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Study The Effect of Compost on Improving Soil Fertility and Increasing Barley Plant Productivity

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Abstract
Over the past few decades, soil quality has drastically decreased due to intensive agricultural methods and the ongoing use of artificial fertilizers. Therefore, using compost is one significant alternative for restoring soil fertility in a sustainable agriculture-based strategy. In addition to providing plants with nutrients, compost enhances the soil's physical, chemical, and biological qualities. This study set out to investigate in detail how composting might improve soil fertility and barley plant production. This study employed a qualitative methodology, and a literature review was the technique of data gathering.The study's findings demonstrated that adding compost or organic fertilizer significantly improves soil fertility and barley plant yield.In addition to giving plants the macro and micronutrients they require, compost also helps to enhance the soil's physical, chemical, and biological qualities.Based on the findings of soil tests, farmers are advised to begin incorporating organic fertilizers into an integrated fertilization system, namely by mixing them with inorganic fertilizers in accordance with the particular requirements of the soil.
Keywords: Compost, Soil Fertility, Barley Plant, Productivity

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I. INTRODUCTION

Agricultural land conditions generally suffer from deteriorating fertility, soil erosion, and diminished production. The causes include: a) imbalanced soil nutrient levels; b) nutrient deficiency and depletion; c) decreased levels of soil organic matter; d) plow foot layer shallowing; e) agrochemical or waste-related pollution; f) reduced microbial population and activity; and g) salinization/alkalinization. It is suggested that the majority of rice fields have extremely low amounts of organic matter due to poor fertilizer management. Plant roots cannot fully grow in the field due to a shallower soil layer (Susanti et al., 2023).

Therefore, using organic resources to improve soil quality is a key tactic that is being researched extensively in the field of contemporary agriculture.Nowadays, most people are aware of organic fertilizers, and the government has even started using them to boost agricultural productivity and fertility.Plant tissue is often the source of organic materials in soil.Carbon (C), oxygen, hydrogen (H), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), nitrogen (N), and phosphorus (P) are present in trace levels in plant residues, which are 60–90% water.These minerals are crucial for soil fertility even if they are present in very minute amounts (Yetilmezsoy et al., 2024).

As the primary substrate for plant development, soil is essential for supplying nutrients and preserving the agricultural ecosystem's stability. However, over the past few decades, soil quality has drastically declined due to intensive agricultural methods and the ongoing use of artificial fertilizers. Degradation of soil structure, decreased soil microbial activity, increased erosion, and environmental contamination are the characteristics of this decline. In order to restore soil fertility and promote more ecologically friendly agricultural production, a sustainable agriculture-based strategyamong which is the use of compost is a crucial substitute (Lhaj et al., 2024).

Compost is produced when organic materials, including household garbage, animal waste, plant leftovers, and other organic waste, break down biologically with the aid of microbes (Figure 1). In addition to providing plants with nutrients, compost enhances the soil's physical, chemical, and biological qualities. Compost physically improves the aeration, water retention, and aggregation of soil.Chemically, compost may alter the pH of too acidic or alkaline soil, boost cation exchange capacity (CEC), and supply vital minerals including potassium (K), phosphorus (P), and nitrogen (N).In terms of biology, compost encourages the development of soil microbes that are crucial to the breakdown of organic matter and the cycling of nutrients.Because of these three factors, compost is crucial for increasing soil fertility overall (Ernest et al., 2024).

Figure 1. Compost (Green Living, 2025)

A cereal crop with significant economic significance in many nations, barley (Hordeum vulgare) is used as food, animal feed, and a raw ingredient for the food and beverage industries.This plant is frequently selected for marginal land since it is known to withstand a variety of adverse climatic conditions, including arid temperatures and poor soil.Nonetheless, the availability of nutrients in the soil continues to have an impact on barley output.In addition to the potential benefits for agronomy, increasing barley production using organic methods like applying compost has implications for environmental sustainability and long-term soil health (Salis et al., 2024).

According to earlier research, using compost can boost the productivity of barley and other cereal crops. Because compost releases nutrients gradually yet continuously in response to plant requirements, it can progressively raise the soil's nitrogen level. Furthermore, regular composting helps to raise the soil's organic matter content, which is the primary measure of soil fertility. Composting has been demonstrated to improve root development and boost plant nutrient absorption efficiency in soils with low organic matter concentration, such as sandy soil or soil from formerly intensive agricultural land (Oueriemmi et al., 2021).

Composting in contemporary agricultural systems also promotes a circular economy strategy by recycling organic waste that was previously discarded into valuable agricultural inputs. This lessens reliance on inorganic fertilizers, which may be costly and subject to fluctuations in supply. Furthermore, methane and nitrous oxide, which are frequently created by the overuse of chemical fertilizers, are two greenhouse gases that compost helps to reduce from the agricultural industry (Ansar et al., 2025).

Despite its many advantages, compost's ability to improve soil fertility and crop yields, including barley, depends heavily on a number of variables. The kind of compost source material, the composting procedure, the dosage, the frequency of usage, and the soil and climate conditions in the area are some of these variables (Sayara et al., 2020). Therefore, to precisely assess how compost impacts soil and barley plants under certain circumstances, focused empirical study is required. Guidelines for more successful and efficient organic farming methods may be developed using the findings of this type of study. The purpose of this study was to thoroughly investigate how composting might improve soil fertility and barley plant productivity.

II. LITERATURE REVIEW

Organic Fertilizer

All organic materials originating from plants and animals that can decompose into nutrients that plants may use are collectively referred to as organic fertilizer. Organic fertilizer, which can be either liquid or solid and is used to supply organic materials to improve the physical, chemical, and biological properties of the soil, is made up mostly or entirely of organic materials derived from plants and/or animals that have undergone an engineering process.According to this definition, organic fertilizer is more focused on its organic C value or organic materials than its nutritional content; this is what sets it apart from inorganic fertilizers. It is categorized as an organic soil improver if the amount of organic C is low and does not meet the requirements for organic fertilizer (Badagliacca et al., 2024).

Organic materials have a crucial role in providing the soil with nutrients in the following ways: 1. As a source of nourishment for plants, organic compounds generated from plant waste that contain vital nutrients for the soil then build up. 2. Humus and other stable organic compounds work to absorb and hold onto nutrients so that plants can use them. With a balance of nutrient functions in the soil, humus can: 1) increase fertilizer

efficiency; 2) extend the time that N is utilized; 3) increase the absorption of plant nutrients, particularly P and Ca; 4) lower the risk of pests and plant diseases; 5) buffer salinity in the soil; and 6) act as a catalyst to increase the C status in the soil (Rehman et al., 2023).

Microbial activity in the soil also contributes to the carbon cycle (Figure 2). Trichoderma and Bacillus subtilis are two examples of saprophytic bacteria and fungi that are well-known for their function in breaking down organic materials like cellulose and lignin. The humus, which is formed by the resultant organic leftovers, is essential for determining the ideal soil structure and boosting the soil's ability to retain water and nutrients. The most stable portion of soil organic matter is made up of humic compounds. They promote nutrient availability and plant growth by acting as a substrate and mediator in soil processes (Khan et al., 2024).

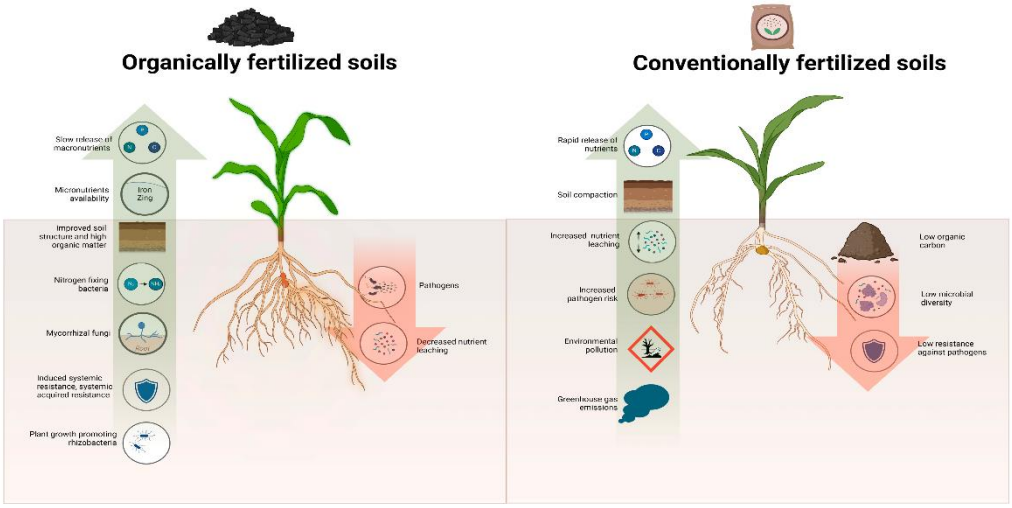

Figure 2. Comparing Conventional And Organic Fertilizers For Soil Improvement(Khan et al., 2024)

Compost

One kind of organic fertilizer is compost. Compost is organic matter that has decomposed in an environment that is shielded from the sun, rain, and controlled humidity. Composted compost is the result of a maturation process that turns garbage into compost. Composting is the process by which biodegradable organic waste is broken down by decomposer agents, which include fungus, bacteria, actinomycetes, and soil organisms. Because compost fertilizer can improve the soil's physical, chemical, and biological fertility, it significantly benefits the organic farming system.In order for the microbes active in the biological process of composting to develop in the best possible environmental conditions, a variety of compost maturation processes must be carried out. These conditions include the water content and nutrient ratio of the basic compost materials, which can be improved by mixing different types of waste. Research is regarded as being very important and is meant to find the best compost fertilizer formulation from the waste materials used (Ayilara et al., 2020).

Organic materials from a variety of sources are used to make compost. Additionally, there are hot and cold water soluble materials (sugar, starch, amino acids, urea, and ammonium salts). In both mesophilic and thermophilic environments, organic components decompose. After three to four months of composting using the piling technique on the soil's surface, the excavation hole yields dark-colored humified materials that serve as a supply of organic matter for sustainable farming.Animal waste in the form of excrement or animal corpses, or plant tissue in the form of litter in the form of stems, roots, and leaves that are subsequently broken down by soil microorganisms, are the sources of organic soil material. Chemically, lignin proteins, carbohydrates, and a variety of other tiny substances like lipids, waxes, and so on make up organic soil material (Bejger et al., 2022).

The microorganisms in the trash and the waste itself interact intricately during the composting process.The three categories of microorganisms that perform this function are actinomycetes, fungus, and bacteria.Actinomycetes are bacteria that resemble fungus and decompose organic materials.The biological activity is the bacteria's consumption of readily accessible carbohydrates, which raises the temperature quickly.Before composting, biodegradable wastes need to be separated:Good-quality compost can only be made from pure food waste, garden waste, wood chips, and, to a lesser extent, paper (Zafar, 2022).

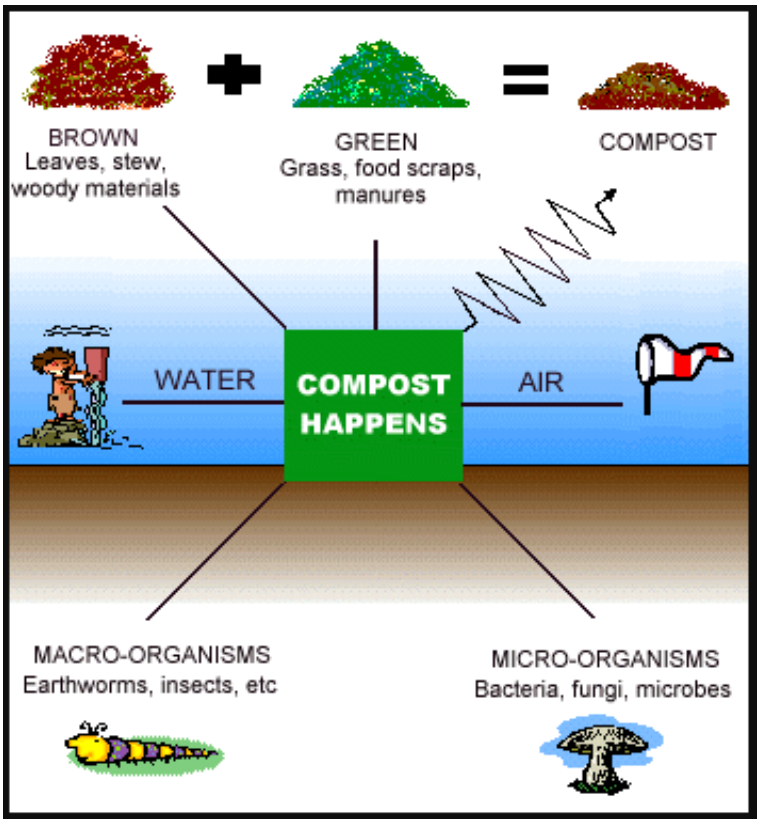

Figure 3. Compost Process (Zafar, 2022)

The breakdown of organic matter produces humus, which has a very high ability to bind water and nutrients. It has colloidal specificity and can bind 80–90% of its dry weight, while clay can only bind 15-20% of water. Humus gives the soil a little blackish appearance and is particularly valuable for agriculture since it influences the soil structure. The amount of organic matter in the soil has a direct impact on how quickly the soil weathers. Compared to organic matter with a high C/N ratio, organic matter with a low C/N ratio will decompose more quickly.Nitrogen must be added to the soil, namely through the addition of rapidly decomposing organic matter, in order for it to break down. However, the role of oxygen contained in the soil is highly crucial, because decreasing oxygen levels also impact microbial activity in breakdown. This has to do with the availability of nutrients that plants can take from organic substances (Piccolo & Drosos, 2025).

Soil Fertility

A state of soil fertility is one in which the components of water, air, and nutrients are reasonably balanced and accessible in accordance with the physical, chemical, and biological requirements of plants. A deep profile (extremely deep depth) of more than 150 cm, a loose crumb structure, a pH of 6-6.5, and high (maximum) microbial activity are all characteristics of fertile soil. There are no soil obstacles preventing plant growth, and there is a enough amount of nutrients available to plants. The chemical characteristics of the soil, including its pH, light intensity, moisture content, and temperature, can be used to discern its fertility (Wolf et al., 2023).

1. Soil pH

The concentration of hydrogen ions (H+) and hydroxyl ions (OH-) is determined by the pH value of the soil. These ions are inversely proportional to one another; a higher H+ ion content will result in a lower OH-ion content, and vice versa. The soil will be acidic if the H+ content is more than the OH-content, and alkaline if the H+ content is lower. On the other hand, the soil is neutral (pH=7) if the H+ and OH-ion contents are equal (Jeon et al., 2023).

2. Soil Moisture

Water that fills some or all of the soil's pores above the water table is referred to as soil moisture.Land usage can be determined by the degree of soil moisture.This is due to the fact that soil moisture content affects plant growth.Because of transpiration, percolation, and evaporation through the soil surface, soil moisture is very dynamic (Rasheed et al., 2021).

3. Soil Temperature

In addition to moisture, structure, microbial and enzymatic activity, plant residues, and the availability of plant nutrients, soil temperature is a crucial soil characteristic that has a direct impact on plant growth. Along with water, air, and nutrients, soil temperature is a critical component in plant development (Liu et al., 2022).

4. Soil Light Intensity

Because it plays a part in physiological processes including photosynthesis, respiration, growth and disposal, stomata opening and shutting, germination, and plant development, light is crucial for plants. Through the process of photosynthesis, sunlight may influence the development, reproduction, and yield of plants (Chutimanukul et al., 2024).

Barley Plant

One of the first cereal crops that people have grown for thousands of years is barley (Hordeum vulgare L.). Due to its exceptional capacity to adapt to a wide range of climatic conditions, including regions with minimal rainfall and freezing temperatures, this plant, which is native to the Middle East, has spread around the world. Barley is a crucial food crop in marginal regions because of its short life cycle and ability to thrive on less fertile ground.This plant is used extensively as animal feed, as a raw material for beverages (such beer and whiskey), and as a food element for humans, such as in cereal, soup, or flour. Furthermore, barley has a significant dietary fiber content, particularly beta-glucan, which has health benefits including decreasing cholesterol and preserving stable blood sugar levels (Jiang et al., 2025).

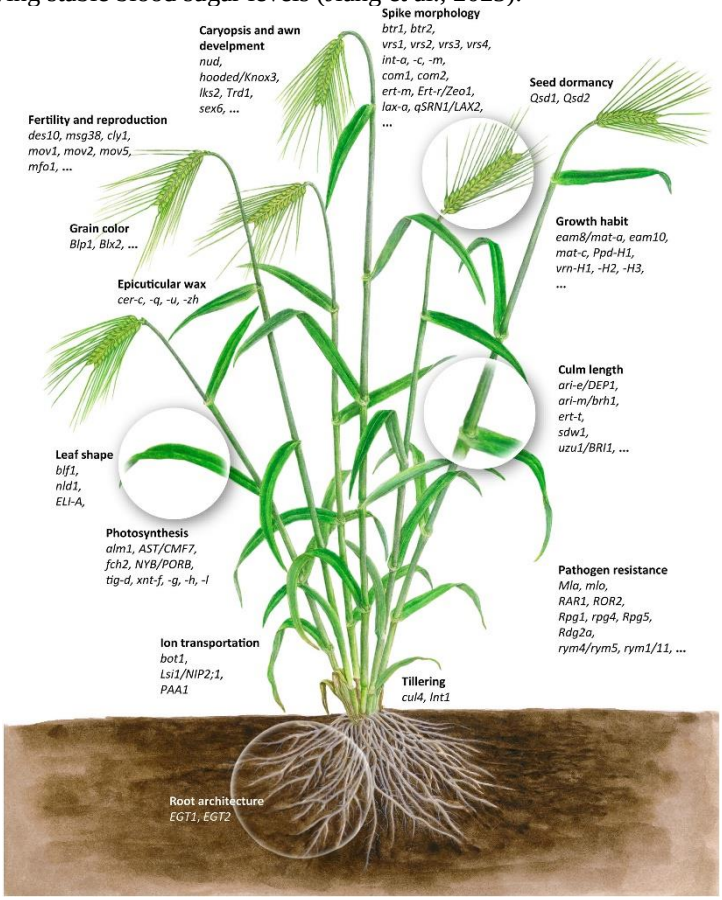

Figure 4. Barley Plant (Jiang et al.,2025)

III. METHODOLOGY

This study employs a qualitative methodology that analyzes a variety of textual sources of information in an effort to gain a thorough understanding of the phenomena under investigation. This study's data gathering approach is a literature study, which is a process that involves examining, locating, and evaluating a variety of books, research reports, scientific journals, and other pertinent materials pertaining to the research issue. Literature studies are used to trace the findings of earlier research that bolster the discussion in this study and to get a solid intellectual and theoretical grasp. By using this method, researchers may get a thorough and in-depth examination of the issues brought up in the study by looking at different viewpoints and previous findings (Sekaran& Bougie, 2020).

IV. RESULT AND DISCUSSION

The Effect Of Compost On Improving Soil

Organic fertilizers have a significant role in enhancing the physical, chemical, and biological characteristics of the soil, in contrast to synthetic chemical fertilizers that only offer one or a few types of nutrients. Despite having a comparatively modest nutritional content, organic fertilizers have a significantly greater impact on the chemical characteristics of the soil than synthetic chemical fertilizers.The chemical properties of the soil are affected by organic fertilizers in the following ways: (a) adding macronutrients (N, P, K, Ca, Mg, and S) and micronutrients (Zn, Cu, Mo, Co, B, Mn, and Fe); (b) raising the soil's Cation Exchange Capacity (CEC); and (c) forming complex compounds with toxic metal ions (Al, Fe, and Mn) to make these metals non-toxic (Rashid et al., 2023).

Composting, in particular, is a biological process that recycles organic waste in aerobic conditions to create a valuable product that may be used safely for animal feed or crop development. The pace at which the compost breaks down is influenced by a number of variables, including temperature, pH, moisture, oxygen, particle size, and the C/N ratio. The ideal parameters for composting have been identified as 45 to 55 °C in the thermophilic phase, 5.0 to 7.0 pH, 50 to 60% humidity, and a C/N ratio of 25 to 35%.However, the development of humic substances byproducts of the composting process is crucial for enhancing the soil's biological, physical, and chemical characteristics, which raises crop production.Composting has been demonstrated to be useful in enhancing crop yields as well as the cultivation of acidic and salinized soil (Figure 3) (Ho et al., 2022).

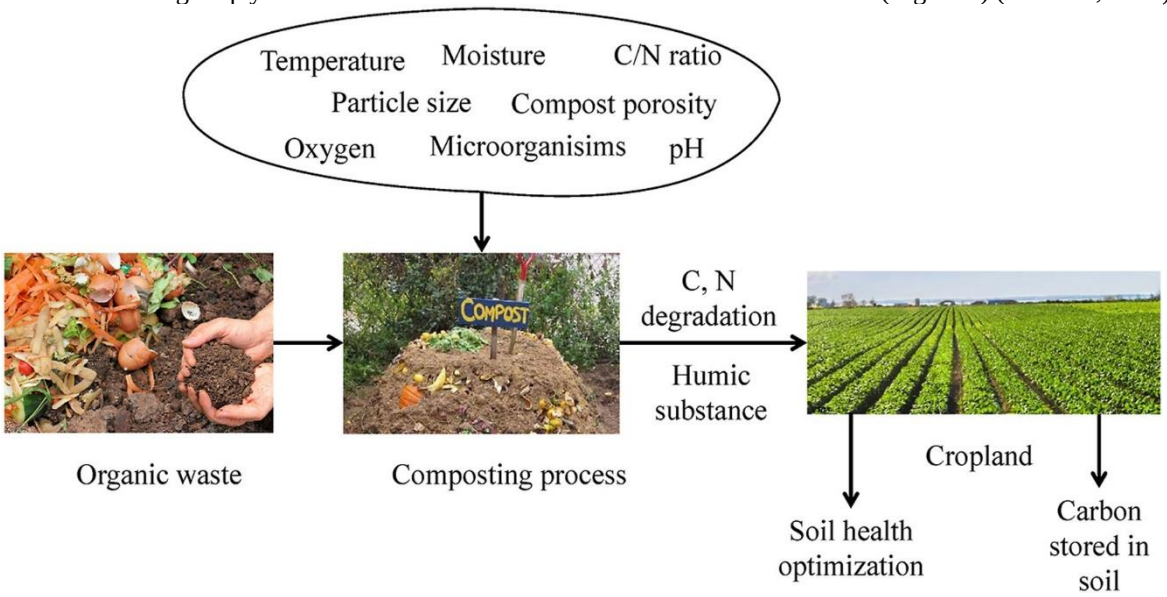

Figure 5. Compost On Improving Soil (Ho et al., 2022)

The physical characteristics of soil are improved by organic fertilizers in three ways: (a) by improving soil structure, as organic matter can "bind" soil particles into stable aggregates; (b) by improving the distribution of soil pore sizes, which improves the soil's ability to hold water and air movement (aeration); and (c) by lowering (buffering) temperature fluctuations in the soil. Organic fertilizers have an impact on the biological characteristics of soil by providing food and energy to the micro and meso fauna.The presence of enough organic matter boosts soil organism activity, which in turn boosts nutrient availability, the soil nutrient cycle, and the capacity of macroorganisms like termites, earthworms, and colembola to produce micro and macro soil pores. Artificial chemical fertilizers do not supply carbon compounds that enhance the physical and biological qualities of the soil; instead, they can only supply one kind of plant nutrients (single fertilizer) or many types (compound fertilizers) (Dincă et al., 2021).

As a result, using inorganic fertilizers in excess of organic fertilizers can harm the structure of the soil and lower its biological activity. In Indonesian agricultural systems, organic fertilizers and ingredients are frequently utilized, particularly in highland vegetable producing systems. Granular organic fertilizers, which are frequently found on the market, are made mostly from cow or chicken dung, straw, or empty oil palm bunches. A filler, such as lime, P-natural, gypsum, or rice husk ash, is added as a supplement.Commonorganic resources found in the field include green fertilizer (tithonia, sesbania, and legumes), manure (chicken, cow, goat, and horse), and harvest leftovers (straw, maize stalks, and vegetable crop residues like cabbage and broccoli). During the breakdown process, these organic sources will transform from organic to mineral and other components (Panday et al., 2023).

Mineralization and immobilization are two examples of this shift that take place concurrently when the material is added to the soil. The process is influenced by the substance's biochemical makeup, the biological activity of the soil, and abiotic variables. Among the characteristics of organic matter, the C/N ratio and N concentration have a significant impact on the process of transformation. According to study findings, the C/N ratio and the amount of nitrogen in plant wastes are frequently the main drivers of the breakdown process.Furthermore, superior mineralization patterns can occasionally be influenced by the biochemical characteristics of organic matter, such as lignin, polyphenols, cellulose concentration, or their mixtures. Because of the quantity emitted and the rate of mineralization, nitrogen content not only speeds up the process but also poses a threat to the environment (Yang et al., 2021).

The Effect Of Compost On Increasing Barley Plant Productivity

The productivity of rice plants is positively correlated with the amount of organic matter present; the lower the organic matter content, the lower the land productivity. By serving as a biological buffer, organic matter enables the soil to supply plants with nutrients in proportionate proportions. Because most of the fertilizers will be lost from the root environment, soils with low levels of organic matter will have a lower buffering capacity for fertilizers, which will lower the effectiveness of inorganic fertilizers. Given the significant contribution of organic matter to the soil's physical, chemical, and biological fertility, nutrient management must be implemented holistically, combining organic fertilization with the application of inorganic fertilizers determined by soil testing (Jiang et al., 2023).

According to Ghouili et al. (2022), barley seedling development at the tillering stage was significantly impacted by the use of organic fertilizer (Figure 1). Plots treated with date palm waste compost differed significantly from the control in terms of plant height during the tillering stage, according to statistical analysis. The plants treated with compost grew taller than the control, reaching 49.66 ± 1.52 cm, a 55.18% increase. The dry weight of the roots and shoots grew by 22.03% and 115.46%, respectively, demonstrating a comparable impact. Nevertheless, the barley plants' root length was not significantly impacted by the addition of date palm waste compost.It's interesting to note that adding compost improved grain yield according to statistical data. There was a notable 49.82% rise in grain yield. The compost treatment had the highest value (4.33 ± 0.67 t ha−1), whereas the control treatment had the lowest value (2.89 ± 0.54 t ha−1)(Ghouili et al, 2022).

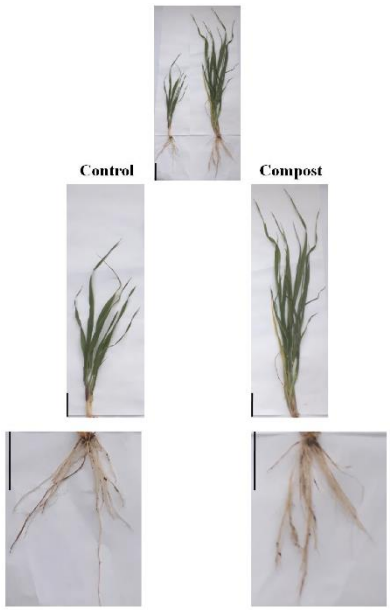

Figure 5. Date palm waste compost's morphological effects on barley plant roots and shoots(Ghouili et al, 2022)

Bulk organic fertilizer is more effective than granular organic fertilizer, or at least about as effective.Bulk organic fertilizer often works better than granular organic fertilizer for caisim plants that are only there for a month.This is because bulk organic fertilizer has a larger surface area of contact between the fertilizer and the soil than granular organic fertilizer. As a result, the soil's chemical, physical, and biological qualities are improved more effectively than with granular organic fertilizer, and nutrients are supplied more quickly to meet plant nutrient requirements (Bhardwaj et al., 2024).

Organic fertilizers significantly increase plant productivity, according to tests on the effects of granular and bulk organic fertilizers.While organic fertilizers with ¾ NPK do not differ considerably from conventional

fertilizers, they do dramatically boost production when compared to full controls.Compared to conventional fertilizers, rice yield is reduced when organic fertilizers whether granular or bulk are treated without NPK fertilizers.This demonstrates that in order to boost productivity, organic fertilizers whether granular or bulk must be supplied in conjunction with NPK fertilizers (Šarauskis et al., 2020).

Organic Fertilizer Technology Innovation

In comparison to inorganic (manufactured) fertilizers, organic fertilizers often have a slower rate of nutrient delivery and a lower nutritional concentration. Therefore, fertilizer formulations that enrich mineral materials and green materials like Tithonia diversifolia, which has high levels of N, P, and K nutrients, are required in order to boost the nutritional content in organic fertilizers. Natural phosphate and dolomite, which are less expensive natural resources that include macro and micronutrients, are examples of these mineral materials. Because Tithonia is an in situ material, easy to grow, and has relatively high quantities of N, P, and K minerals, it may be used as a fertilizer source for organic crops (Nuwarapaksha et al., 2023).

Tithoganic, POG, and POCr plus are organic fertilizer products produced by the Soil Research Institute.In addition to being slow-release, lowering the application dose, and speeding up the composting process, Tithoganic, an organic fertilizer enhanced with Tithonia diversifolia green material, is anticipated to improve the nutritional content and quality of organic fertilizer.Physical attributes include 20% aggregate stability and 20% water retention, whilst biological attributes have the potential to boost soil respiration.Tithoganic has the benefit of boosting fertilization efficiency to minimize the usage of inorganic fertilizers by 30% while also raising the dose of organic fertilizer by up to 50% with the same impact (Ho et al., 2022).

The issue of low-quality granular organic fertilizers that are commonly used in today's society is addressed by bulk and granular organic fertilizers plus.There are now many different kinds of organic fertilizers available, most of which are liquids or granules with varying plant-benefit ratios. The government must standardize the usage of organic fertilizers for it to be successful.To protect farmers and boost plant output, strict guidelines for producers of organic fertilizers and quality control measures for organic fertilizers must be implemented (Gaudutis et al., 2023).

V. CONCLUSION

The use of compost or organic fertilizer has a major impact in improving soil fertility and barley plant productivity, according to the study's findings. In addition to giving plants the macro and micronutrients they require, compost also helps to enhance the soil's physical, chemical, and biological qualities. Enhancing soil structure, cation exchange capacity, water-holding capacity, and promoting the activity of soil microorganisms involved in the nutrient cycle are all examples of this.According to research, providing compostparticularly from date palm wastesignificantly boosts barley plant height, dry weight of roots and stems, and grain output. Consequently, using compost is a crucial tactic in sustainable agriculture, particularly on ground with little organic matter.

It is advised that farmers begin incorporating organic fertilizers into an integrated fertilization system, namely by mixing them with inorganic fertilizers in accordance with the particular requirements of the soil as determined by the results of soil tests. Because of their quicker nutrient delivery and absorption, bulk organic fertilizers are also advised for short-lived plants. Furthermore, in order to improve fertilization efficiency and lessen reliance on chemical fertilizers, organic fertilizer innovations like Tithoganicwhich are made with nutrient-rich and slow-release materialsneed to be developed and promoted more extensively as an eco-friendly substitute.It is anticipated that the government and academic institutions would contribute to the implementation of organic fertilizer technology by providing technical help, subsidies, and training.

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