EFFECT OF LOCAL AND IMPORTED BIOFERTILIZERS ON GROWTH AND YIELD OF POTATO

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ABSTRACT

A field experiment was carried out in loam soil at the research station of the College of Agriculture University of Baghdad, using randomized complete block design. The experiment included three local biofertilizers types (*Bacillus megaterium*, *Pseudomonas fluorescens*, *Azotobacter chrococcum*) and an imported biofertilizer (Nitrosoil) by Iraqi's Ministry of Agriculture, beside, two levels of mineral fertilization (50% and 75%) of the mineral fertilizer recommendation with use of two types of carriers (corn cobs residue, broth liquid medium) in addition to the control treatments. Three replicates for each treatment were used on growth and yield of potato. The results showed a significant effect of biofertilizer in most of the studied traits. The results also showed that use of local biofertilizer with (75%) of mineral fertilizer increased plant height, dry weight of the total vegetables part of plants and total yield tuber with value reached 73.53 cm, 2.48 and 21.97 Mg ha^{-1} 12.33 respectively, compared with the imported biofertilizer and control treatments, while the results showed that the use of half of the fertilizer recommendation with local bio-fertilization carried with liquid medium was sufficient to reach the best amount of nitrogen and phosphorus concentration by the plants in which the value reached to 2.62%, 0.79% compared to imported biofertilizer treatment which showed superiority in the amount of potassium absorbed to the same level of the recommendation and the value was 1.20%.

Keywords: *Bacillus megaterium* , *Pseudomonas fluorescens* , *Azotobacter chrococcum*, Plant

***Part of M.S.c. thesis of the first author**

تأثير الأسمدة الحيوية المحلية والمستوردة في نمو وحاصل البطاطا

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1- قسم مكافحة التصحر – كلية الزراعة – جامعة بغداد

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المستخلص

نفذت تجربة حقلية في تربة مزيجه في أحد حقول الأقسام العلمية- كلية الزراعة – جامعة بغداد (الجادرية) باتباع تصميم القطاعات تام التعشية تضمنت التجربة سماد حيوي محلي من بكتريا ***Bacillus megaterium*** و***Pseudomonas fluorescens*** و ***Azotobacter chrococcum*** وسماد حيوي مستورد (النايتروسول) من قبل وزارة الزراعة العراقية وبمستويين من التسميد المعدني (50% و75%) من التوصية السمادية مع استعمال نوعين من الحوامل (كالح الذرة، وسط زرعي سائل) إضافةً لمعاملات المقارنة وبثلاثة مكررات لكل معاملة في تأثيرها على نمو وحاصل البطاطا. أظهرت النتائج وجود تأثير معنوي لاستعمال الأسمدة الحيوية المعززة بالسماد المعدني مع حامل كالح الذرة في معظم الصفات المدروسة كما أظهرت نتائج التداخل الثلاثي ان استعمال السماد الحيوي المحلي مع (75%) من التوصية السمادية محمل على كالح الذرة أدى الى حصول زيادة في ارتفاع النبات والوزن الجاف للمجموع الخضري والحاصل الكلي و متوسط عدد الدرنات اذ سجلت قيم مقدارها 73.53 سم، 2.48 ميكاغرام هـ$^{-1}$، 21.97 ميكاغرام هـ$^{-1}$، 12.33) على التتابع مقارنة بمعاملات السماد الحيوي المستورد والتوصية السمادية الكاملة وبدون إضافة سماد حيوي ومعدني في حين أظهرت النتائج ان استعمال نصف التوصية السمادية مع التسميد الحيوي المحلي المحمل على سائل يعد كافياً للوصول الى افضل كمية ممتصة من النيتروجين والفسفور في المجموع الخضري اذ سجلت قيم مقدارها 2.62% ، 0.79% مقارنة بمعاملة السماد الحيوي المستورد الذي اظهر تفوق في الكمية الممتصة للبوتاسيوم لنفس المستوى من التوصية اذ بلغ 1.20% .

الكلمات المفتاحية: *Bacillus megaterium*، *Pseudomonas fluorescens*، *Azotobacter chrococcum* ، النبات

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INTRODUCTION

Potato is one of the most important vegetable crops in the Arab world and in some countries of the world, which represents the fourth most important food crops after maize, wheat and rice. It contains high levels of starch, sugars, protein, organic acids and vitamins, with an annual production of 321 million tons of 19 million hectares. In the last two decades, Potato cultivation in Iraq has widely spread, and amounted to approximately 39000 ha and the production rate of 16.036 tons ha^{-1} in 2003 (20). The use of biofertilizers is one of the modern techniques used to reduce the excessive using of chemical fertilizers, sources of environmental pollution and to reduce the high prices of fertilizers. The biofertilizers are cheap compared with mineral fertilizers and are produced after the selection of the highly efficient microbe and its propagation. The biofertilizer produced there after is kept in suitable conditions until it is used as an inoculation to soil or seed. The idea of biofertilizer production is based on the fact that agricultural soils are rich with beneficial microbes that lead to increasing their fertility, decompse their complex materials, and make nutrients elements easy to absorb (5). There are many types of biological fertilizers, including nitrogen fixation bacteria, whether those bacteria live as symbiosis, as in *Rhizobium* spp or those bacteria that free-living, such as *Azotobacter* spp., these biofertilizers provide about 35% of the amount of nitrogen fertilizers added to improve yield characteristics and improve soil fertility. The other type is phosphate solubilizing bacteria (PSB) which is capable of solubilizing inorganic phosphorus from insoluble compounds and which contribute to reducing the rate of phosphate fertilization by about 50%, thus saving its costs and also reducing the rate of soil and environment pollution with increasing production in quantity and quality of yield. This biofertilizer is an environmentally friendly-fertilizer as well as the renewal of soil fertility and the provision of protection of plants against drought and some pathogens (39), (27) and (4) noted that the integration of fertilization with the addition of half of the specific amount of nitrogen and phosphorus with bio-fertilization given similar results to those used in the whole quantity of chemical fertilizers but at lower economic costs with increased production. (29) recommended the use of Phosphate solubilizing bacteria (*Pseudomonas* and *Bacillus*) as biofertilizers to improve plant growth through increased solubility of phosphorus. (30) noted that Pseudomonas, Bacillus and other highly effective bacteria in dissolving phosphorus compounds to ready elements to be absorbed by plants and explained that inoculating root of potatoes with *Azotobacter* bacteria and with phosphate soluble bacteria together improved plant growth, dry biomass and thus lead to increase the crop yield. (37) and (53) indicated that inoculation of corn roots with Pseudomonas and Bacillus bacteria resulted in a significant increase in plant height and dry weight relative to the comparison treatment. Biofertilization the roots of potato plants led to an increase in the components and yield of the crop (25). Some bacterial biofertilizers such as *Pseudomonus* sp and *B. megatherium* have the potential to release some organic acids such as Fumeric acid and Acetate acid, which have the ability to convert the unfixed phosphorus form to phosphate ions in the soil to be absorbed by plant roots (24). The aim of the present work is to study the role of biofertilizers in growth and production of potatoes crop through:

1- Production of new biofertilizers from the isolation and identification of *Bacillus megaterium*, *Pseudomona fluorescens* and *Azotobacter chrococcum* from different crops and test the efficiency of these biofertilizers compared with Nitrosoil fertilizer which was imported by Iraq's Ministry of Agriculture.

2-Comparison between the artificial culture medium and the corn cobs residue as bacterial carrier that use the biofertilizer production to improve there servant rates.

MATERIALS AND METHODS

A field experiment was carried out at research station of College of Agriculture / University of Baghdad / AL- Jadria in the loam soil in the Autumn season 2017. Before planting, random samples of depth 0-30 cm were taken to measure chemical and physical properties.

Table 1. shows some chemical and physical properties of soil before planting

Qualities	Value	Unit
pH	7.18	
ECe	2.10	dsm $^{-1}$
N	20	mg Kg^{-1}
mg Kg^{-1} P	3.80	mg Kg^{-1}
gm Kg^{-1} soil K		7.29
Sand		492
Silt	300	gm Kg^{-1} soil
Clay	208	gm Kg^{-1} soil
Soil Texture	Loam	

The experiment was carried out with RCBD and included the following field experimental factors

The first factor:

The bacterial inoculum comprises three types:

a- A combination of local biofertilizer from *Bacillus megaterium*, *Pseudomonas fluorescens* and *Azotobacter chrococcum*.

b-Nitirosoil biofertilizer which was imported by Iraqi's ministry of Agriculture.

c-No addition of biofertilizer

The second factor:

Type of carrier:

a-corncob as carrier

b-broth media.

The third factor (mineral fertilizer):

Two levels of mineral fertilizer were used (50% and 75%) of the recommended mineral fertilizer. The experiment was conducted in three replicates with a total of experimental 36 units. The experiment included also two control treatments, the first represented no addition of biofertilizer or mineral fertilize while the second represented addition of complete recommended mineral fertilizer of N, P, K with the value 320,120 and 400 kg ha^{-1} respectively. Total experimental units:

36 + 3 + 3 = 42 experimental units

Treatments codes

A1: - local biofertilizer liquid supplemented corncob as carrier + 50% of the recommended mineral fertilizer.

A2: - local biofertilizer liquid supplemented corncob as carrier + 75% of the recommended mineral fertilizer.

B1:- local biofertilizer liquid not supplemented corncob as carrier + 50% of the recommended mineral fertilizer.

B2:- local biofertilizer liquid not supplemented corncob as carrier + 75% of the recommended mineral fertilizer

D1:- nitirosoil biofertilizer supplemented corncob as carrier + 50% of the recommended mineral fertilizer

D2:- nitirosoil biofertilizer supplemented corncob as carrier + 75% of the recommended mineral fertilizer

S1:- nitirosoil biofertilizer not supplemented corncob as carrier + 50% of the recommended mineral fertilizer

S2:- nitirosoil biofertilizer not supplemented corncob as carrier + 75% of the recommended mineral fertilizer

K1:- corncob as carrier + 50% of the recommended mineral fertilizer

K2:- corncob as carrier + 75% of the recommended mineral fertilizer

N1:- broth media + 50% of the recommended mineral fertilizer

N2:- broth media + 75% of the recommended mineral fertilizer

M:- control treatment the first term no addition of biofertilizer or mineral fertilize

H:- the second control treatment second was the addition of complete recommended mineral fertilizer of N, P, K

To prepare the local combination or biofertilizers, 1 ml of *P. fluorescens*, *B. megeterium*, *A. chroccoocum* inoculum was added separately to 2-liter flasks, at dilution 1×10^5.

The flasks were incubated for 72 hours at 28C°. The imported Nitrosoil fertilizer was diluted by taking 10 ml and then added to two liters of distilled water. The corn cobs residue was grinded to pass 0.5 mm sieve and then packed in thermal bags and sterilized at 121 C° and 15 pounds/square inch pressure for carrying the biofertilizers on them. Under controlled and sterile conditions, the combination of the local biofertilizers mixture was carried out, 1 liter of each biofertilizers was mixed in a 5-liter sterile flask and used directly as a liquid biofertilizers mixture, and 1 liter of each biofertilizers was mixed in a 5-liter sterile flask contain corn cobs residue and the container was shake to mix well its contents together to be ready for adding to the potato (saver) tubers. A thin layer of Arabic gun solution was added to the potato tubers in clean and sterilized plastic pots to ensure the adhesion of biofertilizers with tubers. Then, under the sterilization conditions, the tubers were treated with the local biofertilizers mixture and with the imported fertilizers and left for an hour before sowing.

RESULTS AND DISCUSSION

Effect of fertilization of local and imported biofertilizers in some growth indicators of the potato plant:

Plant height

The results shows that addition of biofertilizer (local and imported) led to a significant increase in the plant height. The treatment of the addition of local biofertilizers (A) gave the highest height (72.20 cm) compared to the treatment without adding (N) which was 59.42 cm, followed by imported biofertilizer (D) treatment in where the height of the plants reached 70.38 cm (Figure 1). The increase in plant height may be attributed to the role of bacteria which was used as biofertilizers in this study. The bacteria have a wide range of positive properties that promote plant growth, including the ability to increase the dissolving of phosphorus in the soil and convert the raw form to a more readily prepared form due to produetion of different types of organic acids including citric acid, oxalic and 2-Ketogluconic which dissolve insoluble phosphate compounds. As well as its role in the competition of phosphates on sites of adsorption of high energy and increase the availbility of phosphate and nitrogen in growth culture media through biological fixation as well as the release of the substances that promoting growth such as auxin (AAI), gibberellins and cytokinins (12, 15, and 54). The results showed that the significant effect of addition of (75%) of the fertilizer recommendation 68.31 cm plant height compared to the treatment of (50%) of the fertilizer recommendation which gave (66.36 cm) plant height, while the plant height in treatment of the complete fertilizer recommendation was superior on control treatment without addition of biofertilizer in which the height plant was 66.27 cm, while the control treatment gave the lowest height (48.20 cm). This may be attributed to the increase in the added amount of NPK to the soil, and this led to increase plant height and may be contribute to increase of the absorbed amount, that was positively reflected on the growth of the plant and increase its height as a result of the growth of the root and total phyllosphere due to increase of the phosphorus concentration as well as increasing concentrations of nitrogen and potassium in the soil. Our results had an agreement with Al-Rawi et al (7) results. On the other hand, the results of Figure 1. indicated a significant increase in the height of plants treated with corn cobs residue and it reached 68.14 cm compared with treatment of the liquid carrier in which height plant was 66.52 cm. While the treatments of the biofertilizers added with carriers showed significant differences. The highest of plant height (72.60 cm) was in the treatment of the local biofertilizer carried on the corn cobs residue followed by the imported fertilizer treatment for the same carrier (71.83 cm), but it reached 58.83 cm in the plants treated with the liquid media. There were not significant results in other treatments, although there were clear differences between the average of plants height. The reason for the differences in the height of the plants may be due to the nature of the composition of the carriers in terms of mineral and physical properties and their nutrient content. Therefore, the carriers use of bacteria may have very different effects on the density of the bacteria in the soil as it is a source of energy and nutrients needed by the bacteria and thus increase its activity in the soil and plant growth promotes that leads to increasing plant height. These results agreed with Bashan et al (14) who attributed the reason for the increase in plant height when the carrier is organic to the difference in the susceptibility of these carriers to supply of microorganisms in energy (source of carbon) and nutrients, as organic carriers lead to increase soil microorganisms because their need for simple sugars for exploited as an energy source and construction of their cells. The carriers have protected the bacteria from external influences, as well as the ability to supply bacteria with energy and nutrients, thus providing a suitable environment for the survival of bacteria activity for the maximum possible time. The results of the interaction between the manure and the mineral treatments showed that the local biofertilizers treatment was best than other, plant height reached 73.30 cm with 75% of the fertilizer recommendation morally, while it reached 58.03 cm with 50%. On the other hand, the results of the triple interference between the biofertilizers, mineral and the

carriers were not significant.The plan heights in the treatments of biofertilizers and fertilizer recommendation with 75% carried on corn cobs residue were reached 75.53 cm and 73.07 cm respectively, and the height reached 57.73 cm with fertilizer recommendation at 50% carried on liquid media. while it reached 72.40 cm with imported biofertilizers at 75% of the fertilizer recommendation carried on corn cobs residue. The height in the treatment of local biofertilizers at 75% of the fertilizer recommendation carried on corn cobs residue was 73.53 cm and significantly higher than that of total fertilizer recommendation treatment in which reached 66.27 cm. This may be due to the efficiency of *P. fluorescens* and *B. megaterium* bacteria in increasing nutrient availability of phosphorus and potassium, and release them from their un-ready sources, thereby increasing their concentration in the soil and increasing plant growth as well as the beneficial effect of *A. chroococcum* bacteria, which produce plant growth hormones and improved nutrient absorption and plant protection of pathogens (40 and 18). These results were in agreement with Schoebitz et al (34) who obtained a significant increase in plant height and some quantitative and qualitative characteristics of wheat plants that were fertilized with fluorescent bacteria, and correlated with (56) resulted that showed an increase in the corn plant height which reached (179.0 - 187.6 cm) after treated with *A. chroococcum*. It was noted by (9) that a significant increase in the height of rice plants after treating with *B. megaterm*. Absorption of phosphorus and height of wheat plant increased when treating with *Pseudomonas* sp. and *Bacillus* sp. (2).

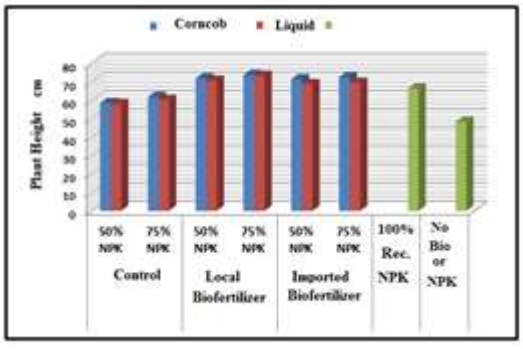

Figure1. Effect of biofertilizers, mineral fertilizers and carriers on plants height

Shoot dry weight

The results of this study showed an increase in shoot dry weight of potato plant in local and imported biofertilizers treatments, where the dry weight of the shoot part reached 2.05 Mg h^{-1} and 1.25 Mg ha^{-1} respectively while it reached 0.98 Mg ha^{-1} in control treatment (non-treated). This increase may be due to various mechanisms of microorganisms, including dissolving some nutrients from their insoluble form in the soil, as well as the production of certain organic acids, hormones and growth regulators such as aoxins, gibberlins, cytokines and ethylene, which affect on cell division and promoting plant growth. These elements support plant growth, including increase of dry weight. The superiority of biofertilizer may be attributed not only to increased absorption of nutrients but also to plant protection against diseases. This is confirmed by Mohammed (37) and Tahir (50). In addition, the results of (53) showed that the inoculation of corn plant with Pseudomonas and Bacillus resulted significant increase in dry weight compared with control treatment.The treated barley plants with *A. chroococcum* gave significant increase of shoot dry weight of barley (53). On the other hand, the treatment of addition of (75%) of the fertilizer recommendation gave significant in the dry weight of the shoot part, and it was 1.48 $Mgha^{-1}$ compared to the treatment (50%) of the recommendation of the fertilizer where the dry weight reached 1.37 Mg ha^{-1}. This significant increase may be due to increase availability of phosphorus, potassium, and nitrogen as well as increasing the added levels which increased the ability of roots to absorb nutrients. As for phosphorus, the availability it to plant at the beginning of its growth will encourage the formation of a strong and solid root system and increase of nutrient absorption and transfer to other parts of the plant, finally this leads to increasing the number of branches and surface area of leaves and increase of nutrients need for construction of plant tissues, which resuited positively on the dry weight of the total shoot (36 and 51). There were no significant differences between the average of carriers, although there were differences among the averages. The results in Table 1 showed effect of binary Interference between

carriers and biofertilizers, the results showed that local biofertilizers with corn cobs residue treatment was superior in dry weight of the vegetative part which reached 2.19 Mg ha^{-1} compared with the treatment of biofertilizers without corn cobs residue that reached to 0.91 Mg ha^{-1}. The results of the interaction between the mineral fertilizer and the corn cobs residue showed that 75% of the fertilizer recommendation treatment was greater when the corn cobs residue was as a carrier and dry weight reached 1.51 Mg ha^{-1}, followed by the treatment of 75% of the fertilizer recommendation with a liquid carrier treatment in which it reached 1.45 Mg ha^{-1}, while the 50% of the fertilizer recommendation carried on the liquid media treatment recorded the lowest dry weight rate that reached 1.37 Mg ha^{-1}, and this variation in the mean of shoot dry weight may be due to the properties of the added bacterial inoculum and the efficacy of these bacteria to promote plant growth and its branching due to secretion plant growth promoting substance and hormons which increase leaf and stem number, the results showed no significant effect of carriers on shoot dry weight. It was noticed that the interaction between the biofertilizers and the mineral fertilizer had a significant effect on the dry weight trait. The highest value (2.32 Mg ha^{-1}) was in the treatment of local biofertilizers with 75% of the fertilizer recommendation, dry weight. compared with local biofertilizers treatment without the fertilizer recommendation treatment in which it was 0.91 Mg ha^{-1}. This may be due to the efficiency of the bacteria to increase the nutrient availability, especially phosphorus, and production of phosphatase enzyme, as well as production of organic and mineral acids and CO_2 (3). The mineral fertilizer added to the soil leads to increase nutrient availability in the soil, resulting formation of an efficient root system capable of absorbing the nutrients and transferring them to the higher parts. Thus, the role of integration between the addition of biofertilizers with mineral fertilizers may reflecte positively on the dry weight index of the plant and this agrees with what confirmed by (4) who found a significant increase in dry weight of the plant as a result of the interaction between biofertilizers and mineral fertilization.

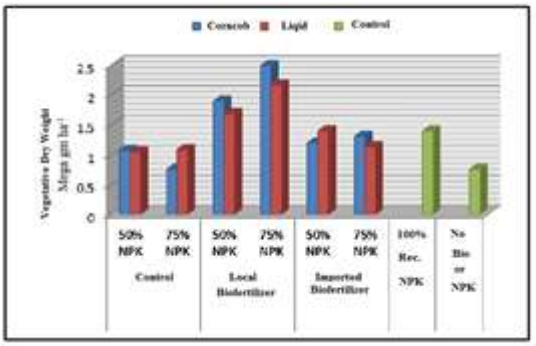

Figure 2. Effect of biofertilizers, mineral fertilizers and carriers in vegetative dry weight

Triple interference between biofertilizers, mineral fertilizers and carriers showed the high significant increases (Figure 2) in the dry weight of the plant and in the same direction of increasing the height of the plant, which led to an increase in dry weight. The treatment of the addition of local biofertilizer with 75% of the fertilizer recommendation gave 2.48 Mg ha^{-1} of dry weight, while the treatment of local biofertilizer with corn cobs residue and without 75% of the fertilizer recommendation was 0.75 Mg ha^{-1}. In addition, the treatment of local biofertilizer with 75% of the fertilizer recommendation was significantly higher with the increase of 2.48 Mg ha^{-1} compared with complete fertilizer recommendation that reached 1.39 Mg ha^{-1}. The ability of biofertilizers to increase the dry weight of the plant may be due not for the solely availability of nutrients but also to its ability to protect plants from various pathogens, as well as the integration of biofertilizers, mineral fertilizers and the type of carriers on tubers of potato may provide high protection of tubers against pathogens and increase the ability of microorganisms to be more efficient and in hence its reproduction. It was suggested by (8) that addition of biofertilizers to plants led to increases the resistance of plants to disease through some mechanisms of biological control diseases such as the production of antibiotics that have a role to reduce the intensity of pathogens, and ability to degradation some harmful compounds to plants, using microbial inoculation as natural antagonists to some pathogens that affect the plant and effecting positively on the various growth characteristics, including wet and dry

weight of plants.It was shown by (19) that increasing dry weight of potato tubers was a clear indication of good nutrition in this study, which reflectd positively on the qualities and quantity of yield.

Total yield and potato tuber number

Results in figer 3 and 4 shows significant increase of the total yield and tubers number of potato due to the addation of biofertilizer, local biofertilization caused highest yield 19.41 Mg ha^{-1} and heighst tuber number 4.53 compare with the non-inoculation treatment that gave the lowest yield (10.67 Mg ha^{-1}) and lowest tuber number (4.52), while yield and tuber number were 13.99 Mg ha^{-1} and 6.82 respectively for the imported biofertilizer. The positive effect can be attributed nutrient to bacterial inoculum which was important for nutritional requirements, especially for nitrogen and phosphorus, thus increasing the number of tubers and thus resulting a significant increase in the weight of the potato yield. On other hand, these results agreed with morajdhwaj (38) who confirmed impact of the use biofertilizer on the size of the tubers the yield of the potato plant. Moreover, the results revealed that addition of mineral fertilizer in the treatment (50% of the recommended mineral fertilizer) affected significantly in the total yield status with a value 14.95 Mg ha^{-1}, while there was no significant differences between the levels of fertilization mentioned above in the status mean of tuber number , this may be due to the addition of (50%) of the recommended mineral fertilizer was enough to meet the requirements of the plant for various vital activities, especially when working on a system of integration between mineral and bio fertilizers. Increase in mineral fertilizer (75% of the recommendation) may cause a reduction in the efficacy of bacteria because there is no need for it to be effective with excess nutrients. It was shown by (32), that use of biofertilizer could provide 50% of the mineral fertilizer (NPK). On the other hand, the corncob treatment gave significant superior in total yield and tuber number with a value 15.17 Mg ha^{-1} and mean of tubers number 8.37, while on use of broth media treatment (N) as carrier the value was 14.2 Mg ha^{-1} and mean of tubers 6.88. The interaction between the binary showed biofertilizer and carrier outweighs the treatment of biofertilizer with the corncob significant 21 Mg ha^{-1} in the weight of total yield and higher mean of tuber number with a value 12.17 compare with the treatment of broth media with supplemented corncob as carrier that recorded value less a 9.97 Mg ha^{-1} and mean of tubers number with a value 4.55 On the other side, the supplementation (50% and 75%) of the fertilizer recommendation with corncob was significantly superior for the total yield of the plant as the weights reached (15.16 and 15.19) Mg ha^{-1} respectively compare with the treatment (50% and 75%) of the fertilizer recommendation with the liquid carrier in which the values were (13.67 and 14.74) Mg ha^{-1} respectively. That such results show an important role of hormones secretion from the types of biofertilizer and the positive effect of the interaction between the use of bacterial inoculum and the corncob in increasing the various growth indicators and yield ingredients for plants, as there is a positive interaction between bacteria *Bacillus megaterium*, *Pseudomonas fluoresces* and *Azotobacter chrococcum* with the use corncob carrier which provides the required protection compared to the liquid carrier leading to increased biofertilizer activity of the rhizosphere thus increasing growth indicators and yield components by increasing cell division and elongation and then expanding root hairs which in turn will increase the surface area of the roots nutrient uptake was greater than that reflected positively on increasing vegetative growth, dry matter and number of tubers, thus increasing plant productivity. These results correspond with Bashan (13), who found that ability of these carriered to the supply of energy and nutrients was different since carrier of organic origin were degraded by the microorganisms carrier as a result of the need for simple substances that these organisms exploited as a source of energy and built their cells and then increase their numbers. It was referd by (34), that the presence of Bacillus bacteria in high numerical density in the rhizosphere root region and their production of organic acids contribute to reduce pH of soil solution rhizosphere and increase dissolving phosphorus compounds that were added as phosphate fertilizers. These

results came in agreement with what Siddiqui was referred by (48) that use of the bacterial isolates Bacillus was one of the successful methods in increasing the availability of the insoluble phosphorus and its absorption by the plant, also agreed with Brown (16) who indicated that improving the growth of wheat plant when inoculated with different types of bacteria accompanying *Azospirillum brasilense, Azotobacter chroococcum* and *Bacillus megaterium* comes through the production of these bacteria the growth regulators such as oxins, gerlins and cytokines and not because of their processing of nutrients in the processes of metallization nitrogen fixation. The results showed the local biofertilizer with 75% of the recommended mineral fertilizer was superior significant in weight of yield 20.18 Mg ha^{-1} and mean of tuber number 11.17 compare with the nitirosoil biofertilizer treatment that was supplemented with 75% of the recommended mineral fertilizer and it gave a value 13.05 Mg ha^{-1} and mean of tuber number 7.05. As both of the above two fertilizers were superior over the treatment broth media with 75% of the recommended mineral fertilizer treatment that gave the minimum weight of the yield value 10.04 Mg ha^{-1} and mean of tuber number a value 4.70. The interaction between biofertilizers and mineral fertilizers increased the yield of some crops may be due to the increasing activity of microorganisms in the rhizosphere area which led to improve availability of some nutrients which were in the form of undissolved compounds, including phosphorus compounds, which reduced the use of mineral fertilizers (50). As well as the secretion of some antibiotics caused a biological control on the pathogens and maintained the integrity of the roots and created a clean environment free of diseases, which reflected positively on increase yields of plants and number of potato tubers (21 and 52).

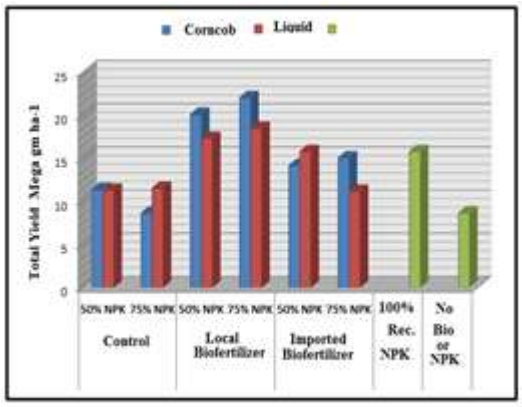

Figure 3. Effect of biofertilizers, mineral fertilizers and carriers on total yield of potato

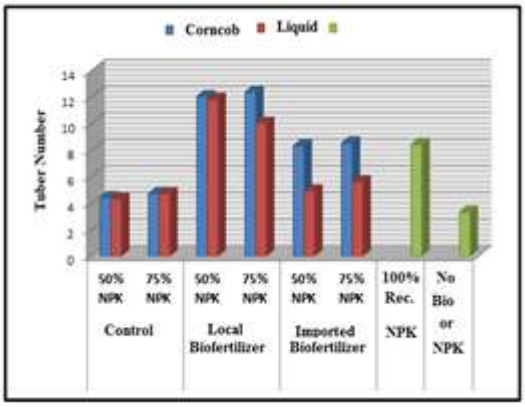

Figure 4. Effect of biofertilizers, mineral fertilizers and carriers on potato tubers number

While the results of triple interaction between biofertilizers, mineral fertilizers and carriers was significantly superior in the local biofertilizer (*Bacillus megaterium*, *Pseudomonas fluorescens* and *Azotobacter chrococcum*) with (75%) of the fertilizer recommendation carried on corncob treatment in the total yield and number of tubers as it had the maximum yield weight 21.97 Mg ha^{-1} and mean of tuber number 12.33 compare with the imported biofertilizer with(75%) of the fertilizer recommendation treatment that recorded the value average weight of yield 14.98 Mg ha^{-1} and mean of tuber number 8.50 , where the results showed the significant superiority of the treatment broth media + 75% of the recommended mineral fertilizer with value of yield rate 8.61 Mg ha^{-1} and mean of tuber number 4.70. This was due to the nature of the integration between the organic fertilizers carried on organic carriers and mineral fertilizers, which was due to increase nutrient availability in the soil, which was positively reflected on the absorption by the

plant thus increasing the vegetative growth and yield due to the efficiency of the bacterial inoculum during the addition of biofertilizer, which the ability to stabilize the nitrogen and the secretion of enzymes such as phosphatase and phyticase, which works to release phosphorus from organic compounds, especially phytic acid and the secretion of growth regulators such as indole acetic acid (IAA), cytokines and glycerolin (6 and 1), these results agree with (42). Who found that the use of the Azotobacter inoculum as a biofertilizer with 75% of the nitrogen fertilizer recommendation resulted in a significant increase in total yield, weight of fruits and number of tomato branches compare with the treatments of biofertilizer with(100%) of the fertilizer recommendation in another study, the use of Bacillus as a biofertilizer had led to increase in the quantity and quality of potato yields (44) , It was also in agreement with (17) who used *Pseudomonas fluorescence* with *Pseudomonas putida*, which resulted in a significant increase in total potato yield. The results showed that triple interference of local biofertilizer supplemented with corncob as carrier with 75% of the recommended mineral fertilizer gave a significant effect in the total yield and number of tubers of the plant as recorded in the maximum yield with a value 21.97 Mg ha^{-1} and mean of tuber number 12.33 compare with a complete recommended mineral fertilizer 15.72 Mg ha^{-1} and mean number of tubers 8.40 , and superiority was significantly higher on a treatment compare with addition of biofertilizer or mineral fertilize as it recorded the minimum yield 8.61 Mg ha^{-1} and mean number of tubers 3.30 , as well as the findings of (43) in an experiment conducted in Egypt by Zagazig University. It was found that the addition of *Bacillus megaterium*, *Azotobacter chroococcum* and *Azospirillum lipoferum* as biofertilizers increased total yield and number of potato tubers through different mechanisms that increased the availability of nutrients and it was pointed out that the biofertilizer could replace a good alternative to mineral fertilizers to maintain a clean and safe environment for plants.

Effect of addition of biofertilizer, mineral fertilizers and carriers in the concentrations of NPK (%) of the shoot

Nitrogen: Figure 5 shows effect of type of biofertilizer in nitrogen concentration in the plant, the results indicated that there were no significant differences between the treatments, despite the existence of statistically significant differences between the mean of that trait, where the addition of local biofertilizer gave the maximum amount of nitrogen in the vegetative part of the plant 2.30% compare with the treatment of broth media which recorded minimum value of 2.23%. On the other hand, the results showed that addition of the liquid carrier led to a significant superiority, reaching 2.32%, compared to use of the corncob as a carrier of the biofertilizer with the proportion of nitrogen absorbed 2.07% there was no significant difference between levels of mineral fertilization in their effect on the amount of nitrogen concentration in the plant as the results were similar to (5) results, while the results of the statistical analysis of the interaction between biofertilizer and a carrier exceeded the treatment of the addition of local biofertilizer with the liquid carrier significantly as recorded the maximum percentage of nitrogen 2.57% compared with the treatment corncob as carrier broth media 2.06%. Phosphate biofertilizers can increase phosphate uptake and increase the bio-stabilization of nitrogen with increase availability of some important nutrients for growth and vital events through the production of plant growth promoters (31)

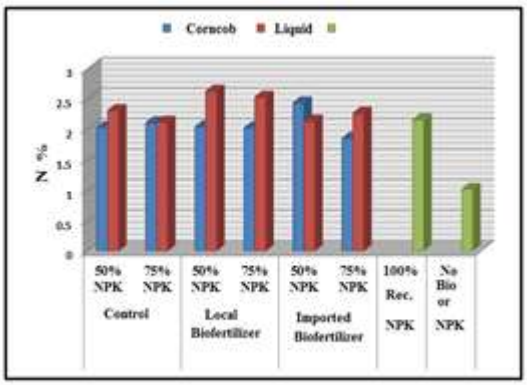

Figure 5. Effect of biofertilizer, mineral fertilization and carrier in nitrogen concentration (%) in the shoot

While no interaction between mineral fertilizer and the carrier was observed, although there was a significant difference in the mean

percentages of total nitrogen where it was given an additional treatment (50%) of the fertilizer recommendation with the liquid carrier was the maximum recorded quantity of 2.35% compared to the treatment of addition (75%) of the fertilizer recommendation with corncob, which amounted to 1.99%. There was no significant difference between the biofertilizer and the mineral fertilizer in the total nitrogen concentration of the vegetative potato plant. The triple interaction between the biofertilizer, the mineral fertilizer and the carrier was higher than the treatment of the addition of local biofertilizer with (50%) of recommended mineral fertilizer carried with the liquid carrier as the significant of that status was recorded at 2.62% as well as imported biofertilizer with (50%) of recommended mineral fertilizer carried with the corncob as it recorded 2.43% compare with the treatment of imported biofertilizer as it recorded the minimum value of 1.85%. In addition, the treatment of the addition of local biofertilizer with (50%) of the fertilizer recommendation with the liquid carrier was significantly a value 2.62%. This may due to the fact that increase in mineral fertilizer (75% of the recommendation) may cause a decrease in the effectiveness of bacteria because they do not need to be effective with a surplus of nutrients, the increase in nitrogen concentration can also be attributed to the positive role of the used bacteria as a inoculum with a wide range of positive properties that promote plant growth, including its ability to stabilize the nitrogen and then increase the plant concentration of nitrogen also, when phosphorus uptake by the plant is increased due to the use of specialized inoculum to increase the phosphorus availability, this can lead to an increase in nitrogen uptake (11 and 49) in their study on calcareous soils in arid and semi-arid regions, it was by reported (47) that the inoculation of maize seeds with Bacillus bacteria increased the concentration and content of the nitrogen uptake.

Phosphorus

The results showed in figure (6) indicated no significant differences in concentration of phosphorus in the vegetative part, but the treatment of the addition of local biofertilizer was statistically significant with a value 0.73% compared the treatment broth media 0.55%. This may be due to that biofertilization raises the nutrient release rate, which reduces the proven amount, especially phosphorus, and increases the efficiency of the use of mineral fertilizers, these results agree with (30). On the other hand, no significant difference was observed between the levels of the used carriers and the mineral fertilization in concentration of phosphorus in the vegetative part by the vegetative part, as the results were between them form (6) despite the existence of differences, but was not significant. The results also showed significant differences between the biofertilizer and the carrier type on the concentration of phosphorus in the vegetative part of the plant with the maximum value (0.75%)for the treatment of the addition of local biofertilizer carried on the liquid and the minimum value (0.46%) in the treatment broth media with corncob. The results agree with Schoebitz (34), who obtained a significant increase in the amount of phosphorus absorbed by sun flower yield for the treatments added to the phosphate fertilizer with the bio fertilizer of Pseudomonas bacteria, this might be due to the effectiveness of the bacteria in the conversion of organic phosphorus to metal phosphorus as well as the release of phosphorus from its due to the secretion of phosphatase enzyme and organic acid and its secretion of substances that promte the growth which increases its concentration in the soil and thus increases the absorbed amount, which increases its concentration with in the plant, as confirmed by Fitriatin (22). The increase in phosphatase activity in the soil with the addition of biofertilizer had been attributed to the increase in activity of microorganisms, it is also significantly increases the activity of the various enzymes and thus improves the biological and enzymatic energy of the soil. The results showed that there was no significant difference between the mineral fertilizer and the type of carrier. No significant difference for the interaction of the biofertilizer and the mineral in their effect on the absorbed amount of phosphorus. The treatment of the addition of biofertilizer with (50%) of the fertilizer recommendation was carried on a liquid with the maximum amount of phosphorus absorbed

a value 0.79% compare with the treatment of broth media without biofertilizer (50%) of the fertilizer recommendation which was carried on a corncob with the minimum amount of phosphorus absorbed 0.44%. It was also noticed that there was no significant difference between the treatment of the addition of local biofertilizer with (75%) of the fertilizer recommendation carried with corncob in the amount of phosphorus absorbed by 0.74% compared to the treatment of complete recommended mineral fertilizer of N, P, K which reached 0.68%. This may be caused to the integration of fertilization with addition of half of the specified amount of nitrogen and phosphorus with biofertilization, Results similar to those used provide the full amount of nitrogen and phosphorous mineral fertilizer but at lower economic costs while maximizing production, the use of phosphate dissolving bacteria with mineral fertilizers reduced the plant's demand for mineral phosphate fertilizers achieve 50% (26) by converting organic phosphorus to metal in soil as well as by dissolving the deposition of phosphorus (4 and 41).

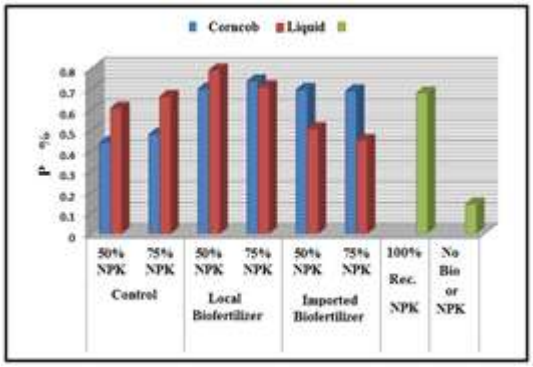

Figure 6. Effect of biofertilizer, mineral fertilization and carriers in the Concentration (%) of Phosphorus in the shoot vegetative Total (%).

Potassium

Figure 7 shows the effect of the type of biofertilizer concentration of potassium in the vegetative part of the plant, indicating that the inoculation with biofertilizer treatments exceeded the non- biofertilizer in the content of their plants for potassium, where the superiority of the domestic biofertilizer significantly as it recorded the maximum amount of 1.10% compared to the treatment without the addition of fertilizer (broth media) as it gave the minimum absorbed amount of 0.96%. This may be due to the fact that the ability of the components of the local biofertilizer to increase soil nutrient uptake is linked to its ability to secrete some plant hormones such as auxins, cytokines and gibberellins, which have an important effect in increasing the surface area of the roots by increasing the lengths of the main roots and their branches, Increases nutrient absorption (45). On the other hand, no significant difference was observed between the levels of mineral fertilizers and the carriers in their effect on potassium concentration, the results were close to figure 6, although there were non-statistical differences. The results also showed significant differences between the biofertilizer and the type of carrier at the 5% probability level. The maximum result was local biofertilizer supplemented corncob as carrier (1.18%) and the minimum value at the no addition of biofertilizer (broth media) supplemented corncob as carrier (0.91%). While the treatment of interaction of the imported biofertilizer (nitirosoil) supplemented with corncob as carrier gave a value (1.15%).This my due to the importance of positive interaction between the biofertilizer and the carrier and their role in increasing the availability of nutrients in the soil as the corncob provides the nutrients needed by microorganisms because it consists of fast decomposition food which through the decomposition leads to the release of these elements and the high proportion of nitrogen and other elements and low value of electrical conductivity of the carrier and the choice of the appropriate method of addition in addition to with potato tubers. This method provides complete coverage of tubers, which is reflected positively in providing the microorganisms necessary nutrients for growth and reproduction compared to other methods (28,45). The difference in the rate of absorbed potassium can be attributed to the nature of the composition of the carrier in terms of minerals and physics. The bacterial carrier affects on the density of the bacteria in the soil as it is a source of energy and nutrients needed by the bacteria and thus increases its activity in the soil or the rhizosphere, which leads to absorption of potassium biofertilization increases the concentration of potassium in the

soil compared with magnesium and calcium. The ability of the biofertilizer components to increase soil nutrient uptake is linked to its ability to secrete some plant hormones such as auxins, cytokines (23). While there was no significant difference between the level of mineral fertilizer and the type of carrier, as well as between the biofertilizer and the mineral fertilizer.

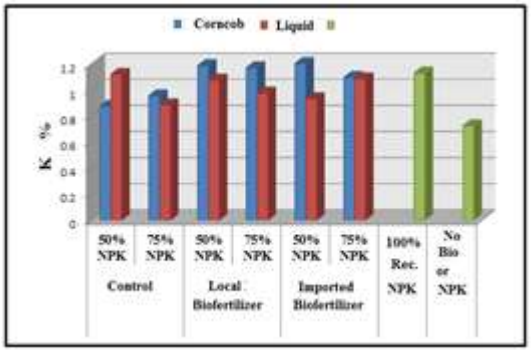

Figure 7. Effect of biofertilizer, mineral fertilization and carrier in Concentration of potassium in the shoot.

The results showed significant differences between the biofertilizer, the carrier type and the level of the mineral fertilizer in the amount of potassium absorbed in the vegetative part of the plant between the treatments that were fertilized with the biofertilizer and non-biofertilizer. imported biofertilizer (nitirosoil) supplemented corncob as carrier The results showed significant differences in the triple interaction with between the biofertilizer, type of carrier and level of mineral fertilizer in the absorbed amount of potassium in the vegetative portion between the biofertilizer and non-inoculant, which was the maximum statistical value when treating the triple intersect imported biofertilizer with (50% of the recommended mineral fertilizer supplemented with corncob as carrier), which amounted to 1.20% , Followed by the treatment of local biofertilizer supplemented corncob as carrier with 50% of the recommended mineral fertilizer a value 1.18% compared to the treatment without adding (50%) of the fertilizer recommendation loaded with corn sorghum value 0.87%. The results showed that there was no significant difference between the treatment of the addition of local liquid biofertilizer supplemented with corncob as carrier with 50% of the recommended mineral fertilizer the value 1.18% and complete recommended mineral fertilizer 1.13% , The causes for this increase may be due to the fact that the corncob was a good carrier that helps the bacteria multiply and increases its activity to contain the essential nutrients of the bacteria and 50% of the fertilizer recommendation was suitable for supporting the bacteria to complete its effectiveness in the production of compounds and metabolic products and to support plant growth and productivity , some studies have indicated that biofertilization increases the rate of slow release of nutrients, which reduces the amount washed, especially nitrogen, and increases the efficiency of the use of mineral nitrogen fertilizers. This is in line with (46). The process of carring microorganisms on different carriers increases the ability of these organisms to perform specialized biochemical processes such as dissolving precipitated phosphates, or nitrogen fixation and their reflection on plant growth (23). The results came in agreement with (55). Soil fertilization with Azotobacter and Pseudomonas was found to be 50% higher than that of the wheat yield and its components. The results showed no significantly difference from the addition of complete recommended mineral fertilizer, the farmers could fertilize with half of the fertilizer recommendation of the wheat if the seeds were fertilized with the vital fertilizers mentioned in the study.

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