Available online at http://bjas.bajas.edu.iq
https://doi.org/10.37077/25200860.2024.37.2.20
College of Agriculture, University of Basrah

Basrah Journal of Agricultural Sciences

ISSN 1814 – 5868
Basrah J. Agric. Sci., 37(2), 264-275, 2024
E-ISSN: 2520-0860

Effects Bacterial Inoculation and organic Fertilization on Some Soil Properties and Growth oF Potato Crop Role in Sustainable Agriculture

Haider A. Al-Maamori

Department of Biology, College of Education for Pure Sciences, Wasit University, IRAQ

***Corresponding authors email**: haidera.f@uowasit.edu.iq

Received 1st October 2024; Accepted 8th December 2024; Available online 31st December 2024

Abstract: A field experiment was carried out at the Agricultural Research Station in Wasit Governorate, with a design of RCBD this study aimed to determine the role of Bacillus, Azotobacter, and organic fertilizers on soil biological and chemical properties and potato growth indicators. The results of the application experiment showed that the mixed treatment with *Azotobacter chroococcum* + *Bacillus megaterium* bacteria was superior in terms of the number of Bacillus bacteria in the soil, the number of Azotobacter bacteria in the soil, the soil pH, the leaf area, the tuber weight,and the yield per plant (7.48×10^6, 8.42×10^6 cfu, 7.03, 1.92%, 13416 cm^2, 129.10 gm, respectively). The organic fertilizer vermicompost was also superior in terms of the number of Bacillus bacteria in the soil, the number of Azotobacter bacteria in the soil, the soil reactivity, the leaf area, the tuber weight, and the yield per plant (4.45×10^6, 5.58×10^6, 7.05, 1.92%, 13434 cm^2, 136.90 gm, 1386.7 gm, respectively).

Keywords: Soil bacteria , Soil chemical and biological properties, plant

Introduction

Sustainable agriculture raises awareness among civil society and policymakers of the importance of soils to human well-being and nature conservation, and promotes effective policies and actions for the sustainable management and protection of soil resources(Suman et al,2022). These efforts are also aligned with the UN Sustainable Development Goals, the so-called Agenda 2030. Among the many priorities of the IUSS is the remediation of degraded soils and minimization of the risk of new degradation by implementing soil contamination countermeasures (Lal, ,2016) Microorganisms have received significant attention in recent years, highlighting their importance as ecological units. Similarly, there has been interest in manipulating the microorganisms involved in the rhizosphere microbial community for sustainable agriculture, resulting in several commercial bioformulations for increasing crop yields and pest resistance. These bioformulations are called biofertilizers, and different types have consistently existed and evolved. However, recently, a new area of interest has been focused on the application of these microorganisms in waste valorization and the production of "bio-organic" fertilizers. (Kiruba and Saeid,2022)
Numerous studies have reported that the overuse of traditionally used synthetic fertilizers contributes to the degradation of soil quality in most cultivated lands and has a negative impact on biological

communities. In response to increasing demand in the past decades, the application of certain chemical fertilizers has improved agricultural production, but now, in the long term, it has raised sustainability issues amid diminishing resources and raw materials. This has created the need to deviate from the traditional linear model of bio fertilizer production and adopt circular production from different kinds of waste-based resources. Although the application of synthetic fertilizers since the 1950s has greatly helped to provide food security in many developing countries, there are also downsides to their overuse. Inefficient and inappropriate use of chemical fertilizers has caused various problems such as soil quality degradation, groundwater contamination, loss of biodiversity, reduced soil fertility, development of pest resistance, and acidification problems, which are potential sources of non-point source pollution resulting from agriculture (Jiang et al,2020)

The plant rhizosphere is home to beneficial bacteria that play a key role in promoting plant growth and development. This review outlines the importance of Azotobacter for long-term agricultural viability. Plant growth processes such as nitrogen fixation, phosphate solubilization, and hormone secretion are discussed. Improved plant resistance to biotic and abiotic stresses, reduced use of chemical fertilizers and pesticides, improved nutrient availability, soil fertility, and absorption are all mentioned as potential benefits of Bacillus. PGPR fulfill multiple ecological and practical functions in the soil rhizosphere. One of the various roles of PGPR in agroecosystems is to increase the synthesis of plant hormones and other metabolites that directly affect plant growth. PGPR also aid in soil remediation through a process called bioremediation. The many functions of PGPR include the production of indole acetic acid (IAA), the production of ammonia (NH_3), and more. In addition to aiding in nutrient absorption, PGPR control the production of hormones that increase root size and strength. Improved crop yields, reduced environmental pollution and guaranteed food security are just some of the ecological and economic benefits that can be gained from employing Bacillus and Azotobacter in sustainable agriculture (Hasan et al,2024) Vermicomposting, the process of using earthworms to transform biodegradable materials into nutrient-rich vermicompost, has become a fundamental practice in sustainable agriculture. Rich in growth-promoting hormones, enzymes, and microorganisms, vermicompost significantly enhances plant growth and increases resistance to diseases. With the staggering annual production of organic waste worldwide, expected to increase from 1.3 billion tons to 2.2 billion tons by 2025, vermicomposting has emerged as an environmentally friendly method of organic fertilizer production. Historically revered by Charles Darwin as "nature's cultivator," earthworms contribute to soil health, affecting microbial communities and nutrient availability, and mitigating the effects of heavy metals. Application of vermicompost increases crop yields and improves fruit quality, highlighting the need for careful nutrient balancing. Vermicomposting has a positive impact on soil structure, reducing bulk density, increasing water retention, and mitigating nitrate leaching, promoting environmental sustainability. It positively impacts soil biology, including microbial biomass and enzyme activity, fostering healthier soil ecosystems, playing a pivotal role in the future of agriculture and making a significant contribution to environmental conservation (Manchal et al,2023).

The aim of this study was to determine the interactions of bacterial bio-inoculations and types of organic fertilizer, compost and vermicompost on soil biological and chemical properties and potato plant growth.

Materials & Methods

The applied research was carried out in the fields of the Agricultural Research Station under the Iraqi Ministry of Agriculture. The land was cultivated with a disc plow and improvement treatments were applied. The experimental soil was divided into several experimental units, each with an area of 9 m^2. The treatments were randomly distributed according to a randomized complete block design (RCBD). Potato tubers were planted and soil moisture in the experimental units was maintained after estimating moisture based on the gravimetric method to maintain a moisture content suitable for the activity of the bacteria used in the experiment. Thinning and weeding were also carried out, if necessary, to remove weeds growing in the field that compete with the plants.

2.1 Organic Fertilization

2.1.1 Vermicompost was prepared and produced from earthworms isolated from Iraqi soil, A plastic container with holes at the bottom was prepared to allow the drainage of excess water from the farm and also to improve ventilation. The dimensions of the container were 80 cm long, 25 cm wide and 35 cm deep. The container was filled with 6 cm high fine sawdust, peat moss and a small amount of soil. This was considered the winery and represented a suitable environment for the growth of earthworms. The earthworms were then added uniformly. The earthworms were fed daily, taking into account their stability and adaptability to the surrounding environment. The materials added were (pigmented peels, uncolored paper waste, cucumber, pumpkin, lettuce, vegetables and egg shells) and kitchen waste, excluding fat, meat and onion, which were kept constantly moist and maintained at a temperature of 20°C. (Al-Maamori et al,2023)

2.1.2 We used vegetable compost that we bought at a local market in Iraq, which is an organic fertilizer made from imported plant waste.

2.2 Bacterial Inoculation

They used Azotobacter bacteria isolated from soils in agricultural areas of Iraq to test their nitrogen fixing ability and selected the most efficient isolates, as well as Bacillus bacteria isolated from soils of different agricultural areas that were more efficient at dissolving phosphate.

2.3 Pre-planting soil properties

As stated in (Bashour and Antoine ,2007) the chemical and physical properties of the soil were estimated before planting.

2.4 1 Total bacterial counts

The total bacterial counts in the soil before planting were estimated by dilution and plate counts using nutrient agar medium according to (Black,1965).

2.4.2 Total fungal counts

The dilution and plate count method using PDA medium according to the Martin method was used (Black a ,1965).

2.5 Number of Bacteria in the soil after planting

2.5.1 Number of Azotobacter bacteria in soil after planting

The most probable number (MPN) method was used to enumerate Azotobacter in the soil before planting. Serial dilutions were made and 1 ml was transferred to test tubes containing 9 ml of sucrose mineral salts culture medium, with five replicates for each dilution. The tubes were incubated at 30°C for 48 hours. The most probable number (MPN) was calculated based on the table in Black (1965).

2.5.2 Number of Bacillus bacteria in soil after planting

Estimation of Bacillus counts in field test soils by plate count method The Bacillus counts in the soil were estimated before planting. Dilutions 10^{-5} and 10^{-7} were planted on solid Pikovskaya medium, 1 ml of the 5th, 6th, and 7th dilutions were taken and inoculated into the above-mentioned medium, and the plates were incubated at 28 °C for 72 h. (Black,1965).

2.6 Soil pH

Soil pH was estimated in a 1:1 soil:water suspension using a pH meter device (Richards,1954).

2.7 Organic matter

Organic matter in soil was estimated using potassium dichromate according to the Walkley-Black method (Jackson,1958).

2.8 Nitrogen fixation test by Azotobacter

Nitrogen-free liquid medium was prepared and 50 moles of the liquid medium was placed in a 250 mole bottle and 1% mannitol was added. The bottle was inoculated with 1 mole of liquid culture of the isolate and incubated with mannitol in an incubator at 28°C for 3 weeks. The amount of ammonia produced was estimated in a micro-Kjeldahl apparatus by taking 2 moles as described by(Bremner 1965).

2.9 Phosphate dissolving ability of Bacillus

Solid medium PVK (Pikovskya, 1948) was used. Bacteria were cultivated on solid medium. Dishes were placed in an incubator at a temperature of 28°C and the diameter of the halozone was monitored periodically. Experiments were performed in triplicate.

Table1 Components Pikovaskay Medi

Quantity gm L^{-1}	Media components
10.0	Glucose
0.5	$(NH4)_2SO_4$
0.1	$MgSO_4.7H_2O$
0.5	Yeast extract
0.2	KCl
0.2	NaCl
0.002	$FeSO_4.7H_2O$
0.002	$MnSO_4.\ H_2O$
-	$MgCl_2.6\ H_2O$
5.0	$Ca_3(PO_4)_5$
15.0	Agar
7 ± 0.2	pH

2.10 Preparation of bacterial vaccine

1 kg of commercially available peat moss was sterilized by autoclaving, and 250 ml of nutrient medium. containing Azotobacter and 250 ml of nutrient medium containing Bacillus were gradually added until the carrier was evenly wetted and the bacterial cells were spread on the peat moss.

2.11Experiment transactions

First factor : Bacterial Inoculation

BI0: No addition

BI1: *Azotobacter chroococcum*

BI 2: *Bacillus megaterium*

Second factor : Organic Fertilization

OM0: No addition OM1: Organic compost (Plant waste) OM2: Vermicompost

Table 2. Field soil properties before planting

Character			Value
	pH		7.4
	EC $_{1:1}$	dS m^{-1}	2.90
Soluble nutrient	Ca^{+2}	mmol^{-1}	7.63
	Mg^{+2}		5.24
	Na^{+}		3.21
	CL^{-}		9.00
	$SO4^{-2}$		7.69
Available Nutrients	N	mgkg^{-1}	22.75
	P	mgkg^{-1}	14.97
	K	mgkg^{-1}	193.59
Texture			Clay Loam

Results & Discussion

3.1 Effect of bacterial inoculation and organic fertilizer on the number of Bacillus

Statistical analysis of the experimental results showed Table 3 The results of the statistical analysis showed a significant effect on the number of Bacillus bacteria in the soil, as the treatment of adding the mixed bio-inoculation BI1 + BI2 outperformed. The number of Bacillus bacteria was 7.48 X 10^6 compared to the treatment without the addition of bacterial inoculant BI0 (1.71 X 10^6). Statistical analysis showed that the organic fertilizer treatment was also superior in the density of Bacillus bacteria, with the treatment adding vermicompost OM 2 being superior, with 5.45 X 10^6 compared to the OM0 treatment (4.03 X 10^6). The binary interaction between bacterial inoculant and organic fertilizer resulted in the treatment adding BI 1 + BI 2 + OM2 being superior, with 8.17 X 10^6 compared to the control treatment, and BI 0 + BI 0 + OM 0, with 2.60 X 10^6.

Table 3. Effect Bacterial Inoculation and Organic matter Bio Fertilizers on the Total number Bacillus bacteria in soil CFU* 10^6

Bacterial Inoculation	Organic Fertilization			Mean (B I)
	OM 0	OM 1	OM 2	
BI 0	0.64	1.89	2.60	1.71
BI 1	3.03	3.19	3.86	3.36
BI 2	5.66	6.83	7.19	6.56
BI 1+ BI 2	6.78	7.49	8.17	7.48
L.S.D $_{BI*OM}$		0.17		L.S.D $_{BI}$ =0.10
Mean (OM)	4.03	4.85	5.45	L.S.D$_{OM}$=0.08

3.2 Effect of bacterial inoculation and organic fertilizer on the number of Azotobacter

The results in the table show that adding bacterial bioinoculants has a significant positive effect on increasing the number of Azotobacter cells. The treatment with the addition of mixed bioinoculants BI1+ BI2 was superior with 8.42 x 10^6 compared to the treatment without the addition of inoculant BI0 (0.86 x 10^6). The organic fertilizer treatments were also superior in the number of Azotobacter bacteria, the treatment with the addition of vermicompost OM2 was superior with 5.58 x 10^6 compared to the OM0 treatment (3.67 x 10^6). The results of the binary interaction between bacterial bioinoculants and organic fertilizer show that the BI1+BI2+OM2 treatment was superior with 9.55 x 106 compared to the BI 0 + BI 0 + treatment, which was 0.50 x 10^6 for OM0.

Table 4. Effect Bacterial Inoculation and Organic matter Bio Fertilizers on the Total number Azotobacter bacteria in soil CFU* 10^6

Bacterial Inoculation	Organic Fertilization			Mean (B I)
	OM 0	OM 1	OM 2	
BI 0	0.50	0.84	1.23	0.86
BI 1	4.21	6.59	7.00	5.93
BI 2	2.89	3.80	4.54	3.74
BI 1+ BI 2	7.09	8.62	9.55	8.42
L.S.D $_{BI*OM}$		0.15		L.S.D $_{BI}$ =0.09
Mean (OM)	3.67	4.96	5.58	L.S.D$_{OM}$=0.08

Inoculation with Azotobacter isolates significantly increased the number of bacteria. The reason is their successful effectiveness in the soil after inoculation and the absence of biological competitors. These results are consistent with the results of (Kisten et al, 2006) Vermicompost also helps to increase the number of bacteria in the soil, as it helps to improve the chemical, biological and physical properties of the soil, provide a suitable environment for the growth of soil microorganisms and increase the cell density. The increase in the number of Bacillus bacteria is due to the presence of bacteria added as a mixed biological inoculant. The ability of Azotobacter to fix nitrogen, which is necessary for building the cells of other organisms, and the availability of energy sources and nutrients in the soil as a result of the addition of vermicompost. These results are consistent with the results of (Azzawi And Kamal,2023). The interaction of bacteria with vermicompost significantly increased the number of bacteria and improved the biological properties of the soil. The reason is that it exerts its effect in the soil after inoculation.

3.3 Effect of bacterial inoculation and organic fertilizer on pH in soil

The results of the statistical analysis in the table4 show that the addition of bacterial bioinoculants had a significant effect on lowering the soil pH after planting. In the BI 1+ BI treatment it reached 27.03, while in the BI 0 treatment it was 7.38. The Bacillus megaterium bacteria also performed significantly better with 7.08. The addition of organic fertilizer significantly reduced the soil pH, reaching 7.05 in the OM2 treatment, followed by 7.15 in the OM1 treatment, above the control OM 0 which reached 7.31.

Table 5. Effect of Organic fertilizer and Biofertilizers in pH soil

Bacterial Inoculation	Organic Fertilization			Mean (B I)
	OM 0	OM 1	OM 2	
BI 0	7.44	7.29	7.42	7.38
BI 1	7.38	7.02	7.17	7.19
BI 2	7.25	6.94	7.04	7.08
BI 1+ BI 2	7.17	6.95	6.98	7.03
L.S.D $_{BI*OM}$		0.10		L.S.D $_{BI}$ =0.06
Mean (OM)	7.31	7.15	7.05	L.S.D$_{OM}$= 0.05

3.4 Effect of bacterial inoculation and organic fertilizer on Organic Matter in Soil

Statistical analysis of the table6 showed that the organic fertilizer used in the experiment had a significant effect on the percentage of organic matter in the soil after planting, with the results showing that the vermicompost treatment was significantly better, showing 1.92%, followed by the treatment with added vegetable compost, showing 1.55%. Adding bacterial bio-inoculants increased the percentage of organic matter compared to the treatment without added organic fertilizer (1.26%), with the treatment with added bacterial mixture BI 1 + BI 2 being significantly better, showing 1.92% compared to the treatment without added inoculation (1.41%). Statistical analysis of the two-way interaction between organic and biological bacterial bio-inoculants showed that the highest percentage of organic matter in the soil was BI 1 + BI 2 + OM2, showing 2.61%, while BI 0 + BI 0 + OM0 treatment had 0.93%.

Vermicompost containing *Azotobacter chroococcum* and *Bacillus megaterium* affects soil pH, The reason for the decrease in soil pH is that vermicompost decomposes over time, releasing hydrogen ions, various organic acids, and carbon dioxide gas during decomposition, which reduces soil pH (Pan and Huang,2024) *Bacillus megaterium* and *Azotobacter chroococcum* bacteria led to an improvement in all properties of the studied soil.

Table 6. Effect of Organic fertilizer and Bio fertilizers on Organic matter in soil %

Bacterial Inoculation	Organic Fertilization			Mean (B I)
	OM 0	OM 0	OM 0	
BI 0	0.93	1.46	1.86	1.41
BI 1	1.34	1.51	1.57	1.47
BI 2	1.28	1.54	1.64	1.49
BI 1+ BI 2	1.47	1.69	2.61	1.92
L.S.D BI*OM		0.08		L.S.D $_{BI}$ =0.05
Mean (OM)	1.26	1.55	1.92	L.S.D$_{OM}$= 0.04

Due to the work of *A. chroococcum* bacteria to improve plant growth, the soil pH value decreased significantly, root secretions and hydrogen ions increased, the respiration process increased with the release of CO2 gas and the formation of carbonic acid, which in turn decreased the soil pH value and increased the available nitrogen, phosphorus, and organic matter elements in the soil (Palta and Kumar) The results of this study are consistent with those of(Ibrahim et al,2024) *Bacillus megaterium* and *Azotobacter chroococcum* showed that when soil pH decreased, unavailable mineral elements were released in a available form, which increased their concentration in the soil solution, increased their absorption by plants, increased root branching during the plant growth stage, increased organic matter in the soil, and also increased old leaf litter, which increased the amount of organic matter, and the results of this study are consistent with (Alkobaisy and Mutlag,2021) The decrease in soil pH is due to the effect of vermicompost, which forms humic acid and reduces the degree of soil reactions. Vermicompost enriches the soil with millions of bacteria and fungi that secrete organic acids that reduce the degree of soil reactions. The mixed bio fertilizer has the ability to change the soil pH due to the action of *Azotobacter chroococcum* and *Bacillus megaterium* and their ability to secrete various organic compounds such as succinic acid, acetic acid, isovaleric acid, etc., increasing the solubility of low soluble compounds (Minuț et al, 2022) .

3.5 Effect of bacterial inoculation and organic fertilizer on Leaf area

The results of the statistical analysis in the table 7 show a significant effect of bacterial inoculant on the leaf area of plants, with BI 1 + BI 2 treatment showing 13416 cm^2 and BI 0 treatment showing 11658 cm^2. BI1 treatment was also significantly superior, showing 13057 cm^2. The addition of organic fertilizer significantly increased the leaf area of plants, with OM 2 treatment showing 13434 cm^2 and OM 0 treatment showing 11844 cm2. The results of the two-way interaction also showed a significant advantage in leaf area with OM1 + BI 1 + BI 2 treatment showing 13814 cm^2, followed by OM2 + BI 1 + BI 2 treatment showing 13576 cm^2, and the lowest value was OM 0 BI 0 treatment showing 9198 cm^2.

Table 7. Effect of Organic fertilizer and Biofertilizers on Leaf area cm^2

Bacterial Inoculation	Organic Fertilization			Mean (B I)
	OM 0	OM 1	OM 2	
BI 0	9198	12952	12825	11658
BI 1	12663	13536	12971	13057
BI 2	12656	13435	12752	12948
BI 1+ BI 2	12858	13814	13576	13416
$L.S.D_{BI*OM}$		299		$L.S.D_{BI}$ =172
Mean (OM)	11844	13031	13434	$L.S.D_{OM}$=149

3.6 Effect of bacterial inoculation and organic fertilizer on Tuber weight

The results in Table 8 show that bacterial inoculant had a significant effect on increasing tuber weight, reaching 2129.10 g in the BI 1 + BI treatment and 113.70 g in BI 0. Adding organic fertilizer also significantly increased tuber weight, reaching 136.90 g in the OM2 treatment, then 124.00 g in the OM 1 treatment and 108.00 g in the OM 0 treatment. The two-way interaction between bacterial bioinoculants and organic fertilizer resulted in the highest tuber weight, reaching 139.4 g in the BI 2 OM 2 treatment, then 135.70 g in the BI 1 + BI 2 + OM2 treatment and 84.60 g in the control BI 0 + BI 0 + OM0.

Table 8. Effect of Organic fertilizer and Biofertilizers on Tuber weight gm

Bacterial Inoculation	Organic Fertilization			Mean (B I)
	OM 0	OM 1	OM 2	
BI 0	84.6	116.3	140.2	113.7
BI 1	101.5	129.5	132.3	121.1
BI 2	110.3	134.0	139.4	127.9
BI 1+ BI 2	135.5	116.1	135.7	129.1
$L.S.D_{BI*OM}$		6.0		$L.S.D_{BI}$ =3.4
Mean (OM)	108.0	124.0	136.9	$L.S.D_{OM}$=3.0

3.7 Effect of bacterial inoculation and organic fertilizer on Yield per plant

The results of the field experiment in Table 9 show that the addition of bacterial inoculants had a significant effect on the yield per plant. It reached 21425.90 gm in the BI 1 + BI treatment, followed by 1284.00 gm in the BI 2 treatment. In the treatment without the addition of bio inoculants BI 0, it reached 909.40 gm. Also, the addition of organic fertilizer plays an important role in increasing the weight of the yield per plant. In the vermicompost treatment OM2, 1386.70 was obtained, while in the treatment without the addition of organic fertilizer, OM 0, it was 977.40. As a result of the two-way interaction between bacterial inoculants and organic fertilizer, the highest yield per plant was obtained in the BI 1 + BI 2 + OM2 treatment, which reached 1652.80 gm. The next highest yield was the BI 1 + BI 2 + OM1 treatment with 1533.20 gm, surpassing the control treatments BI 0+ BI 0 + OM0 with 600.20 gm.

Table 9 Effect of Organic fertilizer and Biofertilizers on Yield per plant gm plant^{-1}

Bacterial Inoculation	Organic Fertilization			Mean (B I)
	OM 0	OM 1	OM 2	
BI 0	600.20	967.30	1160.80	909.40
BI 1	992.00	1307.40	1344.00	1214.50
BI 2	1225.80	1236.80	1389.40	1284.00
BI 1+ BI 2	1091.60	1533.20	1652.80	1425.90
L.S.D $_{BI*OM}$		30.70		L.S.D $_{BI}$ =35.50
Mean (OM)	977.40	1261.20	1386.70	L.S.D$_{OM}$ 30.70

Results so far have revealed that the application of vermicompost to urea fertilizer and *Azotobacter chroococcum* and *Bacillus megaterium* to vermicompost increases the characteristics of vegetative growth and yield (leaf area, tuber weight, yield per plant). The increase in these characteristics is due to the role of microorganisms in providing the necessary energy and carbon sources for biological processes (Ibrahim et al,2024). Thus, these two elements have different effects on plant growth, since they are involved in many important activities. Nitrogen is involved in increasing cell division, which leads to an increase in leaf area. Nitrogen is also involved in the construction of chlorophyll molecules, which increases the relative chlorophyll content. An increase in chlorophyll content leads to an increase in the photosynthetic process, which leads to the conversion of manufactured carbohydrate compounds into storage areas, tuber weight and yield per plant. Bacteria fix atmospheric nitrogen, which improves plant growth through nutritional supplementation with nitrogen, which improves the photosynthetic process, which is reflected in the yield characteristics (Boubaker et al , 2023) Vermicompost, consisting of free amino acids and beneficial microorganisms such as PGPR, was found to be effective in enhancing seed potato growth parameters and yield.

The combined effect of changing the nitrogen content with vermicompost application was noteworthy. This effect was confirmed by a significant improvement in tuber growth parameters, yield when compared to treatments with nitrogen or vermicompost alone. Vermicompost is effective for various plant species, such as potato, as it is rich in microorganisms that utilize amino acids, phenols and polymers, improving microbial metabolic activity. The stimulatory effect of nitrogen-fixing bacteria includes enhanced nitrogen fixation, which increases nitrogen assimilation by plants and subsequently stimulates plant growth (Boubaker et al ,2021) In addition, biofertilizers contribute to improved mineral absorption in plants, promoting improved root growth and function. Biofertilizers produce plant hormones such as indole acetic acid, gibberellins and cytokinins while reducing abscisic acid. In addition, biofertilizer activity produces amino acids and phenolic compounds that contribute to the overall health of the plant. Another benefit is improved plant water status. Increased nitrate reductase activity improves nutrient utilization and biofertilizers also help in the production of pathogen-fighting compounds. It has been reported that the application of bacterial inoculants in combination with organic fertilizers significantly increases potato tuber yield compared to untreated plants in our experiments (Lone et al . 2015).

Conclusion

The use of bacterial vaccine containing nitrogen-fixing and phosphate-dissolving bacteria caused a significant increase in the properties of the studied soil and plant growth indicators.

The interaction between organic fertilizer and bacteria has a positive role in increasing plant growth and improving the fertility of the soil.

Acknowledgements

The authors would like to thank the , College of Education for Pure Sciences, Wasit University for the support of the study.

ORCID

https://orcid.org/0009-0007-3233-8304Previewpublicrecord

Conflicts of interest

The authors declare that they have no conflict of interests.

References

Alkobaisy, J. S., & Mutlag, N. A. (2021). Effect of the use of vermicompost and rhizobial inoculation on some soil characteristics, growth and yield of mung bean Vigni radiate L. *Iraqi Journal of Agricultural Sciences*, *52*(1). https://doi.org/10.36103/ijas.v52i1.1248

Al-Maamori, H. A., Salman, A. D., Al-Budeiri, M., Al-Shami, Y. A. O., & Al-shaabani, E. M. (2023, July). Effect of Vermicompost Production on some Soil Properties and Nutrients in Plants. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1214, No. 1, p. 012006). IOP Publishing. http://doi.org/10.1088/1755-1315/1214/1/012006

Azzawi, S. S., & Kamal, J. A. K. (2023, April). Effective of Bacterial Inoculation Azotobacter Chroococcum and Bacillus Subtillis in Inoculation Density and Available Phosphorus in Soil and Plant. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1158, No. 2, p. 022002). IOP Publishing. http://doi.org/10.1088/1755-1315/1158/2/022002

Bashour, I., & Antoine, A. S. (2007). Soil Analysis Methods for Arid and Semi-arid regions. https://doi.org/10.4236/cus.2015.34027

Black, C. A., Evans, D. D., Ensminger, L. E., White, J. L., & FE (Ed.) CLARK.

(1983). *Methods of soil analysis*. ASA. https://doi.org/10.4236/oalib.1107329

Boubaker, H., Saadaoui, W., Dasgan, H. Y., Tarchoun, N., & Gruda, N. S. (2023). Enhancing seed potato production from in vitro plantlets and microtubers through biofertilizer application: Investigating effects on plant growth, tuber yield, size, and quality. *Agronomy*, *13*(10), 2541. https://doi.org/10.3390/agronomy13102541

Boubaker, H., Daşgan, H. Y., & Tarchoun, N. (2021). Effects of the bio-fertilizers on potato mini tubers number and size produced from tissue culture plants. *International Journal of Agriculture Environment and Food Sciences*, *5*(4), 514-523. https://doi.org/10.31015/jaefs.2021.4.11

Bremner, J. M., & Keeney, D. R. (1966). Determination and isotope-ratio analysis of different forms of nitrogen in soils: 3. Exchangeable ammonium, nitrate, and nitrite by extraction-distillation methods. *Soil Science Society of America Journal*, *30*(5), 577-582. https://doi.org/10.2136/sssaj1966.03615995003000050015x

Ibrahim, G. H., & Al-Alawy, H. H. M. (2024, July). Effect of Enriching Vermicompost with Chemical and Biological Fertilizers on the Growth and Yield of Sunflower. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1371, No. 8, p. 082034). IOP Publishing. http://doi.org/10.1088/1755-1315/1371/8/082034

Palta, P., & Kumar, A. (2024). Effect of vermicompost additive on physical, chemical and dielectric properties of soil and its modeling. *Journal of Microwave Power and Electromagnetic Energy*, *58*(3), 186-206. http://doi.org/10.1080/08327823.2024.2378668

Pikovaskya, R.I . (1948) Mobilization of phosphorus in soil in connection with vital activity of some microbial species. Mikrobiologiya, 17: 362-370. https://doi.org/10.4236/ojss.2015.55010

Pan, C. C., & Huang, C. H. (2024). Cow dung compost and vermicompost amendments promote soil carbon stock by enhancing labile organic carbon and residual oxidizable carbon fractions in maize field soil. *Soil Use and Management*, *40*(4), e13122. https://bsssjournals.onlinelibrary.wiley.com/doi/abs/10.1111/sum.13122

Richards, L. A. (Ed.). (1954). *Diagnosis and improvement of saline and alkali soils* (No. 60). US Government Printing Office. https://www.scirp.org/reference/referencespapers?referenceid=1885791#:~:text=http%3A//dx.doi.org/10.1097/00010694%2D195408000%2D00012

Suman, J., Rakshit, A., Ogireddy, S. D., Singh, S., Gupta, C., & Chandrakala, J. (2022). Microbiome as a key player in sustainable agriculture and human health. *Frontiers in Soil Science*, *2*, 821589. https://doi.org/10.3389/fsoil.2022.821589

تأثير التلقيح البكتيري والتسميد العضوي على بعض خواص التربة ونمو محصول البطاطا ودوره في الزراعة المستدامة

حيدر عباس المعموري

قسم علوم الحياة، كلية التربية للعلوم الصرفة ، جامعة واسط، العراق

المستخلص: أجريت تجربة حقلية في محطة البحوث الزراعية في محافظة واسط / وزارة الزراعة / العراق بتصميم القطاعات العشوائية الكاملة RCBD هدفت هذه الدراسة إلى معرفة دور بكتيريا Bacillus و Azotobacter والأسمدة العضوية في بعض الخصائص الحيوية والكيميائية للتربة ومؤشرات نمو البطاطا، وقد أظهرت نتائج تجربة تفوق معاملة خليط بكتيريا *Azotobacter chroococcum + Bacillus megaterium* من حيث اعداد بكتيريا Bacillus و اعداد بكتيريا Azotobacter في التربة ودرجة تفاعل التربة والمساحة الورقية ووزن الدرنة وحاصل النبات الواحد(7.48×10^6، 8.42×10^6، 7.03، 1.92%، 13416 سم^2، 129.10 غم على التتابع). كما تفوق السماد العضوي من حيث عدد بكتيريا Bacillus في التربة، وعدد بكتيريا Azotobacter في التربة، ودرجة تفاعل التربة، والمساحة الورقية، ووزن الدرنة، وحاصل النبات الواحد (4.45×10^6، 5.58×10^6، 7.05، 13434 سم^2، 136.90 غم، 1386.7 غم على التتابع).

الكلمات المفتاحية: بكتيريا التربة، *الخصائص الكيميائية والحيوية للتربة* ، النبات