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Effect of Vermicompost and Biochar Fertilizers on the Growth and Yield of Green Onion (*Allium cepa* L.)

Ahmed A. Sadoon* and Raghed M. H. Al-Sultan



Department of Horticulture and Landscape, College of Agriculture and Forestry. University of Mosul, Mosul, Iraq

*Corresponding author: ahmedengneer3@gmail.com

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Abstract: This study was conducted during the spring season of 2025 in the vegetable field of the Department of Horticulture and Landscape Engineering / College of Agriculture and Forestry / University of Mosul. Planting was conducted on 1/27/2025, with the aim of studying the effect of vermicompost and biochar on the soil before planting and the interaction between them on the growth and yield of green onion (*Allium cepa* L.) crops. The experiment was carried out according to a randomized complete block design (R.C.B.D.) with a factorial experiment with two factors: vermicompost at four levels (0, 5, 7.5, 10 tons ha⁻¹) and biochar at three levels (0, 5, 7.5 tons ha⁻¹). They were statistically analyzed according to the design used and the means were compared according to Duncan's multinomial test at the probability level of 0.05. The results showed that adding vermi compost led to an improvement in growth characteristics and yield, as the level (10 tons ha⁻¹) achieved the highest significant values in most of the vegetative growth characteristics (chlorophyll, plant height, and leaf area), as well as quantitative yield indicators such as the average weight of a single bulb without leaves, the percentage of dry matter in the bulbs, the percentage of double bulbs, and the average weight of a single bulb. The biological bulb, the quotient of the experimental unit area, the biological quotient of the total unit area, and the percentage of bulb (50.201 mg.g⁻¹, 69.265 cm, 405.160 cm², 38.833 g, 25.009%, 13.33%, 193.267 g, 3.862 kg, 58.515 tons ha⁻¹, 34.861%, respectively, superior to the rest of the addition levels and the comparison treatment. The results also showed a significant effect of adding biochar on all the studied traits, as the addition treatment at the level of (7.5 tons ha⁻¹) significantly exceeded the total chlorophyll content in the leaves, plant height, leaf area of the plant, average weight of one bulb without leaves, average biological bulb weight, biological yield per unit of experimental area, biological yield per unit of total area, percentage of dry matter in Bulbs, the percentage of double bulbs, and the percentage of bulbs compared to the treatment of no addition and addition to the level (5 tons ha⁻¹), (44.507 mg.g⁻¹, 65.471 cm, 344.180 cm², 38.369 gm, 165.667 gm, 3.313 kg, 50.204 tons ha⁻¹, 21.842%, 8.75%, and 30.914%, respectively. As for the binary interaction coefficients, they showed significant superiority when treating the interaction of adding (10 tons ha⁻¹) of vermicompost with (7.5 tons ha⁻¹) of biochar in most

of the studied traits, especially in plant height, leaf area, the average weight of a single bulb without leaves, the percentage of double bulbs, the biological weight of the bulb, and the biological yield per unit experimental area. The biological yield per unit area is the total area, as well as the percentage of follicles. (71.213 cm, 435.310 cm², 43.343 g, 18.33%, 212.533g, 4.251 kg, 64.409 tons ha⁻¹, 38.488%) compared to all other interference treatments and the comparison treatment that recorded the lowest values.

Key words: Onion, Vermicompost, Biochar.

1. Introduction

Onion (*Allium cepa* L.) belongs to the Alliaceae garlic family and is considered one of the distinctive crops grown in Iraq and the world due to its high nutritional value and many daily uses, onions are a source of vitamin C and have a high energy content and a moderate percentage of protein and nutrients (Amin *et al.*, 2014). Mahmood *et al.* (2021) also showed that onions have a high nutritional value, as they contain vitamin E and minerals such as sodium, potassium, and zinc, and have great health benefits, including: prevention of diseases such as stomach cancer, osteoporosis, brain cancer, anti-diabetes, anti-inflammatory, anti-genetic mutations, bacterial infections, analgesic, and antipyretic. The demand for onions has increased day by day, as most countries have tended to expand its cultivation and raise the level of its production, and the latest statistics of the Central Agency for Agricultural Statistics indicate that the area cultivated in Iraq with the onion crop reached (18.391 dunams) with a productivity of (2557.2 kg dunams⁻¹) (Central Bureau of Statistics, Ministry of Planning, 2022). It is still in limited production within the private sector. Onion is one of the most consumed and cultivated plant crops in the world, and onions are traditionally used for medicinal purposes in many countries of the world, and it also contains many medicinal properties, including: antimicrobial, antioxidant. Pain reliever, anti-inflammatory, anti-diabetic, hypolipidifier, antihypertensive (Teshika *et al.*, 2019). The growth and production of this crop is greatly affected by many factors, most notably the selection of the appropriate variety for the prevailing climatic conditions in the region, the application of appropriate field service processes, as well as the use of soil physical and chemical enhancers and additives of biofertilizers, which greatly affect the productivity and quality of the crop and the attempt to raise the productivity of the unit area using advanced agricultural methods and techniques, including the selection of good types of organic and bio-fertilizers and the reduction of the use of chemical fertilizers (Aneseyee and Wolde, 2021). In recent years, agricultural systems have increasingly adopted sustainability concepts with reliance on alternative inputs such as biochar, which has emerged over the past 15 years as a means of mitigating the effects of environmental change. Currently, sustainable agriculture is based on the application of environmentally friendly practices aimed at food production while meeting local needs, along with the conservation of biodiversity and reducing the negative impacts of chemical fertilizers using vermi compost residues in improving the efficiency of soil organic matter management and water resources (Le *et al.*, 2025).vermi compost is a Latin word that consists of two words: vermi, which means worms, and the word compost, which is manure, and the meaning of vermi compost, which is a bioorganic fertilizer that contains a variety of plant nutrients from major and minor minerals, several bacterial, enzymatic and fungal groups, and growth regulators that contribute to increasing the productivity of the plant, raising its systemic resistance, improving the properties of the soil and raising its fertility. In light of the modern global trend towards the preservation of the environment, humans and animals, the development of organic farming systems and the achievement of sustainable agriculture, a large number of countries are moving towards organic fertilizers to be used in the production of various agricultural crops due to their health safety, low material cost and the safety of the food produced, in addition to the increase in soil problems around the world and the threat to their distinctive functions necessitates the introduction of management systems and practices aimed at soil conservation. With its properties and its positive impact on soil health and agricultural product, and supplying the agriculture sector with various forms of fertilizers that contribute to maintaining our food security. It is an environmentally friendly and easy-to-apply technology that relies on the interaction between worms and microorganisms, as the worms consume organic waste (Al-Shabat *et al.*, 2023). Biochar is one of the modern agricultural technologies that has

received increasing attention in the field of sustainable agriculture, due to its effective role in improving the physical, chemical and biological properties of the soil. Biochar is produced from the pyrolysis of plant or animal organic matter under conditions of limited or no oxygen, which gives it a porous composition and high stability in the soil for long periods of time, and the addition of biochar to the soil contributes to increasing its ability to retain water and nutrients, reduce nutrient loss by leaching, as well as improve the bioactivity of the soil and promote plant growth, and biochar is an important tool in reducing greenhouse gas emissions by fixing carbon in the soil, making it a promising choice for supporting Sustainable agricultural production and environmental conservation (**Banu *et al.*, 2023**).

Objectives of the study:

- 1- Demonstrating the effect of adding the best level of vermi compost fertilizer to the soil on the growth and yield of green onions.
- 2- Demonstrate the effect of adding the best level of biochar fertilizer to the soil on the growth and yield of green onions.
- 3- Finding the best combination between vermi compost and biochar to improve the growth and yield of green onions.

Review references Effect of Fermi Compost

Vermi compost is one of the most important bio-organic fertilizers that are environmentally friendly and is produced through the decomposition of organic matter by earthworms vermi compost is characterized by being rich in macro and micronutrients, in addition to containing organic acids, enzymes and beneficial microorganisms, and the use of vermi compost contributes to improving the physical, chemical and biological properties of the soil, increasing the readiness of nutrients, promoting plant growth, and raising agricultural productivity, making it one of the main inputs in sustainable and organic farming systems. (**Atiyeh *et al.*, 2000**). **Edwards and Arancon (2004)** showed that vermi compost is a highly efficient bioorganic fertilizer, prepared through biotreatment of organic waste by earthworms. These worms convert non-decomposing organic matter into a stable, nutrient-rich substance. Vermi compost is characterized by its balanced composition of nutrients, in addition to containing beneficial microorganisms that contribute to improving the biological activity of the soil and increasing its fertility, as well as playing an important role in improving the structure and aeration of the soil and increasing its ability to retain water, which reflects positively on the growth of the root and vegetative groups of the plant, and vermi compost is one of the effective alternatives to chemical fertilizers, due to its role in reducing environmental pollution, achieving agricultural sustainability, and improving soil fertility and raising its fertility (**Al-Shabat *et al.*, 2023**). **Ansari (2008)** conducted a study in India in Uttar Pradesh to find out the effect of vermi compost at a fixed level of 6 (t ha⁻¹) on the growth and production of red onion (NasikRed), as the results showed that the use of vermi compost at two levels (1:5 and 1:10) caused a significant increase in the onion yield of the red variety compared to the rest of the other treatments. A study conducted by **Srivastava *et al.* (2012)** indicated the importance of using vermi compost in the growth and productivity of onion plants (N-53), and vermi compost was used at the level of (10 t ha⁻¹), as it confirmed that the use of vermi compost to the field soil reflects positively to give the best growth of the onion plant in terms of vegetative growth and a significant increase in the size and weight of the bulbs, as the size of the bulbs increased by 54% and the wet weight of the bulbs increased by 198%. The study by **Abolmaaty and Fawaz (2016)** in Egypt, Minya Governorate, aimed to show the effect of adding vermi compost at a rate of (1,2,3,4,5,6 tons ha⁻¹) on the onion plant variety (Giza6) to achieve a significant increase in plant height, bulb diameter, wet and dry onion weight, and the yield of The experimental unit when adding 6 t ha⁻¹) compared to untreated plants (64.66 cm. plant⁻¹, 60 mm, 130 g, 32 g, 14.74 kg) respectively. **Gebremichael *et al.* (2017)** conducted a field experiment in the Seliklika region of northwestern Ethiopia to evaluate the effect of adding vermi compost to the soil on the growth and productivity of onion (Bombay Red) and at three levels of vermi compost (0, 2.5, 5 t ha⁻¹) The results showed that the addition of 5 t/h⁻¹ of vermi compost achieved the best significant results in vegetative growth traits in terms of plant height, onion neck diameter, bulb length and diameter, average onion weight and total yield (71.67 cm, 1.51 cm, 5.51 cm). cm, 5.90 cm, 92.64 g, 35.25 tons ha⁻¹) respectively compared to the rest of the levels.

Asgele et al. (2018) conducted a field experiment in northern Ethiopia during the 2016-2017 season to study the effect of vermi compost fertilization on the growth and production of red onion (Bombay Red) and included four levels of vermi compost (0, 2.5, 5, 7.5 t ha⁻¹), where the results showed that the addition of vermi compost at a rate of 2.5 t ha⁻¹ had a significant effect on vegetative growth traits such as plant height and total yield (1.462 t ha⁻¹).

In the city of Tehologo, West Africa, the largest onion producing city, the Purple Galmi variety, the researcher (**Coulibaly et al., 2020**) used five levels of vermi compost (0, 10, 20, 30, 40 tons ha⁻¹) with two methods of addition (complete addition to the manure before planting or adding half of the amount before planting + the other half in the stage of bulb formation and swelling), where the treatment was superior to the concentration of 40 t ha⁻¹ at once and the highest increase in the length and diameter of the bulb, while the highest rate of total yield was for the treatment (20 t ha⁻¹) at once before Agriculture compared to non-addition and amounted to 19.8 and 2.5 tons ha⁻¹) respectively.

Setyowati et al. (2021) studied the effect of vermi compost on the growth and productivity of green onions (Bengkulu Local Shallot) in Indonesia using three levels (0, 10, 20 tons ha⁻¹) The results showed that the level of 20 (tha⁻¹) vermi compost gave the best significant values in vegetative growth traits and yield represented by plant height and productivity (43 cm plant⁻¹, 20 t ha⁻¹) and respectively. (**Abdel-Haleem et al. 2022**) added vermi compost Tea in the field of Qena University (Egypt) during the 2018-2019 growing season at a rate of 50% on the onion plant (Giza 6), as it led to a significant increase in the rate of plant height and wet and dry weight. The leaf content of chlorophyll and total yield (70 cm, 160 g, 35 g, and 32 t ha⁻¹) respectively.

The study by (**Setyowati et al., 2023**) aimed to determine the optimal level of vermi compost addition on red onion plants (Bombay Red). In the city of Bengkulu in Indonesia, with five levels of vermi compost (0, 10, 20, 30, 40 tons ha⁻¹), the results showed that the addition of vermi compost at the level (40 tons ha⁻¹) 10 days before planting gave the highest significant values in the length of the vegetative part of red onions (neck + leaves) (36.6 cm). It significantly affected the increase in the percentage of onion diameter (19.18 mm), onion weight (4.75 g), and average biological bulb weight (837.73 g).

During the 2023 and 2024 planting seasons at the Research Center of Sardar University in India, **Prakash et al. (2024)** conducted a study on the effect of adding vermi compost at three levels (0, 3, 5 t ha⁻¹) on improving the growth, production and quality of onion yield (nhrdfred-3). Plant⁻¹), while the treatment (3 t ha⁻¹) of vermi compost recorded the best results for average onion weight (6.66 g) and experimental unit yield (31.08 kg) Thus, the addition of vermi compost with a concentration of 3 (tha⁻¹) resulted in a significant improvement in the production and quality qualities of the total onion yield.

Arif (2024) conducted a study on the effect of adding vermi compost (tea waste extract) at a rate of 500 ml to the experimental unit on the onion plant of the local variety at the Islamic University of Kawpur, where the leaf content of chlorophyll (42.8 mg.g. soft weight) and the rate of plant height, onion diameter and wet weight of the bulb when adding vermi compost (75 cm, 6.5 cm, 132.8 g) and the product of the experimental unit of bulbs (4.8 kg) respectively.

In Vietnam, a study was conducted by (**Luu et al., 2024**) to show the efficiency of adding vermi compost to field soil at different levels (10, 20, 30, and 40 tons ha⁻¹) to enhance the growth and productivity of green onions (fistulosum), as the results showed that the addition of vermi compost and all levels of addition had positive and significant effects on vegetative growth traits represented by plant height, and a significant increase was achieved in the biological yield of bulbs amounting to (4.86 kgm²) at the level of (40 tons ha⁻¹) of vermi compost compared to the treatment of Do not add.

Lado et al. (2025) at the Research Center in Indonesia investigated the effect of vermi compost fertilization on the growth and productivity of green onions (Shallot). The study included the addition of four levels of Fermi Compost (5, 10, 15, 20 t ha⁻¹) The results indicated a positive improvement in plant height and an increase in the wet and dry weight of the leaves for most of the levels used in the experiment, and the treatment of 15 tons ha⁻¹ (vermi compost achieved the highest significant values of the above traits).

Lehmann and Joseph (2015) showed that biochar is a carbon substance produced through the pyrolysis of plant or animal biomass in conditions with limited or no oxygen, and biochar is characterized by its high porosity and large surface area, which makes it able to improve the physical, chemical and biological properties of the soil, such as increasing the ability to retain water and nutrients and reducing their loss by washing. The positive and beneficial effects of biochar can be identified primarily in some of its physical and chemical properties, such as the high porosity responsible for its potential Water retention and high ionic exchangeability due to its cationic and ionic adsorption surfaces, which makes it a reservoir of some nutrients, and greatly reduces the loss of elements by leaching mineral fertilizers from the elements beyond the range of the roots towards groundwater, which enhances nutrient retention and reduces their loss from the soil, as well as its ability to be an incubating environment and beneficial for the activity of beneficial bacteria microorganisms (**Sohi et al., 2010**).

Due to the importance of the crop, it has recently taken care of the use of some production enhancers such as amino acids and soil improvers of organic or biological origin in order to improve the physical and chemical properties of the soil, preserve water in sandy soils, prevent its seepage, and reduce water loss in light of the water scarcity crisis. Some studies have shown that the addition of different percentages of biochar and its different forms to the soil has beneficial positive effects, as these additives have increased the field capacity of the soil, especially in sandy soils that are poor in nutrients globally, and ensure a clean and sustainable environment free of food chemical additives, as well as the ability of the soil to retain water and nutrients and reduce the impact of heavy elements such as cadmium (lead) (**Wan et al., 2014**).

Lehmann and Joseph (2015) showed that biochar is a stable carbon substance produced through the thermal decomposition of plant or animal biomass in limited or no oxygenated conditions, and biochar is characterized by its high porosity and large surface area, which makes it able to improve the physical, chemical and biological properties of the soil, such as increasing the ability to retain water and nutrients and reducing their loss by washing. Greenhouse gases and carbon sequestration for long periods make it a promising technology in the field of sustainable agriculture and environmental resource management.

The study by **Rageendrathas and DeSilva (2017)** conducted in Sri Lanka concluded to know the effect of adding biochar at four levels (0, 2.5, 5, and 7.5 t ha⁻¹) different to the soil on the growth and productivity of the local variety onion plant, and the results showed that the level of (7.5 t ha⁻¹) was significantly superior in most of the growth traits and yield, as the results showed that the addition of biochar led to a significant increase in plant height, bulb diameter, and wet and dry onion weight, as well as The experimental unit yield was 68.4 (plant⁻¹ cm, 58.6 mm, 125.3 g, 30.7 g, and 13.9 kg) respectively, demonstrating the effective role of biochar in improving soil properties and increasing nutrient readiness and its positive impact on onion growth and productivity.

The study by **Ali et al. (2020)** conducted in India to find out the effect of adding biochar at four levels (0, 2, 4.8 t ha⁻¹) on the growth and productivity of the local variety onion plant, the results showed that the best level of biochar addition was at the level of (8 t ha⁻¹) as it led to a significant increase in plant height and onion diameter, wet and dry weight of the onion, as well as the product of the experimental unit. 65.7) cm. plant⁻¹, 57.9 mm, 126.8g, 30.9g, 13.6kg) respectively. This has reflected positively on the growth and yield of the onion plant.

In one of the villages of Ethiopia, **Aneseyee and Wolde (2021)** compared the addition of two locally produced biochar charcoal and Biochar Chat on the local onion plant at a rate of (0.5 kg m²) led to a significant increase in the rate of maturation rate and plant height, and the market quotient of onions increased significantly by (31.17 t ha⁻¹) when using Biochar Grass compared to using Biochar Chat (24.44 t ha⁻¹) respectively.

In a study conducted by (**Bhatt et al., 2022**) at Himalayan University in Kritipur (Nepal) on the onion plant of the Red Creole variety, the addition of biochar at a rate of (30 t ha⁻¹) led to a significant increase in onion diameter, biological and total yield (15.25 t ha⁻¹).

The study conducted by (**Abdel-Haleem et al., 2022**) in Egypt to find out the effect of adding biochar at four levels (0, 2.5, 5, and 7.5 t ha⁻¹) on the growth and productivity of the onion plant, concluded that the best level of biochar addition was (7.5 t ha⁻¹) as it led to a significant increase in plant

height, onion diameter, wet and dry weight of the bulb, as well as the experimental unit yield (66.9 cm, 59.2 mm, 128.4 g, 31.5 g, and 14.2 kg) respectively.

While the results conducted by (AlSultan *et al.*, 2023) with their experiment in the vegetable field of the Department of Horticulture and Horticultural Engineering / Faculty of Agriculture and Forestry / University of Mosul during the 2021-2022 season to know the effect of adding biochar with four concentrations (0, 3.5, 7, 10.5 t ha⁻¹) on the green onion plant (Karbala) variety (Karbala) showed that the addition of biochar at the rate of (7 t ha⁻¹) to the soil led to a significant increase in the growth traits and the result represented by (the number of bulbs, the diameter of the bulb, the wet and dry weight of the leaves, and the average weight of the The onion and the biological quotient).

The study, conducted by (Higashikawa *et al.*, 2023), aimed to assess the impact of the successive use of increasing rates of biochar on the nutrition and productivity of BellaDura, a commercial yellow variety. The experiment was carried out in the state of Santa Catarina in Brazil during two agricultural seasons in 2017 and 2018 for different levels of biochar (1, 2, 4, 10 t ha⁻¹), where the results showed that the highest onion yield (39.9 t ha⁻¹) was achieved at the level of 10 (t ha⁻¹) of biochar. They also observed a significant increase in onion yield of 0.308 tons ha⁻¹ for each increase of biochar by (1 t ha⁻¹).

In an experiment carried out by (Cedeno *et al.* 2024) in the fields of Ecuadorian villages, the use of three types of bio charcoal (Cocoa, Oryza, Arachis) and four levels of addition (1, 1.5, 3, 5%) on the onion plant of the Alvara variety (planted in plastic anvils to have a net weight of 4 kg) also increased the dry weight of the biological quotient at the same level and the same factor, while the average wet weight of the onion increased significantly when using Arachis and Cocoa at the level of 1% compared to the other levels and fertilizer Oryza Bio charcoal.

In the Abaya region of West Ethiopia State, (Asume *et al.*, 2024) conducted a study that included four levels of biochar (0,5,10,15 t ha⁻¹) on six varieties of onions (Adama Red, Bombay Red, Robaf, Nasik Red Nafis, Local variety) where the rate of addition was significantly higher than 10 (10 t ha⁻¹) and the highest rate of onion length and diameter, average onion weight and total product (28.45 t ha⁻¹) compared to the non-addition treatment (20.93 t ha⁻¹)

2. Materials and Methods

The experiment was conducted in the vegetable field of the Department of Horticulture and Horticulture Engineering/Faculty of Agriculture and Forestry/University of Mosul, Mosul City, which is located at 36.35 degrees north latitude and 43.15 degrees east longitude, which is 223 (m) above sea level during the 2025 agricultural season, soil samples were taken from the experimental field before planting from the surface layer and at a depth of 30 cm) to determine some physical and chemical properties of the soil as shown in Table (1) in the central laboratory Affiliated to the Faculty of Agriculture and Forestry, University of Mosul, Table 2 shows the average of maximum and minimum temperatures and the amount of rainfall in relative humidity during the study period from the website

2.1. Preparing the land for cultivation

The land was prepared for cultivation by ploughing with a triple flipper plow, two perpendicular tillage, then the smoothing process was carried out by a shovel, and then the field was tilted, and the direction of the marrow was from north to south, and the experimental unit included two marshes with a length of 110 cm and the distance between one and another (30 cm), thus the area of the experimental unit reached (0.66 m²). The fertilizer was added at once after two weeks of planting, as the recommended amount of fertilizer was used in full proportion in the comparison treatment and half the amount for the rest of the experiment treatments were used equally.

Table (1). Some physical and chemical properties of the soil of the experimental field

| Measurement | Result |
|-------------|--------|
| N % | 0.0029 |
| P ppm | 9.48 |
| K ppm | 316 |

| | |
|------------------|------|
| pH | 8.1 |
| Ec Millistans/cm | 0.90 |
| CaCo3 % | 27.5 |
| % organic matter | 2.38 |

The analysis was conducted at the Central Laboratory / Faculty of Agriculture and Forestry / University of Mosu

Table (2). Monthly averages of maximum and minimum temperatures, rainfall and relative humidity during the study period for the city of Mosul (2025)

| year | Month | Minimum Temperature (°C) | Maximum Temperature (°C) | Rainfall Rate (mm) | Relative humidity ratio (mm) |
|------|----------|--------------------------|--------------------------|--------------------|------------------------------|
| 2025 | January | 2-3 | 13-12 | 70-60 | 80%-75% |
| | February | 5-3 | 15-14 | 65-60 | 75%-70% |
| | March | 8-7 | 20-19 | 70-60 | 65%-60% |
| | April | 12-11 | 26-25 | 55-45 | 55%-50% |

Date and method of planting debauchery: (onions) debauchery of the local variety (Karbalai) were purchased from the local market, which is a sweet-tasting white spherical variety with a good ability to store and isolate infected and damaged debauches, and choose good and uninfected debauches with consistent diameters of 2 cm in diameter as much as possible, and dig inside the row and on one side of the row, and put the debauchery inside pits with a depth of 5 cm while keeping the top part out of the soil, and the planting was carried out on 27/1/2025.

Service Operations: Agricultural service operations were conducted in a similar manner to all experimental units such as hoeing, weeding, exporting, preventive control operations for fungal and bacterial diseases, insects and bushes, and added urea fertilizer (46% N), and compound fertilizer NPK 15.15.15 at a rate of 220 kg ha⁻¹ (**Required et al., 1989**). Yufull fungicide at a concentration of 1 mL was used as a soil prophylactic near plant stems to control soil fungi against post-emergence blight disease at the rate of one spray every two weeks, and Copra insecticide 1 mL was used to control piercing and sucking insects.

2.2. Harvest Date

The harvesting process was carried out manually by pick for the plants of the experimental unit and the harvest was conducted on 10/4/2025, where five plants were randomly taken from each experimental unit and readings were taken for some studied traits after harvest.

Factors studied: The experiment included a study of the effect of two factors:

The first factor: vermi compost – which is the organic waste resulting from the feeding of earthworms (*Lumbricus terrestris*) and some livestock residues, as well as the residues of damaged fruit crops and tree leaves, and then purchased from a farmer and producer of vermi compost in the district of Balad (Iraq) mixed by hand with the soil and homogeneously for the studied experimental units.

Use vermi compost with four levels added to the soil before planting:

- 1- Not adding vermi compost at the level of 0 tons. hectare⁻¹).
- 2- Adding Fermi Compost at the level of 5 tons. hectare⁻¹).
- 3- Adding Fermi Compost at the level of 7.5 tons. hectare⁻¹).
- 4- Adding Fermi Compost at the level of 10 tons. hectare⁻¹).

The second factor: biochar – the product was purchased from the local market in the city of Mosul and imported from Ukraine, which is the stems of the oak plant and produced by pyrolysis in the absence or lack of oxygen shown in Table (3), the residues of the stems (biochar) were ground by hand by the

hammer into small pieces with a size ranging from (1.5 to 2.5 mm) and added a mixture to the soil by pick to the studied experimental units.

Table (3). Biochar Components

| Measurement | Result |
|-------------|----------|
| PH | 10.08 |
| Total C% | 91.45 |
| Total N% | 1.17 |
| C/N | 78.1 |
| CaO% | 4.2 |
| Mg O% | 5 |
| $K_2O\%$ | 0.47 |
| K% | 0.39 |
| $Fe_2O_3\%$ | 0.0117 |
| Zn% | 0.00036 |
| Mn% | 0.000248 |

Biochar was used in a mixture with the soil before planting and at the following levels:

- 1- Not adding at the level of 0) tons. hectare⁻¹).
- 2- Addition at the level of 5) tons. hectare⁻¹).
- 3- Addition at the level of 7.5 tons. hectare⁻¹).

2.3. Statistical design used

The experiment was carried out using the design of complete random sectors with three repeaters and the coefficients were randomly distributed within one replicator, the number of transactions in each repeater was 12 transactions (3×4) and the total number of experimental units was 36 units in the experiment, and each experimental unit included Marzin for Agriculture.

Studied qualities: Characteristics of vegetative growth: The measurements studied were performed on five plants from each experimental unit.

1. Total chlorophyll content is measured in the laboratory (mg⁻¹ milligram). The leaf content of Chlorophyll was measured according to the method mentioned by (plummer, 1974) in the Central Laboratory of the Faculty of Agriculture and Forestry by taking a gram of the leaves of tender and mature green plants, then they were crushed with a concentration of 80% and then placed in a centrifuge for five minutes at a speed of 3000 rpm, and then the photoabsorption of the extract was measured using a spectrophotometer at wavelengths (645 and 663 nm), then the amount of total chlorophyll dye was calculated using the following equation: Leaf content of total chlorophyll = (mg-1 suspension) - Absorption ×5.8
2. Percentage of dry matter in leaves
3. Percentage of dry matter in leaves = ((g) for dry leaves weight) / ((g) for soft leaves weight) × 100
4. Plant height (cm. plant⁻¹): Measure the height of the plant from the base of the stem near the soil surface to the top of the highest point in the leaves and then lift it vertically with a tape measure.
5. Paper Area (cm². Plant⁻¹) Five plants were randomly selected from each repeater and for all coefficients and plant leaves were taken from them to measure the length and width of the leaf (at the middle of the leaf) at the harvest date, the average length and width of five leaves for each plant were measured, then the average of the length and width of the leaf was calculated, this average was used to estimate the leaf area (cm²) according to the following equation:

$$\text{The area of the leaf (cm}^2\text{)} = 0.91 \times (\text{length} \times \text{width of the leaf}) \text{ (Faisal, 1999).}$$

Leaf area of a plant (cm²) = area per leaf (cm²) × number of leaves/plant

Estimation of the qualities of the quantitative product:

1. The average weight of the onion. (grief) (Paperless) Take the average weight of five bulbs without the leaves after cutting them with a knife from each experimental unit and then extract the rate.
2. Percentage of dry matter in bulbs
3. Percentage of double bulbs: Percentage of double bulbs from the field during the harvest process was calculated and recorded by each experimental unit and each repeater and the percentage of duplicate bulbs was calculated according to the equation: Percentage of double bulbs = (number of double bulbs)/(bulbs total number) × 100
4. Biological weight rate of onion (onion + leaves) (g), Rate five buds with leaves after removing the root sum and then extract the modifier.
5. Biological quotient per unit of experimental area (kg), It was calculated from the weight of all (bulbs + leaves) of the experimental unit after removing the root sum.
6. Total biological yield (ton ha⁻¹) An amount of the average weight of the biological quotient of the experimental unit according to the equation:

Total biological quotient = (experimental unit total yield) / (experimental unit area) × 10000 m²

Estimation of the qualitative qualities of the product:

Percentage of Bulge

- 1- The percentage of insights was calculated in the following law:

Bulbing ratio = (neck diameter)/(bulb diameter) × 100 (Cockshull and Heath 1962)

- 2- Percentage of dry matter in bulbs

According to the following law:

Percentage of Dry Matter = (Dry Weight)/(Wet Weight) × 100

- 3- Statistical analysis of the experiment: The results were statistically analyzed according to the design method used and using the ready-made software SAS (2017) and the averages were compared using the Duncan polynomial test at a probability level of 0.05 (Al-Rawi and Khalafallah, 2000).

3. Results and Discussion

The effect of adding vermi compost and biochar fertilizer and their overlap on vegetative growth traits

Laboratory measurement of total chlorophyll content (mg⁻¹ mg soft weight)

Table (4) shows a significant superiority in the treatment of addition of vermi compost at the level of 10 (t h⁻¹) to achieve the highest leaf content of chlorophyll and on all other additive coefficients that differed significantly and amounted to 50.201 mg. mg⁻¹) soft weight and the lowest value of the leaf chlorophyll content was (37.023 mg.1 mg) at the non-addition treatment which was significantly different from all other addition coefficients. While there was a significant increase in the chlorophyll content of the leaves, the treatment of addition of 7.5 tons of bio-carbon coal was significantly superior to the non-addition and addition treatments at the level (5 t ha⁻¹), which did not differ significantly between them as it reached 44. 507 mg. mg⁻¹).It can be seen from the same table that the treatment of adding biochar at the level of 7.5 t ha⁻¹) with the addition of vermi compost at the level of (10 t ha⁻¹) is significantly superior to all the bilateral interference coefficients except for the treatment of adding the same level of vermi compost and by interfering with the addition of biochar at the level of (5 t ha⁻¹)

which amounted to(51.047 and 50.227 mg. g⁻¹) and the lowest chlorophyll content in the leaves was at the non-addition treatment of both factors, which was (35.577 mg⁻¹).

Table (4). The effect of the addition of vermi compost and biochar and their interaction on the total chlorophyll content (mg⁻¹) of green onion crop

| Vermi compost levels (t ha ⁻¹) | Biochar levels (t ha ⁻¹) | | | Average of vermi compost |
|--|--------------------------------------|--------------|--------------|--------------------------|
| | 0 | 5 | 7.5 | |
| 0 | 35.577 e | 36.386 ed | 39.107 cd | 37.023 d |
| 5 | 40.420 c | 41.202 c | 41.642 c | 41.087 c |
| 7.5 | 42.511 c | 42.645 c | 46.234 b | 43.796 b |
| 10 | 49.329 ab | 50.227 a | 51.047 a | 50.201 a |
| Average of biochar | 41.959 ب | 42.615 ب | 44.507 ا | |

The averages that share the same letter for each factor and the overlap between them do not differ significantly from each other according to Duncan's polynomial test at the level of probability. 0.05

Plant height cm. Plant⁻¹

It is clear from Table (5) that the addition of 10 tons of vermi compost was significantly superior to all the addition coefficients and at the three levels used in this study, where the average plant height was (69.265 cm plant⁻¹) and the non-addition gave the lowest plant height and reached (57.180 cm plant⁻¹). It can be seen from the same table that there was a significant increase in plant height as the treatment of adding (7.5 tons ha⁻¹) of biochar was significantly superior and achieved the highest rate of plant height and reached (65.471 cm. plant⁻¹) compared to the non-addition treatment and the addition of (5 t ha⁻¹) of biochar, which did not show a significant difference and reached (63.211 and 63.975 cm. plant⁻¹) respectively. As for the binary interference treatment, the interference treatment of (7.5 t ha⁻¹) of biochar and (10 t ha⁻¹) of vermi compost recorded the highest significant difference for plant height compared to all bilateral interference coefficients in this table was (71.213 cm plant⁻¹) and the absence of the two factors used in this experiment recorded the lowest value in the plant height trait (57.180 cm. plant⁻¹).

Table (5). The effect of adding vermi compost and biochar and the interaction between them on the height of the plant (cm. plant⁻¹) of the green onion crop

| Vermi compost levels (t ha ⁻¹) | Biochar levels (t ha ⁻¹) | | | Average of vermi compost |
|--|--------------------------------------|--------------|--------------|--------------------------|
| | 0 | 5 | 7.5 | |
| 0 | 57.180 h | 58.510 gh | 59.846 g | 58.512 c |
| 5 | 62.476 f | 63.210 ef | 64.433 de | 63.373 c |
| 7.5 | 65.046 cd | 65.743 cd | 66.393 c | 65.727 b |
| 10 | 68.143 b | 68.440 b | 71.213 a | 69.265 a |
| Average of biochar | 63.211 b | 63.975 b | 65.471 a | |

The averages that share the same letter for each factor and the overlap between them do not differ significantly from each other according to Duncan's polynomial test at the level of probability. 0.05

Leaf area of the plant (cm² plant⁻¹)

In Table (6), it was observed that the lowest value of the paper area was at the time of non-addition treatment (255.850 cm².plant⁻¹) and it was found from the table that there were significant differences between the levels of addition of vermi compost and the three levels used in this experiment and they differed significantly between them and with the non-addition treatment and that the highest rate of paper area was achieved when treating the addition of (10 t ha⁻¹) which amounted to (405.160 cm².plant⁻¹). In the table, a significant increase in the paper area is observed when adding (7.5 t ha⁻¹) of biochar, as this addition overcame the treatment of addition (5 t ha⁻¹) and non-addition and reached (344.180 cm².plant⁻¹) and the treatment of biochar at the level of (5 t ha⁻¹) outweighed the treatment of no addition in which the average leaf area reached (306.930 cm².plant⁻¹). In the coefficients of bilateral interference between the levels of addition of biochar and vermi compost, it is shown in the table that the addition of (7.5 t ha⁻¹) of biochar and (10 tons ha⁻¹) of vermi compost which overcame all the coefficients of the binary interference in this table with a significant difference of (435.310cm².plant⁻¹) followed by the addition treatment of (5 t ha⁻¹) biochar with (10 t ha⁻¹).fermi compost amounted to (404.450 cm².plant⁻¹) which differed with all coefficients The bilateral interference and that the lowest leaf area of the plant was found in the non-addition treatment of the workers used in this experiment was (241.330 cm².plant⁻¹).

Table (6). Effect of adding vermi compost and biochar and their interaction on the leaf area of green onion (cm² plant)

| Vermi compost levels (t ha ⁻¹) | Biochar levels (t ha ⁻¹) | | | Average of vermi compost |
|--|--------------------------------------|----------------|---------------|--------------------------|
| | 0 | 5 | 7.5 | |
| 0 | 241.330 j | 251.180 ij | 275.060 hi | 255.850 c |
| 5 | 286.240 gh | 301.330 f-h | 313.750 eg | 300.430 c |
| 7.5 | 324.420 d-f | 339.280 de | 352.620 cd | 338.770 b |
| 10 | 375.740 c | 404.450 b | 435.310 a | 405.160 a |
| Average of biochar | 306.930 c | 324.060 b | 344.180 a | |

The averages that share the same letter for each factor and the overlap between them do not differ significantly from each other according to Duncan's polynomial test at the level of probability. 0.05

Percentage of dry matter in leaves (%)

The data of the results of the study in the dry weight of the leaves in Table (7) indicated that the treatment of adding vermi compost at the level of (10 t ha⁻¹) and amounting to (15.888%) indicated that the treatment of no addition of vermi compost which gave the lowest values for the percentage of dry matter in the leaves and reached(15.431%)and did not differ significantly with the addition treatment at levels(5 and 7.5 tons ha⁻¹).The addition of biochar did not have a significant effect on this trait and at the three levels, and the highest value was achieved when adding biochar at the level of (7.5 t ha⁻¹), which amounted to (15.825%). In the binary interference treatment, the interference treatment between the level of (7.5 t ha⁻¹) of vermi compost and the non-addition of biochar recorded the highest rate of the percentage of dry leaf weight, which reached (16.300%) compared to some binary interference coefficients, and the lowest percentage of dry weight of leaves was at the comparison treatment (15.293%).

Table (7). The effect of adding vermicompost and biochar and the interaction between them on the percentage of dry matter in the leaves of green onion crop

| Vermi compost levels (t ha ⁻¹) | Biochar levels (t ha ⁻¹) | | | Average of vermi compost |
|--|--------------------------------------|---------------|---------------|--------------------------|
| | 0 | 5 | 7.5 | |
| 0 | 15.293 c | 15.339 bc | 15.661 a-c | 15.431 b |
| 5 | 15.639 a-c | 15.692 a-c | 16.066 ab | 15.799 ab |
| 7.5 | 16.300 a | 15.530 bc | 15.531 bc | 15.787 ab |
| 10 | 15.773 a-c | 15.847 a-c | 16.043 a-c | 15.888 a |
| Average of biochar | 15.751 a | 15.602 a | 15.825 a | |

The averages that share the same letter for each factor and the overlap between them do not differ significantly from each other according to Duncan's polynomial test at the level of probability. 0.05

Qualities of the Quantity

Onion weight rate (g onion⁻¹): The results of Table (8) show that the addition of vermi compost gave the highest rate of weight per bulb increased and differed significantly, reaching (38.833 g.onion⁻¹) when treating the addition at the level of (10 t h⁻¹) compared to the non-addition treatment in which the average weight of one onion decreased to (27.477 g.onion⁻¹) and compared to the two addition treatments at the two levels (5 and 7.5 t ha⁻¹) which did not differ significantly between them and differed with the comparison treatment, as they reached (33.501 and 35.211 g.onion⁻¹).respectively. With regard to the treatment of biochar at the level of (7.5 t ha⁻¹), it achieved the highest weight rate of one onion (38.369 g. onion⁻¹) and significantly outperformed the two treatment of addition (5 tons ha⁻¹) which amounted to (33.770 g.onion⁻¹) and the non-addition of biochar which recorded the lowest value of the average The weight of one bulb was (29.128 g. onion⁻¹). The average weight of one bulb differed significantly and increased when the binary interference between the level (10 t ha⁻¹) of vermi compost and (7.5 t ha⁻¹) of biochar was (43.343g.onion⁻¹) compared to all the binary interference coefficients studied in this experiment and the lowest value recorded in this interference was (20.543 g.onion⁻¹) when treating the non-addition of vermi compost and live charcoal.

Table (8). Effect of adding vermicompost and biochar and their interaction on the average weight per bulb (g.bulk⁻¹) of green onion crop

| Vermi compost levels (t ha ⁻¹) | Biochar levels (t ha ⁻¹) | | | Average of vermi compost |
|--|--------------------------------------|---------------|---------------|--------------------------|
| | 0 | 5 | 7.5 | |
| 0 | 20.543 c | 29.277 f | 32.610 d-f | 27.477 c |
| 5 | 29.947 ef | 34.880 c-e | 35.677 cd | 33.501 b |
| 7.5 | 31.243 d-f | 32.543 d-f | 41.847 bc | 35.211 b |
| 10 | 34.777 c-e | 38.380 bc | 43.343 a | 38.833 a |
| Average of biochar | 29.128 c | 33.770 b | 38.369 a | |

The averages that share the same letter for each factor and the overlap between them do not differ significantly from each other according to Duncan's polynomial test at the level of probability. 0.05

Average dry weight of bulb (g)

From the results of the data examined, Table (9) shows that the addition of vermi compost indicates that the coefficients of the three additives used in the experiment are significantly superior to the comparison treatment, which in turn recorded the lowest percentage of dry matter in the bulbs (16.483g) and that the highest rate of dry weight was when the vermi compost supplement was treated at the level of (10 t ha⁻¹), which in turn outperformed all the treatments used in this experiment and reached (25.009 g). With regard to the effect of biochar on the soil at the level of (7.5 t ha⁻¹), it significantly affected the percentage of dry matter in the bulbs, which amounted to (21.842 g) compared to the non-addition treatment at the level of (5 t ha⁻¹), which in turn outperformed the comparison treatment in which the percentage of dry matter decreased, reaching (21,105 to 19,850 g) respectively. The results of the binary interference from the addition of biochar and vermi compost in this table indicated the superiority of the addition coefficients at levels (5 and 7.5 t ha⁻¹) of biochar by interfering with vermi compost at the level of (10 t ha⁻¹) by giving the highest rate of the percentage of dry matter in the bulbs, thus significantly superior to all the coefficients of bilateral interference and did not differ significantly, and that the highest significant value found in this interference was superior to the interference treatment at the level of (10 tons ha⁻¹) vermi compost with (7.5 t ha⁻¹) hectare-of biochar (25.630 g) while the non-addition treatment of both fertilizers recorded the lowest percentage of dry matter in bulbs (15.234 g).

Table (9). Effect of adding vermicompost and biochar and their interaction on the average dry weight of the bulb (g) of green onion crop

| Vermi compost levels (t ha ⁻¹) | Biochar levels (t ha ⁻¹) | | | Average of vermi compost |
|--|--------------------------------------|-------------|-------------|--------------------------|
| | 0 | 5 | 7.5 | |
| 0 | 15.234 k | 16.701 j | 17.512 i | 16.483 d |
| 5 | 18.539 h | 19.830 e | 20.678 f | 19.682 c |
| 7.5 | 21.435 e | 22.686 d | 23.548 c | 22.556 b |
| 10 | 24.193 b | 25.204 a | 25.630 a | 25.009 a |
| Average of biocha | 19.850 c | 21.105 b | 21.842 a | |

The averages that share the same letter for each factor and the overlap between them do not differ significantly from each other according to Duncan's polynomial test at the level of probability. 0.05

Percentage of Double Bulbs (%)

This trait is a genetic characteristic specific to the variety used and is desirable for farmers in green onion production. The vermi compost application treatment, at the levels used in this study, significantly increased the percentage of double bulbs compared to the control treatment, where the percentage of double bulbs decreased to a low of (1.11%). The vermi compost application at a rate of 10 tons per hectare (10 t h⁻¹) achieved the highest percentage of double bulbs (13.33%), significantly outperforming all other application levels, including the non-application level. The results in this table indicate the significant role of adding biochar at a level of (7.5 t ha⁻¹) in achieving the highest percentage of double bulbs, significantly superior to the treatments of no addition and addition at a level of (5 t ha⁻¹), which showed no difference, reaching (8.75%). In the dual interaction treatments between vermi compost and biochar, the results in this table show that adding biochar to the soil at a level of 7.5 t ha⁻¹ with the addition of vermi compost at a level of 10 t ha⁻¹ significantly outperformed all other dual interaction treatments, giving the highest percentage of double bulbs, reaching (18.33%). The lowest percentage of double bulbs recorded in this trait was in the treatment of no addition of biochar and vermi compost to the soil, reaching (0%).

Table (10). Effect of adding vermicompost and biochar and their interaction on the percentage of double bulbs in green onion crop

| Vermi compost levels (t ha ⁻¹) | Biochar levels (t ha ⁻¹) | | | Average of vermi compost |
|--|--------------------------------------|-------------|-------------|--------------------------|
| | 0 | 5 | 7.5 | |
| 0 | 0 f | 1.66 ef | 1.66 ef | 1.11 c |
| 5 | 1.66 ef | 3.33 d-f | 5.00 c-f | 3.33 c |
| 7.5 | 6.66 b-e | 8.33 b-d | 10.00 bc | 8.33 b |
| 10 | 10 bc | 11.66 b | 18.33 a | 13.33 a |
| Average of biochar | 4.58 b | 6.25 b | 8.75 a | |

Means that share the same letter for each factor and the interaction between them do not differ significantly from each other according to Duncan's polynomial test at a probability level of 0.05.

Average biological bulb weight (g)

Table (11) shows that 10 tons ha⁻¹ of vermi compost gave the highest average biological bulb weight with a significant difference between the two addition treatments (7.5 and 5 t ha⁻¹), as it reached (193.267, 161.511, 140.489 g) respectively, and the absence of addition, which achieved the lowest average biological bulb weight, reaching (127.200 g). The same table shows that the highest significant increase in the average biological onion weight occurred with the addition of (7.5 t ha⁻¹) of biochar, resulting in a significant increase of 165.667 g. This was followed by the treatment with (5 tons ha⁻¹) of biochar, which yielded (155.433 g). Both treatments significantly outperformed the treatment without biochar addition, which resulted in the lowest average biological onion weight of (145.750 g). The table also shows the interaction between two treatments for the average biological onion weight.

Table (11). Effect of adding vermicompost and biochar and their interaction on the average biological weight (g) of green onion crop

| Vermi compost levels (t ha ⁻¹) | Biochar levels (t ha ⁻¹) | | | Average of vermi compost |
|--|--------------------------------------|---------------|---------------|--------------------------|
| | 0 | 5 | 7.5 | |
| 0 | 120.400 i | 128.267 hi | 132.933 gh | 127.200 d |
| 5 | 134.533 gh | 141.733 fg | 145.200 ef | 140.489 c |
| 7.5 | 151.333 e | 161.200 d | 172.000 f | 161.511 b |
| 10 | 176.733 c | 190.533 b | 212.533 a | 193.267 a |
| Average of biocha | 145.750 c | 155.433 b | 165.667 a | |

Means that share the same letter for each factor and the interaction between them do not differ significantly from each other according to Duncan's polynomial test at a probability level of 0.05.

The same table shows that adding (7.5 t ha⁻¹) of biochar in combination with (10 t ha⁻¹) of vermi compost gave the highest average biological onion weight of (212.533 g), which significantly outperformed all other additions (pairwise interaction coefficients) used in this experiment. This was followed in terms of increase by the treatment of combining (5 t ha⁻¹) of biochar with (10 t ha⁻¹) of vermi compost, which differed from it and the other treatment combinations, reaching (190.533 g). The lowest biological weight recorded for the bulb was (120.400 g) in the treatment without adding either factor.

Yield per experimental area (biological yield kg)

The data presented in Table (12) indicate that the addition of (10 t ha⁻¹) of vermi compost resulted in the highest significant yield per experimental area of green onions (biological yield), reaching (3.862 kg), compared to all other treatments studied in this experiment. The other two addition treatments (5 and 7.5 t ha⁻¹) also achieved the highest biological yield compared to the treatment without addition, which recorded the lowest value of green onions (biological yield) per unit area, reaching (2.544 kg). The effect of adding biochar at levels (5 and 7.5 t ha⁻¹) was significantly superior and achieved the highest yield per experimental unit area compared to the treatment without addition, which recorded the lowest value of the yield per experimental unit area of green onions (biological yield at (2.915 kg). The highest significant value recorded for the yield per experimental unit of green onions was with the treatment of adding biochar at level (7.5 tons ha⁻¹), which reached (3.313 kg).

Table (12). The effect of adding vermicompost and biochar and the interaction between them on the biological yield per experimental unit area (kg) of green onion crop

| Vermi compost levels (t ha ⁻¹) | Biochar levels (t ha ⁻¹) | | | Average of vermi compost |
|--|--------------------------------------|-------------|--------------|--------------------------|
| | 0 | 5 | 7.5 | |
| 0 | 2.408 h | 2.565 gh | 2.659 f-h | 2.544 d |
| 5 | 2.691 fg | 2.835 ef | 2.904 de | 2.810 c |
| 7.5 | 3.027 de | 3.224 d | 3.440 c | 3.230 b |
| 10 | 3.535 c | 3.106 b | 4.251 a | 3.862 a |
| Average of biocha | 2.915 c | 3.106 b | 3.313 a | |

Means that share the same letter for each factor and the interaction between them do not differ significantly from each other according to Duncan's polynomial test at a probability level of 0.05.

The results of the binary interaction between the levels of vermi compost and biochar showed that the highest yield per experimental area of biological yield (green onions) was (4.251 kg), which was recorded in the treatment of adding vermi compost at the level of (10 t ha⁻¹) with the addition of biochar at the level of (7.5 t ha⁻¹), which significantly outperformed all the binary interaction treatments studied in this study. Meanwhile, the average yield per experimental area of biological yield (green onions) decreased and gave the lowest biological yield per experimental area, which amounted to (2.408 kg), in the treatment of not adding either biochar or vermi compost.

Total biological yield (ton ha⁻¹)

The results of Table (13) indicate that the three additions of vermi compost used in the experiment all achieved a progressively significant superiority in the average total biological yield (t ha⁻¹) compared to the treatment of not adding vermi compost, in which the average biological yield decreased to (38.545 t ha⁻¹). The highest significant value we obtained from the three additions was when adding vermi compost at level (10 t ha⁻¹), as it reached (58.515 t ha⁻¹), with an increase of (51.81%) compared to not adding. As for the addition of biochar at the level of (7.5 t ha⁻¹), it achieved the highest increase in the average biological yield per unit area of green onions, reaching (50.204 t ha⁻¹). Thus, it significantly outperformed the two treatments of addition at the level of 5 tons ha⁻¹ and no addition, in which the average biological yield (green onions) decreased to (44.171 t ha⁻¹), which was outperformed by the previous treatment in this characteristic, reaching (47.060 t ha⁻¹). Thus, the average biological yield per unit area increased by (13.65%) compared to no addition. The total biological yield per unit area increased by (76.54%) and reached its highest significant value of (64.409 t ha⁻¹) when the two-way interaction between (10 t ha⁻¹) vermi compost and (7.5 t ha⁻¹) biochar was applied, compared to all other two-way interaction parameters in the same table. Conversely, the total biological yield decreased to its lowest value of (36.484 t ha⁻¹) when neither biochar nor vermi compost was added to the soil.

Table (13). Effect of adding vermi compost and biochar and their interaction on the biological yield per unit area (ton ha⁻¹) of green onion crop

| Average of vermi compost | Biochar levels (t ha ⁻¹) | | | Vermi compost levels (t ha ⁻¹) |
|--------------------------|--------------------------------------|--------------|--------------|--|
| | 7.5 | 5 | 0 | |
| 38.545 d | 40.287 gh | 38.864 hi | 36.484 i | 0 |
| 42.576 c | 44.000 ef | 42.955 fg | 40.773 gh | 5 |
| 48.944 b | 52.121 c | 48.848 d | 45.864 e | 7.5 |
| 58.515 a | 64.409 a | 57.576 b | 53.561 c | 10 |
| | 50.204 a | 47.060 b | 44.171 c | Average of biocha |

Means that share the same letter for each factor and the interaction between them do not differ significantly from each other according to Duncan's polynomial test at a probability level of 0.05.

4. Discussion

Discussion of the Vermicompost Effect Results

The study results showed that adding vermicompost to onion crops led to a significant increase in total chlorophyll content in the leaves, plant height, and leaf area, as shown in Tables 4, 5, and 6, particularly at the 10 t ha⁻¹ level, compared to the control treatment. This may be attributed to the role of vermicompost as a rich source of readily available plant nutrients, as well as its humic acid content, which stimulates physiological activity and increases photosynthetic efficiency (Aneseyee and Wolde, 2021). This effect may also be attributed to vermicompost's role in improving the soil's chemical and biological properties and activating microorganisms, thus increasing the availability and absorption of nutrients by plants. Furthermore, it contributes to increasing the soil's organic matter content, improving soil structure and its ability to retain water and nutrients, which enhances the soil's physical and chemical properties and increases onion plant productivity. This supports its adoption in sustainable agriculture and reduces the use of chemical fertilizers, which positively impacts photosynthetic efficiency, improves vegetative growth, and increases the translocation of photosynthetic products to the soil. Storage organs, and thus improved yield characteristics (Singh *et al.* 2019 and Higashikawa *et al.*, 2023).

Regarding the quantitative yield characteristics of green onion (Karbalai), the results showed that the vermicompost application treatments were significantly superior, with the highest application level (10 t ha⁻¹) showing the most significant improvement in average bulb weight, percentage of dry matter in bulbs, percentage of double bulbs, average biological bulb weight, biological yield per experimental unit area, and total biological yield per experimental unit area (t ha⁻¹), as shown in Tables (8, 9, 10, 11, 12, and 13) respectively. This may be due to the direct role of vermicompost in supplying the plant with macro and micronutrients during different growth stages, as well as stimulating the transfer of photosynthesis products from the leaves to the bulbs (Bhatt *et al.*, 2022 and Eisseler *et al.*, 2022). In addition to containing humic acids and natural plant hormones such as auxins and gibberellins, which stimulate cell division and elongation, improve the translocation of photosynthetic products and increase production (Arancon *et al.*, 2004 and Atiyeh *et al.*, 2002). This may be due to improving microbial activity in the root zone and increasing the availability of phosphorus and micronutrients, which helped to raise the efficiency of photosynthesis and increase carbohydrate accumulation, and to its stimulating effect on enzyme and hormonal activity within the plant, as well as its role in improving nitrogen and phosphorus absorption, which increased the efficiency of the translocation of photosynthetic products to the fruits (Gutierrez-Miceli *et al.*, 2007 and Sinha *et al.*, 2010) (Arancon *et al.*, 2005 and Joshi *et al.*, 2015). It may also be due to increased accumulation of carbohydrates and improved photosynthetic efficiency in the leaves, which positively impacted the quality of the yield, its storability, and increased the percentage of dry matter in the bulbs (Zhang *et al.*, 2020 and Higashikawa *et al.*, 2023).

Discussion of the Results of Biochar Application

The results studied in this experiment, and the data presented in the tables for some vegetative growth characteristics of onion plants, showed that the addition of biochar led to a significant increase in the total chlorophyll content in onion leaves (Table 4), particularly at the (7.5 t ha⁻¹) level, compared to the control treatment. This may be attributed to the multiple effects of the bioactive compounds present in biochar, which contribute to improving the physical and chemical properties of the soil and increasing its cation exchange capacity. This, in turn, leads to increased availability of nutrients adsorbed onto the soil colloidal surface and their easier absorption by plant roots, especially nitrogen and magnesium, two essential elements in chlorophyll formation (Atkinson *et al.*, 2010 and Sohi *et al.*, 2010). Adding biochar to the soil of onion plants contributed to an increase in plant height (Table 5). This is attributed to the increased chlorophyll content in the leaves (Table 4) and the increase in photosynthetic processes, which positively impacted the aforementioned traits. This may be due to improved soil aeration, reduced bulk density, increased soil porosity, and improved soil pH and C/H ratio, which in turn helped with better root system growth and spread, and increased water and nutrient absorption efficiency (Wan *et al.*, 2014; Rageendrathas and De Silva, 2017). It may also be because the addition of biochar improved the soil's chemical properties and the abundance of beneficial microbial organisms (PgPB), leading to better soil health and increased availability of potassium and calcium. These two elements are essential for the structure and regulation of vital processes, such as the transport of sugars and metabolic products to storage sites in fruits and their growth (Steiner *et al.*, 2007 and Major *et al.*, 2010).

The explanation may lie in several studies indicating that adding biochar led to a significant increase in plant height and chlorophyll content. This is attributed to improved soil structure, increased cation exchange capacity, and better nutrient retention and availability, particularly nitrogen, potassium, and calcium. It also reduces the negative effects of salinity by restoring ionic balance within the plant, mitigating the toxic effects of sodium ions and increasing potassium ion concentration. This positively impacts photosynthetic efficiency and significantly improves vegetative growth characteristics (Lehmann *et al.*, 2011 and Agegnehu *et al.*, 2017 and Seleiman *et al.*, 2021). These results are consistent with what (Song *et al.* 2014) found, who indicated that adding biochar to the soil is an indirect source of nutrients and its distinctive carbon content in photosynthesis processes, and contributes to improving the physical and chemical properties of the soil, improving the cation exchange capacity (CEC), and increasing plant growth. The results of this study showed a significant increase in the leaf area of onion plants (Table 6). This is likely due to the addition of biochar to the soil, which improved the plant's nutritional status and helped it retain beneficial microbial communities. This was achieved by increasing nutrient retention and reducing leaching losses, thus creating a more favorable environment for vegetative growth. The increase in plant height (Table 5) was also positively reflected in the increased leaf area, as shown in Table 6 (Jones *et al.*, 2012 and Alkheero *et al.*, 2019). It is also possible that the addition of biochar significantly improved yield characteristics, particularly the average weight of a single bulb and the percentage of dry matter (%), as shown in Tables 8 and 9, compared to the control group. Biochar is a rich source of organic carbon and has a large leaf area. High surface area and a large capacity for retaining nutrients and water within the soil, which leads to improved nutrient absorption efficiency and increased photosynthetic efficiency. The improved vegetative growth resulting from the addition of biochar is reflected positively in the increased synthesis of photosynthetic products and their transport from the leaves to the bulbs. This may be attributed to improved soil aeration, increased porosity, and decreased bulk density, which led to increased branching of the root system and increased absorption of water and nutrients, which contributes to increased bulb weight and a higher dry matter content. These results are consistent with the findings of several researchers who have confirmed that biochar improves nutrient utilization efficiency and enhances the translocation of photosynthetic products to storage organs, leading to improved yield characteristics and quality (Glaser *et al.*, 2015; Zhang *et al.*, 2020; Singh *et al.*, 2019; Liu *et al.*, 2020 and Aneseyee and Wolde, 2021). An increase in the percentage of double bulbs (Table 10) was observed when biochar was added at the studied levels, compared to the control group. This is likely due to improved nutritional conditions during the early stages of plant growth, which encouraged an increase in the number of buds within the bulb (Bhatt *et al.*, 2022 and Alsultan *et al.*, 2023). This may be attributed to all that was previously mentioned in the discussion of the distinctive effect of biochar in improving soil quality by affecting the

rhizosphere of roots and accelerating the decomposition of organic matter into elements available for absorption (Hussain *et al.*, 2022 and Yadav and Ramakrishna, 2023).

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تأثير سمادي الفيرمي كمبوست والفحم الحيوي في نمو وحاصل البصل الأخضر *Allium cepa* L.

احمد ارشد سعدون - رغيذ محمد حمزة السلطان

قسم البستنة وهندسة الحدائق - كلية الزراعة والغابات - جامعة الموصل - العراق

الخلاصة

أجريت هذه الدراسة خلال الموسم الربيعي 2025 في حقل الخضراوات التابع لقسم البستنة وهندسة الحدائق / كلية الزراعة والغابات / جامعة الموصل أجريت الزراعة بتاريخ 2025/1/27، بهدف دراسة تأثير سمادي الفيرمي كمبوست و الفحم الحيوي الى التربة قبل الزراعة والتداخل بينهما في نمو وحاصل محصول البصل الأخضر (*Allium cepa* L.). نُفذت التجربة وفق تصميم القطاعات العشوائية الكاملة (R.C.B.D.) بتجربة عاملية بعاملين: الفيرمي كمبوست بأربعة مستويات (0، 5، 7.5، 10 طن هكتار⁻¹) والفحم الحيوي بثلاثة مستويات (0، 5، 7.5 طن هكتار⁻¹) تم تحليلها احصائياً حسب التصميم المستخدم وقورنت المتوسطات حسب اختبار دنكن المتعدد الحدود عند مستوى احتمال 0.05. أظهرت النتائج أن إضافة الفيرمي كمبوست أدت إلى تحسين في صفات النمو والحاصل، إذ حقق مستوى (10 طن هكتار⁻¹) أعلى القيم المعنوية في معظم صفات النمو الخضري (الكلوروفيل وارتفاع النبات، والمساحة الورقية)، فضلاً عن مؤشرات الحاصل الكمي مثل معدل وزن البصلة الواحدة بدون أوراق، والنسبة المئوية للمادة الجافة في الأبصال، والنسبة المئوية الأبصال المزوجة، ومعدل وزن البصلة البايولوجي، وحاصل وحدة المساحة التجريبية، والحاصل البايولوجي لوحدة المساحة الكلي، والنسبة

المئوية للتبصيل (50.201 ملغم.غم⁻¹، 69.265 سم، 405.160 سم²، 38.833 غم، 25.009 %، 13.33 %، 193.267 غم، 3.862 كغم، 58.515 طن هكتار⁻¹، 34.861 %) وعلى التوالي، متفوقاً على بقية مستويات الإضافة ومعاملة المقارنة. كما بيّنت النتائج وجود تأثير معنوي لإضافة الفحم الحيوي في جميع الصفات المدروسة، إذ تفوقت معاملة الإضافة بمستوى (7.5 طن هكتار⁻¹) معنوياً في محتوى الكلوروفيل الكلي في الأوراق، وارتفاع النبات، والمساحة الورقية للنبات، ومعدل وزن البصلة الواحدة بدون أوراق، ومعدل وزن البصلة البايولوجي، والحاصل البايولوجي لوحدة المساحة التجريبية، والحاصل البايولوجي لوحدة المساحة الكلية، النسبة المئوية للمادة الجافة في الأبخال، والنسبة المئوية للأبخال المزروجة، والنسبة المئوية للتبصيل مقارنة بمعاملة عدم الإضافة وإضافة للمستوى (5 طن هكتار⁻¹)، (44.507 ملغم.غم⁻¹، 65.471 سم، 344.180 سم²، 38.369 غم، 165.667 غم، 3.313 كغم، 50.204 طن هكتار⁻¹، 21.842 %، 8.75 %، 30.914 %) وعلى التوالي. أمّا معاملات التداخل الثنائي فقد أظهرت تفوقاً معنوياً عند معاملة تداخل إضافة (10 طن هكتار⁻¹) من الفيرمي كمبوست مع (7.5 طن هكتار⁻¹) من الفحم الحيوي في معظم الصفات المدروسة، ولاسيما في ارتفاع النبات، والمساحة الورقية، ومعدل وزن البصلة الواحدة بدون أوراق، ونسبة الأبخال المزروجة، والوزن البايولوجي للبصلة، والحاصل البايولوجي لوحدة المساحة التجريبية، والحاصل البايولوجي لوحدة المساحة الكلية فضلاً عن النسبة المئوية للتبصيل. (71.213 سم، 435.310 سم²، 43.343 غم، 18.33 %، 212.533 غم، 4.251 كغم، 64.409 طن هكتار⁻¹، 38.488 %) مقارنة بجميع معاملات التداخل الأخرى ومعاملة المقارنة التي سجلت أدنى القيم.

الكلمات المفتاحية: البصل، فيرمي كوبوست، فحم حيوي