Effect of type and concentration of positive salt ions on the growth of Bacillus bacteria and wheat plant growth

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Abstract

This study was conducted at the research station and laboratories of the College of Agriculture, University of Kufa, in the year 2023-2024 to know the effect of different salinity levels at concentrations of (75, 50, 25, 0) mM of sodium and magnesium chloride salts on the effectiveness and activity of Bacillus bacteria and the growth and production of wheat in a sandy loam soil. 10 kg pots were used. Some plant and soil characteristics were measured, including the dry weight of the vegetative and root system and (NPK) for the vegetative and root system, the weight of the crop, the degree of reaction, and the measurement of the electrical conductivity of the soil. The results were as follows:The results showed that KCl salt was significantly excelled and gave the highest rate of total bacterial numbers before and after adding B. subtilis, which amounted to 52.08 and 59.58 × 106 CFU g -1 dry soil, respectively. When adding B.cereus bacteria, MgCl2 salt was significantly excelled and gave the highest rate of bacterial numbers, reaching 44.50 × 106 CFU g-1 dry soil, while CaCl2 salt gave the lowest total bacterial count before addition, reaching 21.00 × 106 CFU g-1 dry soil, while NaCl salt gave less total bacteria after adding B.subtilis and B.cereus bacteria, reaching 21.50 and 21.08 × 106 CFU g-1 dry soil, respectively. While MgCl2 salt gave the lowest rate of dry weight of the plant vegetative group without addition, reaching 6.50 g plant-1, while NaCl salt after adding B.subtilis and B.cereus, reached 6.06 and 10.27 g plant-1, respectively. MgCl2 salt was significantly excelled and gave the highest rate of nitrogen percentage in the plant when adding B.subtilis and B.cereus bacteria and without adding it, and it recorded 1.96, 1.64, and 1.72%, respectively. The highest rate of phosphorus percentage in the plant was when adding B.subtilis and B.cereus bacteria and without adding it, and it recorded (0.81, 0.65, 0.44%), respectively. While the interaction treatment between NaCl with concentration 50mM was excelled and recorded the highest rate of dry weight of the vegetative group in the soil after adding B.cereus, which amounted to 17.15 g plant-1, while the interaction treatment between MgCl2 with concentration 50mM was excelled and recorded the highest rate of plant nitrogen percentage when adding B.subtilis bacteria and without adding it, which amounted to (2.20, 1.98%) respectively, as NaCl with concentration 75mM was excelled and recorded the highest rate of plant potassium percentage when adding B.subtilis bacteria and without adding it, which amounted to 4.87, 4.90% respectively. While the interaction treatment between NaCl with concentration 50mM was excelled and recorded the highest rate of plant potassium percentage after adding B.cereus, which amounted to 4.78%. The results showed that NaCl salt was significantly excelled and gave the highest rate of nitrogen percentage in the roots when adding B. subtilis and B. cereus bacteria and without adding it, and it recorded (2.51, 2.20, 1.96%) respectively,

Keyword: positive salt ions, B.subtilis , B.cereus, NaCl

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Introduction

Wheat (Triticum astivum .L) is one of the most important strategic crops belonging to the Poaceae family and is used as a basic food and an important vital source of plant protein. It is easy to process into different types of food products consumed by billions of people and ranks first in the world in terms of cultivated area. Iraq is one of the original habitats for the emergence of wheat crops, but the conditions and factors of erosion, salinization, and desertification due to the long period of rain withholding, weak vegetation cover, and the harmony of agricultural services with traditional ones play a major role in the decline in productivity and poor quality, as the percentage of cultivated area globally in 2020 amounted to about 215.4 million hectares [7]. The amount of wheat produced in Iraq for the year 2021 amounted to about 4,234,000 tons, a decrease of 32.1% compared to the year 2020, which recorded a production of 6,238,000 tons [8]Microorganisms play an important role in soil fertility and supplying plants with nutrients. Groups of microorganisms that live in the soil and contribute to activating a series of biological reactions through which the availability of some important nutrients for absorption by the plant is fixed or increased are called biofertilizers[1] . Bacterial biofertilizers consist of bacterial cells that dissolve nutrients such as phosphorus and potassium from minerals and rocks containing these elements. Bacillus bacteria are one of the most important genera of root zone bacteria that are characterized by various biomechanics to stimulate plant growth by increasing its supply of nutrients and the process of preparing phosphorus for the plant is one of the most important activities studied by researchers, which is done through the secretion of organic acids by bacteria and works to dissolve insoluble phosphorus and release it from inorganic phosphate compounds in the soil such as calcium triphosphate, diphosphate in addition to phosphate rock. Among the bacterial species are B. subtilis, B. cereus [4] in addition to producing polysaccharides and Siderophores that prevent the movement of toxic ions and help maintain ionic balance and enhance water movement in plant tissues [3]. Studies have also shown that they affect the regulation of plant hormone biosynthesis pathways, modify ethylene levels in plants, and affect the emission of volatile organic compounds. compounds(VOCs) [2].Positive ions have an important effect on the growth of soil organisms and depend on several factors and biological and chemical interactions. Positive ions play a vital role in the metabolic processes and energy transfer within plants, which directly affects their growth and development. Positive ions can also affect the composition and activity of microbes in the soil. Some soil organisms need these ions as essential nutrients, while they negatively affect the growth of some other species [6] . In general, it can be said that positive ions play a vital role in the growth of soil organisms and their interactions, and this effect depends on the ecological balance, soil composition, and the types of living organisms present in it[8].In view of the above, the study aims to:Study the effect of positive ions calcium, magnesium, sodium and potassium in the soil and in the nutrient medium on the growth of Bacillus bacteria. Know the minimum inhibitory concentration (MIC) for positive ions and determine the ion that most affects the growth of Bacillus bacteria.Study the duration of bacteria survival in the nutrient medium and soil under the influence of positive salt ions.

Materials and Methods:

This experiment was conducted at the research station at the University of Kufa on 11/15/2023, where wheat was planted in 10 kg plastic pots with five seeds per pot, and two salts were added that had the greatest effect on bacteria through the laboratory experiment and the incubation experiment, which are sodium chloride salt NaCl and magnesium chloride MgCl2, where the salts were added at concentrations of (0, 25, 50, 75) mM for each pot.The bacteria were then injected into the soil inside the pots for each concentration in both sexes (B. Subtilis, B. Cereus(

During this experiment, the following were measured:

-1Electrical conductivity EC

-2Soil reaction degree pH

-3Dry weight of the vegetative and root systems.

-4Estimation of (NPK) for the vegetative and root systems.

-5Weight of the crop.

6-3Analysis of some chemical, physical and biological properties of the experimental soil before and after planting

3Soil reaction degree pH

The electrical conductivity of soil salts in the saturated paste extract was measured using a pH-Meter as mentioned in [9[

2-36-Electrical conductivity EC

The electrical conductivity of soil salts in the saturated paste extract was measured using an EC-Meter as mentioned in [9[

3-36-Available nitrogen

Available nitrogen was extracted using potassium chloride KCL and nitrogen was estimated using a Kjeldahl apparatus according to the method mentioned in Page et al. (1982.(

available phosphorus

Soil phosphorus was extracted using sodium bicarbonate (NaHCO3) and the color of the extract was developed using ammonium molybdate and ascorbic acid solution. Phosphorus was measured using a spectrophotometer at a wavelength of 882 nm according to the method mentioned in Page et al. (1982)

Available potassium

Available soil potassium was extracted using 0.5 M calcium chloride and measured using a flame photometer as mentioned in [10[

-Positive and negative dissolved ions in soil

Estimated in a soil-water extract according to the methods mentioned in[9.[

Calcium Ca2+ and magnesium Mg2+

Estimated using a buffer solution of ammonium chloride and ammonium hydroxide and adding EBT reagent

Carbonates CO3- and bicarbonates HCO3-

Estimated by correction with sulfuric acid (H2SO4) using phenol reagent and methyl orange indicator. If carbonates are present, the solution will change to light violet and titration is done with sulfuric acid

Sulfates SO4-2

Estimated using a 1-molar barium chloride solution, ethanol and hydrochloric acid

Cation exchange capacity of positive ions

The cation exchange capacity was estimated according to[9[

Adding biofertilizer:

The biofertilizer was added according to its type (B.Subtilis B.Cereus) by injection into the soil immediately after planting the seeds,

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where 5 ml of each sex was added to the soil according to the required treatments.

Soil bacteria count

The total number of bacteria in the soil was estimated by dilution and plate counting using Nutrient Agar medium according to [9[

Physical analyses

Soil Texture

The volume distribution of soil particles was estimated using the Pipette method according to [9.[

Bulk density

The apparent density was estimated using the metal cylinder method (Core Sampler) according to [9[

Table (1) Some physical and chemical properties of field experiment soil

Values	Units	Traits	
Sand 661.4 silt 306.0 Clay 32.6	$g.kg^{-1}$	Soil particle size distribution	
Sandy loam		Texture	
1.2	$Mg.m^{-1}$	Bulk density	
1.9	$DS.m^{-1}$	Electrical conductivity (EC)	
7.70	-	pH	
1.21	$g.kg^{-1}$	Organic matter (O.M)	
4.6	Chloride Cl-1 mmol.L-1 Sulphate SO4= Carbonate CO3= Bicarbonate HCO3- Potassium K+ Sodium Na+ Magnesium Mg++	Chloride Cl-1 mmol.L-1	dissolved ions
5.8			
0.0		Sulphate $SO_4^=$	
2.2		Carbonate $CO_3^=$	
0.3		Bicarbonate HCO_3^-	
6.4		Potassium K^+	
2.7		Sodium Na^+	
3.9		Magnesium Mg^{++}	
5.6	$mg\ kg^{-1}$	Available Nitrogen	
8.4	$mg\ kg^{-1}$	Available Phosphorus	
10.3	$mg\ kg^{-1}$	Available Potassium	
77.00	$ML\ *10^{-6}$	Total Bacteria	
10.3	$Centi\ mole\ kg^{-1}$	Ion Exchange Capacity	

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Studied traits

Number of soil bacteria

The total number of bacteria in the soil was estimated by dilution and plate counting using Nutrient Agar medium according to[9 [

PH

The electrical conductivity of soil salts in the saturated paste extract was measured using a pH-Meter as mentioned in [9.[

Electrical conductivity EC

The electrical conductivity of soil salts in the saturated paste extract was measured using an EC-Meter as mentioned in [9.[

Plant content of nutrients in the plant (N, P, K) for the vegetative group and the root

Many plants were taken according to the experimental parameters to the laboratory, the stem was separated from the root and placed in an oven at a temperature of 65°C until the weight was fixed. After that, the plant samples were completely ground and the digestion process was carried out. The samples were well ground with an electric grinder, then 0.2 gm of each ground sample was taken and digested using concentrated sulfuric acid and perchloric acid in a ratio of 1:1 according to the method proposed by [11] After digesting the samples, the volume was completed with distilled water to 50 ml to estimate the plant's nutritional content.

Statistical Analysis

The laboratory experiment was analyzed according to the (CRD) design as a factorial experiment, while the field experiment was applied according to the Randomized Complete Block Design (RCBD) design with three replicates as a factorial experiment. The results were analyzed using the ANOVA table according to the Genstat program, and the significant differences between the treatments were tested using the Least Significant Difference (L.S.D) at a probability level of 0.05 [12.[

Results and discussion

Effect of type and concentration of positive salt ions on the growth of Bacillus bacteria and wheat plant growth:

Total bacterial numbers

The results in Table (2) showed that the salts added to the soil have a significant effect on the total bacterial numbers. The results showed that MgCl2 salt was significantly excelled and gave the highest rate of total bacterial numbers in the plant without addition, reaching 7.45 × 106 CFU g-1 dry soil, while NaCl salt was significantly excelled and gave the highest rate of B. subtilis and B. cereus bacteria, reaching 6.58 and 2.05 × 106 CFU g-1 dry soil. While NaCl salt gave the lowest total bacterial numbers, reaching 6.50 × 106 CFU g-1 dry soil, while MgCl2 salt gave the lowest number of bacteria with the addition of B. subtilis and B. cereus reached 0.75 and 0.53×106 CFU g-1 dry soil, respectively, while the results of the same table showed the effect of salt concentration on the total bacterial count. The concentration of 25 mM recorded the lowest total bacterial count of 7.65×106 CFU g-1 dry soil, while the total bacterial count increased when the concentration of 50 mM was treated, reaching 7.31×106CFU g-1 dry soil. The concentration of 75 mM recorded the highest bacterial count rate of 4.29×106 CFU g-1 dry soil, while the concentration of 0 mM recorded the highest total bacterial count rate in the soil after adding B.cereus, reaching 1.83×106 CFU g-1 dry soil, while the total bacterial count rate in the soil decreased after adding B. cereus at a concentration of 75 mM and recorded 1.10×106 CFU g-1 dry soil, while the number of bacteria decreased by adding B.subtilis at a

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concentration of 0 mM and recorded 3.35×106 CFU g-1 dry soil. The results also showed that the interaction between salts and concentrations had a significant effect on the total bacterial counts. The interaction between NaCl and concentration 25mM was excelled and recorded the highest rate of total bacterial counts in the soil, reaching 8.80 × 106 CFU g-1 dry soil. The results also showed that the bi-interaction between salts and concentrations did not differ significantly in the number of bacteria after adding B. subtilis bacteria. The interaction between NaCl and concentration 75mM gave the highest rate of bacterial count, reaching 7.17 × 106 CFU g-1 dry soil, while the interaction between NaCl and concentration 0mM was excelled and recorded the highest rate of total bacterial counts in the soil after adding B. cereus reached 3.20 × 106 CFU g-1 dry soil, while the total bacterial counts in the soil decreased when treated with NaCl and concentration 0 mM and gave a total bacterial count rate of 1.11 × 106 CFU ml-1 dry soil, while the NaCl treatment and concentration 25 mM recorded the lowest number of B. subtilis bacteria, reaching 0.44 × 106 CFU g-1 dry soil. As for the total bacterial counts in the soil after adding B. cereus when treated with NaCl and concentration 75 mM, it gave the lowest rate of 0.33 × 106 CFU g-1 dry soil. The reason for the increase in the number of bacteria can be due to the direct addition of bacteria to the soil and to the role of Bacillus spp. bacteria, which have the ability to secrete enzymes, so they have the ability to modify their environment in a self-beneficial way, as well as produce resistant endospores to maintain themselves in unfavorable conditions [13 .[

Table (2) Effect of the type and concentration of positive salt ions and Bacillus bacteria on the total number of bacteria in the soil CFU × 106

average Salts	Concentrations mM				Salts
	75	50	25	0	
7.45	7.49	6.17	6.50	9.63	**$MgCl_2$**
6.50	7.65	8.46	8.80	1.11	**NaCl**
	7.57	**7.31**	**7.65**	**5.37**	**average**
B. subtilis					
0.75	1.40	0.55	0.44	0.60	**$MgCl_2$**
6.58	7.17	6.60	6.43	6.10	**NaCl**
	4.29	**3.57**	**3.44**	**3.35**	**average**
B. cereus					
0.53	0.33	0.50	0.83	0.45	**$MgCl_2$**
2.05	1.87	1.67	1.47	3.20	**NaCl**
	1.10	**1.08**	**1.15**	**1.83**	**average**
	Interaction	**Concentrations**	**Salts**		**LSD 0.05**
	0.450	**0.318**	**0.225**	**No**	
	N.S	**0.338**	**0.239**	***B.***	
	0.132	**0.094**	**0.066**	***B.***	

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pH

The results of Table (3) showed that the salts added to the soil had a significant effect on pH. The results showed that MgCl2 salt was significantly excelled and gave the highest rate of soil reaction pH without addition and with the addition of B. cereus, reaching 8.31 and 8.22, while NaCl salts were significantly excelled and gave the highest rate of soil reaction pH with the addition of B. subtilis bacteria, reaching 8.25. While NaCl salt gave the lowest rate of soil reaction pH without addition and with the addition of B. cereus, reaching 8.16 and 8.13, while MgCl2 salt gave the lowest rate of soil reaction pH with the addition of B. subtilis bacteria, reaching 8.22. The results of the same table showed the effect of salt concentrations on the soil reaction pH. The concentration 75 mM recorded the highest rate of soil reaction pH without addition after the addition of B. cereus pH reached 8.31 and 8.23, while the concentration of 25 mM recorded the highest rate of soil pH reaction with the addition of B. subtilis bacteria, which reached 8.31, while the pH rate decreased without the addition and after the addition of B. cereus at the concentration of 0 mM and recorded 8.14 and 8.13, respectively. The results also showed that the interaction between salts and concentrations had a significant effect on the degree of soil reaction pH, as the interaction treatment between NaCl with a concentration of 50 mM was excelled and recorded the highest rate of soil reaction pH of 8.37. The results also showed that the interaction between salts and concentrations had a significant effect on the degree of soil reaction pH by adding B. subtilis bacteria, as the interaction coefficient between NaCl with a concentration of 25 mM was excelled and recorded the highest rate of soil reaction pH by adding B. subtilis bacteria, which amounted to 8.37, while the interaction coefficient between MgCl2 with a concentration of 75 mM was excelled and recorded the highest rate of soil reaction pH after adding B. cereus, which amounted to 8.27, while the degree of soil reaction pH decreased when NaCl was treated at a concentration of 0 mM and gave 8.05, while the degree of soil reaction pH decreased when B. subtilis bacteria was added when MgCl2 was treated at a concentration of 0. mM and gave 8.13, while the soil pH reaction degree after adding B. Cereus was recorded in the NaCl treatment and concentration of 25 mM and gave the lowest rate of 8.08. The reason for this decrease in the values of the soil reaction degree with the increase in the salinity of irrigation water is the accumulation of neutral salts such as chlorides and sulfates of sodium, magnesium and calcium, which will put pressure on the values of the soil reaction degree of its solution towards neutrality in the soil, which caused a decrease in the soil reaction degree towards neutrality [14]. These results are consistent with what was reached by [15] They showed that there is a decrease in the soil reaction degree towards neutrality with the increase in positive soil salts. Microorganisms also work to reduce the soil reaction degree by producing organic acids and work to chelate and sequester the wave divalent ions responsible for the adsorption of phosphorus and its deposition in calcareous and basic soils [16.[

Table (3) The effect of the type and concentration of positive salt ions and Bacillus bacteria on the soil reaction degree

average Salts	Concentrations mM				Salts
	75	50	25	0	
8.31	8.31	8.37	8.33	8.23	**$MgCl_2$**
8.16	8.30	8.15	8.13	8.05	**NaCl**
	8.31	**8.26**	**8.23**	**8.14**	**average**
B. subtilis					
8.22	8.21	8.28	8.25	8.13	**$MgCl_2$**
8.25	8.17	8.20	8.37	8.25	**NaCl**
	8.19	**8.24**	**8.31**	**8.19**	**average**
B. cereus					
8.22	8.27	8.23	8.24	8.12	**$MgCl_2$**
8.13	8.18	8.15	8.08	8.13	**NaCl**
	8.23	**8.19**	**8.16**	**8.13**	**average**
	interaction	**Concentrations**	**Salts**		**LSD 0.05**
				No	
	0.022	**0.016**	**0.011**	***B***	
	0.022	**0.015**	**0.011**	***B***	

Electrical conductivity of soil (EC) DS. m-1

The results of Table (4) showed that the salts added to the soil have a significant effect on the electrical conductivity of the soil. The results showed that NaCl salt was significantly excelled and gave the highest rate of electrical conductivity of the soil without addition and after adding B. cereus, which amounted to 4.09 and 4.82 DS. m-1, respectively, while MgCl2 salt was significantly excelled and gave the highest rate of electrical conductivity of the soil after adding B. subtilis, which amounted to 3.28 DS. m-1, while MgCl2 salts gave the lowest rate of electrical conductivity of the soil without addition and after adding B. cereus, which amounted to 2.18 and 4.25 DS. m-1, while NaCl salt gave the lowest rate of electrical conductivity of the soil after adding B. subtilis, which amounted to 2.45 DS. m-1The results of the same table showed The effect of salt concentrations on the electrical conductivity of the soil, the concentration 0 mM recorded the highest rate of total soil salts without addition and after adding B. subtilis and B. cereus bacteria, it reached 4.18, 3.50 and 5.42 DS. m-1respectively, while the Ec rate decreased at the concentration 75 mM and recorded 2.21, and the electrical conductivity rate of the soil decreased after adding B. subtilis and B. cereus at the concentration 25 mM and recorded 2.09 and 3.85 dS m-1. The results also showed that the interaction between salts and concentrations had a significant effect on the electrical conductivity of the soil, as the interaction factor between NaCl with the concentration 0 mM was excelled and recorded the highest rate of electrical conductivity of the soil, reaching 5.76 dS m-1, and the interaction factor between MgCl2 with the concentration 0 mM was excelled and recorded The highest rate of electrical conductivity after adding B. subtilis was 4.64 dS m-1. The interaction factor between NaCl concentration 75 mM was excelled and the highest rate of electrical conductivity of the soil was recorded after adding B. cereus, which was 6.12 dS m-1. While the electrical conductivity of the soil

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decreased when treated with NaCl and concentration 75 mM and gave 1.97, while the lowest rate of electrical conductivity was recorded after adding B. subtilis when treated with NaCl and concentration 25 mM and gave the lowest rate of 1.56 dS m-1. While the electrical conductivity of the soil decreased after adding B. cereus when treated with 2MgCl and concentration 25 mM and gave the lowest rate of 2.71 dS m-1.

Table (4) Effect of the type and concentration of positive salt ions and Bacillus bacteria on electrical conductivity For soil (DS. m-1(

average Salts	Concentrations mM				Salts
	75	50	25	0	
2.18	2.45	1.85	1.81	2.61	**$MgCl_2$**
4.09	1.97	3.45	5.18	5.76	**NaCl**
	2.21	**2.65**	**3.50**	**4.18**	**average**
B. subtilis					
3.28	3.64	2.23	2.62	4.64	**$MgCl_2$**
2.45	3.06	2.84	1.56	2.36	**NaCl**
	3.35	**2.54**	**2.09**	**3.50**	**average**
B. cereus					
4.25	3.61	4.71	2.71	5.95	**$MgCl_2$**
4.82	6.12	3.32	4.98	4.88	**NaCl**
	4.86	**4.02**	**3.85**	**5.42**	**average**
	interaction	**Concentrations**	**Salts**		**LSD 0.05**
	0.019	**0.013**	**0.009**	**No**	
	0.035	**0.025**	**0.018**	***B***	
	0.021	**0.015**	**0.011**	***B***	

Nitrogen percentage in the vegetative growth (%)

The results of Table (5) showed that the positive ions added to the soil had a significant effect on the percentage of nitrogen in the vegetative growth. The results showed that MgCl2 salt was significantly excelled and gave the highest rate of nitrogen percentage in the vegetative growth when adding B. subtilis and B. cereus bacteria and without adding it, and it recorded 1.96, 1.64 and 1.72% respectively. While NaCl salt gave the lowest rate of nitrogen percentage in the vegetative growth when adding B. subtilis and B. cereus bacteria and without adding it, reaching 1.52, 1.55 and 1.38% respectively. The same table showed the effect of salt concentrations on the percentage of nitrogen in the vegetative growth. The concentration of 75 mM recorded the highest rate of nitrogen percentage in the vegetative growth when adding B. subtilis and B. cereus bacteria and without adding it, and it reached (1.94, 1.82, 1.67%) respectively, while the concentration of 0 mM recorded the lowest rate of nitrogen percentage in the vegetative growth when adding B. subtilis and B. cereus bacteria and without adding it reached (1.49, 1.44, 1.43%) respectively. The results showed that the interaction between salts and concentrations had a significant effect on the percentage of nitrogen in the vegetative growth. The interaction treatment between MgCl2 with the concentration of 50 mM was excelled and gave the highest rate of nitrogen percentage in the vegetative growth when adding B. subtilis bacteria and without adding it. It reached (2.20, 1.98%) respectively, while the interaction treatment

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between MgCl2 with a concentration of 75 mM was excelled and gave the highest rate of nitrogen percentage in vegetative growth by adding B.cereus bacteria, which amounted to 2.10%. While the percentage of nitrogen in vegetative growth decreased when treated with NaCl and a concentration of 0 mM when adding B.subtilis bacteria and without adding it gave the lowest rate of (0.98, 0.98%) respectively, while the percentage of plant nitrogen decreased when adding B.cereus bacteria when treated with MgCl2 and a concentration of 0 mM and gave the lowest rate of 1.12%. The reason for this increase in the plant nitrogen content is due to the ability of Bacilius bacteria to fix nitrogen in addition to the growth regulators secreted by these bacteria. It is known that these materials work to improve plant growth and form a dense root system, which leads to increased absorption of nutrients, including Nitrogen [17[

Table (5) Effect of the type and concentration of positive salt ions and Bacillus bacteria on the percentage of nitrogen in vegetative growth%

average Salts	**Concentrations mM**				**Salts**
	75	**50**	**25**	**0**	
1.72	1.58	1.98	1.45	1.87	**$MgCl_2$**
1.38	1.75	1.25	1.52	0.98	**NaCl**
	1.67	1.62	1.49	1.43	**average**
B. subtilis					
1.96	1.98	2.2	1.65	2	**$MgCl_2$**
1.52	1.89	1.54	1.65	0.98	**NaCl**
	1.94	1.87	1.65	1.49	**average**
B. cereus					
1.64	2.10	1.56	1.77	1.12	**$MgCl_2$**
1.55	1.54	1.47	1.42	1.75	**NaCl**
	1.82	1.52	1.60	1.44	**average**
	interaction	**Concentrations**	**Salts**		**LSD 0.05**
	0.021	**0.015**	**0.011**	**No**	
	0.260	**0.184**	**0.130**	***B***	
	0.973	**0.688**	**0.486**	***B***	

The percentage of nitrogen in root system(%)

The results of Table (6) showed that the positive ions added to the soil had a significant effect on the percentage of nitrogen in the roots. The results showed that NaCl salt was significantly excelled and gave the highest rate of nitrogen percentage in the root system when adding B. subtilis and B. cereus bacteria and without adding it, and it recorded (2.51, 2.20, 1.96%) respectively. While MgCl2 salt gave the lowest rate of nitrogen percentage in the root system when adding B. subtilis and B. cereus bacteria and without adding it reached (1.94, 1.55, 2.16%) respectively. While the same table showed the effect of salt concentrations on the percentage of nitrogen in the root system, the concentration of 75 mM recorded the highest rate of nitrogen percentage in the roots when adding B. subtilis and B. cereus bacteria and without adding it reached (2.50, 2.61, 1.94%) respectively, while the concentration of 0 mM recorded the lowest rate of nitrogen percentage in the root system when adding B. subtilis and B. cereus bacteria and without adding it reached (1.74, 1.43, 1.55%) respectively. The interaction

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between salts and concentrations had a significant effect on the percentage of nitrogen in the roots, where the interaction treatment between NaCl with the concentration of 75 mM was excelled and recorded the highest rate of nitrogen percentage in the roots when adding B. subllis bacteria and it reached 2.80%. While the interaction treatment between MgCl2 with concentration 75mM was excelled and recorded the highest rate of nitrogen percentage in the root system of B.cereus bacteria, which amounted to 2.63%. While the interaction treatment between NaCl with concentration 50mM was excelled and recorded the highest rate of nitrogen percentage in the roots without addition, which amounted to 2.20%. While the percentage of nitrogen in the roots decreased when MgCl2 treatment and concentration 0mM when adding B.cereus bacteria and without addition and gave the lowest rate of (1.20, 1.10%) respectively, while the percentage of nitrogen in the roots decreased when adding B.cereus bacteria when NaCl treatment and concentration 0mM and gave the lowest rate of 1.36%. This illustrates the effect of salts on plant growth and absorption of nutrients, as the higher the percentage of salts, the lower the amount of elements absorbed by the plant, which leads to plant weakness and deterioration of its growth, as there is an inverse relationship between plant growth and high salinity in the soil due to the imbalance of ionic balance and the increase in the concentration of salts in the soil solution, and the increase in osmotic pressure leads to an imbalance in absorption by the plant [18.[

Table (6) The effect of the type and concentration of positive salt ions and Bacillus bacteria on the percentage of nitrogen in the root system

average Salts	**Concentrations mM**				**Salts**
	75	**50**	**25**	**0**	
1.55	1.89	1.54	1.65	1.10	**$MgCl_2$**
1.96	1.98	2.20	1.65	2.00	**NaCl**
	1.94	1.87	1.65	1.55	**average**
B. subtilis					
1.94	2.20	2.27	2.10	1.20	**$MgCl_2$**
2.51	2.80	2.67	2.30	2.27	**NaCl**
	2.50	2.47	2.20	1.74	**average**
B. cereus					
2.16	2.63	2.30	2.20	1.50	**$MgCl_2$**
2.20	2.58	2.58	2.27	1.36	**NaCl**
	2.61	2.44	2.24	1.43	**average**
	interaction	**Concentrations**	**Salts**		**LSD 0.05**
	0.04	**0.029**	**0.020**	**No**	
	0.027	**0.019**	**0.014**	***B***	
	0.03	**0.02**	**0.016**	***B***	

The percentage of phosphorus in the vegetative growth(%)

The results of Table (7) showed that the positive ions added to the soil had a significant effect on the percentage of phosphorus in the vegetative growth (%). The results showed that MgCl2 salt was significantly excelled and gave the highest rate of phosphorus percentage in the vegetative growth when adding B.subtilis and B.cereus bacteria and without

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adding it, and it recorded (0.81, 0.65, 0.44%) respectively. While NaCl salt gave the lowest rate of phosphorus percentage in the vegetative growth when adding B.subtilis and B.cereus bacteria and without adding it, reaching 0.60, 0.60, 0.34% respectively. The results of the same table indicated the effect of salt concentrations on plant phosphorus, where the concentration of 75 mM recorded the highest rate of plant phosphorus before addition and when adding B. subtilis bacteria, it reached (0.75, 0.46%) respectively, while the concentration of 50 Mm was excelled when adding B. cereus bacteria and recorded the highest rate of phosphorus in vegetative growth 0.85%While the rate of plant phosphorus decreased before addition at the concentration of 50 mM and recorded 0.31%, while the rate of plant phosphorus decreased by adding B. subtilis and B. cereus bacteria at the concentration of 25 mM and recorded (0.67, 0.38%) respectivelyThe results showed that the interaction between salts and concentrations had a significant effect on the phosphorus percentage of vegetative growth, as the interaction treatment between MgCl2 with the concentration of 0 mM was excelled and recorded the highest rate The percentage of plant phosphorus before and after adding B.subtilis bacteria reached (0.97, 0.65%) respectively, while the interaction treatment between NaCl with concentration 50mM was excelled and recorded the highest rate of phosphorus percentage of the green part by adding B. cereus bacteria, which reached 0.85%, while the phosphorus of the green part decreased before and after adding B.subtilis and B. cereus bacteria when treated with NaCl and concentration 0mM and gave the lowest rate of (0.45, 0.46, 0.21%). The reason for this is due to the addition of the biofertilizer containing Bacillus bacteria that dissolve phosphate, as phosphate-dissolving bacteria play an important role in releasing phosphorus present in the soil as a result of their secretion of organic acids (citric, oxalic, formic and malic) or secretion of enzymes such as phosphatase enzyme Phytase increases the availability of phosphorus to the plant [19]. Also, some hydroxy acids may bind with calcium and iron, thus preventing them from binding to phosphate, which increases the effectiveness of phosphate dissolution and use and reduces the pH in basic soils, which helps increase the availability of phosphorus [20] The results are consistent with what was mentioned by Umesha et al., 2014 and Salman, 2016, who observed an increase in the available phosphorus in the soil when adding biofertilizer containing phosphate-dissolving bacteria .

ISSN 2072-3857

Table (7) Effect of the type and concentration of positive salt ions and Bacillus bacteria on the percentage of phosphorus in vegetative growth

average Salts	Concentrations mM				Salts
	75	**50**	**25**	**0**	
0.44	0.50	0.27	0.32	0.65	**$MgCl_2$**
0.34	0.42	0.35	0.38	0.21	**NaCl**
	0.46	0.31	0.35	0.43	**average**
B. subtilis					
0.81	0.74	0.85	0.68	0.97	**$MgCl_2$**
0.6	0.75	0.55	0.65	0.45	**NaCl**
	0.75	0.70	0.67	0.71	**average**
B. cereus					
0.65	0.71	0.84	0.31	0.72	**$MgCl_2$**
0.60	0.62	0.85	0.45	0.46	**NaCl**
	0.67	0.85	0.38	0.59	**average**
	interaction	**Concentrations**	**Salts**		**LSD 0.05**
	0.04	**0.03**	**0.02**	**No**	
	0.03	**0.015**	**0.013**	***B***	
	0.04	**0.03**	**0.02**	***B***	

The percentage of phosphorus in the root system(%)

The results of Table (8) showed that the salts added to the soil had a significant effect on the percentage of phosphorus in the roots. The results showed that NaCl salt was significantly excelled and gave the highest rate of phosphorus percentage in the root system when adding B. cereus bacteria and without adding it, and it recorded (0.23, 0.19%) respectively, while NaCl salt gave the highest rate of phosphorus percentage in the roots when adding B. subtilis bacteria, which amounted to 0.28%. While MgCl2 salt recorded the lowest rate of phosphorus percentage in the roots when adding B. cereus bacteria and without adding it amounted to (0.22, 0.17%) respectively. The percentage of phosphorus in the roots also decreased when adding B. subtilis bacteria, which amounted to 0.26%. While the same table showed the effect of salt concentrations on the percentage of root phosphorus, the concentration of 75 mM recorded the highest rate of root phosphorus percentage when adding B. subtilis and B. cereus bacteria and without adding and reached (0.37, 0.33, 0.23%) respectively, while the concentration of 0 mM recorded the lowest rate of root phosphorus percentage when adding B. subtilis and B. cereus bacteria and without adding it reached (0.18, 0.13, 0.12) respectively. The results also showed that the interaction between salts and concentrations had a significant effect on the percentage of root phosphorus, as the interaction factor between MgCl2 with the concentration of 75 mM was excelled and gave the highest rate of root phosphorus percentage when adding B. subtilis and B. cereus bacteria and without adding it reached (0.38, 0.35, 0.24%) respectively. While the percentage of phosphorus in the roots decreased when treated with NaCl and concentration 0 mM when adding B. subtilis and B. cereus bacteria and gave the lowest rate of (0.15, 0.12%) respectively, while the percentage of phosphorus in the roots decreased without adding bacteria when treated with NaCl and concentration 0 mM and gave the lowest rate of 0.11%. The reason

ISSN 2072-3857

for the increase in the plant's phosphorus content is due to the ability of Bacillus bacteria to increase the availability of the phosphorus element by dissolving compounds that contain phosphorus in the unavailable form by producing some organic acids such as (citric, oxalic, formic and malic or secreting enzymes such as phosphatase and phytase that increase the availability of phosphorus for the plant (Keston), (2013). In addition to the production of growth regulators such as (gibberellic acid, indoleacetic acid and cytokinin) that stimulate the plant and give a total Dense root system capable of extracting nutrients from the soil such as phosphorus, as the increase in the density of the root system increases its ability to absorb [16[

Table (8) Effect of the type and concentration of positive salt ions and Bacillus bacteria on the percentage of phosphorus in the root system

average Salts	Concentrations mM				Salts
	75	50	25	0	
0.19	0.24	0.20	0.17	0.13	**$MgCl_2$**
0.17	0.22	0.20	0.14	0.11	**NaCl**
	0.23	0.20	0.16	0.12	**average**
B. subtilis					
0.26	0.38	0.27	0.24	0.15	**$MgCl_2$**
0.28	0.35	0.30	0.27	0.20	**NaCl**
	0.37	0.29	0.26	0.18	**average**
B. cereus					
0.23	0.35	0.24	0.2	0.12	**$MgCl_2$**
0.22	0.30	0.21	0.2	0.15	**NaCl**
	0.33	0.23	0.2	0.135	**average**
	interaction	**Concentrations**	**Salts**		**LSD 0.05**
	0.025	**0.0132**	**0.094**	**No**	
	0.0229	**0.0162**	**0.0115**	***B***	
	0.0187	**0.0132**	**0.094**	***B***	

Potassium percentage in vegetative growth (%)

The results of Table (9) showed that the positive ions added to the soil had a significant effect on the percentage of potassium in vegetative growth (%). The results showed that NaCl salt was significantly excelled and gave the highest rate of potassium percentage in vegetative growth when adding B. subtilis bacteria and without adding it, and recorded (4.30, 4.12, 4.10%) respectively.

While MgCl2 salt gave the lowest rate of potassium percentage in vegetative growth when adding B. subtilis and B. cereus bacteria and without adding it reached (3.89, 3.71, 3.76%) respectively.

The results of the same table also showed the effect of salt concentrations on the percentage of potassium in vegetative growth. The concentration of 75 mM recorded the highest rate of potassium percentage in vegetative growth when adding B. subtilis bacteria and without adding it, reaching (4.74, 4.68%) respectively. As for adding B. cereus bacteria, the concentration of 50 mM significantly

ISSN 2072-3857

excelled it and recorded the highest percentage of potassium in vegetative growth, reaching 4.48%. While the percentage of potassium in vegetative growth decreased at the concentration of 0 mM when adding B. subtilis bacteria and without adding it, and recorded 3.73, 3.25% respectively, while the percentage of potassium in the plant decreased when adding B. cereus bacteria and recorded the lowest rate at the concentration of 25 mM, reaching 3.39%. It is clear from the same table that the interaction between salts and concentrations has a significant effect on the percentage of potassium in vegetative growth. The interaction treatment between NaCl with a concentration of 75 mM was excelled and recorded the highest rate of the percentage of potassium in the plant when adding B. subtilis bacteria and without adding it, reaching 4.87, 4.90% respectively. While the interaction treatment between NaCl with concentration 50 mM was excelled and recorded the highest rate of plant potassium percentage after adding B.cereus, which amounted to 4.78%. While the percentage of potassium in vegetative growth decreased when MgCl2 was treated and concentration 0 mM when adding B.subtilis bacteria and without adding it, and gave the lowest rate of 3.58, 3.10%, respectively. While the lowest percentage of potassium was recorded when adding B.cereus bacteria when MgCl2 was treated and concentration 25 mM, and recorded the lowest rate of 3.00%, while the potassium of vegetative growth decreased after adding B.cereus when NaCl was treated and concentration 25 mM, and gave the lowest rate of 0.63%. The reason for this may be due to the ability of Bacillus bacteria to form a plant with a dense root system and a wide surface area, which led to increased absorption of many nutrients, including potassium [21.[

Table (9) Effect of the type and concentration of positive salt ions and Bacillus bacteria on the potassium percentage in vegetative growth%

average Salts	Concentrations mM				Salts
	75	**50**	**25**	**0**	
3.76	4.45	4.10	3.40	3.10	**$MgCl_2$**
4.10	4.90	4.00	4.10	3.40	**NaCl**
	4.68	4.05	3.75	3.25	**average**
B. subtilis					
3.89	4.60	3.40	3.98	3.58	**$MgCl_2$**
4.30	4.87	4.42	4.00	3.89	**NaCl**
	4.74	3.91	3.99	3.735	**average**
B. cereus					
3.71	3.74	4.21	3.00	3.89	**$MgCl_2$**
4.12	3.80	4.78	3.78	4.12	**NaCl**
	3.77	4.495	3.39	4.01	**average**
	interaction	**Concentrations**	**Salts**		**LSD 0.05**
	0.328	**0.232**	**0.164**	**No**	
	0.474	**0.335**	**0.237**	***B***	
	0.387	**0.274**	**0.194**	***B***	

ISSN 2072-3857

The percentage of potassium in the root system(%)

The results of Table (10) showed that the positive ions added to the soil had a significant effect on the percentage of potassium in the root system. The results showed that $MgCl_2$ salt was significantly excelled and gave the highest rate of potassium percentage in the roots when adding B.subtilis and B.cereus bacteria and without adding it, and it recorded (3.50, 3.58, 2.71% respectively). While NaCl salt recorded the lowest rate of potassium percentage in the root system when adding B.subtilis and B.cereus bacteria and without adding it reached (3.23, 3.44, 2.54%) respectively. While the same table showed the effect of salt concentrations on the percentage of potassium in the root, as the concentration of 75 mM gave the highest rate of potassium percentage in the root system when adding B.subtilis and B. cereus and without addition and reached (4.10, 3.87, .3.04%) respectively, while the concentration 0 mM recorded the lowest rate of potassium percentage in the root system when adding B. subtilis and B. cereus bacteria and without addition reached (2.62, 3.12, 2.05%) respectively. The results showed that the interaction between salts and concentrations had a significant effect on the percentage of potassium in the root system, as the interaction treatment between $MgCl_2$ with concentration 50 mM was excelled and recorded the highest rate of potassium percentage in the root system when adding B. subtilis and B. cereus bacteria and without addition reached (4.20, 3.98, 3.10%) respectively, while the percentage of potassium in the root system decreased when treating NaCl and concentration 0 mM when adding B. B. subtilis and B. cereus without addition gave the lowest percentage of root potassium (2.45, 3.1, 2%) respectively. The results showed that increasing the salinity of irrigation water leads to a decrease in the percentage of potassium in the roots, and this water may have reduced the absorption of potassium by the roots as a result of the competition between Na^+ and K^+ ions for absorption or the role of sodium in preventing the transfer of potassium through the stem, which in turn enhances the interpretation of the decrease in the percentage of potassium in the roots as a result of the high concentration of sodium in irrigation water. It is also clear that salinity led to the accumulation of chloride ions in the plant, especially at high levels of salinity, as the presence of chloride in the plant is directly or indirectly responsible for inhibiting plant growth by absorbing or removing negative ions from the plant such as nitrates NO_3^- or that the absorption of large amounts of chloride may damage the leaves and then reduce the carbon metabolism process, which negatively affects plant growth [22[

ISSN 2072-3857

Table (10) Effect of the type and concentration of positive salt ions and Bacillus bacteria on the percentage of potassium in the root system%

average Salts	Concentrations mM				Salts
	75	50	25	0	
2.71	3.10	2.87	2.75	2.1	**$MgCl_2$**
2.54	2.98	2.68	2.50	2	**NaCl**
	3.04	2.775	2.625	2.05	**average**
B. subtilis					
3.50	4.20	3.87	3.14	2.78	**$MgCl_2$**
3.23	4.00	3.45	3	2.45	**NaCl**
	4.10	3.66	3.07	2.62	**average**
B. cereus					
3.58	3.98	3.75	3.45	3.14	**$MgCl_2$**
3.44	3.75	3.5	3.4	3.1	**NaCl**
	3.87	3.63	3.43	3.12	**average**
	interaction	**Concentrations**	**Salts**		**LSD 0.05**
	0.0547	**0.0387**	**0.0274**	**No**	
	0.0491	**0.0347**	**0.0245**	***B***	
	0.03	**0.023**	**0.012**	***B***	

Dry weight of vegetative growth

The results of Table (11) showed that the positive ions added to the soil had a significant effect on the dry weight of vegetative growth. The results showed that MgCl2 salt was significantly excelled and gave the highest weight of vegetative growth, reaching 7.45 g plant-1. As for NaCl salt, it was significantly excelled and gave the highest average dry weight of vegetative growth of the plant after adding B. subtilis and B. cereus, reaching 8.95 and 10.35 g plant-1, respectively, while NaCl salt gave the lowest average weight of vegetative growth without addition, reaching 6.50 g plant-1. As for MgCl2 salt after adding B. subtilis and B. cereus, it reached 6.06 and 10.27 g plant-1, respectively. The results of the same table showed the effect of salt concentrations on the dry weight of vegetative growth before and after adding B. subtilis. The concentration of 25 mM recorded the highest average weight of vegetative growth of the plant, reaching 8.53 and 7.65 g plant-1, respectively. The concentration of 50 mM recorded the highest average weight of vegetative growth in the soil after adding B. cereus, reaching 12.41 g plant-1, while the average dry weight of vegetative growth in the soil decreased after adding B. cereus at a concentration of 75 mM and recorded 7.94 g plant-1, while the average dry weight of vegetative growth decreased after adding B. subtilis at a concentration of 0 mM and gave 6.69 g plant-1. The results also showed that the interaction between salts and concentrations had a significant effect on the weight of vegetative growth after adding B. subtilis. The interaction treatment between NaCl with a concentration of 75 mM was excelled and recorded the highest average dry weight of vegetative growth after adding B. subtilis, which amounted to 9.43 g plant-1, while the interaction treatment between MgCl2 with a concentration of 50 mM was excelled and recorded the highest average weight of vegetative growth in the plant after adding B. cereus, which amounted to 17.15 g plant-1. As for the dry weight of vegetative growth, NaCl salt and concentration 0 mM

ISSN 2072-3857

was excelled and recorded 9.63 g plant-1, while the dry weight of vegetative growth in the soil decreased after adding B. cereus when treated with NaCl with a concentration of 25 mM and gave the lowest average of 11.33 g plant-1, while the dry weight of vegetative growth decreased after adding B. subtilis when treated with $MgCl_2$ and concentration 0 mM gave the lowest rate of 3.95 g plant-1, the reason for this is attributed to the role of Bacillus bacteria in improving plant growth by increasing the availability of the necessary elements required for plant growth such as phosphorus and nitrogen, which enter into the construction of amino acids and proteins and their formation, and then the indirect effect in increasing the vegetative weight of the plant, in addition to the production of growth regulators such as auxins, cytokines and gibberellins [23.[

Table (11) Effect of the type and concentration of positive salt ions and Bacillus bacteria on the dry weight of vegetative growth g plant-1

average Salts	Concentrations mM				Salts
	75	50	25	0	
7.45	7.49	6.17	6.50	9.63	**$MgCl_2$**
6.50	7.65	8.46	8.80	1.11	**NaCl**
	7.57	**7.31**	**7.65**	**5.37**	**average**
B. subtilis					
6.06	5.55	6.41	8.35	3.95	**$MgCl_2$**
8.95	8.88	8.77	8.71	9.43	**NaCl**
	7.21	**7.59**	**8.53**	**6.69**	**average**
B. cereus					
10.27	7.04	17.15	10.22	6.66	**MgCl2**
10.35	8.84	7.66	13.55	11.33	**NaCl**
	7.94	**12.41**	**11.88**	**9.00**	**average**
	interaction	**Concentrations**	**Salts**		**LSD 0.05**
	0.450	**0.318**	**0.225**	**No**	
	0.047	**0.033**	**0.024**	***B***	
	0.324	**0.229**	**N.S**	***B***	

Dry weight of the root system

The results of Table (12) showed that the positive ions added to the soil had a significant effect on the dry weight of the root system. The results showed that NaCl salt was significantly excelled and gave the highest average dry weight of the root system without addition and after adding B. subtilis and B. cereus, which amounted to 7.63, 6.11 and 10.27 g plant-1, while $MgCl_2$ salt gave the lowest average root weight before addition and after adding B. subtilis and B. cereus, which amounted to 6.35, 4.95 and 5.87 g plant-1.

The results of the same table also showed the effect of salt concentrations on the weight of the root part. The concentration of 75 mM recorded the highest average weight of the root part, which amounted to 8.77 g, while the concentration of 25 mM recorded the highest average weight of the roots after adding B. subtilis, which amounted to 8.38 g plant-1. While the concentration of 50 mM recorded the highest root weight rate after adding B. cereus, which amounted to 9.79 g plant-1. While the average weight of the root

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decreased at the concentration of 50 mM and recorded 5.40 g plant-1, while the average weight of the root group decreased after adding B. subtilis at the concentration of 50 mM and recorded 3.98 g plant-1. As for the average weight of the roots after adding B. cereus, it decreased at the concentration of 50 mM and recorded 5.63 g plant-1. The results of the same table showed that the interaction between salts and concentrations had a significant effect on the weight of the root part, as the interaction treatment between MgCl2 with the concentration of 75 mM was excelled and recorded the highest average weight of the root part, reaching 10.69 g plant-1, while the interaction treatment between NaCl with the concentration of 25 mM was excelled and recorded the highest average weight of the roots after adding B. subtilis, reaching 9.22 g plant-1, while the interaction treatment between NaCl with the concentration of 0 mM was excelled and recorded the highest average weight of the roots after adding B. cereus, reaching 13.98 g plant-1, while the root weight decreased in the MgCl2 treatment and concentration 25 mM and gave the lowest rate of 3.30 g plant-1. As for the root weight after adding B. subtilis, it decreased in the MgCl2 treatment and concentration 0 mM and gave the lowest rate of 2.34 g plant-1, but after adding B. cereus, it decreased in the NaCl treatment and concentration 0 mM and gave the lowest rate of 3.35 g plant-1. The increase in root weight is attributed to the positive effect of Bacillus bacteria in the root zone and their ability to secrete some growth regulators such as auxins and hormones, in addition to fixing nitrogen, which enters into the construction of amino acids and proteins and their formation, and then the indirect effect in increasing root weight, which is what was indicated by [14 .[

Table (12) Effect of the type and concentration of positive salt ions and Bacillus bacteria on the weight of the root system, g/plant-1

average Salts	**Concentrations mM**				**Salts**
	75	**50**	**25**	**0**	
6.35	10.69	5.63	3.30	5.78	**$MgCl_2$**
7.63	6.86	9.32	7.50	6.86	**NaCl**
	8.77	**7.48**	**5.40**	**6.32**	**average**
B. subtilis					
4.95	3.75	5.61	7.53	2.92	**$MgCl_2$**
6.11	6.43	2.34	9.22	6.45	**NaCl**
	5.09	**3.98**	**8.38**	**4.69**	**average**
B. cereus					
5.78	4.44	7.73	7.60	3.35	**$MgCl_2$**
10.27	6.81	8.33	11.97	13.98	**NaCl**
	5.63	**8.03**	**9.79**	**8.66**	**average**
	interaction	**Concentrations**	**Salts**		**LSD 0.05**
	0.133	**0.094**	**0.067**	**No**	
	0.022	**0.016**	**0.011**	***B.***	
	0.242	**0.171**	**0.121**	***B.***	

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Yield weight (g plant-1(

The results of Table (13) showed that the positive ions added to the soil had a significant effect on the yield. The results showed that NaCl salt was significantly excelled and gave the highest yield rate without addition and after adding B. subtilis, which amounted to 2.72 and 6.63 g plant-1, while the MgCl2 treatment was excelled and recorded a yield rate after adding B. cereus bacteria, which amounted to 2.12 g plant-1, while NaCl salts gave the lowest yield rate before addition and after adding B. subtilis, which amounted to 1.68 and 0.68 g plant-1, while the yield decreased after adding B. cereus bacteria when treated with NaCl, which amounted to 1.99 g plant-1.

The results of the same table also showed the effect of salt concentrations on the yield. The concentration 0 mM recorded the highest yield rate before addition and after adding B.cereus bacteria, which amounted to 3.03 and 3.20 gm respectively, while the concentration 75 mM gave the highest yield rate after adding B.subtilis, which amounted to 4.05 gm plant-1. While the yield rate decreased without bacteria and with the addition of B.cereus bacteria at the concentration 75 mM and recorded 1.60 and 1.44 gm plant-1, while the yield rate decreased after adding B.subtilis at the concentration 0 mM and recorded 3.30 gm plant-1. The results also showed that the interaction between salts and concentrations had a significant effect on the yield. The interaction treatment between MgCl2 with a concentration of 0 mM was excelled and recorded the highest yield rate without bacteria and after adding B.cereus bacteria, which amounted to 3.06 and 3.40 g plant-1, while the interaction treatment between NaCl with a concentration of 75 mM was excelled and recorded the highest yield rate after adding B.subtilis, which amounted to 7.60 g plant-1, while the yield decreased with the NaCl treatment and the concentration of 75 mM and gave the lowest yield rate without bacteria and after adding B.cereus and B.subtilis bacteria, which amounted to 1.00, 1.30 and 0.50 g plant-1. The increase in root weight is attributed to the positive effect of Bacillus bacteria in the root zone and their ability to secrete some growth regulators such as auxins and hormones, in addition to fixing nitrogen, which enters into the construction of amino acids and proteins and their formation, and then the direct effect in increasing the vital processes within the plant, including photosynthesis, nutrient production and storage in seeds, and thus increasing the yield, which is what was indicated by [12.[

ISSN 2072-3857

Table (13) The effect of positive salt ions and Bacillus bacteria on the weight of the yield (g plant-1(

average Salts	Concentrations mM				Salts
	75	50	25	0	
1.68	1.00	1.20	1.50	3.00	**$MgCl_2$**
2.72	2.20	2.60	3.00	3.06	**NaCl**
	1.60	**1.90**	**2.25**	**3.03**	**average**
B. subtilis					
0.68	0.50	0.70	0.93	0.60	**$MgCl_2$**
6.63	7.60	6.90	6.00	6.00	**NaCl**
	4.05	**3.80**	**3.47**	**3.30**	**average**
B. cereus					
2.12	1.30	1.87	2.30	3.00	**$MgCl_2$**
1.99	1.57	1.47	1.50	3.40	**NaCl**
	1.44	**1.67**	**1.90**	**3.20**	**average**
	interaction	**Concentrations**	**Salts**		**LSD 0.05**
	0.294	**0.208**	**0.147**	**No**	
	0.289	**0.205**	**0.145**	***B***	
	0.597	**0.422**	**0.298**	***B***	

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