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Detecting the effect of the organic and mineral fertilizers on the onion growth and the microbes of soil revival

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Abstract

Investigating the influences of organic and mineral fertilizers on onion plant development and microorganisms, aiming to compensate for the negative environmental and living effects of chemical fertilizers. The study examined onion plant responses to organic and mineral fertilizers using four isolated microbes from soil, including Pseudomonas aeruginosa, Klebsiella pneumoniae, Bacillus subtilis, and Escherichia coli, investigating their physicochemical characteristics and bacterial vaccines using culture media and conditions, conducted during the 2023-2024 season. The plants' leaves' height and length were unaffected by the fertilizers used. However, the use of poultry manure led to a significant increase in plant leaf numbers, with the lowest number being 21.10 leaves for chemical fertilizer treatment. Fresh and dry weights also increased significantly, reaching 95.15 g and 4.20 g, respectively. Sheep manure treatment did not significantly affect the number of bulbs. The population density of the four isolates was higher in areas with higher organic and mineral matter content and vegetation cover. The plant height was superior in the treatment of adding organic and mineral matter, reaching 72.10 cm. The interaction between microbial treatments and organic and mineral matter had a significant effect on plant height. The treatment mixing the four isolates with fertilizers also outperformed the average plant height, reaching 70.65 cm. Research in agriculture highlights the importance of mineral and organic fertilizers in enhancing plant growth, soil properties, and essential element absorption, thereby enhancing photosynthesis and auxin production, and improving soil and plant fruit quality.

Keywords: Microbiology, Mineral fertilizers, Organic fertilizers, Root vegetables.

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1. Introduction

Recently, new methods have been developed as alternatives to chemical fertilizers and pesticides in order to reduce and limit the effects resulting from their excessive use and the dangerous environmental impacts on living organisms, including humans. This has led the world to adopt the method of clean agriculture or organic agriculture by utilizing natural resources such as organic fertilizers of both animal and plant types [1] in addition to mineral fertilizers, which have a positive and significant impact, they increase production, improve the product in terms of quantity and quality, and reduce the cost of production compared to manufactured chemical fertilizers, which are relatively expensive compared to organic and mineral fertilizers. It can be said that they are safe and environmentally friendly [2]. Good organic fertilizer is one that ensures there is no imbalance in plants and has a low content of salts, weed seeds, and pollinating units of pathogens, and it can be added to crops as mentioned [3]. The effect of organic matter is twofold: firstly, it improves various soil characteristics; secondly, it enhances soil fertility. The significance of the first aspect outweighs that of the second, given its importance in influencing the physicochemical properties of the land, particularly permeability, as well as the movement of water and air within the soil [4]. Mineral fertilizer is one of the essential nutrients for plants, which are absorbed in greater quantities than other nutrients due to their importance in feeding plants. Therefore, fertilization has become a vital factor for the development and growth of modern agriculture. Fertilization is also considered one of the most advanced agricultural sciences at present [5]. In the field of agriculture, research is crucial. Mineral and organic fertilizers enhance the chemical and physical characteristics of the soil, promote plant development, and improve the plant's ability to absorb vital components like nitrogen, which is essential for chlorophyll production. This accelerates photosynthesis and inhibits the synthesis of auxin, which is vital for amino acid synthesis. In addition to microorganisms, tryptophan fertilizers also help to improve the soil and promote fruit growth. The use of organic and mineral fertilizers significantly affects vegetable growth and soil microbiology. Organic fertilizers, such as compost and manure, promote soil fertility, structure, and biota, leading to improved vegetable yields and quality [6]. Mineral fertilizers, such as NPK, provide essential nutrients for plant growth, but excessive use can lead to soil degradation and environmental pollution [7]. Fertilization techniques change the makeup and quantity of soil bacterial and fungal populations [8]. Organic fertilizers tend to increase microbial diversity, while mineral fertilizers can reduce it Guo, et al. [9]. A study on wheat-maize rotation systems found that partial replacement of NPK fertilizers with biofertilizers improved soil nutrient contents, enzyme activities, and microbial diversity [10]. Improved soil fertility through organic fertilizers enhances soil organic matter, nitrogen, and phosphorus availability, leading to increased crop productivity [11]. Biofertilizers stimulate soil microbial metabolism, promoting beneficial microbial taxa and improving soil health [12]. Integrating organic and mineral fertilizers offers a promising approach to sustainable agriculture, reducing environmental risks associated with excessive chemical fertilizer use [13].

The study aims to determine the possibility of using organic and mineral fertilizers to improve the growth of onion plants and to assess their impact on microorganisms. It also seeks to evaluate whether these fertilizers can replace chemical fertilizers, considering their adverse effects on living organisms and the environment.

2. Materials and Methods

The experiment utilized one of the common root vegetables, which is onions, and was conducted in the Abu-Chraib district on agricultural land during the 2023-2024 season to study the impact of using different kinds of organic and mineral fertilizers on the growth of onion plants and their effect on microscopic soil life. The experiment included five treatments: chemical fertilization at 60 Kg/dunam, urea at 60 kg/dunam, superphosphate, 60 Kg/dunam of potassium sulfate, and poultry manure at a rate of 15 m^3/dunam. Sheep manure was applied at a rate of 25 m^3/dunam, horse manure at 35 m^3/dunam, and mineral fertilizer at a rate of 40 m^3/dunam in the form of urea (46% nitrogen) [14].

2.1. Isolation of Bacteria from Soil

Twelve samples were collected from different agricultural Fields in the Abu-Chraib district Table 1, and from different locations, the samples were placed in plastic bags and then transferred to the laboratory. They were divided into two sections: one to isolate bacteria, specifically species intended for use in the experiment, *Pseudomonas aeruginosa, Klebsiella pneumoniae, Bacillus subtilis, and Escherichia coli*. The other section was used to conduct physico-chemical tests of the soil from the experimental field, Table 2. The decimal thinning method was used as mentioned [14] in isolating the required bacterial species from the soil and on the culture media specific to each type. After purifying the isolates, they were diagnosed phenotypically and microscopically, as mentioned [15].

Table 1.
Areas from which soil samples were taken.

Area	The type of girls implanted
AlHamdaniyah	Radish
victory and peace	Radish
Similar	Potatoes
Zidane	Radish
ALRisala area	Potatoes
Olives area	Potatoes

Table 2.
Some physio-chemical characterization of organic and mineral wastes and field soil.

Units	Value	Adjective
-	7.5	PH
9/Kg	9	Organic Mater
Dessemns/M	3.25	Electrical conductivity (EC)
PPM	54	Nitrogen (N)
PPM	150	Potassium (K)
PPM	45.62	Phosphorus (P)
9/Kg	220	calcium carbonate
9/Kg	380.5	Sand
9/Kg	170.3	Clay
9/Kg	235.8	Alluvial
-	Mixture	Soil texture

2.2. Preparation of Bacterial Vaccine

The vaccine of each isolate was prepared by inoculating [4]. Glass flasks of a volume of one hundred milliliters were equipped with 40 ml of peptone, an activated medium. Each flask was inoculated with the vaccine of bacterial isolates and placed in an electric vibrating incubator for 10 minutes, then transferred to an incubator at 30°C for 3 days to obtain the maximum amount of vaccine. Subsequently, 5 ml of the liquid culture of each bacterial species was taken and added to 1-liter flasks containing 300 ml of activated medium, then placed in an incubator at 30°C for 3 days. The experiment was conducted based on a completely randomized block design in the Abu-Chrib district, in mixed soil, and was divided into three sectors. Treatments were randomly distributed to the experimental units in each sector, with three replicates for each treatment, involving four isolates of *P. aeruginosa*, *K. pneumoniae*, *B. subtilis*, and *E. coli*. These were combined with the addition or non-addition of organic and mineral materials, respectively, including a comparison treatment with and without organic and mineral materials. Additionally, materials mixed with poultry, horse, and sheep waste were added at a rate of 40 kg/dunam, as mentioned by de Andrade, et al. [16]. Holes were made in the soil along the planting line at a depth of 20 cm, and the bulbs were planted on 10/15/2023. The bulbs were immersed in the bacterial vaccine for 30 minutes and then planted at a distance of 20 cm between each plant [17], taking into account planting bulbs that were not inoculated with bacteria first to ensure that they are not contaminated. After completing the planting, irrigation was carried out uniformly for all transactions as mentioned [18]. The plant was harvested manually on 15/3/2024 when the plant's flower leaves began to appear [19]. Took a group of plants to record measurements of vegetative growth, which included plant height, length, several plant leaves, fresh and dry weight, and some bulbs.

2.3. Statistical Analysis

The collected data have been statistically analyzed using the SAS system [20]. The averages were also calculated according to Duncan's multiple range test at the 0.05 level.

3. Results and Discussion

The effects of different types of fertilizers on plant characteristics were studied. The results showed no significant effects on onion leaf height and length when treated with various fertilizers. However, poultry manure significantly increased the number of plant shoots, reaching 26.14 leaves, outperforming the other five treatments. The lowest number of leaves was 21, observed in the chemical fertilizer treatment Table 3.

Table 3.
The effect of fertilizers on the height, length, and number of plant leaves.

Transactions	Plant height	Leaf length	Number of leaves
Mineral Fertilizer	79.20*	71.50*	24.41
Poultry Manure	77.56*	66.70	26.14*
Sheep Manure	74.30*	65.30*	22.60
Horse Manure	77.25*	69.42*	23.20
Chemical fertilizer	80.40*	70.33*	21.10

Note: *Similar signals do not have significant differences below the 0.05 probability level
The averages indicated do not have significant differences below the 0.05 probability Level.

There is a significant increase in both fresh (5.15 g) and dry weight (9.20 g) of leaves in the poultry manure group treatment (sheep manure), while the number of bulbs was not significantly affected by the fertilizer group [21]. Also, the organic fertilizer group treatment improved by increasing the same vegetative characteristics due to the mixing of organic fertilizer with poultry, which affects the physico-chemical and bio-properties of the soil and its capacity for H_2O retention. Especially since the soil of the study field is mixed, and the percentage of sand in it is 380.5, in addition to increasing its content of the main nutrients, especially nitrogen, phosphorus, and potassium [12]. The increase in the availability of nutrients in the soil enhanced the efficiency of element absorption by the plant, which was reflected in the improvement of vital processes such as nitrogen assimilation. The formation of chlorophyll and other characteristics increased, thereby enhancing the efficiency of the photosynthesis process and protein synthesis [22]. Nitrogen also stimulates the plant to produce auxin (IAA) as nitrogen is an essential element for building the amino acid tryptophan, which is the basic material for synthesizing indole-3-acetic acid [23]. The role of auxin is known in encouraging cell division and elongation, and all of these lead to the formation of substantial vegetative growth, which increases the leaf area of the plant and, consequently, the fresh and dry weight. These results are consistent with Muscolo, et al. [24]. The averages indicated do not have significant differences below the 0.05 probability level, Table 4.

Table 4.
Effect of fertilizers on the fresh and dry weight of leaves and the number of bulbs.

Transactions	Fresh weight	Dry Weight	Number of bulbs
Mineral fertilizer	80.22 Δ	11.00 Δ	4.30*
Poultry Manure	95.15	12.30 ◯	4.25*
Sheep Manure	75.28 Δ	9.20 Δ	414*
Horse Manure	86.33□	10.75□	4.28*
chemical fertilizer	85.8*	12.50*	4.10*

Note: *Similar signals do not have significant differences below the 0.05 probability level

The results of isolation and estimation of the population density of the isolated bacterial isolates also showed *P. aeruginosa, K. pneumoniae, B. subtilis,* and *E.coli.* In Table 5, the results showed that isolate P_4 was the most dense recording, 42×10^5, which was isolated from the Hamdaniyah region from the radish crop, while isolate K_2 recorded 38×10^5, which was isolated from the Al-Samilat region from the potato crop. Among the three isolates, *E.coli* bacteria recorded the highest density of 29×10^5, isolated from the Al-Zaidan area of the potato crop.

Table 5.
Population density of four bacterial isolates.

Bacterial Isolates	Isolation	Place of Isolation	The Crop Grown	Bacterial Renovation
P. aeruginosa	P1	Al-Zaytoun	Potatoes	12
P. aeruginosa	P2	Al-Risala	Potatoes	21
K. pneumoniae	K2	Smileys	Potatoes	15
K. pneumoniae	K1	Smileys	Potatoes	38
K. pneumoniae	K3	Victory and Peace	Potatoes	20
B. subtilis	B1	Al-Hamdaniyah	Radish	14
B. subtilis	B2	Al-Risala	Radish	36
E. coli	E1	Al-Zaidan	Potatoes	24
E. coli	E2	Al-Zaytoun	Radish	22
P. aeruginosa	P3	Zaytoun	Potatoes	18
P. aeruginosa	P4	Al-Hamdaniyah	Radish	42
E. coli	E3	Al-Zaidan	Radish	10

As for *B. subtilis* bacteria, it recorded the highest density of 36x18, isolated from the Al-Risala neighborhood area. This difference in the presence of the numbers of the four bacterial isolates is attributed to the type of soil, its content of organic and mineral matter, and vegetation cover. Additionally, the nature of the microscopic salinizing organisms in each area influences these variations [25, 26].

Table 6.
Effect of different treatments on plant height.

	+ OXMi	-OXMI	M
Control	66.35	40.49	52.50
P. aeruginosa	69.70	46.50	56.20
K. pneumonia	68.80	42.11	53.41
B. subtilis	69.05	45.00	56.00
E. coli	79.70	4700	57.00
MIX	70.65	50.30	61.55
M	72.10	45.60	
LeD=0.05	0.75	0.464	+0xMi -0xMi 1.045

Note: -0xMi: without adding organic and mineral materials
+0xMi: adding organic and mineral materials

The results of the treatment of the four bacterial isolates, their mixing, and the addition or non-addition of organic and mineral materials showed that the effect depended on the type of microorganisms added and the fertilizers used, as the results are shown in Table 6 the average plant height was recorded in the treatment of adding organic and mineral materials at 72.10 cm. It was morally superior compared to the treatment without adding fertilizers, which recorded a height of 75.60

cm. The treatment also outperformed the bacterial species *P. aeruginosa* and *K. pneumoniae* and the plant growth stimulant and their mixture, which significantly affected the plant height, reaching 56.20 cm, 53.20 cm, 56.00 cm, 57.00 cm, and 61.55 cm. The interaction between microbial treatments and organic matter had a significant effect on plant height. The treatment of mixing the four isolates with fertilizer was significantly superior in the plant, with a height reaching 70.65 cm, compared to the control treatment without adding fertilizers, which reached 40.49 cm [27, 28].

4. Conclusions

The results showed that organic fertilization (poultry, horse, and sheep waste) and mineral fertilization using bacteria that stimulate the growth of onion plants had a significant effect on the height of onions and contributed to increasing the number of microorganisms in the soil [26, 28] this is due to the organic matter containing many essential nutrients that are easily absorbed by the plant in a balanced manner, which promotes the growth and development of the vegetative group through cell division and elongation, as well as protein synthesis. The role of microorganisms in enhancing the growth standards of the onion plant is attributed to their effect on the metabolic processes occurring within the plant [29, 30] and stimulates the production of many plant growth regulators, such as auxin, gibberellins, and cytokinins, in addition to increasing the availability of some nutrients necessary for the plant, such as nitrogen, phosphorus, iron, and other essential elements in the plant's life cycle [31]. In addition, organic and mineral fertilizers contributed to increasing the activity of microbial enzymes such as dehydrogenase, nitrogenase, and urease [32].

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