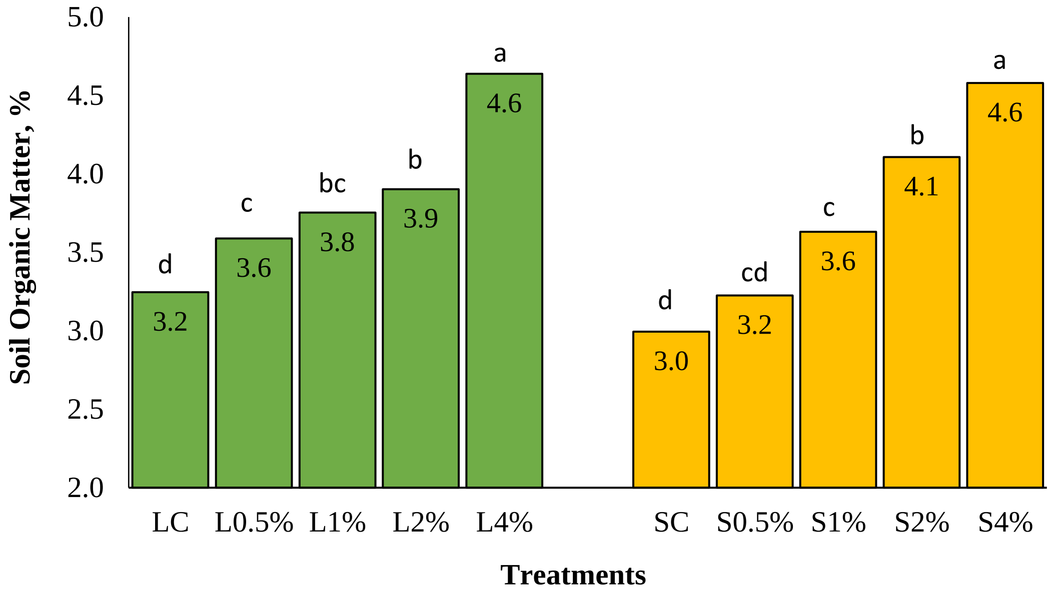

Figure 4.6. The influence of different vermicompost application doses on Soil Organic Matter in Soybean and Linen soil. The abbreviations used in the figure are as follows:

LC	: Linen control (without vermicompost)	SC	: Soybean control (without vermicompost)
L0.5%	: Linen with 0.5% vermicompost dose	S0.5%	: Soybean with 0.5% vermicompost dose
L1%	: Linen with 1% vermicompost dose	S1%	: Soybean with 1% vermicompost dose
L2%	: Linen with 2% vermicompost dose	S2%	: Soybean with 2% vermicompost dose
L4%	: Linen with 4% vermicompost dose	S4%	: Soybean with 4% vermicompost dose

F-value for Linen : 33.1808** *F*-value for Soybean : 25.0029**

4.3.3. Nitrogen content

According to the statistical analysis, vermicompost application at different dose levels significantly increases the Nitrogen (N) content of the soil in Linen ($p<0.01$) and increases it in Soybean ($p<0.05$). The effects of treatment application on N content are depicted in Figure 4.7. Overall, there is an increase in N content in both Soybean and Linen with the application of different vermicompost dosage levels. The highest N content is observed in the 4% VC dose level for both crops, while the lowest values are found in the control and 0.5% dosage levels, which are nearly the same. This observation is consistent with the findings of Berova et al. (2013) who confirmed the increase in N content with vermicompost application. Vermicompost is rich in organic matter and nutrients, including N. When added to the soil, it releases N slowly, providing a sustainable source of this essential nutrient for plant growth. The increase in N content due to vermicompost application is beneficial for plant nutrition and growth. N is a crucial element for various physiological processes in plants and is a major component of proteins and chlorophyll. Therefore, the enhanced N content in the soil can contribute to improved plant growth, development, and overall yield. In summary, Vermicompost application at different dose levels significantly increases the N content of the soil in both Soybean and Linen. The highest values are observed in the 4% vermicompost dose level, while the lowest values are found in the control and 0.5% dosage levels. These findings align with the research conducted by Berova et al. (2013), confirming the positive effect of vermicompost on N content.

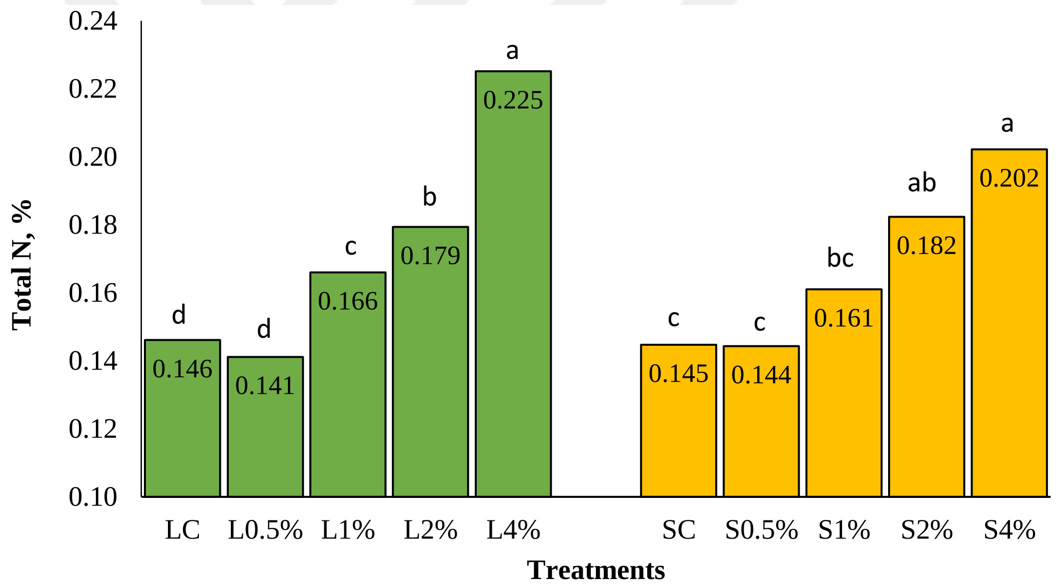

Figure 4.7. The influence of different vermicompost application doses on Nitrogen content in Soybean and Linen soil. The abbreviations used in the figure are as follows:

LC : Linen control (without vermicompost)
L0.5% : Linen with 0.5% vermicompost dose
L1% : Linen with 1% vermicompost dose
L2% : Linen with 2% vermicompost dose
L4% : Linen with 4% vermicompost dose
F-value for Linen : 92.7713**

SC : Soybean control (without vermicompost)
S0.5% : Soybean with 0.5% vermicompost dose
S1% : Soybean with 1% vermicompost dose
S2% : Soybean with 2% vermicompost dose
S4% : Soybean with 4% vermicompost dose
F-value for Soybean : 5.8398*

4.4. The impact of different Vermicompost dose treatments on soil microbial characteristics in Soybean and Linen.

4.4.1. Basal Soil Respiration

According to the statistical analysis, there is no significant difference in Basal Soil Respiration (BSR) among the treated soil samples in Linen ($p>0.05$). However, Vermicompost application at different dose levels leads to a significant increase in BSR in Soybean ($p<0.01$). The effects of treatment application on BSR are illustrated in Figure 4.8. In general, the treatment's effect on BSR in Linen is consistent, with no significant differences observed. However, in Soybean, a high dosage of vermicompost has a negative effect on BSR. Specifically, the BSR value is lowest in the 4% VC dose level among the other treatments, while the highest value is observed in the 2% VC dose level. These findings are in line with the research conducted by Nair et al. (2009), who found that vermicompost has a positive effect on BSR. BSR is an indicator of microbial activity in the soil, reflecting the decomposition of organic matter and nutrient cycling processes. Vermicompost, being rich in organic matter and microorganisms, can enhance microbial activity and metabolic processes, thereby increasing BSR. The negative effect of high vermicompost dosage on BSR in Soybean could be attributed to several factors, such as the imbalance in nutrient availability, changes in soil moisture content, or alterations in the microbial community composition. Further studies are necessary to investigate the underlying mechanisms behind this observation and optimize the vermicompost application rate for optimal soil respiration in Soybean. In summary, there is no significant difference in BSR among the treated soil samples in Linen. However, vermicompost application at different dose levels significantly increases BSR in Soybean, except for the 4% vermicompost dose level, which exhibits the lowest BSR value. The positive effect of vermicompost on BSR aligns with the findings of Nair et al. (2009), highlighting the influence of vermicompost on microbial activity and nutrient cycling in the soil.

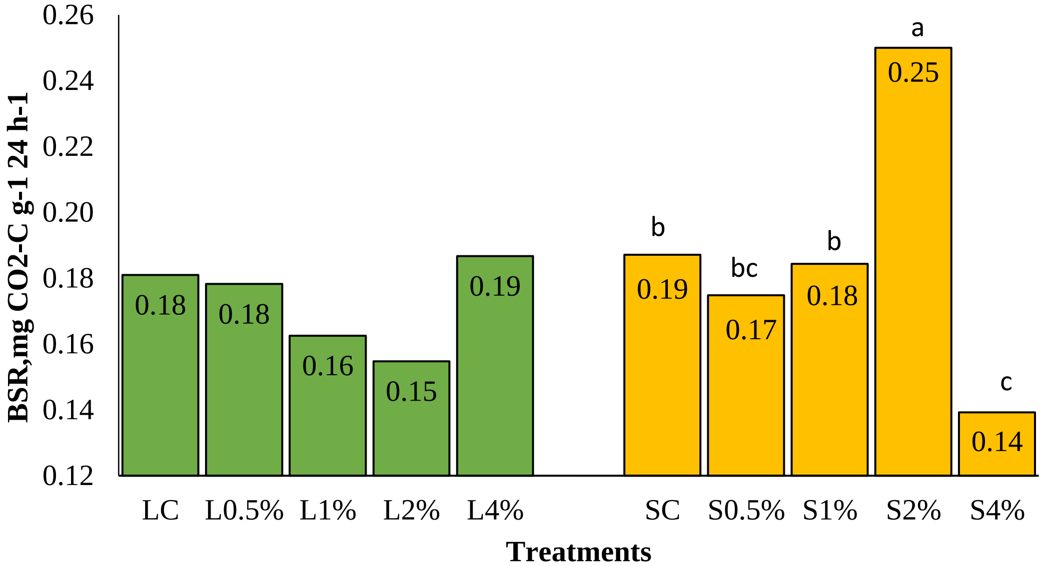

Figure 4.8. The influence of different vermicompost application doses on Basal Soil Respiration (BSR) in Soybean and Linen soil. The abbreviations used in the figure are as follows:

LC	: Linen control (without vermicompost)	SC	: Soybean control (without vermicompost)
L0.5%	: Linen with 0.5% vermicompost dose	S0.5%	: Soybean with 0.5% vermicompost dose
L1%	: Linen with 1% vermicompost dose	S1%	: Soybean with 1% vermicompost dose
L2%	: Linen with 2% vermicompost dose	S2%	: Soybean with 2% vermicompost dose
L4%	: Linen with 4% vermicompost dose	S4%	: Soybean with 4% vermicompost dose
			F-value for Soybean : 9.8294**

4.4.2. Microbial Biomass Carbon (MBC)

According to the statistical analysis, there is no significant difference in soil Microbial Biomass Carbon (MBC) among the treated soil samples in both Soybean and Linen ($p>0.05$). The effects of treatment application on MBC are illustrated in Figure 4.9. Overall, all treatments fall within the same range, indicating an insignificant effect of vermicompost on soil microbial biomass in both Soybean and Linen. However, it is worth noting that all vermicompost treatments, regardless of the dosage, exhibit higher MBC values compared to the control, which recorded the lowest value. The highest MBC value is observed in the 4% VC dose level for both plants. These results align with the findings of Lv et al. (2020), who observed that soil MBC was greater in soil amended with herb residue vermicompost compared to the unfertilized control. Although the differences in MBC between the vermicompost treatments and the control are not statistically significant, the higher MBC values in the vermicompost treatments suggest a potential positive influence on soil microbial communities. Soil microbial biomass carbon is an important indicator of the microbial activity and nutrient cycling potential in the soil. While the lack of statistical significance may suggest no significant effect of vermicompost on MBC, the trend of higher MBC values in the vermicompost treatments indicates a potential beneficial impact on soil microbial communities. Further research is needed to explore the specific mechanisms underlying this observation and to assess the long-term effects of vermicompost application on soil microbial biomass in Soybean and Linen. In summary, the statistical analysis indicates no significant difference in soil microbial biomass carbon among the treated soil samples in both Soybean and Linen. Although all vermicompost treatments show higher MBC values compared to the control, these differences are not statistically significant. However, the findings of Lv et al. (2020) support the notion that vermicompost can enhance soil MBC. Further investigation is necessary to fully understand the impact of vermicompost on soil microbial communities and their ecological functions in Soybean and Linen.

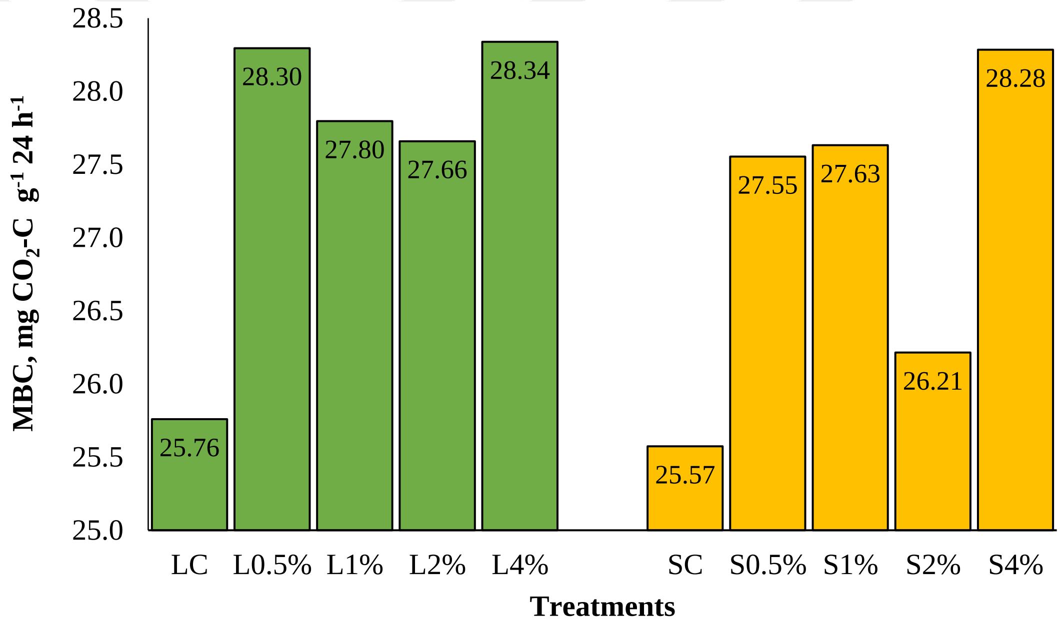

Figure 4.9. The influence of different vermicompost application doses on Microbial Biomass Carbon (MBC) in Soybean and Linen soil. The abbreviations used in the figure are as follows:

LC	: Linen control (without vermicompost)	SC	: Soybean control (without vermicompost)
L0.5%	: Linen with 0.5% vermicompost dose	S0.5%	: Soybean with 0.5% vermicompost dose
L1%	: Linen with 1% vermicompost dose	S1%	: Soybean with 1% vermicompost dose
L2%	: Linen with 2% vermicompost dose	S2%	: Soybean with 2% vermicompost dose
L4%	: Linen with 4% vermicompost dose	S4%	: Soybean with 4% vermicompost dose

4.4.3. Dehydrogenase Enzyme Activity (DHA)

According to the statistical analysis, the application of vermicompost at different dosage levels leads to a significant increase in Dehydrogenase Enzyme Activity (DHA) in both Soybean and Linen ($p<0.01$). The effects of treatment application on DHA are illustrated in Figure 4.10. DHA shows a significant and increasing trend with the increase in vermicompost dosage in both Soybean and Linen. The highest DHA values are observed in the 4% vermicompost dose level for both plants, while the control group exhibits the lowest DHA values. This suggests that vermicompost application enhances the activity of dehydrogenase enzymes in the soil, which is indicative of increased microbial activity and the potential for nutrient cycling. The findings are in line with the results of Alidadi et al. (2016), who observed a fluctuation in DHA enzyme activity across different treatments, but with a general increasing trend. The significant increase in DHA activity with higher vermicompost dosage levels suggests a positive influence on the microbial community and enzymatic processes involved in organic matter decomposition and nutrient transformations. Dehydrogenase enzymes play a vital role in the soil microbial community by participating in the oxidation of organic compounds. Their activity is often considered an indicator of soil microbial metabolic activity and overall soil health. The increased DHA activity observed with vermicompost application indicates improved microbial activity and nutrient cycling potential in the soil. In summary, the statistical analysis confirms that vermicompost application at different dosage levels significantly increases DHA in both Soybean and Linen. Higher vermicompost dosage levels correspond to higher DHA values, indicating enhanced microbial activity and enzymatic processes in the soil. These findings align with the observations of Alidadi et al. (2016) regarding the fluctuating but increasing trend of DHA. Overall, the increased DHA activity suggests a positive impact of vermicompost on soil microbial communities and their metabolic functions in both Soybean and Linen.

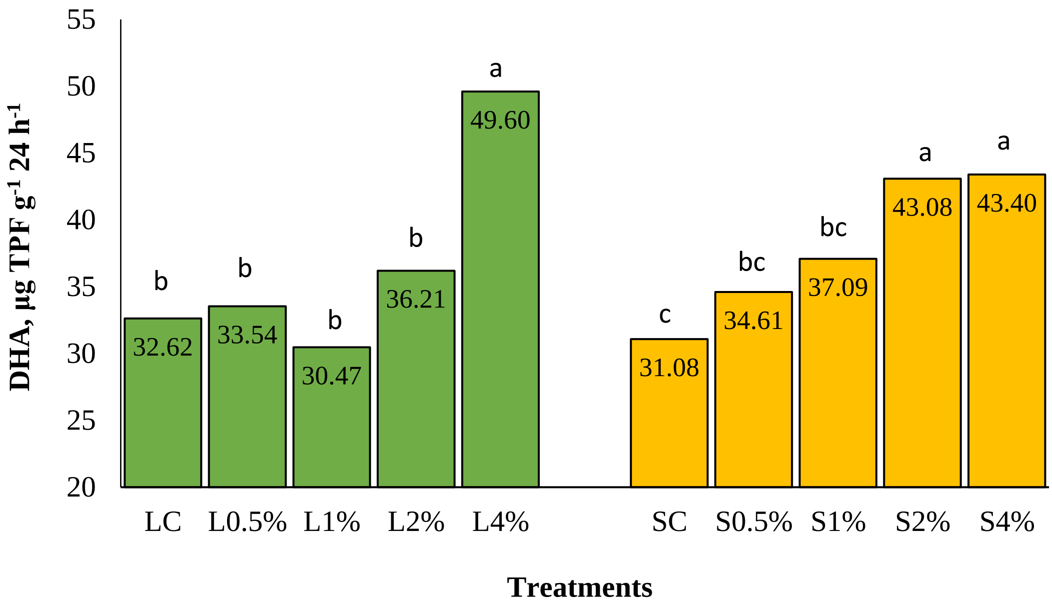

Figure 4.10. The influence of different vermicompost application doses on Dehydrogenase activity (DHA) in Soybean and Linen soil. The abbreviations used in the figure are as follows:

LC	: Linen control (without vermicompost)	SC	: Soybean control (without vermicompost)
L0.5%	: Linen with 0.5% vermicompost dose	S0.5%	: Soybean with 0.5% vermicompost dose
L1%	: Linen with 1% vermicompost dose	S1%	: Soybean with 1% vermicompost dose
L2%	: Linen with 2% vermicompost dose	S2%	: Soybean with 2% vermicompost dose
L4%	: Linen with 4% vermicompost dose	S4%	: Soybean with 4% vermicompost dose

F-value for Linen : 12.9008** *F*-value for Soybean : 10.0940**

4.4.4. Catalase Activity (CA)

According to the statistical analysis, there is no significant difference in soil Catalase Activity (CA) in treated soil of Soybean ($p>0.05$). However, there is a significant effect of Vermicompost on Linen ($p<0.05$). The effects of treatment application on CA are shown in Figure 4.11. In Soybean, CA does not vary significantly with different vermicompost treatment dosages. The highest CA value in Soybean was observed at the 4% vermicompost dose level, while the lowest value was recorded at the 0.5% vermicompost dose level. This indicates that the application of vermicompost does not have a substantial impact on CA in Soybean. On the other hand, vermicompost generally has a positive effect on soil CA in Linen. The highest CA values were observed at the 2% and 4% vermicompost dose levels. This suggests that higher Vermicompost dosages can enhance CA in Linen soil. The findings are consistent with the study conducted by Zuo et al. (2018), which also reported an increase in CA when vermicompost was applied to the soil. Catalase is an enzyme that plays a crucial role in the breakdown of hydrogen peroxide, a harmful byproduct of various metabolic processes. Its activity is often used as an indicator of soil microbial activity and the capacity to cope with oxidative stress. The observed increase in CA with vermicompost application in Linen indicates improved microbial activity and the potential for enhanced antioxidant defense mechanisms. In summary, there is no significant difference in soil CA in Soybean regardless of the vermicompost treatment dosage. However, vermicompost has a positive effect on soil CA in Linen, with higher vermicompost dosages leading to increased CA values. These findings align with the study by Zuo et al. (2018), which also observed an increase in CA with vermicompost application. CA serves as an indicator of soil microbial activity and antioxidant defense, suggesting the positive influence of vermicompost on these aspects in Linen soil.

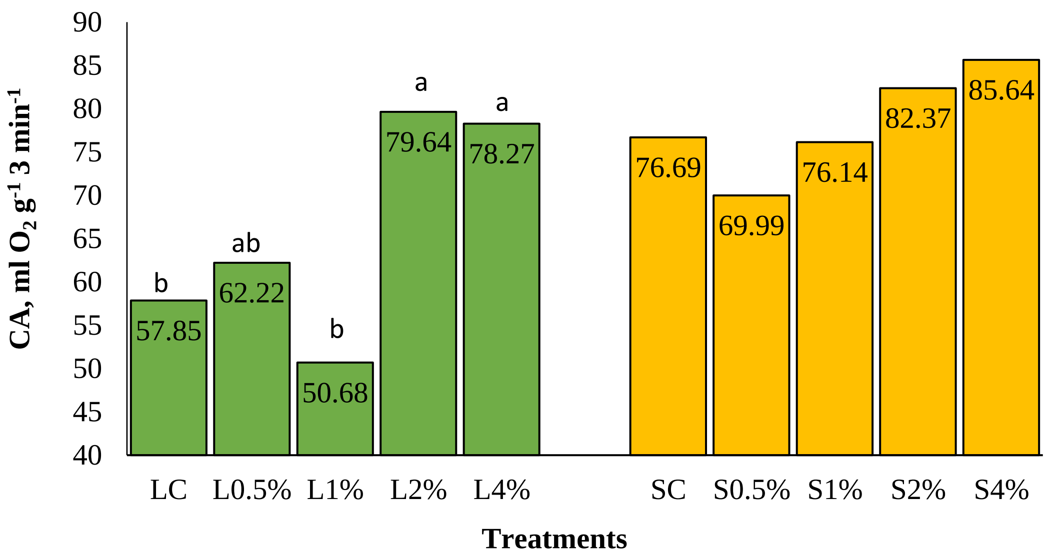

Figure 4.11. The influence of different vermicompost application doses on Catalase activity (CA) in Soybean and Linen soil. The abbreviations used in the figure are as follows:

LC	: Linen control (without vermicompost)	SC	: Soybean control (without vermicompost)
L0.5%	: Linen with 0.5% vermicompost dose	S0.5%	: Soybean with 0.5% vermicompost dose
L1%	: Linen with 1% vermicompost dose	S1%	: Soybean with 1% vermicompost dose
L2%	: Linen with 2% vermicompost dose	S2%	: Soybean with 2% vermicompost dose
L4%	: Linen with 4% vermicompost dose	S4%	: Soybean with 4% vermicompost dose

F-value for Linen : 4.2271*

5. CONCLUSION

In this study, the impact of different doses of vermicompost on plant yield, properties, and soil characteristics in Soybean and Linen was assessed. The results revealed several important findings.

Regarding plant yield, the analysis showed that there were no significant differences in plant fresh weight (PFW) among the different treatments for both Soybean and Linen. However, it is worth noting that the 2% and 4% vermicompost dosages resulted in higher biomass compared to other treatments and the control group.

For plant dry weight (PDW), there was no significant difference among the treated soil conditions for Soybean, while for Linen, the dry weight of the treated plants with vermicompost at different dosage levels showed a significant increase. The highest PDW was observed for both Soybean and Linen at the 4% vermicompost dosage.

Regarding plant height (PH), there were no significant differences among the treated soil conditions for both Soybean and Linen. However, the highest PH value was observed for the 1% vermicompost dosage in Linen, while the control group recorded the highest PH value in Soybean.

The filled pod weight (FPW) showed no significant differences among the treated soil conditions for both Soybean and Linen, except for a negative effect of higher vermicompost dosages on FPW in Soybean.

Regarding root fresh weight (RFW), the vermicompost application at different dose levels had a significant effect on RFW in both Soybean and Linen. In Linen, lower and medium vermicompost dosages tended to increase RFW, while in Soybean, RFW showed a significant increase with higher vermicompost dosages.

Regarding the chemical properties of the soil, vermicompost application did not have a significant effect on soil pH in both Soybean and Linen. However, it led to a significant increase in soil electrical conductivity (EC) in both crops. Additionally, vermicompost application significantly increased the soil organic matter (SOM) content and nitrogen (N) content in both Soybean and Linen.

In terms of soil microbial characteristics, the vermicompost application did not have a significant effect on basal soil respiration (BSR) and microbial biomass carbon (MBC) in both Soybean and Linen. However, it significantly increased dehydrogenase enzyme activity (DHA) in both crops. The effect on catalase activity (CA) varied, with no significant differences in Soybean and a positive effect in Linen at higher vermicompost dosages.

In conclusion, the application of vermicompost at different doses had varying effects on plant yield, properties, and soil characteristics in Soybean and Linen. While there were no significant differences in plant yield for both crops, the 2% and 4% vermicompost dosages generally resulted in higher biomass. Additionally, vermicompost application positively influenced soil organic matter content, nitrogen content, and certain microbial characteristics. These findings highlight the potential of vermicompost as an organic soil amendment to enhance plant growth and improve soil properties. Further research is recommended to explore the long-term effects of vermicompost application and optimize the dosage for maximum benefits in agricultural practices.

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ATTACHMENTS

Experiment Preparation

Crushing the soil sample with a wooden hammer

Sowing Soybean (Glycine max (L.) samsoy)

Sowing Linen (Linum usitatissimum rolin)

The pots were watered with rainwater.

Plant Growth Stages

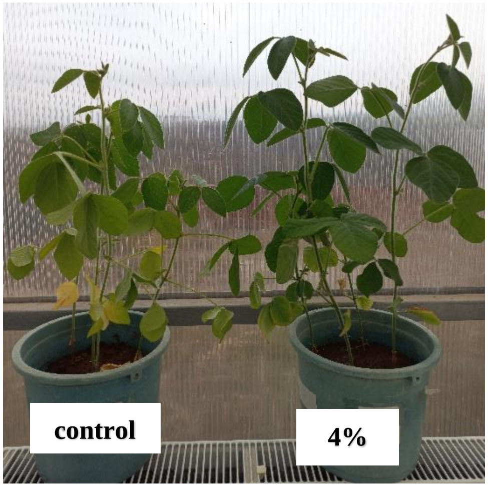
Linen seedling emergence after 4 days

Soybean seedling emergence after 4 days

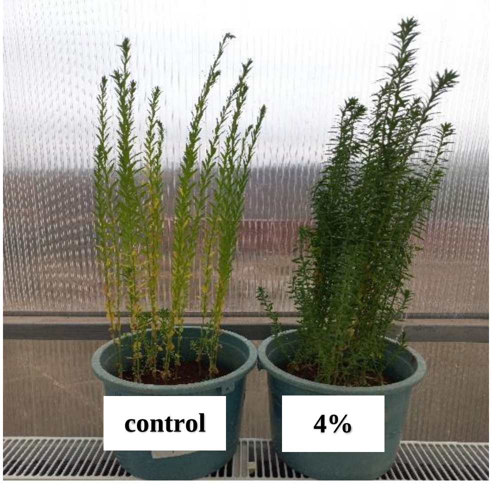
First cotyledons in soybean

Linen seedlings after 44 days of planting.

Soybean seedlings after 44 days of planting



Control compared to 4% VC dose level after 80 days of planting in Soybean.



Control compared to 4% VC dose level after 80 days of planting in Linen.


First Linen flower after 94 days of planting.


First Soybean flower after 65 days of planting


Immature soybean pods


Mature Linen pod

Linen Pre-harvesting, mature Plant.

Soybean pre-harvesting.

Post-Harvesting

Clipping the plant above the soil surface

Measure plant diameter

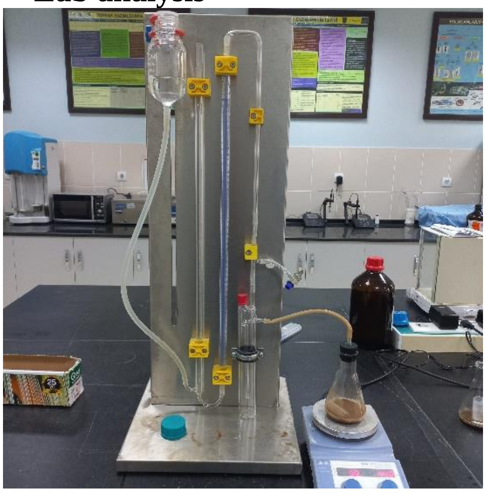
Figure 24. Measure Linen Plant height.

Measure Soybean plant height

Root extraction

Root samples

Lab analysis



Lab- Analysis in process.

CURRICULUM VITAE

Maia Nabil Hafez AZAB graduated from Jordan University of Science and Technology with a bachelor degree in Plant production with Excellent with Honors in 2020. During this period she got a grant to cover an exchange mobility for one semester in Agricultural University of Plovdiv, BULGARIA Issued by ERASMUS+ with the support of European Union (Feb 2019- Aug 2019). In 2021, She enrolled in a joint master degree program ‘’The Erasmus Mundus Master in Soil Science (emiSS)’’ and studied in 2 universities: Turkey: Ondokuz Mayıs University and Poland: University of Agriculture in Krakow.

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Publications :

1. Azab, M., Kizilkaya, R., Al Hayja, S.A. (2022). Possibility of using vermicompost to improve oil plants productivity. International Soil Science Symposium on “Soıl Scıence and Plant Nutrıtıon” 2 – 3 December 2022, Samsun, Türkiye, Book of Proceedings, pp.60-63.
2. Al Hayja, S. A., Gülser, C., & Azab, M. (2022). Potential of using fly ash as amendment for soil characteristics. International Soil Science Symposium on “Soıl Scıence and Plant Nutrıtıon” 2 – 3 December 2022, Samsun, Türkiye, Book of Proceedings, pp.154-159.

Won Awards, Incentives and Scholarships

1. Erasmus Mundus Joint Master Degree Scholarship.
2. Erasmus+ Exchange Mobility.