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RESPONSE OF INDUSTRIAL POTATOES TO BIOLOGICAL AND CHEMICAL FERTILIZERS AND BRASSINOLIDE IN ABSORBING ELEMENTS AND SOME QUALITATIVE TRAITS

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ABSTRACT

The experiment was carried out at southwest Baghdad during fall season 2021 and spring season 2022 on the industrial potato of Arsenal hybrid, and the experiment carried out using randomized complete block design with in split plot arrangement with three replicates (4 × 3 × 3). Bio-fertilizer distributed within main plots and interaction between phosphorus levels and Brassinolide growth regulator within sub plot. Bio-fertilizers included *Aspergillus niger* fungus alone and *Bacillus Megaterium* bacteria alone and the combination between them add the control and phosphorus treatment of three levels of 0.100, 200 kg P_2O_5 ha^{-1} and Brassinolide spraying of three levels of 0, 0.1, 0.2 mg L^{-1}, The results showed a significant effect of the triple interaction among study factors, where the interaction between fungal and bacterial Bio-fertilization and phosphate fertilization 200 kg h^{-1} and spraying at a concentration of 0.1 mg L^{-1} with Brassinolide growth regulator had a significant effects, it gave the highest significant value in the percentage of phosphorus, potassium and iron concentration of leaves for both seasons and nitrogen percentage for the fall season with (0.45, 0.51 and 1.74, 1.74%, 130.00, 138.67 ppm and 1.31%) respectively, while the combination between fungal and bacterial Bio-fertilization and, phosphate fertilization 200 kgP_2O_5 h^{-1} and spraying at a concentration of 0.2 mg L^{-1} with Brassinolide growth regulator had the highest nitrogen percentage in the spring season 1.30% as well as produced the highest dry matter percentage, starch and protein in tubers for both seasons (21.00, 21.83 and 14.72, 15.64 and 1.79, 1.87%) respectively.

Keywords: *Aspergillus niger*, *Bacillus Megaterium* , Bio-fertilizers, growth regulator, phosphate.
***Part of Ph.D. dissertation of the 1st author**

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INTRODUCTION

The potato (*Solanum tuberosum* L.) is the third most important crop after rice and wheat in the world and it's one of the most efficient food crops in yield and production of alimentary fiber, high-quality protein, minerals and vitamins, and is recognized as a good and healthy food crop (Sharde et al., 2023) .It is considered one of the important industrial crops in the world and is used for many purposes, and therefore researchers in a large number of countries have been interested in improving potato cultivation techniques respectively to obtain high production and tubers with good qualitative traits (Morais et al., 2018), and among the techniques used are vaccines bio-fertilizers that improve soil properties and it's structure and increase the availability of nutrients by increasing the solubility of unavailable elements, Therefore, it is one of the most important tools of modern agriculture and the production of healthy agricultural crops and is considered as good ways to increase the efficiency of land use and

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reduce environmental pollution as it provides alternatives or supplements to chemical fertilizers to support plant growth (El-Ghamry et al.,2018) It’s improves nutrient action in the soil, stimulates plant growth and productivity, and replaces 25% of chemical fertilizers. *Bacillus Megaterium* secretes organic acids such as citric acid, gluconic acid and proponic acid (Zhong et al., 2017), and it has been proven that the use of this type of bacteria with mineral fertilizers increases plant height, dry weight, the number of tubers and total yield of the potato plant, and has the ability on breakdown of organic pesticides and their use as a carbon source for the growth of bacteria. The same case for Aspergillus niger fungus which is characterized by its ability to dissolve mineral phosphorus compounds and convert them in available formula for the plant by secreting citric, saxonic, kluconic and oxalic acid (Narsian and Patel, 2000), and this type of fungi is not productive for toxins and is harmless to the plant. Bio-fertilizers increase the efficiency of the use of phosphate fertilizers and make them more effective compared to biological inoculation alone or chemical fertilizer alone where the result is more balanced nutritionally and bio-fertilizers with chemical once increase availability of N.P.K elements for plants. Therefore, the modern research has directed to the use of this technology, phosphorus is one of the important elements that determine the growth and going of the plant in the effective direction of production especially after the appearance of modern hybrids which need different requirements of phosphorus, so it needs a continuous change in the addition of phosphorus element in terms of quantity and dates, determining the appropriate quantities of fertilizers and increasing the efficiency of plant absorption Especially after the rise in fertilizer prices, so it is necessary to discuss good management of the quantities of added fertilizers and achieve maximum benefit from them because there is no ideal relationship between the amount of phosphorus in the soil and its amount inside the plant (Hopkins and Hansen, 2019), phosphorus enters the synthesis of DNA and synthesis of energy reactions enzymes that important in the process RNA nucleic acids and in the of respiration and photosynthesis and in energy-rich bonds such as ATP and ADP and in the synthesis of phospholipids that form with protein cell membranes, and has importance In encouraging root growth (Hasan, 2015), and phosphorus deficiency is one of the determinants of crop production, and the activity of microorganisms has an important role in the readiness of phosphorus in the soil for absorption by the plant and the efficiency of phosphorus absorption in the rhizosphere area can be increased by reducing soil pH or using organic acids especially in basic soils, the rhizosphere is also expanded by increasing root growth and these techniques increase the effectiveness and efficiency of plant absorption (Hopkins et al., 2014). In general, mineral fertilization increases the percentage of nutrient elements in the vegetative parts and then fruits, in addition to its importance in increasing the diameter and area of the roots (Khudhair and Abdulrasool, 2023). Brassinostiroids is one of the new hormones which are composed from complex mixture of fats and exist in a free form or related with sugars, proteins or fatty acids and these compounds are important in plant growth and development through their effect on the growth, elongation ,cell division, differentiation of the vascular system ,formation of transverse roots, construction of wall components and cell membranes, resistance to stresses and the construction of DNA and RNA (Belkhadir and Chory, 2006) and because of the importance of this hormone for the plant in reducing environmental

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stresses which the plant is exposed from the change in temperature and soil salinity in Iraq, it was used in research. because of increasing the demand for industrial potatoes by factory owners varieties with manufacturing specifications have been introduced to be used in the manufacture of chips, but these varieties are flawed for their low production compared to consumer once, The most important characteristic of industrial hybrids is that they contain a high percentage of starch and dry matter and lower percentages of sugars compared to consumer hybrids (Boesch, 2012). Therefore, the study aimed to find out the effect of bio-fertilization, phosphate and spraying with a growth regulator Brassinolide in absorbing nutrients and improving qualitative traits.

MATERIALS AND METHODS

This study was carried out at south-west of Baghdad for the fall 2021 and spring 2022 seasons on the industrial potato crop of the Arsenal. The experiment was conducted as a three factors experiment using randomized complete plot design within Split Plot arrangement. The biological factor was within the main plots and the interaction between the composting levels of phosphorus and the Brassinolide within the sub plots, 36 treatments (4 × 3 × 3) with three replicates and 108 experimental units. The agricultural operations were carried out on the field including plowing, leveling, and smoothing. The land was divided into experimental units with a length of 1.75m and a width of 2m, which equals an area of 3.5m^2. Each unit includes two rows for cultivation, spaced 1m apart, with a distance of 0.25m between plants. This results in an average of 7 plants per row, or 14 plants per experimental unit. The biological factor included two types of fertilizers: *Aspergillus niger* and *Bacillus Megaterium*, symbolizing the treatment without Bio-fertilizer (A_0), *Aspergillus niger* (A_1), *Bacillus Megaterium* (A_2), and a combination of them (A_3) Microbiological isolates and mixed with peatmoss with a biodiversity of 810, which were added at a rate of 20 grams of biomaterial for each plant with soil, adding 800g of organic matter for each experimental unit and a fixed quantity of poultry residues for all treatment. The second factor is fertilization with phosphorus and includes three levels (0, 100, 200) kg P_2O_5 ha^{-1} as recommended (Ali, 2012) and symbolized by P_0, P_1, and P_2 respectively, the amount of phosphate fertilizer added on a single batch after five days from planting, The third factor includes three levels of growth regulator Brassinoslide (0, 0.1, 0.2) mg L^{-1} and symbolized by BL_0, BL_1, and BL_2 respectively, sprayed with three, first sprinkles after the emergence of 15 days the second and third sprinkle at a rate of 15 days. Nitrogen and potassium fertilizer were added in the two batches the first batch was 50% nitrogen after the emergence on 10 days with the addition of 25% of recommended potassium fertilizer and after 20 days from the first batch the remaining nitrogen fertilizer was added with 50% of potassium fertilizer, The remaining potassium fertilizer was added after 15 days from the second batch of nitrogen fertilizer and all experimental units were added equally (250 nitrogen and 300 potassium) kg ha^{-1} as recommended (Ali, 2012). The Gestate program was used in statistical analysis and averages for all the study indicators were compared by little significant difference (L.S.D) at 5%.

RESULTS AND DISCUSSION

1. Concentration of mineral elements N, P, K, Fe in leaves: The results of Table (1) shows the superiority of the A_3 bio-fertilizer treatment by recording the highest value of the nitrogen, phosphorus and potassium in the leaves for both the fall and spring seasons respectively it was amounted 1.26, 1.23 and

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0.40, 0.44 and 1.67, 1.68 % respectively and the A_1 treatment was characterized by producing the highest value in the iron concentration of the leaves for the fall season and the A_3 treatment for the spring season it is amounted to 125.07 and 124.19 ppm respectively, compared to the A_0 treatment which had the lowest value of nitrogen, phosphorus, potassium and iron for both seasons it's amounted to 1.17, 1.13 and 0.27, 0.28 and 1.52, 1.57% and 95.40, 102.26 ppm respectively, and the phosphate fertilization treatment P_2 was also characterized by produced the highest concentration of nitrogen, phosphorus, potassium and iron in leaves and amounted to 1.25, 1.20 and 0.39, 0.42 and 1.64, 1.65% and 119.08, 124.19 ppm compared to the P_0 treatment which had the lowest value to those indicators for both fall and spring seasons respectively and it's amounted to 1.19, 1.16 and 0.31 , 0.33 and 1.58, 1.59% and 107.61, 114.00 ppm, and spraying with growth regulator Brassinolide significantly affected in the concentration of the elements in leaves as the BL_2 treatment had the highest nitrogen value of 1.23% for the fall season and the BL_1 treatment produced the highest value in the spring season amounting to 1.19% and the BL_1 treatment produced the highest value in the phosphorus and iron percentage for both seasons amounting to 0.36, 0.39 % and 116.29, 122.11 ppm, and the same treatment had the highest potassium value of 1.64% for the spring season. There was no significant differences for spraying with Brassinolide for the percentage of potassium in the fall season compared to the BL_0 treatment which produced the lowest value In the content of leaves of nitrogen, phosphorus, potassium and iron amounted to 1.12, 1.16 and 0.34, 0.36 and 1.60, 1.60% and 110.50 and 113.42 ppm.

Table 1. Effect of biological and chemical fertilizers and brassinolide in absorbing elements and some qualitative traits in leaves and tubers of potato plants

	the fall season 2021							spring season 2022						
T	% N in leaves	% P in leaves	% K in leaves	Fe in leaves (ppm)	% dry matter in tubers	% starch in tubers	% protein in tubers	% N in leaves	% P in leaves	% K in leaves	Fe in leaves (ppm)	% dry matter in tubers	% starch in tubers	% protein in tubers
A_0	1.17	0.27	1.52	95.41	19.34	13.23	1.48	1.13	0.28	1.57	102.26	20.90	14.63	1.56
A_1	1.24	0.36	1.63	125.07	19.50	13.38	1.60	1.18	0.39	1.63	124.19	21.34	15.02	1.73
A_2	1.22	0.38	1.61	111.00	19.47	13.35	1.56	1.18	0.39	1.61	119.82	21.36	15.03	1.72
A_3	1.26	0.40	1.67	124.22	19.85	13.69	1.66	1.23	0.44	1.68	129.04	21.48	15.14	1.78
L.S.D 0.05	0.02	0.01	0.05	2.54	N.S	N.S	0.06	0.01	0.01	0.02	3.30	0.46	0.41	0.07
P_0	1.19	0.31	1.58	107.61	19.24	13.14	1.52	1.16	0.33	1.59	114.00	20.86	14.59	1.63
P_1	1.22	0.36	1.60	115.08	19.55	13.42	1.58	1.18	0.39	1.63	118.28	21.40	15.07	1.71
P_3	1.25	0.39	1.64	119.08	19.83	13.67	1.62	1.20	0.42	1.65	124.19	21.55	15.21	1.75
L.S.D 0.05	0.01	0.01	0.02	2.02	0.30	0.26	0.03	0.01	0.01	0.02	2.90	0.32	0.28	0.03
BL_0	1.21	0.34	1.60	110.50	19.24	13.15	1.54	1.16	0.36	1.60	113.42	21.14	14.84	1.66
BL_1	1.23	0.36	1.61	116.28	19.57	13.44	1.58	1.19	0.39	1.64	122.11	21.17	14.86	1.70
BL_2	1.23	0.36	1.61	115.00	19.81	13.65	1.60	1.19	0.38	1.63	120.94	21.50	15.16	1.72
L.S.D 0.05	0.01	0.01	N.S	2.02	0.30	0.26	0.03	0.01	0.01	0.02	2.90	0.32	0.28	0.03

Table (2) shows the significant effect of bilateral interaction between Bio-fertilizers and phosphate treatments as the A_3P_2 treatment had the highest value in the percentage of nitrogen, phosphorus and potassium for both fall and spring seasons and it’s amounted to 1.30, 1.27 and 0.44, 0.39 and 1.73, 1.72% respectively The same treatment also produced the highest iron concentration in the leaves for the spring season amounting to

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134.44 ppm and the A_1P_2 treatment had the highest iron value for the fall season of 128.67 ppm, while the A_0P_0 treatment produced the lowest value in the leaves of the elements concentration for both seasons amounted to 1.15, 1.12 and 0.21, 0.23 and 1.48, 1.52% and 87.78, 97.44 ppm respectively. The treatment of bilateral interaction between Bio-fertilizers and spraying with growth regulator Brassinolide had a significant effects as the A_3BL_1 treatment had the highest value in the leaves of phosphorus and potassium concentration for both seasons that reached to 0.41, 0.46 and 1.68, 1.70% and the same treatment produced the highest nitrogen percentage in the leaves for the fall season and the highest percentage of iron for the spring season it's amounted to 1.26% and 132.68 ppm and the A_3BL_2 treatment produced the highest nitrogen value in the spring season of 1.24% The A_3BL_1 treatment had the highest iron concentration in the leaves amounting to 126.68 ppm for the fall season, while the A_0BL_0 treatment produced the lowest percentage in the leaves for both seasons of nitrogen, phosphorus, potassium and iron concentration that reached to 1.16, 1.12 and 0.26, 0.26 and 1.51, 1.54% and 90.89, 96.56 ppm, also phosphate fertilization and spraying with Brassinolide had a significant effect to the leaves content of elements as the P_2BL_1 treatment had the highest value of phosphorus, potassium and iron in the leaves for both two seasons amounted to 0.40, 0.43 and 1.64, 1.66% and 121.50, and 126.80 ppm respectively, while the P_2BL_2 treatment had the highest value of nitrogen for both seasons 1.26 and 1.21% respectively, compared the P_0BL_0 treatment which had the lowest value for the leaves content of nitrogen, phosphorus, potassium and iron for both seasons that reached to 1.17, 1.14 and 0.30, 0.31 and 1.56, 1.56% and 103.25, 108.08 ppm respectively.The results of Table (3) show the effect of triple interaction between the study factors. Bio-fertilizers, phosphate and spraying with Brassinolide had a significant effects on the leaves concentration from elements, where the $A_3P_2BL_1$ treatment produced the highest value of phosphorus, potassium and iron for both seasons and amounted to 0.45, 0.51 and 1.74, 1.74% and 130.00, 138.67 ppm respectively. The $A_3P_2BL_1$ treatment had the highest nitrogen percentage in the leaves for the fall season amounting to 1.31% and the $A_3P_2BL_2$ treatment produced the highest nitrogen value in the spring season that reached to 1.30% compared to $A_0P_0BL_0$ treatment which had the lowest value in the leaves content of nitrogen, phosphorus, potassium and iron in the leaves for both seasons, where reached to 1.14, 1.12 and 0.88, 0.20 and 1.44, 1.46% and 81.00, 91.33 ppm respectively.

2. Dry matter, Starch and Protein in tubers based on wet weight: The results in Table (1) show the significant effects of using Bio-fertilizers on the qualitative traits of industrial potatoes as A_3 treatment showed the highest value of the protein percentage for both seasons reaching to 1.66 and 1.78% respectively. The same treatment also produced the highest value of dry material and starch percentage for the spring season that reaching to 21.48 and 15.14% respectively. There was no significant differences for using Bio-fertilizers in the fall season compared to treatment A_0 which had lowest value reaching to 1.48 and 1.56% for the percentage of protein in both seasons and 20.90, 14.62% for the percentage of dry matter and starch in the spring season. There was a significant effects of using phosphate fertilizer as treatment P_2 produced the highest value of dry matter, starch and protein for both seasons reaching to 19.83, 21.55 and 13.67, 15.20 and 1.62, 1.78% respectively compared to the lowest value which was for treatment P_0 that reaching to

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19.24, 20.86 and 13.14, 14.59 and 1.52, 1.63% for both seasons respectively. The spraying with growth regulator Brassinolide had a significant effects on the qualitative traits of industrial potato in which Treatment BL_2 produced the highest value of dry matter, starch, and protein that reaching to 19.80, 21.50 and 13.65, 15.16 and 1.60, 1.72% respectively for both seasons while treatment BL_0 had lowest value reaching to 19.24, 21.14 and 13.15, 14.84 and 1.54, 1.66% respectively.

Table 2. Effect of Bilateral interaction for biological and chemical fertilizers and brassinolide in absorbing elements and some qualitative traits in leaves and tubers of potato plants

		fall season 2021							spring season 2022						
T		% N in leaves	% P in leaves	% K in leaves	Fe in leaves (ppm)	% dry matter in tubers	% starch in tubers	% protein in tubers	% N in leaves	% P in leaves	% K in leaves	Fe in leaves (ppm)	% dry matter in tubers	% starch in tubers	% protein in tubers
	P_0	1.15	0.21	1.48	87.78	19.05	12.98	1.42	1.12	0.23	1.52	97.44	20.15	13.96	1.47
A_0	P_1	1.17	0.27	1.54	94.22	19.37	13.27	1.49	1.13	0.29	1.59	104.67	21.26	14.95	1.59
	P_2	1.19	0.33	1.55	104.22	19.58	13.45	1.52	1.15	0.33	1.61	104.67	21.29	14.97	1.63
	P_0	1.21	0.34	1.61	118.44	19.21	13.12	1.56	1.16	0.34	1.61	118.44	21.18	14.87	1.69
A_1	P_1	1.24	0.37	1.61	128.11	19.75	13.60	1.61	1.18	0.40	1.62	121.78	21.31	14.99	1.72
	P_2	1.27	0.37	1.66	128.67	19.53	13.40	1.62	1.19	0.42	1.64	132.33	21.54	15.19	1.77
	P_0	1.19	0.33	1.59	103.00	19.54	13.42	1.55	1.16	0.34	1.59	114.67	21.02	14.73	1.66
A_2	P_1	1.22	0.40	1.61	113.00	19.44	13.33	1.56	1.17	0.42	1.61	119.44	21.50	15.16	1.74
	P_2	1.25	0.42	1.62	117.00	19.43	13.32	1.58	1.19	0.43	1.62	125.33	21.55	15.20	1.75
	P_0	1.21	0.36	1.63	121.22	19.14	13.06	1.55	1.18	0.40	1.63	125.44	21.09	14.80	1.71
A_3	P_1	1.26	0.40	1.66	125.00	19.62	13.49	1.64	1.22	0.43	1.69	127.22	21.52	15.18	1.78
	P_2	1.30	0.44	1.73	126.44	20.78	14.52	1.78	1.27	0.49	1.72	134.44	21.83	15.46	1.85
L.S.D 0.05		0.02	0.02	0.04	4.05	0.59	0.53	0.06	0.02	0.02	0.03	5.81	0.63	0.56	0.06
	BL_0	1.16	0.26	1.51	90.89	18.67	12.64	1.42	1.12	0.26	1.54	96.56	20.52	14.28	1.51
A_0	BL_1	1.17	0.28	1.53	98.33	19.51	13.38	1.50	1.14	0.29	1.59	106.11	20.86	14.59	1.57
	BL_2	1.17	0.28	1.53	97.00	19.83	13.67	1.52	1.14	0.29	1.59	104.11	21.33	15.01	1.60
	BL_0	1.23	0.35	1.62	123.11	19.56	13.43	1.59	1.16	0.37	1.62	119.33	21.41	15.08	1.71
A_1	BL_1	1.24	0.37	1.62	126.67	19.23	13.14	1.58	1.18	0.40	1.63	127.56	21.26	14.94	1.73
	BL_2	1.25	0.36	1.63	125.44	19.70	13.55	1.62	1.18	0.40	1.62	125.67	21.36	15.04	1.73
	BL_0	1.21	0.37	1.59	107.22	18.96	12.90	1.51	1.16	0.38	1.59	115.22	21.18	14.87	1.67
A_2	BL_1	1.22	0.39	1.61	113.67	19.64	13.50	1.58	1.18	0.40	1.62	122.11	21.29	14.98	1.72
	BL_2	1.23	0.39	1.61	112.11	19.82	13.67	1.60	1.18	0.40	1.61	122.11	21.59	15.24	1.75
	BL_0	1.24	0.39	1.66	120.78	19.77	13.62	1.64	1.20	0.42	1.66	122.56	21.46	15.13	1.75
A_3	BL_1	1.26	0.41	1.68	126.44	19.89	13.72	1.66	1.24	0.46	1.70	132.67	21.25	14.94	1.78
	BL_2	1.26	0.40	1.68	125.44	19.89	13.73	1.66	1.24	0.45	1.68	131.89	21.73	15.36	1.80
L.S.D 0.05		0.02	0.02	0.04	4.05	0.59	0.53	0.06	0.02	0.02	0.03	5.81	0.63	0.56	0.06
	BL0	1.17	0.30	1.56	103.25	18.94	12.88	1.48	1.14	0.31	1.56	108.08	20.70	14.45	1.60
P0	BL1	1.20	0.32	1.59	110.33	19.17	13.08	1.52	1.16	0.34	1.61	117.50	20.59	14.35	1.62
	BL2	1.20	0.31	1.59	109.25	19.61	13.48	1.56	1.17	0.34	1.60	116.42	21.28	14.97	1.67
	BL0	1.21	0.35	1.60	112.83	19.09	13.01	1.53	1.16	0.37	1.61	112.50	21.25	14.94	1.67
P1	BL1	1.22	0.37	1.60	117.00	19.78	13.63	1.60	1.19	0.40	1.64	122.00	21.38	15.05	1.72
	BL2	1.23	0.37	1.61	115.42	19.77	13.62	1.60	1.18	0.39	1.63	120.33	21.57	15.22	1.73
	BL0	1.24	0.38	1.63	115.42	19.69	13.55	1.61	1.18	0.40	1.63	119.67	21.47	15.14	1.72
P2	BL1	1.26	0.40	1.64	121.50	19.75	13.60	1.62	1.21	0.43	1.66	126.83	21.52	15.18	1.76
	BL2	1.26	0.39	1.64	120.33	20.05	13.87	1.64	1.21	0.42	1.65	126.08	21.65	15.30	1.77
L.S.D 0.05		0.02	0.01	0.04	3.50	0.51	0.46	0.05	0.02	0.02	0.03	5.03	0.68	0.49	0.05

Table (2) shows the significant effect of treatments on the qualitative traits as the A_3P_2 treatment had the highest value of dry matter, starch and protein that amounted to 20.78, 21.83 and 14.52, 15.46 and 1.78, 1.85% while the A_0P_0 treatment produced the lowest value for all the mentioned traits that amounted to 19.05, 20.15 and 12.98, 13.96 and 1.42, 1.47%

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for both seasons respectively. The bilateral interaction between Bio-fertilizers and Brassinolide had a significant effect as well on the qualitative traits for industrial potatoes the A_3BL_2 treatment had the highest value of dry matter, starch and protein for both seasons that amounted to 19.89, 21.73 and 13.73, 15.36 and 1.66, 1.80% compared to the A_0BL_0 treatment which had the lowest value for all indicators of the mentioned qualitative traits and amounted to 18.67, 20.52 and 12.64, 14.28 and 1.42, 1.56% respectively. The bilateral interaction between phosphate fertilization and growth regulator Brassinolide the P_2BL_2 treatment had the highest value of dry matter, starch and protein for both seasons that amounted to 20.05, 21.65 and 13.87, 15.30 and 1.64, 1.76% respectively.

Table 3. Effect of triple interaction for biological and chemical fertilizers and brassinolide in absorbing elements and some qualitative traits in leaves and tubers of potato plants

	fall season 2021							spring season 2022						
T	% N in leaves	% P in leaves	% K in leaves	Fe in leaves (ppm)	% dry matter in tubers	% starch in tubers	% protein in tubers	% N in leaves	% P in leaves	% K in leaves	Fe in leaves (ppm)	% dry matter in tubers	% starch in tubers	% protein in tubers
BL_0	1.14	0.19	1.44	81.00	18.04	12.08	1.33	1.12	0.20	1.46	91.33	19.40	13.29	1.42
P_0 BL_1	1.15	0.23	1.50	91.67	19.10	13.02	1.43	1.13	0.24	1.55	101.00	20.03	13.85	1.45
BL_2	1.15	0.23	1.50	90.67	20.02	13.84	1.51	1.13	0.25	1.55	100.00	21.02	14.73	1.53
BL_0	1.15	0.26	1.53	91.67	18.51	12.50	1.42	1.12	0.27	1.57	98.00	21.11	14.81	1.54
A_0 P_1 BL_1	1.17	0.28	1.54	96.33	19.79	13.64	1.53	1.15	0.30	1.59	110.33	21.18	14.88	1.61
BL_2	1.18	0.28	1.54	94.67	19.82	13.66	1.53	1.14	0.30	1.60	105.67	21.50	15.16	1.61
BL_0	1.19	0.32	1.55	100.00	19.46	13.35	1.52	1.12	0.32	1.58	100.33	21.04	14.75	1.58
P_3 BL_1	1.20	0.34	1.54	107.00	19.63	13.49	1.53	1.16	0.34	1.62	107.00	21.36	15.03	1.66
BL_2	1.19	0.33	1.55	105.67	19.65	13.51	1.52	1.16	0.33	1.62	106.67	21.46	15.13	1.66
BL_0	1.19	0.33	1.60	115.33	19.24	13.15	1.55	1.15	0.33	1.60	114.33	21.05	14.76	1.66
P_0 BL_1	1.21	0.35	1.62	120.33	19.09	13.01	1.56	1.17	0.35	1.62	121.33	21.15	14.85	1.70
BL_2	1.23	0.35	1.61	119.67	19.31	13.21	1.58	1.17	0.34	1.61	119.67	21.34	15.02	1.71
BL_0	1.23	0.36	1.62	127.00	20.21	14.01	1.63	1.16	0.38	1.60	116.67	21.35	15.03	1.71
A_1 P_1 BL_1	1.24	0.38	1.58	130.00	19.41	13.30	1.59	1.18	0.42	1.64	126.00	21.28	14.96	1.74
BL_2	1.24	0.37	1.62	127.33	19.62	13.49	1.61	1.18	0.41	1.63	122.67	21.31	14.99	1.71
BL_0	1.26	0.37	1.65	127.00	19.23	13.14	1.59	1.18	0.40	1.65	127.00	21.84	15.46	1.76
P_3 BL_1	1.27	0.38	1.66	129.67	19.21	13.12	1.60	1.20	0.43	1.65	135.33	21.34	15.02	1.76
BL_2	1.27	0.37	1.66	129.33	20.15	13.96	1.67	1.20	0.44	1.64	134.67	21.43	15.10	1.78
BL_0	1.17	0.33	1.57	97.33	19.24	13.15	1.52	1.14	0.32	1.58	105.67	20.95	14.67	1.61
P_0 BL_1	1.19	0.34	1.60	106.00	19.51	13.39	1.56	1.17	0.35	1.61	119.67	20.82	14.55	1.67
BL_2	1.19	0.32	1.60	105.67	19.87	13.71	1.58	1.17	0.35	1.60	118.67	21.29	14.97	1.71
BL_0	1.21	0.39	1.59	109.67	18.16	12.18	1.45	1.16	0.40	1.58	115.33	21.19	14.88	1.68
A_2 P_1 BL_1	1.23	0.41	1.61	115.67	19.97	13.79	1.61	1.18	0.43	1.62	120.33	21.51	15.17	1.75
BL_2	1.23	0.41	1.63	113.67	20.19	14.00	1.62	1.17	0.42	1.61	122.67	21.81	15.43	1.78
BL_0	1.25	0.41	1.61	114.67	19.47	13.35	1.57	1.18	0.42	1.60	124.67	21.40	15.07	1.73
P_3 BL_1	1.25	0.42	1.63	119.33	19.43	13.31	1.58	1.20	0.43	1.64	126.33	21.55	15.21	1.76
BL_2	1.26	0.42	1.62	117.00	19.41	13.30	1.59	1.19	0.42	1.63	125.00	21.69	15.33	1.75
BL_0	1.19	0.36	1.62	119.33	19.22	13.13	1.54	1.16	0.38	1.61	121.00	21.42	15.09	1.72
P_0 BL_1	1.23	0.37	1.64	123.33	18.97	12.91	1.54	1.19	0.42	1.65	128.00	20.38	14.16	1.67
BL_2	1.22	0.35	1.63	121.00	19.23	13.14	1.57	1.20	0.41	1.63	127.33	21.49	15.15	1.74
BL_0	1.26	0.39	1.65	123.00	19.47	13.36	1.62	1.21	0.42	1.68	120.00	21.35	15.03	1.73
A_3 P_1 BL_1	1.26	0.40	1.67	126.00	19.97	13.79	1.67	1.24	0.45	1.70	131.33	21.54	15.19	1.80
BL_2	1.25	0.40	1.66	126.00	19.43	13.32	1.63	1.22	0.44	1.69	130.33	21.67	15.31	1.80
BL_0	1.28	0.43	1.71	120.00	20.62	14.37	1.75	1.24	0.46	1.70	126.67	21.61	15.26	1.81
P_3 BL_1	1.31	0.45	1.74	130.00	20.72	14.47	1.78	1.29	0.51	1.74	138.67	21.85	15.47	1.87
BL_2	1.30	0.44	1.74	129.33	21.00	14.72	1.79	1.30	0.49	1.72	138.00	22.03	15.64	1.87
L.S.D 0.05	0.04	0.03	0.07	7.01	1.03	0.92	0.10	0.04	0.04	0.06	10.06	1.09	0.98	0.10

Table (3) shows the effect of triple interaction between the study factors on the qualitative traits of industrial potatoes as the $A_3P_2BL_2$ treatment had the highest value of dry matter,

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starch and protein for both seasons that reached to 21.00, 21.83 and 14.72, 15.64 and 1.79, 1.87% respectively while the $A_0P_0BL_0$ treatment produced the lowest value of 18.04, 19.40 and 12.08, 13.92 and 1.32, 1.47% respectively. Tables (1-3) show the effect of the study factors in the absorption of elements and qualitative traits for industrial potato tubers in both the fall and spring seasons, that represented in the concentration of nitrogen, phosphorus, potassium and iron in the leaves and dry matter, starch and protein in the tubers, where the study factors showed a clear effect on the quality indicators of industrial potato tubers and this may be due to the positive characteristics of the study factors in improving vegetative growth and the concentration of nutrients in leaves which is reflected in the quality of the tuberous yield, bio-fertilizers has many properties that increase the plant's ability to absorb elements and the quality of yield, which may be attributed to the positive effect in these indicators. The bio-fertilizer is represented by Aspergillus niger and *Bacillus Megaterium* bacteria which dissolve minerals and facilitate unprepared nutrients in the soil solution, in addition to releasing hormones and semi-hormones that improving soil properties, stimulating resistance against pathogens and overcoming plant stresses (Joshi et al., 2021), among the hormones secreted by these organisms are IAA auxins and gibberellins, which have an indirect role to increase readiness of plant nutrients (Nagaa et al., 2023), by improving the vegetative growth of the plant as a result of its effect on root growth and absorption of elements and then improving the yield and nutritional status of the plant and its qualitative traits. Bio-fertilizers also have the ability to release siderophores compounds that work to chelate iron and make it available for absorption from plants and increase the accumulation of iron in the leaves Tables (1-3) as well as their importance in dissolving unprepared and fixed phosphates in the soil (Ab Rahman et al., 2018), and iron is one of the important elements in improving qualitative traits and increasing the percentage of protein in tubers (Al-Dulaimi and Al-Amri, 2020). There is a very important issue among the characteristics of bio-fertilizers especially fungal, which is their ability to increase the growth of the root group, root hairs and other plant organs from branches and leaves that increases the efficiency of nutrient absorption and vegetative growth and as a result, it is reflected on the carbon structure and the biological composition of the plant up to the quality features of the yield (Nazia et al., 2019), also one advantages of bio-fertilizers is the secretion a group of enzymes that work to decompose large organic molecules in the soil including the Amylase and Pectinase enzymes in addition to proteins and organic enzymes these work to release nutrients from organic matter in the soil and increase their readiness in the soil solution (Meyer and Ram, 2011), also have the ability to release many elements including zinc and potassium (Moreno Quevedo et al., 2015). Bacteria used in bio-fertilization also produce Siderophores (Santos et al., 2014) and some secondary metabolites compounds and increase ready nutrients in the soil (Devi et al., 2017).which works to improve vegetative growth indicators by increasing the absorption of nutrients which are positively reflected on manufactured carbohydrates and important amino acids that move to the tuberous parts for increasing the dry matter in tubers and according to that, the percentage of starch, the percentage of protein in tubers increases and the effect of fungal fertilization agrees with (Kalic et al., 2021) in the absorption of nutrients and some qualitative traits (Attia et al., 2022; Jain and Singh, 2015) in improving qualitative traits, (Ekin et al., 2019; Khalouf et al., 2019) on the role of bacterial fertilizer in qualitative traits and nutrient absorption and in increasing ready phosphorus in soil. It was also found that one characteristic of microorganisms is the increases in the percentage of calcium and potassium in addition to iron and phosphorus (Bhatt and Maheshwari, 2020). and these elements are important in improving the construction, transportation and storage of processed carbohydrates in tubers which is reflected in qualitative traits and have an active participation in the formation of sugars and protein (Taiz and Zeiger, 2010). Phosphate fertilization and the addition of supplemental fertilizers of nitrogen and potassium may have a role in improving the quality traits of yield, nutrient absorption and nutrient absorption balance nitrogen, phosphorus and potassium tables (1-3), each of them plays a physiological and effective role in plant vital activities such as carbon synthesis, amino acids and proteins (Huang et al., 2020) and is reflected in the percentage of proteins in tubers. Phosphate fertilization has an important and effective role in the growth and spread of the root system in the soil (Hailu et al.,2017), and this increases the possibility of the plant obtaining nutrients from the soil and increasing their accumulation in the plant, which is reflected in its growth and then the quality of the yield (Fernandes et al., 2017), and in enzymes of energy reactions for respiration, carbon synthesis and nucleic acid synthesis enzymes (Bechtaoui et al., 2021). The effect of phosphorus on yield quality is agreed with (Ali and Al-Jothari, 2012; Ali and Al-Jothari, 2021). Phosphate fertilization increasing the readiness of these nutrients and their high concentrations in the plant parts leads to improving the quality of the qualitative traits of the plant due to the importance of these elements in carbon construction and the production of carbohydrates and their transfer to the stored parts such as tubers, which is reflected in the indicators of qualitative traits. or it could be attributed to the effective effect of the Brassinolide growth regulator on the vegetative growth and increases the plant's ability to tolerate biological and non-biological stresses and in the organization of physiological processes, so it was used in the production of environmentally friendly crops and sustainable agriculture was increased (Sharma, 2021), Also its increases growth and yield due to its importance in elongation and cell division and increasing plant ability to tolerance oxidative damage and salt stresses (Li et al., 2021), on the other hand, it activates enzymes involved in chlorophyll biosynthesis and increases the efficiency of carbon synthesis and carbohydrate synthesis (Siddiqui et al., 2018), and modifies carbohydrate absorption properties, which indicates to the integration of growth with the participation of other hormones (Müssig, 2005). It was found that it increases the activity of enzymes involved in plant biological processes and as a result, it improves element absorption and fruit quality (Ali, 2017). Its use on the plants at different stages of the plant life cycle, whether the vegetative or fruitful stage, it was found that external spraying does not only improve vegetative growth, but also improves the quality of the qualitative traits of the yield, one of its most important roles is the growth and development of the root system (Pacifici et al., 2015) that is important in absorbing nutrients from the soil, which increases their accumulation in the leaves and then participated in building a vegetative and root plant structure, which increases the manufacture of nutrients to the extent that they are surplus to the need of the plant and stored in the external parts and improves the quality of the yield, as it was found that it increases the amino acids in the plant (Yuan et al., 2012), amino acids are the basis for the

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synthesis of proteins, which increases the quality of the yield, and increases in dry matter in tubers leads to an increases in the percentage of indicators of other qualitative traits (Abdeldaym et al., 2019), and the role of Brassinolide in improving qualitative traits is agreed with (Bideshki et al., 2019; Siddiqui et al., 2018).

CONCLUSION

Through the study of the two seasons, it could be conclude that the use of bio-fertilizers for the combination of the two types and phosphate fertilization with spraying with a growth regulator Brassinolide within the levels used had a positive effect in increasing the concentration of the leaves, increasing the elements and improving the qualitative traits according to the measured indicators of industrial potato tuber.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

DECLARATION OF FUND

The authors declare that they have not received a fund.

REFERENCE

- Ab Rahman, S. F. S., Singh, E., Pieterse, C. M., and Schenk, P. M. 2018. Emerging microbial biocontrol strategies for plant pathogens. Plant Science, 267, 102-111. https://doi.org/10.1016/j.plantsci.2017.11.012
- Abdeldaym, E. A., El-Sawy, M. B. I., and El-Helaly, M. A. 2019. Combined application of different sources of nitrogen fertilizers for improvement of potato yield and quality. Plant Archives, 19 (2) 2513-2521. https://doi.org/10.1016/j.plantsci.2017.11.012
- Al-Dulaimi, N. H. A., and Al-Amri, N. J. K. 2020. Stimulation growth and yield of potato by buttonwood prunning residues and spraying several micronutrients. Iraqi Journal of Agricultural Sciences, 51(4):1048-1057. https://doi.org/10.36103/ijas.v51i4.1083
- Ali, B. 2017. Practical applications of brassinosteroids in horticulture—some field perspectives. Scientia Horticulturae, 225, 15-21. https://doi.org/10.1016/j.scienta.2017.06.051
- Ali, N. S.(2012). Fertilizer Technologies and Uses. College of Agriculture, University of Baghdad. Iraq.pp: 1-202.
- Ali, N. S; and Al-Jothari. Effect of phosphorous and amino acid on growth and yield of pea. Int. J. Agricult. Stat. Sci. 17(1), 81-84. https://connectjournals.com/03899.2021.17.81.
- Ali, N. S; and Al-Jothari, H. W. 2012. Phosphorus readiness and distribution in the soil planted with potatoes, fertilized with different fertilizers and irrigated with different irrigation methods. Diyala Journal of Agricultural Sciences, 4 (1): 268-284. https://journal.djas.uodiyala.edu.iq/index.php/dasj/article/view/292
- Attia, M. S., Abdelaziz, A. M., Al-Askar, A. A., Arishi, A. A., Abdelhakim, A. M., and Hashem, A. H. 2022. Plant growth-promoting fungi as biocontrol tool against fusarium wilt disease of tomato plant. Journal of Fungi, 8(8), 775. https://doi.org/10.3390/jof8080775.
- Bechtaoui, N., Rabiu, M. K., Raklami, A., Oufdou, K., Hafidi, M., and Jemo, M. 2021. Phosphate-dependent regulation of growth and stresses management in plants. Frontiers in Plant Science, 12, 679916. https://doi.org/10.3389/fpls.2021.679916.

P-ISSN: 0075- 0530/ E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/67vppy65

- Belkhadir, Y. and Chory, J. 2006. Brassinosteroid Signaling: a paradigm for steroid hormone bioactivity and applications. Braz. J. Plant Physiol. 14,83-121. DOI: 10.1126/science.1134040
- Bhatt, K., and Maheshwari, D. K. 2020. Zinc solubilizing bacteria (Bacillus megaterium) with multifarious plant growth promoting activities alleviates growth in Capsicum annuum L. 3 Biotech. 10 (2), 36. https:// /10.1007/s13205-019-2033-9.
- Bideshki, A., Arvin, M. J., Aien, A., Hasandokht, M. R. and Khalighi, A. 2019. Interactive effects of Foliar 24-Epibrassinolide and selenium applications on yield, reduce nitrate accumulation and selenium enrichment in potato tuber in field. Cogent Food and Agriculture, 5(1): 1690315. https://doi.org/10.1080/23311932.2019.1690315
- Boesch, I. 2012. Preferences for attributes of industrial potatoes: an empirical investigation of the Swiss market. American Journal of Potato Research. 89(3),199-206. https://link.springer.com/article/10.1007/s12230-012-9244-5.
- Devi, A. R., Kotoky, R., Pandey, P., and Sharma, G. D. 2017. Application of Bacillus spp. for sustainable cultivation of potato (Solanum tuberosum L.) and the benefits. In Bacilli and agrobiotechnology (pp. 185-211). Cham: Springer International Publishing. https://link.springer.com/chapter/10.1007/978-3-319-44409-3-9.
- Ekin, Z. 2019. Integrated use of humic acid and plant growth promoting rhizobacteria to ensure higher potato productivity in sustainable agriculture. Sustainability, 11(12), 3417. https://doi.org/10.3390/su11123417.
- El-Ghamry, A., Mosa, A. A., Alshaal, T., and El-Ramady, H. 2018. Nanofertilizers vs. biofertilizers: new insights. Environment, Biodiversity and Soil Security, 2(2018), 51-72.. https://journals.ekb.eg/article_8905.html.
- Fernandes, A. M., Soratto, R. P., Souza, E. D. F. C. D., and Job, A. L. G. 2017. Nutrient uptake and removal by potato cultivars as affected by phosphate fertilization of soils with different levels of phosphorus availability. Revista Brasileira de Ciência do Solo, 41, https://doi.org/10.1590/18069657rbcs20160288.
- Hailu, G., Nigussie, D., Ali, M., and Derbew, B. 2017. Nitrogen and phosphorus use efficiency in improved potato (Solanum tuberosum L.) cultivars in southern Ethiopia. American journal of potato research, 94(6), 617-631. https://link.springer.com/article/10.1007/s12230-017-9600-6.
- Hasan, A. A. 2015. Basics and technology of vegetable production. Scientific Book House for Publishing and Distribution, Egypt.
- Hopkins, B. G., and Hansen, N. C. 2019. Phosphorus management in high-yield systems. Journal of environmental quality, 48(5), 1265-1280. https://doi.org/10.2134/jeq2019.03.0130.
- Hopkins, B. G., Horneck, D. A., and MacGuidwin, A. E. 2014. Improving phosphorus use efficiency through potato rhizosphere modification and extension. American Journal of Potato Research, 91(2), 161-174. https://link.springer.com/article/10.1007/s12230-014-9370-3.
- Huang, X. Q., Xiang, Y. J., Zhang, L., and Liu, Y. 2020. Effects of different rotation patterns on the occurrence of clubroot disease and diversity of rhizosphere microbes. Journal of Integrative Agriculture, 19(9), 2265-2273.

Iraqi Journal of Agricultural Sciences –2026:57(1):105-118
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DOI: https://doi.org/10.36103/67vppy65

https://doi.org/10.1016/S2095-3119(20)63186-0

- Jain, P., and Singh, D. (2015). Study on the role of phosphate solubilising fungi in phosphorus bioavailability and growth enhancement of potato. Chemical Science Review and Letters, 4(13), 101-108. https://chesci.com/wp
- Joshi, P., Saini, A., Banerjee, S., Bose, R., Bhandari, M. S., Pandey, A., and Pandey, S. 2021. Agriculturally important microbes: challenges and opportunities. Microbiological activity for soil and plant health management, 1-34. https://link.springer.com/chapter/10.1007/978-981-16-2922-8_1.
- Khalouf, A., Al-Khader A.; Khazal, A., Kreidi, N., and Wahba, S.(2019).The effect of Biofertilizers on some characteristics of fertile soil and some productive and qualitative characteristics of potato crop. Syrian Local Agricultural Research, 6(1):276-287. https://agri-research-journal.net/SjarEn/?page_id=1766.
- Khudhair, A. T., and Abdulrasool, Q. J. 2023. The concentrations of N, P, and K nutrients in the vegetative and fruiting parts and eggplant yield are affected by mineral fertilization and the locations where fertilizers are applied. Bionatura (ISSUE 3), 8 (1), 1-8. 10.21931/RB/CSS/2023.08.03.13
- Klaic, R., Guimarães, G. G., Giroto, A. S., Bernardi, A. C., Zangirolami, T. C., Ribeiro, C., and Farinas, C. S. 2021. Synergy of Aspergillus niger and components in biofertilizer composites increases the availability of nutrients to plants. Current microbiology, 78(4), 1529-1542. https://link.springer.com/article/10.1007/s00284-021-02406-y.
- Li, S., Zheng, H., Lin, L., Wang, F., & Sui, N. 2021. Roles of brassinosteroids in plant growth and abiotic stress response. Plant Growth Regulation, 93(1), 29-38. https://link.springer.com/article/10.1007/S10725-020-00672-7.
- Meyer, V., Wu, B., and Ram, A. F. 2011. Aspergillus as a multi-purpose cell factory: current status and perspectives. Biotechnology letters, 33(3), 469-476. https://link.springer.com/article/10.1007/s10529-010-0473-8 .
- Morais, T. P. D., Asmar, S. A., Silva, H. F. D. J., Luz, J. M. Q., and Melo, B. D. 2018. Application of tissue culture techniques in potato. Bioscience Journal, 34 (4),952–969. https://distantreader.org/tmp/dsxmpeguuzwz/bj-38775.
- Moreno Quevedo, A. P., Osorio Vega, N. W., and González Murillo, O. A. 2015. In vitro dissolution of acidulated rock phosphate by phosphate solubilizing microorganisms. Acta Biológica Colombiana, 20(2), 65-71. http://dx.doi.org/10.15446/abc.v20n2.42713.
- Müssig, C. 2005. Brassinosteroid-promoted growth. Plant biology, 7(2), 110-117. DOI: 10.1055/s-2005-837493.
- Nafaa, M., Rizk, S. M., Aly, T. A. G. A., Rashed, M. A. S., Abd El-Moneim, D., Ben Bacha, A., ... and Magdy, M. 2023. Screening and identification of the rhizosphere fungal communities associated with land reclamation in Egypt. Agriculture, 13(1), 215. https://doi.org/10.3390/agriculture13010215
- Narsian, V., and Patel, H. H. (2000). Aspergillus aculeatus as a rock phosphate solubilizer. Soil Biology and Biochemistry, 32(4), 559-565. https://doi.org/10.1016/S0038-0717(99)00184-4
- Naziya, B., Murali, M., and Amruthesh, K. N. 2019. Plant growth-promoting fungi (PGPF) instigate

plan. https://doi.org/10.3390/biom10010041t growth and induce disease resistance in Capsicum annuum L. upon infection with Colletotrichum capsici (Syd.) Butler and Bisby. Biomolecules, 10(1), 41. https://doi.org/10.3390/biom10010041.

- Pacifici, E., Polverari, L., and Sabatini, S. 2015. Plant hormone cross-talk: the pivot of root growth. Journal of experimental botany, 66(4), 1113-1121. https://doi.org/10.1093/jxb/eru534
- Santos, S., Neto, I. F., Machado, M. D., Soares, H. M., and Soares, E. V. 2014. Siderophore production by Bacillus megaterium: effect of growth phase and cultural conditions. Applied biochemistry and biotechnology, 172(1), 549-560. https://link.springer.com/article/10.1007/s12010-013-0562-y.
- Sharde, R., Tripathi, M. K., Bhatt, D., Tiwari, S., Sharma, M., Tomar, Y. S., &and Tripathi, N. 2024. Influence of plant growth regulators on in vitro morphogenesis in sprout culture of potato (Solanum tuberosum L.). Potato Research, 67(2), 399-420. https://link.springer.com/article/10.1007/s11540-023-09640-w.
- Sharma, S. K. 2021. Brassinosteroids application fesponses in fruit crops-A review. International Journal of Agriculture, Environment and Biotechnology, 14(2): 123-140. DOI: 10.30954/0974-1712.02.2021.2.
- Siddiqui, H., Hayat, S., and Bajguz, A. 2018. Regulation of photosynthesis by brassinosteroids in plants. Acta Physiologiae Plantarum, 40(3), 59. https://link.springer.com/article/10.1007/s11738-018-2639-2.
- Taiz, L; and E. Zeiger. 2010. Plant Physiology. Sinauer Associates,Inc. publisger Sunderland, Massachus-AHS.USA
- Yuan, L., Shu, S., Sun, J., Guo, S., and Tezuka, T. (2012). Effects of 24-epibrassinolide on the photosynthetic characteristics, antioxidant system, and chloroplast ultrastructure in Cucumis sativus L. under Ca (NO3) 2 stress. Photosynthesis Research, 112(3), 205-214. DOI: 10.1007/s11120-012-9774-1
- Zhong, C., Jiang, A., Huang, W., Qi, X., & Cao, G. (2017, May). Studies on the acid-production characteristics of Bacillus megaterium strain P17. In AIP Conference Proceedings (Vol. 1839, No. 1, p. 020054). AIP Publishing LLC. https://doi.org/10.1063/1.4982419.

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استجابة البطاطا الصناعية للأسمدة البيولوجية والكيميائية والبراسينولايد في امتصاص العناصر وبعض الصفات النوعية

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المستخلص

نُفذت التجربة في جنوب غرب بغداد في الموسم الخريفي 2021 والموسم الربيعي 2022 على محصول البطاطا الصناعية هجين (Arsenal)، ونفذت التجربة باستعمال تصميم القطاعات الكاملة التعشية بترتيب الألواح المنشقة وبثلاث مكررات (4×3×3)، وزع المخصب الأحيائي ضمن الألواح الرئيسية والتداخل بين مستويات الفسفور ومنظم النمو البراسينولايد ضمن الألواح الثانوية تضمنت الأسمدة الحيوية فطر *Aspergillus niger* لوحده وبكتريا *Bacillus Megaterium* لوحدها والتوليفة بينهما إضافة إلى معاملة المقارنة والفسفور بثلاث مستويات هي 0، 100، 200 كغم P_2O_5 هـ$^{-1}$ والرش بالبراسينولايد بثلاث مستويات 0، 0.1، 0.2 ملغم لتر$^{-1}$ حيث أظهرت النتائج الأثر المعنوي للتداخل الثلاثي بين عوامل الدراسة حيث كان للتداخل بين التسميد الحيوي الفطري والبكتيري والتسميد الفوسفاتي 200 كغم P_2O_5هـ$^{-1}$ والرش بالتركيز 0.1 ملغم لتر$^{-1}$ بمنظم النمو البراسينولايد أثراً معنوياً فقد أعطت أعلى قيمة معنوية في النسبة المئوية من الفسفور والبوتاسيوم وتركيز الحديد في الأوراق لكلا الموسمين والنسبة المئوية للنيتروجين في الأوراق في الموسم الخريفي وبلغت 0.45 ، 0.51 و 1.74 ، 1.74% و 130.00 ، 138.67 ppm و1.31% بالتتابع حيث أعطت التوليفة بين التسميد الحيوي الفطري والبكتيري والتسميد الفوسفاتي 200 كغم P_2O_5هـ$^{-1}$ والرش بالتركيز 0.2 ملغم لتر$^{-1}$ بمنظم النمو البراسينولايد أعلى نسبة نيتروجين في الموسم الربيعي وبلغت 1.30% وكذلك أعطت أعلى قيمة في النسبة المئوية للمادة الجافة والنشأ والبروتين في الدرنات لكلا الموسمين وبلغت 21.00 ، 21.83 و 14.72 ، 15.64 و 1.79 ، 1.87% بالتتابع.

الكلمات المفتاحية : ***Aspergillus niger*،*Bacillus Megaterium* ، اسمد حيوية، منظم نمو ، فسفور.**

***مستل من أطروحة دكتوراه للباحث الأول**