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Evaluation of the effect of integrated fertilization on some soil Armenian cucumber properties and the growth and yield of (*Cucumis melo* var.flexuosus Nauds)

Kadhimiyah Jawad AL-Mmansor

Abstract

This study aimed to evaluate the effect of integrated fertilization (chemical, organic, and biological) on some chemical and biological properties of soil as well as the growth and yield of Armenian cucumber (*Cucumis melo* var. flexuosus).

A field experiment was carried out with five fertilizer treatments (control without fertilizer, chemical fertilizer (CF), organic fertilizer (OF), biological fertilizer (BF) and their mixture (CF+OF+BF). The following properties were evaluated: soil salinity (EC), soil reaction (pH), organic matter content (OM), NPK concentration in soil and plant, and numbers of Azotobacter and Pseudomonas bacteria in the rhizosphere.

The results showed that the integrated fertilization treatment was superior in improving the chemical properties of the soil, as it reduced the EC and pH values, and increased OM. It also recorded the highest concentrations of major nutrients in the soil and plant (N: 40,000, P: 44,000, K: 40,000 mg kg^{-1}), compared to the control treatment.

It led to a significant increase in the numbers of beneficial bacteria 28.66×10^3 and 23.33×10^3 cfu /g soil for Azotobacter and Pseudomonas, respectively. These results confirm the effectiveness of integrated fertilization in enhancing soil fertility and improving nutritional and biological efficiency, which supports its adoption as a sustainable strategy as an alternative or complement to traditional chemical fertilization.

Keywords: Integrated fertilization ,Organic fertilization, Bio-fertilizers, Sustainable agriculture.

I. Introduction

Fertilization management is a fundamental pillar in enhancing crop productivity and improving crop quality. It also contributes effectively to maintaining soil fertility and the sustainability of agricultural systems (Meena *et al*., 2017). In light of the increasing environmental challenges resulting from the excessive use of chemical fertilizers, research efforts have shifted toward adopting modern technologies based on organic and biodynamic agriculture, including the use of organic fertilizers and biofertilizers containing beneficial microorganisms that improve both soil and plant health (Zaki and Abdel Halim, 2007). Achieving optimal plant growth requires a soil environment with favorable physical, chemical, and biological properties, most notably an abundance of essential nutrients. (Patel *et al*., 2016) However, Iraqi soils are often characterized by high calcium carbonate content and high pH values, which leads to the fixation of some major nutrients, such as phosphorus and nitrogen, and thus reduces their availability to plants. This also increases the likelihood of environmental pollution and the degradation of soil microbiome (Alguacil *et al*., 2005). From this perspective, the concept of integrated fertilization has emerged as a sustainable solution (Parewa *et al*., 2014). It is a system that relies on combining organic, chemical, and biological fertilizers to improve the efficiency of nutrient absorption, reduce negative environmental impacts, and lower economic costs. Studies indicate that this type of fertilization enhances plant growth, improves plant nutritional status, and increases the quantity and quality of crops (Patel and Minocheherhomji, 2018). Organic farming is an integrated agricultural system that ensures the production of clean and healthy food through environmentally and economically sustainable means, while maintaining ecological balance and biodiversity (Al-Halfi and Falih, 2017).

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TheArmenian cucumber (Cucumis melo var. flexuosus Naud) belongs to the Cucurbitaceae family and is an economically important summer vegetable crop in Iraq, where it is grown for its fresh fruit. The cultivated area in Iraq has reached approximately 65,715 dunums, with a production of 158,835 tons, of which 19,320 dunums were in Basra Governorate, with a production of 34,776 tons (Ministry of Planning/Central Statistical Organization). Many Iraqi agricultural soils suffer from deteriorating fertility due to unsustainable agricultural practices, particularly the excessive use of chemical fertilizers, which has contributed to the deterioration of the soil's physical, chemical, and biological properties and a decline in its productivity. Therefore, this study aims to evaluate the impact of integrated fertilization systems on some soil fertility properties and on the growth and yield of the cucumber plant. It also aims to compare these systems with traditional agriculture in the region, attempting to understand possible improvement mechanisms and providing scientific recommendations based on experimental data that support sustainable agricultural trends in Iraq.

II. Materials and Methods

This study was conducted during the 2018 growing season in a private agricultural field located in the Al-Hawtah area/Shatt al-Arab district in Basra Governorate . The soil type was classified as silty clay . the objective was to evaluate the impact of integrated fertilization (biological , organic , chemical) on the growth and yield of Armenian cucumber plants, and to compare this with the traditional fertilizer used in the region. Soil samples were randomly taken from different locations in the study area before planting at a depth of 0-30 cm to form a composite sample. Part of the sample was refrigerated until biological analysis was performed. The soil was then air-dried, ground, and sieved through a 2 mm sieve. Chemical and physical analyses were performed (Table 1).

Table (1) Some physical, chemical and biological properties of the study soil

values	Unit of measurement			Cretirea
7.6	—			pH
8.8	$^{1-}$ds m			EC
11.07	$^{-}$Cmol(+) Kg^{1}			CEC
152.03	g kg^{-1}			$CaCO_3$
0.18	g kg^{-1}			Organic matter
12.37	Mmole L^{-1}			Ca
7.4	Mmole L^{-1}			Mg
22.01	Mmole L^{-1}			Cl
0.0	Mmole L^{-1}			CO_3
18.3	Mmole L^{-1}			HCO_3
0.17	g kg^{-1}			Total N
11.9	m g kg^{-1}			Avail.N
0.18	Mmole L^{-1}			P
1.11	Mmole L^{-1}			K
Silty clay	%sand	%silt	%clay	Soil texture
	9.47	42.25	47.38	

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10^6 * 3.4	**Cfu gm^{-1}**	**Total bacteria**
10^3 * 0.51	**Cfu gm^{-1}**	**Total fungi**
10^2 * 0.99	**Cfu gm^{-1}**	**Azotobacter**
10^2 *0.0003	**Cfu gm^{-1}**	**Psedomonas**

The land was plowed, leveled, and divided into three equal sectors. After that, grooves were opened in each sector to a length of 3 m and a width of 40 cm, with a distance of 2 m between each groove. Then, holes were dug 10 cm deep on both sides of the groove, with a distance of 50 cm between each hole. Treatments were distributed randomly within the sectors. The soil was moistened, then Armenian cucumber seeds (Nauds flexuosus.var melo Cucumis), the local variety (germination rate 90%), were sown, with three seeds in each hole. The plants were watered periodically to reach field capacity, based on the soil moisture content during the growing season.

Preparing biofertilizers

Azotobacter and Pseudomonas bacteria:

Inoculate the liquid medium (Sucrose Mineral Salts) by taking 1 cm3 of the above-prepared soil dilutions to inoculate test tubes containing 9 cm3 of the above-prepared specialized medium, which was sterilized in an autoclave for 20 minutes at a temperature of 121 °C and a pressure of 1.5 kg.cm-2, with five replicates for each dilution. The tubes were incubated at a temperature of 28 °C for 5 to 7 days. The tubes were examined by observing the brown film formed on the surface, which is a positive indicator for the growth of Azotobacter bacteria. Then, the number of bacteria was counted by the most probable count method.

For the purpose of purifying Azotobacter bacteria, 0.1 cm3 was taken from the tubes that gave a positive growth indicator and spread on the surface of a Petri dish containing solid medium (Sucrose Mineral Salts Agar). The dishes were incubated at a temperature of 28°C for 2 to 3 days until colonies appeared. Then, the plan was repeated four consecutive times in order to obtain pure isolates of bacteria. Using this method, pure isolates of *Azotobacter.spp.* were obtained.

Slant agar tubes were prepared from the specialized medium for the purpose of preserving the isolates in the refrigerator by taking a portion of the pure culture growth using a loop and inoculating the slant agar tubes and placing them in the incubator at a temperature of 28°C for one day, then transferring them to the refrigerator. (Sharma, 2003; Black, 1965).

Sloping cultures were prepared for isolation, after which 2 ml of sterile distilled water was added to the culture. The growth was harvested and transferred to sterile transparent plastic tubes for the purpose of standardizing its concentrations by comparing it to the standard turbidity. 1 ml of the isolate was taken and inoculated with a liter or half liter liquid culture medium as required. The inoculated cultures were then incubated in a shaking incubator at 100 rpm and a temperature of 28°C for three days. After the growth period, this bacterial culture was ready for withdrawing the liquid bacterial inoculum from it.

In this way, liquid vaccines with uniform numerical densities were prepared using McFarland's standard solution to avoid the effect of the vaccine density or concentration on the course of the experiment. The numerical density of the liquid vaccines of Azotobacter isolates for use in the biofertilization treatment was 108 cfu ml-1.

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The isolate was obtained from the Department of Plant Protection, College of Agriculture, University of Basra, and preserved on Kings medium for 24 hours. The isolate was stored at 4°C and activated every 3-4 weeks by growing it for 24 hours on Nutrient Broth (Stephane and Jacques, 2000).

The liquid inoculum was prepared for the isolation of Azotobacter bacteria and Pseudomonas bacteria and placed in a sterile container. The local cucumber seeds were soaked in it with the addition of Arabic gum to increase the adhesion of the seeds. The inoculated seeds were left for an hour and a half, away from direct sunlight or temperatures above room temperature, to allow the inoculum to adhere to the seeds. Some seeds were left uninoculated as a control treatment. Then the inoculated and uninoculated seeds were planted in the designated soil according to the treatments:

1. Comparative treatment without using organic, biological, or chemical fertilizers. 2. Chemical Fertilization Treatment: Nitrogen was added in the form of urea fertilizer (46% N (240 kg N -1 ha) in two doses during the growing season. The first dose was added 30 days after planting, and the second dose was added 60 days after planting. As for phosphorus and potassium fertilization, triple superphosphate (47% P2O5) was used as a source of phosphorus, at a level of 160 kg P2O5 per ha-1, and 200 kg K2O per ha-1, and potassium sulfate (43% K) were used. These fertilizers were added in two doses, the first at flowering and the second at fruiting.

3. Organic fertilizer at a level of 5% of the dry soil weight.

4. Biofertilizer (a mixture of Azotobacter and Pseudomonas bacteria).

5. Organic fertilizer + biofertilizer + chemical fertilizer

Crop maintenance operations were carried out identically for all treatments until the end of the growing season. Soil samples were collected at the end of the season from the 0-30 cm layer of the soil surface. Composite samples were taken from the middle of the experimental unit and placed in plastic bags immediately afterward. They were air-dried, ground, and sieved through a 2 mm sieve. They were stored in plastic bags until analysis. A portion of the samples was kept undried and unground for biological measurements. Leaf samples were taken at the same time as soil samples. A whole plant was placed in paper bags, transported to the laboratory, wiped with a cloth moistened with distilled water, and then oven-dried at 70°C until completely dry. They were then ground and stored in plastic bags until elemental determination was achieved. At the end of the season, soil salinity, soil reaction rate, available nitrogen, phosphorus, and potassium in the soil samples and soil organic matter were estimated.

The nitrogen, phosphorus, and potassium content of the vegetative part was estimated according to the method of Bremner (1970) and Murphy and Riley (1962). The numbers of Azotobacter and Pseudomonas bacteria in the rhizosphere soil after harvest were estimated using the most probable count method. The results were statistically analyzed using a randomized complete block design (RCBD). Data were analyzed using SPSS version 11, and means were compared at the 0.05 probability level (Al-Rawi and Khalaf Allah, 2000).

III. Results and Discussion

The effect of five fertilizer treatments (chemical fertilizer, organic fertilizer, biological fertilizer, their mixtures, and a control treatment without fertilizer) on some soil chemical properties (salinity (EC), pH, organic matter content (OM), and the major nutrients nitrogen (N), phosphorus (P), and potassium (K)) was evaluated.

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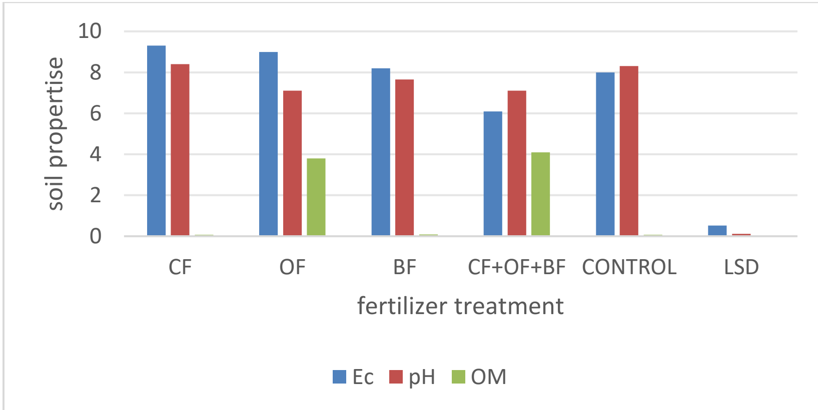

Figure (1) The effect of integrated fertilization treatments (mineral fertilization CF, organic fertilization OF, biofertilization BF and their mixture) on some soil properties (soil salinity EC, soil reaction degree pH and soil organic matter content OM)

The results (Figure 1) showed that the chemical fertilization treatment (CF) gave a significant increase in the value of electrical conductivity (EC) and acidity (pH) which reached 9.2 and 8.3, respectively, while it did not affect the soil organic matter (OM) content. The organic fertilization treatment led to a significant increase in the salinity values and a reduction in the degree of soil reaction, in addition to increasing the soil organic matter content. As for the results of the biological fertilization, its addition led to an increase in the value of soil salinity and a reduction in its degree of reaction, but did not significantly affect the values of organic matter in it.

All fertilizer treatments, especially the integrated fertilization treatment CF+OF+BF, contributed to reducing the EC and pH values and increasing the OM content compared to the control, indicating an improvement in the soil chemical properties. The decrease in EC and pH is attributed to the role of organic matter and microorganisms in salt balance and adjusting alkalinity. The addition of organic wastes reduces soil salinity in the surface layer and is a successful practice to reduce the damage caused by irrigation water salinity due to improving soil permeability, washing salts down to the root zone, in addition to adjusting the nutritional balance that is disturbed due to the increase in soil solution salinity (Mahdy, 2011).

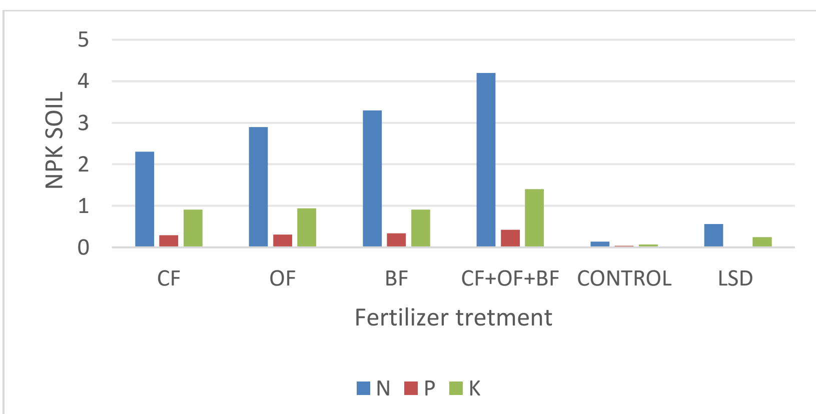

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Figure (2) The effect of integrated fertilization treatments (mineral fertilization CF, organic fertilization OF, biofertilization BF and their mixture) on the soil NPK content.

The results of Figure (2) showed that the integrated fertilization treatment (CF+OF+BF) was superior in raising the concentration of NPK elements in the soil, as the highest values were recorded for nitrogen (4.3), phosphorus (1.3), and potassium (1.5). This reflects the cumulative and symbiotic effect of using more than one type of fertilization in improving the nutritional balance of the soil, which enhances its ability to continuously provide elements to the plant. This improvement is attributed to the integrated role of organic matter in improving the physical and chemical properties of the soil and to microorganisms in facilitating the absorption of elements, in addition to mineral fertilization as a direct source of elements.

The lowest values were recorded in the control treatment (CONTROL), where NPK levels dropped to the lowest values for all elements, reflecting poor soil fertility without the addition of fertilizer. The organic fertilization (OF) treatment also showed relatively low levels, particularly of phosphorus and potassium, indicating slow decomposition of organic matter and its longer duration of availability. It is noted that the biofertilization (BF) and mineral fertilization (CF) treatments contributed effectively to raising NPK content compared to the control treatment, but to a lesser extent than integrated fertilization, indicating that using a single type of fertilizer may not be sufficient to achieve optimal nutrient response (TNAU, 2019).

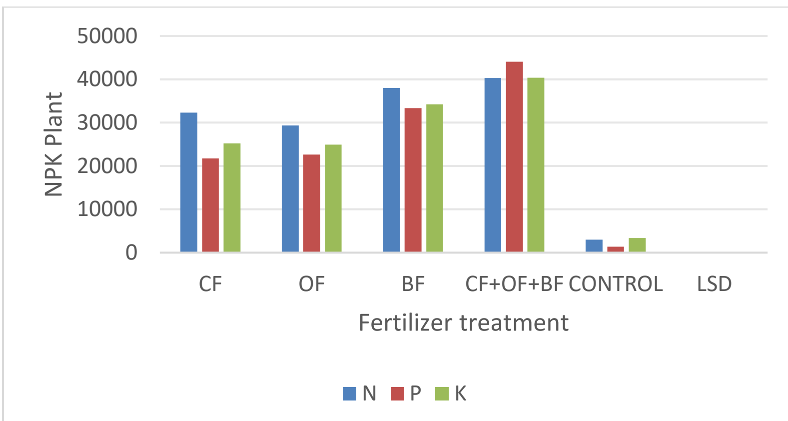

Figure (3) The effect of integrated fertilization treatments (chmical fertilizaer CF, organic fertilizer OF, biofertilizer BF and their mixture) on the plant's NPK content (mg.kg-1)

It is noted from Figure (3) that the addition of chemical fertilizer significantly affected the content of nitrogen, phosphorus and potassium in the plant, as it gave (32333, 21333, 25000) respectively. Also, the addition of organic fertilizer significantly affected the content of the cucumber plant of nitrogen, phosphorus and potassium, and the cucumber plant's content of NPK elements increased when the biofertilizer was added. As for integrated fertilization, it had the most important role in increasing the plant's content of NPK elements, as its rates reached (40000, 44000, 40000), compared to the comparison treatment (without fertilization).

Chemical fertilization alone is not preferred in sustainable agricultural systems due to its high cost, deterioration of soil properties and causing imbalance between nutrients in the soil solution. The superiority of integrated fertilization treatment (chemical + organic + biological) over chemical fertilization alone is due to the fact that organic fertilizer increases the soil's ability to hold water, thus increasing the availability of added nutrients, in addition to increasing

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the soil CEC, thus preserving nitrogen from loss, as well as increasing the activity of the urease enzyme and reducing its decomposition by the protease enzyme (Nsabimana *et al*., 2004).

Table (2) The effect of adding fertilizer treatments (comparison treatment, chemical fertilizer FC, organic fertilizer OF, biofertilizer BF and their mixture) on the numbers of Azotobacter and Pseudomonas bacteria in the rhizosphere soil after harvest (cell. gm-1 soil * 102).

LSD	Fertilizer treatment					
	CF+OF+BF	BF	OF	CF	CONTROL	
1.25	28.66	13.110	3.559	2.963	.130	Azotobacter
0.03	23.330	10.31	.350	.850	.080	Psedomonas

It is noted from Table (2) that the different fertilization treatments (FC chemical fertilizer, OF organic fertilizer, BF biofertilizer and their mixture) significantly affected the increase in the numbers of Azotobacter and Pseudomonas bacteria after harvest, and the highest rate was affected by the integrated fertilization treatment (CF+OF+BF) and reached 28.66*103 and 23.330 cells. g -1 soil for Azotobacter and Pseudomonas bacteria, respectively, while the lowest rate was 0.08*103 and 0.130 cells. g -1 soil for Azotobacter and Pseudomonas bacteria, respectively, for the comparison treatment (without fertilization). Also, the addition of nitrogen fertilizer and organic fertilizer led to a significant increase in the number of Rhizobium bacteria after harvest, while the addition of biofertilizer led to a significant increase in the number of Rhizobium bacteria after harvest. The addition of organic fertilizers increases the microorganisms as well as increases the activity of various enzymes, thus improving the bioenergy and enzymatic properties in the soil. In addition, organic fertilizers have the ability to reduce the values of bulk density, soil reaction degree, electrical conductivity, and increase available water and nutrients (Joshi *et al*., 2016).The increase in the number of Azotobacter bacteria in the rhizosphere soil of Armenian cucumber plants, especially with the effect of the integrated fertilizer treatment (CF+OF+BF), indicates the importance of relying on integrated fertilization with reducing chemical fertilizer to safe limits to provide a suitable environment and nutritional elements for the plant and reduce environmental pollution resulting from its use and economic cost to ensure the success of sustainable agriculture.

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