EFFECT OF ADDITION OF VERMICOMPOST, BIO AND MINERAL FERTILIZER ON THE AVAILABILITY OF SOME NUTRIENTS IN SOIL AND POTATO YIELD

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ABSTRACT

A nitrogenous bio-fertilizer comibination was prepared contain *Azospirillum lipoferum*, and *Azotobacter chroococcum* bacteria. A phosphate bio-fertilizer consisting of *Bacillus megaterium* and *Glomus mosseae* fungus was also prepared. vermicompost was produced from earthworms imported from Iran and others isolated locally. A factorial experiment was carried to evaluate the effect of the interaction between these combinations and vermicompost types under levels of 0%, 25% and 50% of NPK. The results showed a significant superiority of the bio-fertilizer (nitrogen and phosphate) treatment in available nitrogen in the soil after harvest, number of tubers, yield per plant , and the total yield with 39.70 mg N kg $^{-1}$, 11.03 tuber plant $^{-1}$, 1367.40 g plant^{-1}, and 43.76 Mg ha^{-1} respectively. While phosphate bio fertilizer treatment giving available phosphorus in the soil by 22.74 Mg P kg $^{-1}$, vermicompost produced from imported earthworms was superior in giving available phosphate in the soil with value 22.74 mg p kg $^{-1}$. While the tri interaction was superior for all studied characteristics.

Keywords: earth worms , nitrogenous bio fertilizer , phosphate bio fertilizer , plant
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تأثير إضافة السماد الدودي و الحيوي و المعدني في جاهزية بعض المغذيات في التربة وفي حاصل نبات البطاطا

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المستخلص

حُضرت توليفة سماد حيوي نتروجيني مكونة من بكتريا *Azospirillum lipoferum* و *Azotobacter chroococcum* كما حُضرت توليفة سماد حيوي فوسفاتي مكونة من بكتريا *Bacillus megaterium* و فطر *Glomus mosseae*, تم إنتاج السماد الدودي من ديدان أرض مستوردة من أيران وأخرى عزلت محلياً . نُفذت تجربة عاملية لتقييم تأثير التداخل بين هذه التوليفات ونوعي السماد الدودي تحت مستويات صفر و 25% و 50% من NPK أظهرت النتائج تفوق معاملة توليفة السماد الحيوي الخليط (النتروجيني والفوسفاتي) معنوياً في النتروجين الجاهز في التربة بعد الحصاد وعدد الدرنات وحاصل النبات الواحد والحاصل الكلي لتعطي قيم 39.70 ملغم Nكغم$^{-1}$ و 11.03 درنة نبات$^{-1}$ و 1367.40 غم نبات$^{-1}$ و 43.76 ميكاغرام هـ$^{-1}$ على التتابع فيما تفوقت معاملة السماد الحيوي الفوسفاتي في أعطاء فسفور جاهز في التربة بلغ 22.74 ملغم P كغم$^{-1}$ كما تفوق السماد الدودي المنتج من ديدان أرض مستوردة في جميع الصفات المدروسة . و تفوق التداخل الثلاثي على المعاملات بشكل منفرد ولجميع الصفات المدروسة .

الكلمات المفتاحية : ديدان الأرض , سماد حيوي نتروجيني , سماد حيوي فوسفاتي , النبات .

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INTRODUCTION

Most of the land of agricultural importance in arid and semi-arid Zones suffers from low availabilty of many important nutrients in plant nutrition and productivity, as well as the decrease in the soil organic matter and under these conditions occurs a significant reduction in biomass in the soil. One of the most important inputs in achieving the increase in production is using of mineral fertilizers, but this increase was accompanied by environmental risks as well as the economic cost spent on mineral fertilization. Therefore, modern research has tended to reduce the additions of chemical fertilizers, nitrogen and phosphate, by means of increasing the availability in the soil and absorption by the plant without affecting the production of the crop. One of the most important of these is biofertilization because it is the least expensive and safer environment (4). For example, nitrogenous biofertilizers that fix atmospheric nitrogen (Symbiotic), such as *Rhizobia* bacteria with legume crops, and non-symbiotic or free living bacteria such as Azotobacter and Azospirillum characterized by high capacity on atmospheric nitrogen fixation, and spread its use as a bio-fertilizer with non-legume plants, As well as the role of these genera of bacteria in the secretion of some hormones, enzymes, vitamins and growth regulators, this improves the growth of the treated plants as indicated by many researchers (1). Or through the use of phosphate biofertilizers such as bacillus bacteria and mycorrhizal fungus, they are also widespread in various agricultural environments, it is an integral part of the ro-ecosystem and plays a major role in provide plants with minor and major mineral elements as well as protecting plants from the pathogens endemic to soil One of the organisms found in the soil, which is a very important bio-fertilizer and increased attention in the recent period significantly is Earthworm belong to the phylum *annelida*, Class: *Polychaeta* and Order: Opisthopora. It is one of the large decomposes of organic matter and is found in soils of temperate and tropical areas and soils affected by excess water, and their Colors, sizes and lengths vary by type (13). Soil containing earthworms is vital because the presence of these organisms in the soil makes it fertile and rich in organic matter through the production of Vermicompost, it is rich in nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium, iron and other minerals. Vermicompost contains a number of enzymes that enhance the activity of microbial organisms already in the soil, and thus increase the microbial biomass in the soil such as enzymes (cellulose and amylase, invertase, protease, peroxidase, Urease, phosphatase and dehydrogenase (20). Vermicompost is used as an organic fertilizer that increases the nutrient content in the soil, growth regulators and enzymes and increases productivity, it improves the physical properties of the soil and creates a safe ecosystemfor food production. Vermicompost also act as a slow-release fertilizer for nutrients, while chemical fertilizers release nutrients quickly into the soil solution and quickly lose either through volatilization or Leaching. The aim of the present study is to evaluate the effect of the interaction between the biofertilizer combinations and the vermicomposts produced in nitrogen and phosphorus availability in soil and potato yield using different fertilization levels of mineral

MATERIALS AND METHODS

First: Preparation of vermicompost

Vermicompost fertilizer was prepared once using earthworms imported from Iran and again from earthworms isolated from the local environment from some agricultural and horticultural fields from Wasit province by developing these worms in plastic containers of 20 cm length, 25 cm width and 35 cm height. Sawdust was placed 6 cm high inside the containers and a little peat moss, then the worms were added, the food was added then to the worm daily and the process lasted three months until the vermicompost was completed.

Second: Propagation of mycorrhizal fungus *Glomos mosseae*

This fungus, obtained from the Agricultural Research Department / Ministry of Science and Technology, was propagated by conducting a potted experiment were the subsurface soil was contaminated by adding 100 g of the fungus inoculum, beside 100 g of fungus inoculum added and mixed to surface soil, and barley seeds were sown. After 80 days of germination, the root was removed and cut into small pieces, then keep it and the surrounding soil containing fungus spores in special containers in a cool place until use. Parts of the root sections were examined to ascertain the infection and the number of spores in the soil sample. The number of spores in the inoculum produced was 2700 spores per 100 g of dry soil and 75% of the roots were infected.

Fourth: Isolation and diagnosis of *Azotobacter chroococcum*

Sucrose Mineral Salts media was prepared and sterilized a series of decimals dilutions were performed for the rhizosphere soil samples of different crops, it was cultured on this media and incubated at 28 °C for 5 days and the tubes forming the annular membrane were examined on the surface, which is an indicator of the presence of these bacteria. A series of biochemical tests were conducted to diagnose these bacteria at the species level.

Fifth: Activation and multiplication of *Bacillus megaterium*

This isolate was activated previously from agricultural soil in Baghdad and tested its ability to dissolve phosphate in the center of Pikovskaya medium. This isolation was used in the combination of bio-fertilizer in the field experiment.

Third: Isolation and diagnosis of *Azospirillum lipoferum*

These bacteria were isolated from different plant root forms cultivated in some fields in Wasit province after crushing and dilute them and spreading them to the sterilized media of Nfb (6). The appearance of white annular growth below the surface of the media is a positive indicator of the growth of these bacteria and then conducted a series of microscopic and biochemical tests to diagnose bacteria at the level of the species.

Sixth: Field experiments

Field experiment factors included

First factor:

bio-fertilizer included (no addition of bio fertilizer B_0 , nitrogenous bio fertilizer NB , phosphate bio fertilizer PB , and bio fertilizer mixture nitrogen + phosphate NB + PB).

Second factor: Vermicompost fertilizer , included the following: without addition of vermicompost V_0 , vermicompost produced from imported earthworms V_1 , vermicompost produced from local earthworms V_2.

Third factor: Mineral fertilization levels including: 0 % (no mineral fertilizer added C_0 , 25% of the recommended fertilizer C_1 , and 50% of the recommended fertilizer C_2 .

2 - Implementation of the field experiment

The field experiment was conducted at the Agricultural Research and Experimental Station of the Wasit Governorate Agriculture Directorate / Horticulture Development Project. After preparing the land from plowing, smoothing and dividing into experimental units, the area of each unit is 9.3 m^2. Treatments were randomly allocated to the experimental units according to RCBD design. Potato tubers var. EVEREST (class : Elit)were planted, with 10 tubers in each furrow and the distance between tubers were 0.3m. Field soil was analyzed prior planting to determine its chemical, physical and biological properties (17) as show in Table 1.

Table 1. Some Chemical, Physical and Biological Characteristics of Soil Pre – planting

Character		Value	Units
	pH	7.60	
	EC1:1	2.64	dsm^{-1}
	Ca^{2+}	6.62	
	Mg^{2+}	2.40	
	Na^{+}	8.00	
	K^{+}	0.09	$mmol^{-1}$
	$SO4^{2-}$	5.34	
	HCO_3^{-}	2.10	
	O.M	12.00	g kg^{-1} soil
	Lime	300.00	
Avialable nutrients	N	22.00	
	P	8.21	$mgkg^{-1}$
	K	82.10	
Partical Size distribution	Sand	220.00	
	Silt	460.00	g kg^{-1} soil
	Clay	320.00	
	Texture	Clay Loam	
	Bulk density	1.29	Mg m^{-3}
	Total bacteria	$9.66X10^{8}$	Cfu g^{-1} dry soil
	Total fungus	$0.7X10^{6}$	Cfu g^{-1} dry soil

Peat moss was sterilized by autoclave at 121 ° C and 15 lb $inch^{-1}$ pressure and then carried by the bacteria involved in the production of a combination. The potato tubers were then moistened with a 15% concentration of Arabic gum solution, which was subsequently contaminated with the bacterial biofertilizer according to the experiment treatments. In addition, 50 g of mycorrhizal vaccine was added to each hole when planting, and the vermicompost was added 25 g per hole. This experiment lasted for 100 days after which the number of tubers per plant and the total yield were calculated while the amount of available nitrogen and phosphorus in in the soil after harvest was estimated

RESULTS AND DISCUSSION

Number of tubers

The results of statistical analysis showed significant differences for mean number of tubers when adding vermicompost (Table 2). The treatment of vermicompost produced from imported earthworms achieved the highest average number of tubers, which was 9.98 tuber $plant^{-1}$ compared to treatment without adding vermicompost, which recorded the lowest average number of tubers 8.64 tuber. As for the bio-fertilizer, the results showed that the treatment of combination of nitrogen bio-fertilizer + phosphate bio-fertilizer was superior to other treatments in the number of tubers, averaging 11.03 tuber $plant^{-1}$ while treatment without addition of bio-fertilizer was the lowest 7.63 tuber $plant^{-1}$.The addition of 50% of the recommended mineral fertilizer was superior with 9.75 tuber $plant^{-1}$. The di interaction between bio-fertilizer and vermicompost showed that the treatment of nitrogen + phosphate bio-fertilizer with vermicompost produced from imported earthworms was significantly higher in the number of tubers (11.83 tuber $plant^{-1}$) compared to the non-addition of biomass and vermicompost, which recorded the lowest percentage of tubers amounted to 6.67 tuber $plant^{-1}$, On the other hand, other di interactions between vermicompost and 50% of the recommended fertilizer or between the addition of bio-mineral fertilizer showed a similar effect on the number of tubers. The tri interaction between vermicompost, bio-fertilizer and mineral fertilizer showed no significant differences between treatments. Some of tri interaction outperformed the full fertilizer recommendation 8.33 tuber $plan^{-1}$, especially the treatment of imported earthworm's composite vermicompost with a mixture comibination with 50% of the recommended fertilizer. The results of the tri interaction showed the superiority of treatment of imported worms with interaction

Plant yield

The results of statistical analysis showed significant differences for yield per plant when adding vermicompost (Table 3). The treatment of vermicompost produced from imported earthworms achieved the highest average for plant yield , which was 1306.90 g $plant^{-1}$ compared to treatment without adding vermicompost, which recorded the lowest average number of tubers 955.20 g $plant^{-1}$. The results also showed that the treatment of nitrogen + phosphate bio fertilizer was superior to other treatments in this characteristic, averaging 1367.40 g $plant^{-1}$, while the lowest average was recorded in the treatment without adding bio-fertilizer 907.50 g $plant^{-1}$ in plant yield. The results showed that the treatment of nitrogen + phosphate bio fertilizer with vermicompost produced from imported earthworms was significantly higher in the plant yield as it reached 1540.10 g $plant^{-1}$ compared with the non-addition of bio fertilizer and vermicompost which recorded the lowest single plant yield which was 604.50 g. $plant^{-1}$. The results of the tri interaction showed the superiority of treatment produced from imported worms with combination of nitrogenous fertilizers with phosphate bio fertilizer and 50% of the recommended mineral fertilizer.

Table 2. Effect of vermicompost, bio-fertilizer and mineral fertilizer on number of potato tubers (tuber $plant^{-1}$)

vermicompost (V)	Biofertilizer (B)	Mineral Fertilizer (C) C_0 0	C_1 25%	C_2 50%	V * B Interaction
No vermicompost V_0	B0	5.43	7.03	7.56	6.67
	NB	8.47	9.26	9.60	9.11
	PB	8.80	9.03	8.86	8.90
	NB+PB	9.56	10.00	10.13	9.90
Imported vermicompost V_1	B0	8.03	8.16	8.43	8.21
	NB	9.76	10.03	9.80	9.86
	PB	9.90	10.06	10.10	10.02
	NB+PB	11.63	11.80	12.06	11.83
Local vermicompost V_2	B0	7.73	7.83	8.43	8.00
	NB	9.26	9.46	9.46	9.40
	PB	10.53	10.56	10.63	10.57
	NB+PB	11.00	11.16	11.93	11.36
LSD			N.S		0.70
Mean mineral fert.		9.17	9.53	9.75	
LSD			0.35		
			V * C Interaction		
vermicompost (V)		C_0 0	C_1 25%	C_2 50%	Mean vermicompost
V_0		8.06	8.83	9.04	8.64
V_1		9.83	10.01	10.10	9.98
V_2		9.63	9.75	10.11	9.83
LSD			N.S		0.35
			C * B Interaction		
Bio-fertilizer (B)		C_0 0	C_1 25%	C_2 50%	Mean bio-fertilizer
B_0		7.06	7.67	8.14	7.63
NB		9.16	9.58	9.62	9.45
PB		9.74	9.88	9.86	9.83
NB + PB		10.73	10.98	11.37	11.03
LSD			N.S		0.40
			CONTROL		
%100 recommended NPK				8.33	
LSD				1.22	

Total yield (Mg ha^{-1})

The results of statistical analysis showed significant differences for total yield when adding vermicompost (Table 4). The treatment of vermicompost produced from imported earthworms achieved the highest total yield , which was 41.92 Mg ha^{-1} compared to treatment without adding vermicompost, which recorded the lowest average yield of 30.84 Mg ha^{-1}. The results also showed the superiority of nitrogen + phosphate bio-fertilizer treatment was superior to other treatments in total yield, averaging 43.76 Mg ha^{-1}, whereas the average yield of the 50% of the recommended mineral fertilizer (39.32 Mg ha^{-1}) significantly higher than the treatment which was no mineral fertilizer was added which was 36.05 Mg ha^{1}. The results showed that the treatment of nitrogen + phosphate bio fertilizer with vermicompost produced from imported earthworms was significantly higher in total yield as it reached 49.32 Mg ha^{-1} compared to 19.50 Mg ha^{-1} of no bio fertilizer and vermicompost treatment. On the other hand, the interaction between vermicompost and mineral fertilizer showed that the treatment of vermicompost produced from imported earthworms with 50 of the recommended mineral fertilizer was significantly higher in the total plant yield as it reached 43.32 Mg ha^{-1}. The results also showed that the tri interaction treatment was superior to the full recommended fertilizer with 35.21 Mg ha^{-1}. The clear effect of

Table 3. Effect of vermicompost, bio-fertilizer and mineral fertilizer on single plant yield (g plant^{-1})

vermicompost (V)	Biofertilizer (B)	Mineral Fertilizer (C) C_0 0	C_1 25%	C_2 50%	V * B Interaction
No vermicompost V_0	B0	488.40	572.70	752.30	604.50
	NB	927.80	959.20	1004.00	963.70
	PB	1112.60	1159.40	1273.00	1181.70
	NB+PB	1005.80	1098.90	1107.90	1070.90
Imported vermicompost V_1	B0	1049.10	1115.50	1257.30	1140.60
	NB	1267.80	1266.70	1264.80	1266.40
	PB	1301.20	1277.10	1263.30	1280.50
	NB+PB	1465.80	1534.20	1620.40	1540.10
Local vermicompost V_2	B0	959.10	988.40	984.30	977.30
	NB	1258.20	1266.60	1265.50	1263.40
	PB	1177.50	1246.80	1270.50	1231.60
	NB+PB	1387.20	1560.10	1526.70	1491.30
LSD			72.30		41.70
Mean mineral fert.		1116.70	1170.50	1215.80	
LSD			20.90		
			V * C Interaction		
vermicompost (V)		C_0 0	C_1 25%	C_2 50%	Mean vermicompost
V_0		883.70	947.50	1034.30	955.20
V_1		1271.00	1298.40	1351.50	1306.90
V_2		1195.50	1265.50	1261.70	1240.90
			36.10		20.90
			C * B Interaction		
Bio-fertilizer (B)		C_0 0	C_1 25%	C_2 50%	Mean bio-fertilizer
B_0		832.20	892.20	998.00	907.50
NB		1151.30	1164.20	1178.10	1164.50
PB		1197.10	1227.80	1268.90	1231.30
NB + PB		1286.30	1397.70	1418.30	1367.40
LSD			41.70		24.10
			CONTROL		
%100 recommended NPK				1091.70	
LSD				71.87	

vermicompost on the number of tubers, plant yield and total yield is show in Tables 2, 3 and 4. This is due to the role of vermicompost produced from earthworms, whether imported or local, in improving the properties of soil fertility, physical, chemical as well as biological, which facilitates the penetration of the roots and the expansion of the stems represented by tubers, which is reflected on the qualities of tubers in a positive way. In addition to the role of vermicompost in the provision of nutrients in the vicinity of the root system, which increases the absorption by the roots, which helps to improve vegetative growth that is reflected on the growth of the plant by transferring metabolic products to the vegetative parts and then to the tubers, which led to increase the weight and number of tubers (16) (22). In addition to increasing the availability of the nutrients necessary for plants and microorganisms, which reflected on the activity and growth of the plant and increase production and this is confirmed by 25. Smith (21) in a study in which the liquid extracted from vermicompost (tea compost) was sprayed on the vegetative part on the potato plant and added vermicompost led to increase plant yield, number of tubers and their mineral content. These results agreed with Herath (9) that vermicompost is an excellent enhancer of soil properties and increases yield and other qualities. whereas, The addition of bio-fertilizer can be attributed to increase in the total yield and yield per plant and the number of tubers to the positive role of the bacterial bio-fertilizer and mycorrhizal fungus in providing food needs, especially nitrogen and phosphorus elements and then increase the number of tubers and a significant increase in the yield of potato plant. The addition of bio-fertilizer can be attributed to the increase in the yield per plant and the total yield and the number of tubers to the positive role of the bacterial bio- fertilizer and mycorrhizal fungus in providing nutrients needs, especially nitrogen and phosphorus elements and then increase the number of tubers and a significant increase in the yield of potato plant. These results were also agreed with Singh (20) which confirmed the significant effect of bio fertilizers on tubers size and weight of potato plant that *Bacillus megaterium* released phosphorus from their unavailable resources and increase the amount of dissolved orthophosphate and increases the ability of the potato's absorption capacity, as well as the ability of these bacteria to secrete phosphatase enzyme. The addition of mycorrhizal fungus as a phosphate bio fertilizer besides bacillus bacteria led to increase both total yield and tuber number. Also, mixing these bacteria in a combination with other bacteria such as Azospirillum and Azotobacter which fix nitrogen contributed to raising the efficiency of these bacteria and their ability to carry out their biological activity and the secretion of compounds that stimulate plant growth. As well as increasing the effectiveness of bacteria in the secretion of organic and mineral acids that work to increase the availability of major and minor elements and fixation of nitrogen and increase the availability of phosphorus and release from unavailable sources, as confirmed by Kang (11) Mohapatra (13). The results show response of the potato to the fertilization by nitrogen bio-fertilizer, Azospirillum and Azotobacter nitrogen-fixing and this is due to the ability of these bacteria to reduction nitrogen and exploited by the plant as well as the production of various growth regulators that promote the growth of roots and increase their number (7). This increases the absorption capacity of the roots and increases the absorption of nitrates, phosphates and potassium , this leads to an increase in the nitrogen content in the plant, which in turn leads to the increase growth of plant cells, their division and their role in the synthesis of proteins, amino acids and organic bases. It is involved in the formation of chlorophyll and cytochrome compounds which are important in photosynthesis and respiration processes, it then increases production, yield and number of tubers (2) (18) The di interaction between vermicompost and bio-fertilizer has increased the yield due to vermicompost's role as an excellent soil organic fertilizer and more suitable for microorganism growth and hormone secretion (4). Also, the role of nitrogen and phosphate bio-fertilizer represented by bacteria that stimulate plant growth and mycorrhizal fungi in increasing vegetative growth, which is reflected on the number and weight of tubers. This is due to the ability of these organisms to provide a suitable environment for plant growth and increase the availability of micro and macronutrients important in plant nutrition and production of antibiotics that stimulate the plant to resist some diseases endemic in the soil and benefit the plant and its production The addition of a mixture of *Bacillus megaterium* and *Azospirillum spp* increases the effectiveness of nitrogenase and increases the plant's nitrogen and phosphorus content, which increases plant growth and productivity.

Table 4. Effect of Addition vermicompost, Bio-Fertilizer and Mineral Fertilizer in total yield of Potato (Mg ha^{-1})

vermicompost (V)	Biofertilizer (B)	Mineral Fertilizer (C) C_0 0	C_1 25%	C_2 50%	V * B Interaction
No vermicompost V_0	B0	15.75	18.47	24.27	19.50
	NB	30.90	32.01	31.38	31.44
	PB	38.14	37.40	41.17	38.90
	NB+PB	30.85	34.04	35.73	33.54
Imported vermicompost V_1	B0	35.50	35.98	40.55	37.34
	NB	40.48	40.45	39.72	40.22
	PB	41.48	40.12	40.75	40.78
	NB+PB	46.20	49.49	52.27	49.32
Local vermicompost V_2	B0	30.45	31.98	32.82	31.75
	NB	39.51	40.45	40.82	40.26
	PB	38.52	39.14	42.05	39.90
	NB+PB	44.74	50.25	50.32	48.44
LSD			N.S		1.59
Mean mineral fert.		36.05	37.48	39.32	
LSD			0.79		
			V * C Interaction		
vermicompost (V)		C_0 0	C_1 25%	C_2 50%	Mean vermicompost
V_0		28.92	30.48	33.14	30.84
V_1		40.92	41.51	43.32	41.92
V_2		38.30	40.45	41.50	40.09
LSD			1.38		0.79
			C * B Interaction		
Bio-fertilizer (B)		C_0 0	C_1 25%	C_2 50%	Mean bio-fertilizer
B_0		27.23	28.81	32.55	29.53
NB		36.97	37.64	37.31	37.30
PB		39.38	38.88	41.32	39.86
NB + PB		40.60	44.59	46.11	43.76
LSD			N.S		0.92
			Control		
%100 recommended NPK				35.21	
LSD				2.93	

The presence of vermicompost as an organic fertilizer and soil reformer provides a favorable environment for the activity of bacteria and fungi as it contains a low C/N ratio which is appropriate as well as retention of appropriate humidity and good ventilation, which increases the activity of microorganisms and their effectiveness. The interaction between vermicompost and mineral fertilizer had a significant effect on the plant yield as well as the total yield. This superiority is due to the positive effect of vermicompost as an organic fertilizer by interfering with the mineral fertilizer on the qualities and yield of potatoes. This leads to the construction of a dense vegetative mass and the availability of the necessary elements available form in the soil solution as a result of this interaction. The needs of the plant are ready, which has a role to play the plant bio-efficient with high efficiency, which reflected on the manufacturing of energy compounds well and then stored in the tubers and this is consistent with (3) This represents the integration between organic and mineral fertilizer, which results in good growth of the plant and improve its quantitative and productive qualities, and this is consistent with the results obtained by some researchers of the positive interaction between the kinds of fertilizers.

Available nitrogen in soil after harvest (mg N kg^{-1} soil): The results shows in Table 5 indicates that the effect of the type of vermicompost in the amount of available nitrogen in the soil, it indicated the superiority of vermicompost produced from imported earthworms in achieving available nitrogen level of 41.92 mg N kg^{-1} soil compared to the non-addition of vermicompost where the average available nitrogen was 30.84 mg N kg^{-1}soil . On the other hand, the results showed that the addition of nitrogen + phosphate bio fertilizer resulted in a significant superiority in the average nitrogen available as it reached 39.70 mg N kg^{-1} soil compared to treatment without addition of bio fertilizer, which averaged available nitrogen in the soil 26.46 mg N kg^{-1} soil. Mean of mineral fertilizer significantly exceeded the amount of available nitrogen in the soil, where the amount of available nitrogen increased in the treatment of 50% of the recommended fertilizer 32.75 mg N kg^{-1} soil compared to the treatment of non-application of mineral fertilizer, where the average of available nitrogen is 30.96 mg N kg^{-1} soil. On the other hand, the outperformed treatment of the interaction between nitrogen + phosphate bio fertilizer in the presence of 50% of the recommended fertilizer 41.22 mg N kg^{-1} soil compared to non-addition of fertilizer and mineral fertilizer, which amounted to 24.61 mg N kg^{-1} soil . The treatment V_1NB+PB C_2 recorded the highest available 47.00 mg N kg^{-1} soil as compared to V_0 B_0 C_0 which gave the lowest available N at 17.83 mg N kg^{-1} soil. When comparing the V_1NB+PB C_2 treatment to the full recommended fertilizer (control) which gave 35.33 mg N kg^{-1} soil, there was no significant difference between them.

Table 5. Effect of Vermicompost, Bio-Fertilizer and Mineral Fertilizer on available Nitrogen (mg Nkg^{-1}soil)

vermicompost (V)	B Biofertilizer ( )	Mineral Fertilizer (C) C_0 0	C_1 25%	C_2 50%	V * B
No vermicompost V_0	B0	17.83	22.33	24.33	21.50
	NB	31.20	32.67	33.33	32.44
	PB	25.00	24.67	24.67	24.78
	NB+PB	34.00	34.67	36.33	35.00
Imported vermicompost V_1	B0	28.67	29.00	30.67	29.44
	NB	36.67	37.67	32.33	35.56
	PB	28.00	29.00	30.33	29.11
	NB+PB	42.33	43.67	47.00	44.33
Local vermicompost V_2	B0	27.33	28.33	29.67	28.44
	NB	34.00	35.00	35.33	34.78
	PB	27.00	27.33	28.67	27.67
	NB+PB	39.33	39.67	40.33	39.78
LSD			3.00		1.73
Mean mineral fert.		30.96	32.00	32.75	
LSD			0.86		

V * C Interaction

vermicompost (V)	C_0 0	C_1 25%	C_2 50%	Mean vermicompost
V_0	28.92	30.48	33.14	30.84
V_1	40.92	41.51	43.32	41.92
V_2	38.30	40.45	41.50	40.09
LSD	1.38			0.79

C * B Interaction

Bio-fertilizer (B)	C_0 0	C_1 25%	C_2 50%	Mean bio-fertilizer
B_0	24.61	26.56	28.22	26.46
NB	34.00	35.11	33.67	34.26
PB	26.67	27.00	27.89	27.19
NB + PB	38.56	39.33	41.22	39.70
LSD		1.73		1.00

Control

%100 recommended NPK	35.33
LSD	3.04

Available phosphorus in soil after harvest (mg P kg^{-1} soil): The results in Table 6 shows the effect of vermicompost on soil phosphorus availability, the results indicated that vermicompost produced from imported earthworms was superior in increasing available phosphorus in soil after harvesting to 17.97 mg P kg^{-1}soil, compared to non-addition of vermicompost treatment in which the average of available phosphorus was 11.72 mg P kg^{-1}soil. On the other hand, the results showed that the addition of bio fertilizer had a significant effect in increasing the amount of available phosphorus in the soil. The treatment of bio fertilizer phosphate gave the highest amount of available phosphorus in the soil was 22.74 mg P kg^{-1} soil compared to the treatment of non-addition of fertilizer was an average of 8.05 mg P kg^{-1} soil. While the results of the di interaction showed the superiority of imported earth worms in combination with bio fertilizer phosphate for the availability of phosphorus in the soil to reach 27.66 mg P kg^{-1}soil compared to no addition of vermicompost and bio-fertilizer which reached 4.03 mg P kg^{-1} soil. The results also showed an increase in the amount of available phosphorus in the soil in the treatment of interaction between imported earth worms in the soil with 50% of the recommended fertilizer 20.01 mg P kg^{-1} soil. The results of the statistical analysis of the tri interaction showed the superiority of the treatment V1 PB C_2 and reached 30.33 mg P kg^{-1} soil, compared with the treatment of non-addition of vermicompost, bio-fertilizer and mineral fertilizer, which amounted to 3.63 mg P kg^{-1} soil. When comparing tri interaction with NPK individually, a significant difference was found between the highest value of tri interaction and NPK and reached 13.80.

Table 6. Effect of Addition of Vermicompost, Bio-Fertilizer and Mineral Fertilizer on Phosphorus availability (mg p kg^{-1} Soil)

vermicompost (V)	Biofertilizer (B)	Mineral Fertilizer (C) C_0 0	C_1 25%	C_2 50%	V * B Interaction
No vermicompost V_0	B0	3.63	4.13	4.33	4.03
	NB	5.60	8.40	9.60	7.86
	PB	15.66	18.00	19.66	17.77
	NB+PB	13.66	17.66	20.33	17.22
Imported vermicompost V_1	B0	10.66	12.00	13.66	12.11
	NB	8.33	9.33	11.40	9.68
	PB	25.66	27.00	30.33	27.66
	NB+PB	20.66	22.00	24.66	22.44
Local vermicompost V_2	B0	6.33	8.16	9.53	8.01
	NB	10.66	12.16	15.33	12.72
	PB	21.00	23.33	24.00	22.77
	NB+PB	16.66	19.33	22.33	19.44
LSD			1.18		0.68
Mean mineral fert.		13.21	15.12	17.10	
			0.34		
			V * C Interaction		
vermicompost (V)		C_0 0	C_1 25%	C_2 50%	Mean vermicompost
V_0		9.64	12.05	13.48	11.72
V_1		16.33	17.58	20.01	17.97
V_2		13.66	15.75	17.80	15.73
LSD			0.59		0.34
			C * B Interaction		
Bio-fertilizer (B)		C_0 0	C_1 25%	C_2 50%	Mean bio-fertilizer
B_0		6.87	8.10	9.17	8.05
NB		8.20	9.96	12.11	10.09
PB		20.77	22.77	24.66	22.74
NB + PB		17.00	19.66	22.44	19.70
LSD			0.68		0.39
			Control		
%100 recommended NPK				13.80	
LSD				1.19	

It is clear from the results of tables 5 and 6 that the addition of vermicompost had significant effects in increasing nitrogen and phosphorus availability in the soil and this may be attributed to the vermicompost has many positive properties and effects. Vermicompost in general improves the physical, fertility, chemical and biological properties of the soil by first decomposition and release of these substances and elements. it is rich in organic materials and nutrients and this is indicated by a study of. Smith(21). Vermicompost also synthesizes humic organic acids and reduces the pH of the soil, thereby increasing the availability of essential nutrients in soil such as nitrogen and phosphorus. These results are consistent with the results of Mohapatra (13) who indicated that the addition of vermicompost works to enrich the soil with millions of beneficial bacteria and fungi that have a significant role both in fixing nitrogen and increasing the availability of nitrogen and potassium. The earth worm's digestive system, through which soil and organic matter passes, contains acids that neutralize acidity. As for the bio-fertilizer, we note the increase of the amount of nitrogen availability in the treatment of nitrogen bio-fertilizer + phosphate bio-fertilizer, because this treatment combination contains bacteria that stimulate the growth of the plant in addition to mycorrhizal fungus as the nitrogen-fixing bacteria such as *A.lipoferum* fixing the nitrogen in conjunction with plant roots, result in increasing the amount of nitrogen in the soil due to the secretion of the enzyme nitrogenase which is associated with the presence of high density of nitrogen-fixing bacteria, thus increase the rate of nitrogen fixation (8). Also, the presence of the bacteria Azotobacter which is important bacteria for the soil and the plant being free nitrogen fixation is not symbiotic, so we note the high values of available nitrogen in the soil of the experiment added bio fertilizer As well as secreting substances important for plant growth and increase the availabilitity of elements such as production of plant hormones su auxins, gibberellins and cytokinins , and fixation of nitrogen. These characters make Azotobacter the most successful and widely spread group and the double inoculation with *Azospirillium* and *Azotobacter*, may have led to a significant increase in the concentrations of indole acetic acid (IAA), potassium, magnesium, nitrogen and total dissolved sugars, this is what Rahman (15) pointed out when adding *Azotobacter* with phosphate-dissoiving bacteria to a field planted with potato plant, the results showed an increase in potato yield as well as increased weight of tubers and increased nitrogen in soil. The increase in the availability of phosphorus in the soil may come from the process of dissoiving by the bacteria and confirmed by the fact that the bacteria *Bacillus megaterium* as it is one of the most efficient bacteria to dissolve phosphate because the ability of these bacteria to produce different organic acids Such as Lactic, Succinic, lsobutyric, lsovaleric and Acetic acid, which increase the solubility of minerals (10), and the organic acids have the potential to form chelating compounds associated with the positive ions Fe^{+3}, Al^{+3}, Mg^{+2} and Ca^{+2}, leading to increased release of $H_2PO_4^-$, HPO_4^{-2}. As well as mycorrhiza has the ability to absorb phosphorus through the spread of hyphae to areas beyond the reach of the roots and Prepared for the plant easily and ready for absorption (23) , Mineral fertilizer has a role in increasing the available nitrogen in the treatment of mineral fertilizer due to the availability of mineral nitrogen for absorption by the plant as a result of the addition of urea fertilizer, as well as the role of mineral fertilizer in increasing the soil content of nutrients. These results show the positive role of mineral fertilizer in increasing the amount of available nitrogen in the soil with increasing the addition because it is an element that increases the quantity by adding mineral sources (12) (5). The reason for the increase of available phosphorus in the soil in the treatment of bio-fertilizer phosphate in combination with vermicompost may be due to the role of vermicompost in the formation of organic acids that reduce pH, which has an important role in increasing the availability of phosphorus.Vermicompost activates and microorganisms. Consequently, the added microorganisms act as bio-fertilizer dissolve compounds and materials, freeing the elements to the plant. Vermicompost activates chelating, metallization, enzyme secretion and growth regulators by microorganisms. All this increases the availability of the essential elements to the plant, such as nitrogen and phosphorus. These results are consistent with those obtained by Shehata (19). The interaction between bio-fertilizer and mineral fertilizer has a clear effect on the availability of elements in soil. As the nitrogen bio fertilizer, is a combination of Azospirillum + Azotobacter and in the presence of mineral fertilizer, increased the amount of available nitrogen. Considering the bio-fertilizer has a role in the production of compounds such as auxins and gibberellin that act as growth regulators as well as the secretion of acids and energy compounds that stimulate the plant. The increased concentration of available phosphorus is due to the efficiency of the bio-fertilizer and its interaction with the added phosphorus. The availability of available phosphorus by the addition of phosphate fertilizer, although at the level of a quarter or half of the recommended fertilizer leads to the activation and reproduction of microorganisms in the soil including bacteria Bacillus, the phosphate solvent and mycorrhizal fungus, this combination of phosphate bio-fertilizer acts to represent available phosphorus, dissolve insoluble phosphate compounds and reduce phosphorus deposition, this is confirmed by (14) (21) .

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