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Article

Effect of adding Biohealth, zeolite and mineral fertilizer on some measurements of potato yield

Al-Hassan Jamal Abdul Razzaq[1,], Shaker and Iman Qassem Mohammed Al-Bahrani[2]*

[1] *Department of Soil Sciences and Water Resources, College of Agricultural Engineering Sciences, University of Baghdad;*

[2] *Department of Soil Sciences and Water Resources, College of Agricultural Engineering Sciences, University of Baghdad;*

***** *Correspondence: alhasan.jamal1207a@coagri.uobaghdad.edu.iq*

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ABSTRACT

To know the effect of bio-enhancer (zeolite), biohealth, mineral fertilizers and their interactions, the possibility of replacing mineral fertilizers with bio-enhancers and bio-enhancers, and their effect on some potato yield measurements. A field experiment was conducted at one of the field stations of the College of Agricultural Engineering Sciences, University of Baghdad, near the electronic calculator center, research station (F) in Al-Jadriya region in the loam mixture soil during autumn season 2021-2022 AD, It was designed using a completely randomized block design (RCBD) with three replicates. The factors of the study experiment included three levels of zeolite (0, 6 tons ha-1, and 12 tons ha-1), which were symbolized by (Z0), (Z1) and (Z2), respectively. As for the bio-enhancer (Biohealth), it was added at two levels (0 and 5) to kg ha-1, which was symbolized by the symbols (B0) and (B1), respectively. As for the mineral fertilizer treatments, they were added at three levels (0, 50%, and 75%) of the fertilizer recommendation, which was (300 kg ha-1 N, 100 kg ha-1 P, and 300 kg ha^{-1} potassium), symbolized by (F0). and (F1) and (F2), respectively. Potato seed, Rivera cultivar, was planted as a furrow on 1/23/2022. The area of the experimental unit was 6 m 2 (3 m 2 x 2 m^2). Eighteen treatments were distributed randomly in the sectors (replicates), so the number of units became 54 experimental units.

Keywords: Potato; Biohealth; Zeolite; Mineral Fertilizer.

INTRODUCTION

The continuous deterioration of the natural resources of the soil and the inconsiderate use of chemical fertilizers is a major concern for the future of agriculture. Therefore, bio-enhancers are a promising complement to chemical fertilizers and gain importance for achieving sustainable agriculture. Biological amendments have a major role in increasing crop yields and maintaining soil fertility long-term, which is important for meeting global food demand [1]. The global increase in

population represents a major challenge to food security in the world. There is a large gap between production and consumption (7.2 million tons of nutrients deficit) due to population expansion and shrinking agricultural land over time, so crop production must be increased significantly to meet the population's growing demand for food. Chemical fertilizers have been widely used to enable crop outputs to bridge the gaps between production and consumption. Ultimately resulting in massive damage to natural ecosystems and human health. Therefore, the exploitation of biofertilizers is a complement to chemical fertilizers in agriculture due to the abundance of safe and sound food. [2] (Zeolite is a soil improver that helps farmers and agronomists deal with many problems, such as soil or water pollution, heavy metal contamination, and nutrient loss. This natural crystalline aluminosilicate is a soil improver that improves the soil's chemical, physical and fertility properties, such as infiltration rate, cation exchange capacity (CEC) and water holding capacity. Zeolites are considered sustainable products that directly contribute to improving agro-ecosystems as a sustainable product [3]. Potato (Solanum tubersum. L) is an important crop due to its high nutritional value and its high content of various nutrients such as carbohydrates, protein, and fiber [4]. Potatoes contain (76% water and 24% dry matter). They also contain vitamins, and starch occupies the largest part of them. It also contains the mineral elements Ca, Fe, P, K, Na and S. Potato tubers also contain many organic acids such as acid Citric acid, malic acid, and oxalic [5]

MATERIALS AND METHODS

The field experiment was conducted at the research station of the College of Agricultural Engineering Sciences - University of Baghdad, Al-Jadriya Complex, near the electronic calculator center, for the autumn season 2022-2021 in clay soil classified to a level below the supergroups (Typic Torrifluvent) according to the modern American classification (2006). (Soil Survey Staff, The area required for the experiment was determined according to a scientific design, and the soil was prepared for cultivation through plowing and smoothing and divided into furrows. Samples were taken from random locations of field soil at a depth of 0-30 cm. It was mixed well for homogeneity, then air-dried and ground using a wooden hammer, then passed through a sieve with a diameter of 2 mm. Then, a compound sample was taken from it to conduct physical and chemical analyses (Table 1). Potato seeds (Solanum tubersum L., RIVIERA rank (E), were grown and stored at a temperature of 4 °C in the refrigerated private warehouses of (Nahar Al-Awrad Company for Potato Trading and Agricultural Supplies Ltd.). Which were taken out two weeks before the planting date to break the dormancy phase. The tubers were selected with the correct shape, planted on January 23, 2022, and planted at a depth of 8-10 cm. The distance between one tubercle and another is 30 cm. The crop service was done by manual hoeing whenever the need arose.

Experimental Design

The statistical analysis was done by applying a factorial experiment with a randomized complete block design (RCBD) with three factors: the first represents the addition of zeolite at three levels, the second factor represents the addition of Biohealth at two levels, and the third factor represents the addition of mineral fertilizer at three levels, all of which is soil. Using the least significant difference at a significant level of 0.05 and applying the ready-made statistical analysis program (SAS) to analyze the data.

Traits	Values		Units
Ph	7.4		_____
Electrical Conductivity EC	3.4		$dS.m^{3}$
Available Nitrogen	42		$mg.kg^{-1}$
Available Phosphorous	11.27		$mg.kg^{-1}$
Available Potassium	192.6		$mg.kg^{-1}$
Cec	19.51		cmolc/kg
Bulk Density	1.35		$mg.m^{-3}$
True Density	2.55		$mg.m^{-3}$
Positive Dissolved Ions	Ca^{+2}	13.8	meq $.L^{-1}$
	Mg^{+2}	10.6	
	Na^{+}	2.2	
	K^{+}	1.2	
Negative Dissolved Ions	SO^{-4}	7.6	meq $.L^{-1}$
	CO^{-3}	Nill	
	HCO_3^{-}	1.1	
	Cl^{-}	21.4	
Soil Separates	Sand	4.9	$g.kg^{-1}$
	Clay	62.8	
	Silt	32.3	
Soil Texture	Clay Loam		

Table 1. Some physical and chemical properties of the soil before planting

Experience Factors

- The first factor is adding natural zeolite to the soil in three levels: the first level without addition, the second level 6 tons ha^{-1}, and the third level 12 tons ha^{-1}
- The second factor: the addition of Biohealth, the first level without addition, the second level, the addition of 5 kg ha-1, and the third level
- The third factor adds mineral fertilizers, the first level without addition, the second level adds 50% of the fertilizer recommendation, and the third level adds 75%. The fertilizer recommendation is 300 kg ha^{-1} N, 100 kg ha^{-1} P, and 300 kg ha^{-1} K[6].

Studies Traits

- Calculating the dry weight of vegetative
  Five plants were randomly harvested from the sorrel in the center, each experimental unit, and the area in contact with the soil. They were washed with water, air-dried, and then dried in an electric oven at 65 °C until the weight stabilized. [6]) and the average was calculated for the weight of Five plants.
- Calculating the total yield of tubers, ton ha^{-1}
  The yield of one plant was calculated by dividing the yield of five plants by their number and according to the total yield per hectare according to the following equation:
  Total yield = (yield of one plant X number of plants in the experimental unit) 10000X/area of the experimental unit
- Calculate the percentage of protein

The percentage of protein in tubers was calculated based on dry weight [7] according to the following equation:
Protein percentage based on dry weight = percentage of nitrogen in tubers x 6.25

- Calculate the percentage of starch in the tubers
  It was calculated from the equation shown in [7] as follows:
  % starch = 17.55 + 0.89 (% dry matter - 24.18).

RESULTS

Dry Weight of Vegetative (g.plant^{-1})

Levels of zeolite, bio-enhancer and mineral fertilizer added to the soil significantly affected the dry weight of vegetative. Table (2) shows that the addition of zeolite (Z) to the soil had a significant effect on these traits, where the highest value was recorded in the treatment (Z2) 30.28 (g.plant^{-1}) compared to the control treatment (Z0) 27.43 (g.plant^{-1}), with an increased rate reached 10.39%, The reason for this is due to the increase in the soil content of adding nitrogen as a result of zeolite retaining nitrogen and preventing its loss from the soil, and then this led to an increase in its uptake by the plant, which led to an increase in the growth rate (Sarkar and Naidu, 2015). The addition of the bio-enhancer B to the soil significantly affected these traits, where it recorded the highest value for treatment (B1) (29.83 g.plant^{-1}) compared to the control treatment (B0) 27.94 (g.plant^{-1}), with an increase of 6.76%. The dry weight of the plant increased with the increase in the levels of mineral fertilizer added to the soil, as the highest value was recorded for the treatment ((F2 31.24 (gram plant-1) compared to the control treatment F0)) 26.37 (g.plant-^{1}), with an increase of 18.46%. The reason for this is due to the direct positive effects of adding mineral fertilizer (nitrogen), which leads to an increase in the number of cells and their division in meristematic tissues, where it is an essential element in most components of a living cell, and an increase in building amino acids through its physiological role, and the consequent significant increase in dry weight. To plant, this is in line with what he mentioned (Muhanna et al., 2015). Likewise, phosphorus is important in building energy for the plant, and potassium works to transport and store nutrients. All of these have helped increase the plant's dry weight. As for the bi-interaction between the bio-enhancer and the adding zeolite (ZxB), it recorded an increase in the dry weight of the plant in the treatment (Z2B1) and amounted to (31.85 grams (plant-1) compared to the control treatment (Z0B0), which recorded the lowest value (26.74 grams (plant-1), by a percentage of an increase of 19.10%.The effect of the bi-interaction between the bio-enhancer and the adding mineral fertilizer (FxB) was an increase in the dry weight of the plant for the treatment (B1F2). It amounted to 32.57 (gram plant-1) compared to the control treatment (B0F0), which amounted to 25.59 (g.plant^{-1}), an increase of 27.27%. The effect of the interaction between zeolite and mineral fertilizer (FxZ) significantly increases the dry weight of the plant. The highest value was recorded in the treatment (Z2F2) 31.89 (g. plant-1) compared to the control treatment (Z0F0) (24.00 g. plant-1), with an increase of 32.87%. The reason is that adding zeolite is characterized by the ability to preserve nitrogen in the soil due to the absorption of ammonium on the zeolite surfaces and to reduce its loss from the soil [8]. The triple interaction between the study factors (F × B × Z) significantly affected the dry weight of vegetative, where the treatment (Z2B1F2) excelled in achieving the best value of the dry weight of the plant, which amounted to 33.86 (g.plant^{-1}) Compared to the control treatment, which amounted to 23.46 (gram plant-1), with an increase of 44.33%, the reason for this significant increase is due to the addition of mineral fertilizers and the availability of essential nutrients in them in available to plant form and absorbed by the plant from the soil and then converting them into amino acids and protein compounds through the vital

processes of the plant, and this leads to an improvement in plant growth. As phosphorus and nitrogen enter into the building of most of the cellular membranes in plant tissue, especially the chloroplasts, and potassium contributes to the formation of chlorenchyma cells, which increase the thickness of the stem and strengthen it, and then lead to an increase in the dry weight of the plant These results are consistent with [99] as well as the interaction of zeolite and the bio-enhancer with mineral fertilizers adding to the soil, achieving an important nutritional balance for the plant and by improving some soil fertility, vital and physical properties [10]

Adding zeolite levels	**Adding bio-enhancer levels**	**Adding mineral fertilizer levels**		
Z	B	F0	F1	F2
Z0	B0	23.46	27.54	29.22
	B1	24.54	28.42	31.44
Z1	B0	25.86	28.74	30.56
	B1	26.56	29.57	32.43
Z2	B0	27.45	28.74	29.93
	B1	30.38	31.32	33.86
$LSD_{0.05}$		LSD: Z*B*F =5.710		
Effect of bi-interaction between adding zeolite and mineral fertilizer (FxZ)				
FxZ	F0	F1	F2	Average Z
Z0	24.00	27.98	30.33	27.43
Z1	26.21	29.15	31.49	28.95
Z2	28.91	30.03	31.89	30.28
L.S.D Z * F = 0.04916				L.S.D Z = 0.02007
The effect of the bi-interaction between bio-enhancer and the mineral fertilizer (FxB)				
FxB	F0	F1	F2	Average B
B 0	25.59	28.34	29.90	27.94
B 1	27.16	29.77	32.57	29.83
L.S.D F*B = 0.028				L.S.D B = 0.016
Effect of bi interaction between zeolite additive and bio-enhancer (ZxB)				
Z x B	B0	B1		Average F
Z 0	26.74	28.13		26.37
Z 1	28.38	29.52		29.05
Z 2	28.71	31.85		31.24
L.S.D Z*B=0.028				L.S.D F =0.020

Table 2. Effect of Z, B, and F and their interactions on average plant dry weight (g.plant^{-1})

Total Yield (Mg ha^{-1})

The statistical analysis results, Table (3), showed that the total yield of tubers was significantly affected by the levels of zeolite and the bio-enhancer and the levels of mineral fertilizer added to the soil. The addition of zeolite significantly affected the achievement of the highest value in treatment Z2 (27.07 (mg ha^{-1}) compared to the control treatment (Z0) 23.27 (mg ha^{-1}).With an increased rate of 16.33%, this is due to the use of zeolite to improve some soil fertility and physical properties and then an increase in yield, thanks to its unique properties.The ion exchange properties of zeolite can be used in agriculture due to its large porosity and high capacity for cation exchange, and this is by (Kavvadias et al 2018), and adding bio-enhancer B to a significant increase in the total tuber yield As the B1 treatment recorded 27.73 (Mg ha^{-1}) compared to the control treatment (B0) 22.01 (Mg ha^{-1}),

an increase of 25.98%.The reason is due to the bio-enhancer having a role in increasing the readiness of potassium and phosphorus in the soil and protecting them from stabilization processes due to the secretion of some enzymes and organic acids through the activity of the microorganisms present within the bio-enhancer [5] All of the previous shows us the extent of potassium readiness and its role in increasing the total yield of tubers. The total yield increased with the increased levels of adding mineral fertilizer. The treatment (F2), which is the second level of mineral fertilizer, recorded 29.02 ($Mg.ha^{-1}$) compared to the control treatment (F0), 20.39 ($Mg.ha^{-1}$), an increase of 42.32%.The reason may be explained by the role of fertilizers adding before planting, especially potassium (potassium sulfate), and its role in increasing the productivity of potato tubers by helping the accumulation of carbohydrates to increase the number of plant tubers, and this is consistent with ([2] addition, potassium affects the physiological processes of the crop, and the availability of potassium in the soil is of great importance in maintaining the balance between nutrient use efficiency and sustainable agriculture [11]The effect of the bi-interaction between the bio-enhancer and the adding zeolite (ZxB) was significant in increasing the total yield rate, where the highest value was recorded in treatment Z2B1 (29.42 ($Mg.ha^{-1}$) compared to the control treatment Z0B0 (19.52 $Mg.ha^{-1}$), with an increase rate of (50.71%), The reason for this is that the moisture-preserving materials (the adding zeolite) increased the production of vegetables, and this is consistent with what was mentioned by [13] in addition to that the addition of zeolite to the soil led to an improvement in plant growth and productivity by improving the exchange capacity of the soil and its physical and chemical properties. and vitality.This is consistent with [6], similar to what was obtained by [10]. As for the bilateral interaction between the bio-enhancer and the adding mineral fertilizer (FxB), it recorded an increase in the total yield rate.The highest value was in treatment (B1F2) (31.87 ($Mg.ha^{-1}$) compared to the control treatment (B0F0) (18.35 $Mg.ha^{-1}$), with an increase of 73.67%. The reason is due to the role of mineral fertilizers in providing essential nutrients to the plant and the beneficial microorganisms Bacillus and Trichoderma present within the bio-enhancer, which led to an increase in yield compared to the control treatment (no addition). This is consistent with [14] In addition to the effect of nitrogen fertilizer, which led to an increase in the growth of the root system and the number of leaves, consistent with [13].The effect of the interaction between zeolite and the addition of mineral fertilizer had a significant effect on the total yield rate. The highest treatment (Z2F2) was recorded with a value of 32.04 ($Mg.ha^{-1}$) compared to the control treatment (Z0F0), 19.04 ($Mg.ha^{-1}$), with an increase of 68.27%.The reason is that adding zeolite increases the efficiency of using nitrogen and potassium fertilizers added to the soil. Then lower levels of fertilizers can be used for the same crop and stay longer in the soil, which affects the increase in crop production, and this is consistent with [4] The triple interaction of the study factors (F x B x Z) achieved a significant effect on this trait, where the treatment (Z2B1F2) excelled in achieving the best average of the total yield, which amounted to 33.36 ($Mg.ha^{-1}$) compared to the control treatment, which achieved the lowest value in the total yield. It reached (17.47 $Mg.ha^{-1}$), with an increase of (90.95%). The reason may be explained by the role of the adding mineral fertilizer in the availability of the nutrients that the plant needs and absorbs directly from the soil, as well as the role of zeolite in improving some of the physical, chemical and fertility traits of the soil, which in turn leads to an increase in the spread of roots and an increase in the absorption of water and nutrients and that these two factors lead to the formation of a good root system that reflects positively on the absorption of nutrients and the processes that take place inside the plant and are stored in the tubers and then an increase in the weight of the tuber and then the total yield of the plant [15]

Adding zeolite levels	Adding bio-enhancer levels	Adding mineral fertilizer levels		
Z	B	F0	F1	F2
Z0	B0	17.47	19.72	21.38
	B1	20.61	29.05	31.39
Z1	B0	18.43	20.58	26.39
	B1	21.72	27.64	30.86
Z2	B0	19.14	24.27	30.72
	B1	25.00	29.91	33.36
$LSD_{0.05}$		LSD: Z*B*F =3.005		
Effect of bi-interaction between adding zeolite and mineral fertilizer (FxZ)				
FxZ	F0	F1	F2	Average Z
Z0	19.04	24.39	26.38	23.27
Z1	20.08	24.11	28.62	24.27
Z2	22.07	27.09	32.04	27.07
L.S.D Z * F = 22.07				L.S.D Z =1.227
The effect of the bi-interaction between bio-enhancer and the mineral fertilizer (FxB)				
FxB	F0	F1	F2	Average B
B 0	18.35	21.52	26.16	22.01
B 1	22.44	28.87	31.87	27.73
L.S.D F*B = 1.735				L.S.D B = 1.002
Effect of bi interaction between zeolite additive and bio-enhancer (ZxB)				
Z x B	B0	B1		Average F
Z 0	19.52	27.02		20.39
Z 1	21.8	26.74		25.2
Z 2	24.71	29.42		29.02
L.S.D Z*B=1.735				L.S.D F =1.227

Table 3. The effect of Z, B and F and their interactions on the total yield rate trait.

The Percentage of Protein in The Tubers, %

The results of the statistical analysis in Table (4) showed that the percentage of protein in the tubers was significantly affected by the levels of addition of zeolite, bio-enhancer and mineral fertilizer in the soil. The addition of zeolite significantly affected the percentage of protein in the tubers to achieve an increase in the protein character. The highest value of the transaction was recorded (Z2) at 8.196%, compared to the control treatment (Z0) at 7.168%, with an increase of 14.34%. The reason for this is that the use of zeolite led to an increase in soil fertility through its ability to retain soil moisture and prevent the loss of nitrogen, and then increase the plant's uptake of nitrogen, which was positively reflected in the protein content of the tubers, and this is consistent with ([16] The effect of the bio-enhancer (B) was significant on the percentage of protein in the tubers, where the highest value was recorded in the treatment (B1) 8.078%, compared to the control treatment B0 (7.519%), with an increase of 7.43%. The reason is that using microorganisms present in the bio-enhancer bio-enhancer can enhance potatoes' morphological and physiological characteristics, which is consistent with [10]. The percentage of protein increased with increasing levels of mineral fertilizer added to the soil as it recorded the highest value for the treatment (F2), 8.503%, compared to the control treatment (F0), 7.519%, with an increase of 13.08%. The reason for this may be due to the availability of nitrogen in the soil and potassium as a result of adding fertilizers containing nitrogen and potassium, then leads to an increase in the proportion of carbohydrates and protein, and this is consistent with (Pushpalatha et al. 2017). As

for the effects of the bilateral interactions between the bio-enhancer and the adding zeolite (ZxB), it recorded an increase in the protein character of treatment Z2B1 (8.769%) compared to the control treatment (Z0B0) by 7.114%, with an increase of 23.26%. The reason for this is attributed to the use of beneficial microorganisms present within the bio-enhancers that were originally present in the soil, which led to the enhancement of potatoes' physiological traits, which is consistent with [10]. The bi-interaction between the bio-enhancer and the addition of mineral fertilizer (FxB) increased the protein character. It reached 8.807% in the treatment (B1F2) compared to the control treatment (B0F0) at 6.848%, with an increase of 28.60%. This is because the biological enhancer contains seaweed, which in turn contains macronutrients (nitrogen), reflected positively in the protein content of the tubers [11] and nitrogen added to the soil. The bi-interaction between zeolite and the adding mineral fertilizer (FxZ) achieved an increase in the protein character, and the highest value was in the treatment (Z2F2) 8.814% compared to the control treatment (Z0F0) 6.629%, with an increase of 32.96%. This may be due to the addition of the bio-enhancer containing fungal and bacterial organisms and the amount of mineral fertilizer added, which increased the availability of nitrogen in the soil and then increased the amount absorbed by the plant. This led to an increase in the percentage of protein in the tubers. This means that the combination of zeolite and nitrogen fertilization could be a useful approach to increase the efficiency of nitrogen fertilizers and improve the sustainability of the agricultural system. This agrees with Aslani et al. 2021. As for the effect of the triple interaction of the study factors (F x B x Z), it was significant in this trait, where the triple interaction treatment (Z2B1F2) recorded the best value for protein in tubers, which amounted to 9.296% compared to the control treatment, which amounted to 6.600, with an increase of 40.84%. The large increase in the proportion of protein is due to the role of fertilizers in increasing the readiness of primary and secondary nutrients, which leads to their absorption easily by the plant, which leads to the establishment of a good root system through which the plant can absorb nutrients. The plants perform various vital activities, such as carbon metabolism. Through it, various compounds are manufactured and then transferred to the tubers for storage. This led to an increase in the protein content of potato tubers[12]

Percentage of Starch in Tubers %

The statistical analysis results from Table (5) showed that the percentage of starch in the tubers was significantly affected by the levels of zeolite, the bio-enhancer and the mineral fertilizer added to the soil. %) Compared to the control treatment (Z0), it was 13.38%, with an increase of 27.8%, and the adding bio-enhancer recorded an increase in the tuber starch character. The highest treatment (B1) recorded 16.15% compared to the control treatment (B0) 14.83%, with an increase of 8.9%. This is because the bio-enhancer-containing seaweed added to the soil contains many active minerals and organic compounds. Complex polysaccharides such as laminarin, fucoidan, alginate, and phytohormones that promote plant growth increase the starch content in the tubers. This is consistent with [16]. The percentage of starch in the tubers increased with the increase in mineral fertilization levels. Through Table (5), the results of the statistical analysis showed that the adding fertilizer recorded an increase in the traits of tuber starch, and the highest value was in the treatment (F2) 16.22% compared to the control treatment (F0) 14.63%, with a percentage of an increase of 10.86%The increase in the percentage of starch may be due to the fact that the adding zeolite increases the efficiency of the use of potash fertilizers adding to the soil.

Adding zeolite levels	Adding bio-enhancer levels	Adding mineral fertilizer levels		
Z	B	F0	F1	F2
Z0	B0	6.600	7.035	7.706
	B1	6.658	7.100	7.906
Z1	B0	6.894	8.000	8.563
	B1	7.448	8.067	9.219
Z2	B0	7.050	7.487	8.331
	B1	7.850	9.160	9.296
$LSD_{0.05}$		LSD: Z*B*F = 0.2842		
Effect of bi-interaction between adding zeolite and mineral fertilizer (FxZ)				
FxZ	F0	F1	F2	Average Z
Z0	6.629	7.068	7.806	7.168
Z1	7.171	8.033	8.891	8.032
Z2	7.450	8.324	8.814	8.196
L.S.D Z * F = 0.2009				L.S.D Z =0.1160
The effect of the bi-interaction between bio-enhancer and the mineral fertilizer (FxB)				
FxB	F0	F1	F2	Average B
B 0	6.848	7.508	8.200	7.519
B 1	7.319	8.109	8.807	8.078
L.S.D F*B = 0.1641				L.S.D B = 0.0947
Effect of bi interaction between zeolite additive and bio-enhancer (ZxB)				
Z x B	B0	B1		Average F
Z 0	7.222	7.114		7.083
Z 1	8.244	7.819		7.808
Z 2	8.769	7.623		8.503
L.S.D Z*B= 0.1641				L.S.D F =0.1160

Table 4. The effect of Z, B and F and their interactions on the average percentage of protein.

The longer stay in the soil [14] increases the plant's potassium absorption and the percentage of starch in the tubers. It is noted from the results that the bio-enhancer has significant effects on starch yield, but the percentage was lower than that of mineral fertilizer. These results agree with (Asmaa, 2010). The effect of the bi-interaction between the bio-enhancer and the adding zeolite (ZxB) increased the tuber starch quality, as it recorded the highest value of treatment (Z2B1) 17.59% compared to the control treatment (Z0B0) 12.63%, with an increase of 39.27%. This is due to the positive role of humic acid in adding bio-improver in improving photosynthesis and tuber quality, which is consistent with (Man-Man-Hong et al. 2020) as for the bio-enhanced bi-interaction and adding mineral fertilizer (FxB), a significant increase was recorded in the tuber starch character. The highest value was in the treatment (B1F2) (16.79%), compared to the control treatment (B0F0) (13.99%), with an increase of 20.01%. The results of the statistical analysis (Table 5) showed that the binary interaction between zeolite and the adding mineral fertilizer (FxZ) recorded an increase in the tuber starch trait in the treatment (Z2F2) by 17.91% compared to the control treatment (Z0F0) by 12.66%, with an increase of 41.46%. The triple interaction of the study factors (F × B × Z) between zeolite,

Adding zeolite levels	Adding bio-enhancer levels	Adding mineral fertilizer levels		
Z	B	F0	F1	F2
Z0	B0	12.12	12.70	13.08
	B1	13.20	14.40	14.79
Z1	B0	14.31	15.20	16.29
	B1	15.78	17.08	17.36
Z2	B0	15.55	16.67	17.61
	B1	16.84	17.72	18.22
$LSD_{0.05}$		LSD: Z*B*F =0.02850		
Effect of bi-interaction between adding zeolite and mineral fertilizer (FxZ)				
FxZ	F0	F1	F2	Average Z
Z0	12.66	13.55	13.93	13.38
Z1	15.04	16.14	16.82	16.00
Z2	16.19	17.19	17.91	17.10
L.S.D Z * F = 0.02016				L.S.D Z = 0.01164
The effect of the bi-interaction between bio-enhancer and the mineral fertilizer (FxB)				
FxB	F0	F1	F2	Average B
B 0	13.99	14.85	15.66	14.83
B 1	15.27	16.40	16.79	16.15
L.S.D F*B = 0.01646				L.S.D B = 0.00950
Effect of bi interaction between zeolite additive and bio-enhancer (ZxB)				
Z x B	B0	B1		Average F
Z 0	14.13	12.63		14.63
Z 1	16.74	15.26		15.62
Z 2	17.59	16.61		16.22
L.S.D Z*B=0.01646				L.S.D F = 0.01164

Table 5. Effect of Z, B and F and their interactions on the percentage of starch.

DISCUSSION

The bio-enhancer and the mineral fertilizer achieved a significant value for the starch traits, where the treatment (Z2B1F2) recorded the best value for the starch characteristic in tubers, which amounted to 18.22% compared to the control treatment, which amounted to 12.12%, with an increase of 50.33 %. The reason for this is due to the use of mineral fertilizers, which leads to an increase in the percentage of available elements and then benefits from them, enabling the plant to carry out all vital activities and provide better production in quantity and quality. As a result of increasing the availability of nitrogen leads to an increase in the percentage of protein, starch and dry matter in the tuber, as there is a correlation between them. This is in line with [1,8]

CONCLUSIONS

The results showed that there were significant differences in the addition of the bio-enhancer, zeolite, and mineral fertilizer, as the triple interaction treatment was achieved (adding the bio-enhancer 5 kg ha-1 + zeolite 12 tons ha-1 + the third level of mineral fertilizers) and symbolized by the symbol (Z2B1F2), which obtained the highest values. In the dry weight of shoots, total yield, protein percentage and starch percentage, the values were 33.86 (gm. plant-1), 33.36 (mcg h-1), 9.296% and 18.22%, respectively.

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