Effect of Natural and Bio-Fertilizers on Productivity and Quality of Table Beet (*Beta vulgaris* L.) Grown in Sandy Soil at Siwa Oasis, Egypt

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ABSTRACT

A field experiment was conducted on table beet (Detrweet cv.) throughout two consecutive winter seasons of 2015/2016 and 2016/2017 in Khimisah experimental farm which is located at the latitude of 29°12' 34.5 N'', and the longitude of 25° 24' 2.56'' E., at Siwa Research Station, Matrouh Governorate, Desert Research Center, Cairo, Egypt. The field experiment was conducted in a randomized complete block design with split plot. The main factor was the mineral fertilizer (MF) at 62kgP_2O_5 + 100kgK_2O/fed as calcium super phosphate (15.5% P_2O_5) + potassium sulfate (50%K_2O) i.e. recommended dose (RD), 62kgP_2O_5 as rock phosphate (RP), 100kgK_2O/fed as rock feldspar (RK) and RP+RK, while the sub main factor have been dedicated to the bio-fertilizers (BF) treatments i.e. without inoculation, with phosphate dissolving bacteria (PDB), with potassium solublizing bacteria (KSB) and PDB+KSB.

Results indicated that the most effective treatment was the interaction between (RP+RK) + (PDB+KSB) produced the highest significant values of growth, root yield and quality, beside available P and K in soil and their content and uptake by table beet plants as well as, the microbial densities and dehydrogenase activity in the rhizosphere of table beet. This treatment also resulted in the maximum total net profit and the maximum total benefit cost ratio "BCR" (*i.e.* total income/total cost) (4.32) as compared to the other treatments.

It can be concluded that the application of natural P and K rocks fertilizers in combination with P and K solubilizing bacteria in sandy soil such as Khimisah soil will increase soil available and plant uptake of nutrients, yield and quality close to those obtained by chemical phosphorus and potassium application. Thus, replacing these chemical phosphorus and potassium fertilizers by natural one will help in reducing environmental pollution, cheaper in price and produce safe human food especially in Siwa Oasis which is nature reserve.

Key words: Rock phosphate, Rock feldspar, P and K available and uptake, bio-fertilizers, table beet plant.

INTRODUCTION

Siwa Oasis is located in the Northern part of the Western Desert in Egypt. It has a cultivated area around 30,000 fed. Agriculture is the main human activity in Siwa Oasis and is depending on the surface irrigation system by groundwater in most areas (EI-Naggar, 2010). Siwa Oasis has a continental climate that is very cold in winter and very hot in summer.

Table beet does not occupy any agricultural area in Siwa Oasis despite its importance for health especially if it is organic product. Red beet (*Beta vulgaris* L.) has a good storability led to availability of fresh product around the year without a need for applying expensive storage equipments. As red beets are widely used in food industry, this generates farmers' interest, including those specializing in sustainable technologies of production. For many years, organic products received consumers interest for their health properties due to the high contents of minerals, vitamins, and pigments, that having beneficial effects on human (Szura *et al*. 2008, Zujko and Witkowska 2009 and Hunter *et al*. 2011). The fertilizer application for crops should be in adequate levels of all nutrients as it is very essential for top quality and yield.

As the world's human population continues to increase, the demands placed upon agriculture to supply future food will be one of the greatest challenges facing the agrarian community. In order to meet this challenge, a great deal of effort focusing on the soil biological system and the agro-ecosystem as a whole is needed to understand better the complex processes and interactions governing the stability of agricultural land. There is, therefore, an urgent need for increase the food production by around 50% in the next 20 years in order to sustain the population pressure (Vasil, 1998; Leisinger, 1999).

However, the recent major problem facing the farmers is the high cost of chemical fertilizers. The alternative to depending on expensive imported fertilizers is to exploit indigenous resources such as P and i.e. K bearing minerals rock phosphate and feldspar or bio-fertilizers.

Phosphorus plays an important role in the most metabolic processes especially in biosynthesis and translocation of carbohydrates. It is very important for developing the fruits and the deficiency appeared in terms of decline on the yield and an adverse effect on fruits quality (Yagodin, 1990). On the Roselle plant, Abdel-Kader and Saleh (2017) reported that the highest growth and yield were obtained from plants treated with 200 kg/fed rock phosphate plus phosphate dissolving

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bacteria (PDB) in the first experiment and 350 kg/fed feldspar plus potassium solubilizing bacteria (KSB) in the second experiment. Generally, the results suggested that the use of biofertilizer with rock phosphate or with feldspar is economic and environmental friendly and has potential to improve Roselle yield and quality.

Potassium is essential for many plants metabolic processes. It plays many important regulatory roles in plant development (Miller *et al.,* 1990). Aparna (2001) added that, K is considered the most important cation of its physiological and chemical functions. This could be because K^+ is usually absorbed as a single charge cation by an active mechanism and translocated along electrochemical potential gradient (Roghieh and Arshad, 2009). Potassium is essential for growth, maintains cell turgidity and to regulate the water content of plants (Rengel and Damon, 2008). Potassium fertilizer exhibited a significant effect on vegetative characters and physical properties of beet roots, while the Na content level and the productivity of roots yield and recoverable sugar yield were insignificant, (ton/fad) (Ferweez *et al.,* 2018).

Mineral fertilizers and other chemicals that commonly used in agricultural production, not only have harmful effects on the environment, but also they can alter the composition of fruits, vegetables and root crops (Bogatyre, 2000).

Application of natural alternative fertilizers such as rock phosphate $[Ca_{10}(PO_4)_4F_2]$ (RP) and potassium feldspars ($KAISi_3O_8$) (RK) may be agronomically more useful and environmentally more feasible than soluble P and K (Rajan *et al*., 1996). The alternative use of natural elements compounds improving soil physical and chemical properties as well as increasing water uptake and nutrient availability (Eman *et al*., 2010). Natural elements compounds as rock phosphate and feldspar are used as sources for some nutrient minerals that is considered as clean agriculture. Besides these natural minerals, others bear major essential macronutrients (i.e. P and K) are required for plant growth and development to optimize yield and improve quality of production. Thus, the uses of alternative indigenous resources such as feldspar and rock phosphate are gaining importance to alleviate the dependence of import or costly commercial fertilizers (Badr *et al.,* 2006; Hassan et al.2016).

The use of plant growth promoting rhizobacteria (PGPR), including phosphate solubilizing and potassium solubilizing bacteria as bio-fertilizers, was suggested as a sustainable solution to improve the plants nutrition and production (Vessey 2003). Increasing the bioavailability of P and K in soils with inoculation of PGPR or combined inoculation with rock materials may lead to increase P and K uptake and plant growth, (Lin *et al.* 2002; Sahin *et al.* 2004; Girgis, 2006 and Eweda *et al*. 2007).

Phosphate solubilizing bacteria have been used to convert insoluble phosphate compounds such as rock phosphate into a soluble form that is available for plant uptake. These bacteria produce organic compounds that convert the unavailable P form to an available one. In addition, in the same manner potassium solubilizing bacteria have the ability to dissolve K from minerals containing K, such as feldspar into an available form. The sole or dual application minerals containing P and K as rock phosphate and feldspar in combination with the P and K solubilising bacteria provides the growing plants with a continuous supply of phosphorus and potassium for a best plant growth rate (Han and Lee; 2005). The direct application of natural sources of P and K such rock phosphate and feldspar P and K minerals to soils may be more economically feasible than mineral chemical fertilizers (Rajan *et al*.; 1996). Studies on Roselle plants indicated that co-inoculation of PDB (*Bacillus megaterium* var. phosphaticum) and KSB (*Bacillus mucilaginosus*) in conjunction with direct application of rock phosphate at rates of 200 and 250 kg/fed and feldspar at rates of 350 and 450 kg/fed respectively, into the soil, significantly increased the growth characteristics along with yield compared to chemical PK and other treatments (Abdel-Kader and Saleh 2017).

Using of P and K solubilizing bacteria as bio-fertilizers has become a practical solution to supply the plants with both nutrients (Badar; 2006). The co-inoculation of K and P solubilizing bacteria increased the soil phosphorus availability from 12 to 21% and the potassium availability from 13 to 15% as well as it improved their uptake by plants. In addition, the harvested biomass and yield of the treated plants were increased by 23 – 30% over the control (Han *et al.*; 2006).

Abou El Seoud and Abdel-Megeed (2012) stated that co-inoculation of PDB and KSB in conjunction with direct application of rock P and K materials into the soil increased P and K availability and uptake. Basha and Hassan (2017) concluded that the direct application of mineral phosphorus and potassium combined with phosphate and potassium dissolving bacteria to the sandy loam soil improved phosphorus and potassium availability in the soil and improve growth parameters of canola plants significantly compared with the control.

The aims of this study were to evaluate the efficiency of rock phosphate and potassium feldspar applications combined with phosphate and potassium solubilizing bacteria on the availability of P and K and their uptake on growth, yield and quality of table beet plant grown in sandy soil at Siwa Oasis.

MATERIALS AND METHODS

A field experiment was carried out during the winter seasons of 2015/2016 and 2016/2017 on Khimisa experimental farm which is located at the latitude of 29°12' 34.5 N", and the longitude of 25° 24' 2.56" E., Siwa Research Station, Desert Research Center, Egypt, in a randomized complete block design with split plot. The main factor was the mineral fertilizer (MF) at 62kgP_2O_5 + 100kgK_2O/fed as calcium superphosphate (15.5% P_2O5) + potassium sulfate (50%K_2O) i.e. recommended dose (RD), 62kgP_2O_5 as rock phosphate (RP), 100kgK_2O/fed as rock feldspar (RP) and RP+RK, while the sub main factor has been dedicated to the bio-fertilizers (BF) treatments i.e. without inoculation, with phosphate dissolving bacteria (PDB), with potassium solublizing bacteria (KSB) and PDB+KSB. Bacterial strains were applied separately or in combination as soil treatment. Table beet seeds were treated before planting with individual or mixture of bacterial suspensions for 3hrs before transplanting (carboxy methyl cellulose 0.5% was used as an adhesive agent).

Some physical and chemical properties of the experimental soil and irrigation water are shown in Table 1.

Rock phosphate (RP) (P_2O_5 12.5 %, K_2O 0.31 %, SiO_2 7.9 %, CaO 41.22 %, Al_2O_3 0.41%), while rock potassium feldspar (K_2O 10.1%, P_2O_5 0.10%, SiO_2 66.12 %, CaO 0.2%, Al_2O_3 17.59%) were obtained from Abo Tartor Mountain, Kharga region, Western Desert, Egypt.

Rock phosphate (12.5% P_2O_5) and potassium feldspar (10.1% K_2O) were added at a levels 500 and 1000 kg/fed., respectively, and mixed thoroughly with the soil in each plot. The treatments of P and K chemical fertilizers were done by the full recommended dose (RD) of chemical phosphorus at 62kg P_2O_5/fed. as 400kg of calcium superphosphate, 15.5% P_2O_5, and potassium at 100kg K_2O/fed. as 200kg potassium sulphate and 50% K_2O. All plots received nitrogen at 60kg N/fed as ammonium sulphate (20.5% N) and 20m^3 of compost.

Seeds of table beet (Detrweet cv.) were sown on the middle of October 2015 and 2016 seasons with 2-3 balls per hill using dry sowing method on two sides of the irrigation line of the ridge, the planting within six lines for each ridge and 10 cm apart among plants. The area for each net experimental plot was 1/400 fed (10.5 × 1.0 m).

The calcium superphosphate, rock phosphate and potassium feldspar were mixed with compost and incorporated into soil surface two weeks before planting. The chemical analysis of the applied compost showed the flowing values: pH 6.76, EC 2.85 dSm^{-1}, Total N 1.22%, total P 0.24 %, total K 0.64%, C/N 17.33.

The biofertilizer treatments were applied with the planting of table beet and repeated after 30 days of germination, as a soil inoculation in the form of bacterial suspensions (10^8cfu/ml) with Carboxy methyl cellulose (0.5%) as an adhesive agent.

Potassium sulfate (48% K_2O) was applied as a side dressing in two equal doses at 40 and 70 days from sowing. Nitrogen fertilizer was applied as ammonium sulphate (20.5% N) at the rate of 300 kg /fed. and equally divided for five times after 20, 30,40, 50 and 60 days from planting. The common agricultural practices for growing table beet were applied according to the recommendations of Ministry of Agriculture. Table beet plants were harvested after 80 days from sowing date.

Table 1. Some physical and chemical properties of the experimental soil during the two successive growing seasons and some chemical properties of irrigation water

Soil properties	Coarse sand%	Fine sand%	Silt %	Clay %	Soil texture	1:2.5 (soil to water extraction)		Organic matter (g/kg)	$CaCO_3$ (g/kg)	Total N (g/kg)	Available (ppm)	
						pH	EC (dSm^{-1})				P	K
Season1	45.7	29.7	20.1	4.4	Sandy soil	7.28	1.42	6.1	22.4	2.3	13.25	96
Season2	46.0	28.9	19.9	5.2	Sandy soil	7.18	1.58	6.7	22.8	2.8	14.05	106

Irrigation water chemical analysis	EC (dSm^{-1})	pH	SAR	Soluble Cations in $mmolcL^{-1}$				Soluble Anions in $mmolcL^{-1}$			
				Na^+	K^+	Ca^{++}	Mg^{++}	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}
	3.60	7.45	12.92	27.40	0.60	3.30	5.70	Nd	3.50	22.00	11.50

The scored parameters:

1. Vegetative growth parameters

After 70 days of planting, plant samples were taken for the determination of vegetative growth characters. The roots were thoroughly washed with running water and were separated from the shoots. Data for plant height, fresh and dry weights of shoots and roots were recorded. The dried plant samples were pulverized and analyzed for phosphorus and potassium contents in shoots and roots.

2. Yield parameters:

At the harvest date, the plants of one row from each plot were harvested to estimate yield parameters: root fresh weight (g/plant), root dry weight (g/plant), root length (cm), root diameter (cm), root dry yield (MT/fed), shoot length (cm), shoot fresh weight (g/plant), shoot dry weight (g/plant), plant length (cm), plant fresh weight (g), plant dry weight (g). The content of ascorbic acid in roots was determined by using iodate method as described by Samotus *et al*. (1985). Total soluble solids percentage (T.S.S. %) was measured in roots according to A.O.A.C. (1985).

3. Soil analysis:

Soil samples were collected from each plot at the same time of plant sampling, air-dried, passed through a 2 mm sieve and kept for analysis. Particle size distribution was determined using the pipette method according to Jackson (1973). Electrical conductivity (EC) and soil pH was determined in a 1: 2.5 soil to water extract using conductivity meter and Beckman pH meter, respectively according to Jackson (1973) and McLean (1982). Organic carbon content was determined by Walkely and Black's wet oxidation method, total calcium carbonate was determined by Scheibler calcimeter, available potassium was extracted by neutral normal ammonium acetate method and measured by flame photometer and the extracted P (using 0.5 M $NaHCO_3$ at pH 8.5 according to Olsen *et al*., 1982) was measured colorimetrically using the chlorostannus phosphomolybdic-sulfuric acid method as described by according to Jackson (1973).

4. Determination of microbial activity:

Counts of microorganisms were estimated by the dilution plate technique methods (Becky *et al*., 2001). The following microbial analyses (i.e., total bacterial count (TBC), phosphate dissolving bacteria (PDB), potassium solubilizing bacteria (KSB), Total nitrifying bacterial count (TNBC) and total thermophilic bacterial count (TTBC), were carried out in all soil samples according to Pious *et al*. (2015).

Dehydrogenase activity (µg TPF g^{-1}. dry soil 24h.) in rhizosphere soil was determined according to Pramer and Schmidt (1964) and Thalmann (1967). Nitrifies were enriched on according to Hirotsugu *et al*. (2015), Nitrifying bacteria were enumerated by the MPN technique using both modified media of Maite *et al.*, (2005). As a control, nitrite and nitrate were assayed using the standard chemical method (Griess-Ilosvay reagent) by Zhao *et al.* (2015) after 8 weeks of seeding.

5. Plant analysis:

All samples from root and shoot were dried at 70 ^{0}C oven for 48 hr. and were finely grinded. A half gram of ground table beet roots was digested using 10 ml of H_2SO_4 and 2 ml of perchloric acid in a conical flask as described by Chapman and Pratt (1961) and the digests were used to determine total phosphorus spectrophotometrically by chlorostannus-phosphomolybdic sulfuric acid method as described by Jackson (1973). Potassium was determined by using the flame photometer method as described by Knudsen *et al*. (1982).

Statistical and Economic analysis:

The experiment was conducted as a randomized complete block design with split plot technique in three replications. All data were statistically analyzed according to the technique of analysis of variance (ANOVA) as published by Gomez and Gomez (1984), using "SAS 9.1.3" Computer software package. Least Significant Differences (LSD) at 5% was used to test the differences between treatment means. For economic analysis, benefit to cost ratio (BCR) was calculated for all the treatments using prevailing prices of inputs and table beet yield, BCR= (Total income)/ (Total cost) (Idrees *et al*., 2018).

RESULTS AND DISCUSSION

1. Vegetative Growth Parameters:

Table 2 show that there were significant differences among most of all mineral fertilizer treatments (MF) i.e. chemical and natural fertilizers where the dual soil application of RP+RK achieved the highest values (14.92 and 16.92), (272.76 and 342.91), (40.99 and 69.63), (18.33 and 23.17), (534.90 and 634.68) and (101.17 and 139.91) for shoot length (cm), shoot fresh weight (g/plant), shoot dry weight (g/plant), plant length (cm), plant fresh weight (g) and plant dry weight (g) in the first and second seasons, respectively. On the other hand, soil application of RP had the lowest significant effect on all vegetative growth parameters.

Table 2. Effect of mineral natural and bio-fertilizers on vegetative growth parameters of table beet plant grown at two growth seasons.

Season	Season 2016					Season 2017				
*Mineral fertilizer (MF) / **Biofertilizer (BF)	RD	RP	RK	RP+RK	Mean	RD	RP	RK	RP+RK	Mean
Shoot length (cm)										
Without inoculation	12.33	6.33	10.00	13.00	10.42	12.33	8.67	10.67	14.33	11.50
Inoculation with PDB	14.00	8.67	10.67	15.67	12.25	14.00	10.33	13.33	17.67	13.83
Inoculation with KSB	13.00	8.33	12.00	14.67	12.00	13.00	9.67	12.00	17.00	12.92
Inoculation with PDB+KSB	15.67	9.33	13.00	16.33	13.58	17.00	10.67	14.33	18.67	15.17
Mean	13.75	8.17	11.42	14.92		14.08	9.83	12.58	16.92	
LSD0.05	MF= 0.7641 BF=0.7641 RF×BF= 1.5235					MF= 1.1481 BF= 1.1481 MF×BF= 2.398				
Shoot fresh weight (g/plant)										
Without inoculation	117.33	83.53	112.90	135.33	112.27	143.59	103.00	145.00	170.25	140.46
Inoculation with PDB	243.67	147.18	203.48	315.66	227.50	268.51	166.02	265.00	354.42	263.49
Inoculation with KSB	237.33	125.15	189.33	279.37	207.80	250.94	177.38	250.69	313.61	248.15
Inoculation with PDB+KSB	275.08	154.95	237.33	360.67	257.01	326.67	190.00	290.00	533.35	335.00
Mean	218.35	127.70	185.76	272.76		247.43	159.10	237.67	342.91	
LSD0.05	MF= 20.811 BF=20.811 MF×BF= 16.594					MF= 52.921 BF= 52.921 MF×BF= 90.652				
Shoot dry weight (g/plant)										
Without inoculation	28.85	22.58	27.72	30.35	27.38	36.67	33.42	36.24	37.94	36.07
Inoculation with PDB	37.77	32.93	34.63	42.50	36.96	64.80	45.63	53.45	77.82	60.42
Inoculation with KSB	36.26	32.22	32.28	40.68	35.36	61.71	44.40	51.78	69.69	56.89
Inoculation with PDB+KSB	42.45	37.72	39.62	50.41	42.55	68.56	50.79	55.65	93.08	67.02
Mean	36.33	31.36	33.56	40.99		57.93	43.56	49.28	69.63	
LSD0.05	MF= 1.1836 BF=1.1836 MF×BF= 1.0517					MF= 5.1411 BF= 5.1411 MF×BF= 1.2317				
Pant length (cm)										
Without inoculation	14.00	12.33	13.33	15.67	13.83	16.00	14.67	15.33	18.33	16.08
Inoculation with PDB	17.33	15.00	15.67	18.67	16.67	20.67	16.33	18.00	23.67	19.67
Inoculation with KSB	16.67	14.00	15.00	18.00	15.92	20.00	15.67	17.33	22.67	18.92
Inoculation with PDB+KSB	17.67	15.33	16.33	21.00	17.58	23.00	17.00	20.00	28.00	22.00
Mean	16.42	14.17	15.08	18.33		19.92	15.92	17.67	23.17	
LSD0.05	MF= 0.9957 BF=0.9957 MF×BF= 2.132					MF= 1.086 BF= 1.086 MF×BF= 1.4103				
Plant fresh weight (g)										
Without inoculation	263.63	207.77	250.32	283.38	251.28	295.75	233.82	289.55	329.47	287.15
Inoculation with PDB	478.29	310.03	408.67	590.78	446.94	508.00	335.27	476.51	637.21	489.25
Inoculation with KSB	462.56	284.48	384.37	546.05	419.37	482.42	344.96	452.89	587.62	466.97
Inoculation with PDB+KSB	532.15	332.62	453.56	719.39	509.43	591.90	375.65	542.37	984.43	623.59
Mean	434.16	283.73	374.23	534.90		469.52	322.43	440.33	634.68	
LSD0.05	MF= 38.908 BF== 38.908 MF×BF= 17.115					MF= 72.431 BF= 72.431 MF×BF= 72.634				
Plant dry weight (g)										
Without inoculation	72.39	55.02	68.45	76.26	68.03	85.81	73.29	83.27	89.23	82.90
Inoculation with PDB	93.24	71.40	86.39	105.63	89.17	126.99	98.56	111.56	151.04	122.04
Inoculation with KSB	89.44	68.59	77.62	100.91	84.14	120.79	95.33	107.03	138.33	115.37
Inoculation with PDB+KSB	110.12	85.18	99.03	121.88	104.05	142.57	109.03	126.78	181.06	139.86
Mean	91.30	70.05	82.87	101.17		119.04	94.05	107.16	139.91	
LSD0.05	MF= 2.459 BF=2.459 MF×BF= 1.3185					MF= 7.5738 BF= 7.5738 MF×BF= 5.7989				

*RD= recommended dose; 62kgP_2O_5+100kgK_2O/fed as calcium super phosphate (15.5% P_2O5) + potassium sulfate (50%K_2O), RP= 62kgP_2O_5 as rock phosphate & RK=100kgK_2O/fed as rock feldspar ** PDB; phosphate dissolving bacteria (*Bacillus megaterium*), KSB; potassium soluiblizing bacteria (*Bacillus Coagulans*)

It is worth mention that the manufacture chemical fertilizer of P and K at recommended dose (RD) followed the dual soil application of RP+RK concerning their effect on the different studied vegetative growth parameters.

Regarding to the effect of bio-fertilizers, there were significant differences among most of all the treatments of bio-fertilizers i.e. without inoculation, phosphorus-solubilizing bacteria (PDB), potassium-solubilizing bacteria (KSB) and PDB+KSB (table, 2). The highest significant effects on the studied vegetative growth were observed at the dual soil application of (PDB+KSB). The highest values i.e. (13.58 and 15.17), (257.0 and 335.0), (42.55 and 67.02), (17.58 and 22.00), (509.43 and 623.59) and (104.05 and 139.86) for shoot length (cm), shoot fresh weight (g/plant), shoot dry weight (g/plant), plant length (cm), plant fresh weight (g) and plant dry weight (g) in the first and second seasons, respectively.

The most significant interaction treatment effect was the mixed of dual application of P and K mineral natural fertilizer (RP+RK) and bio-fertilizers (PDB+KSB) in all growth parameters of table beet plant (table, 2). Through the average of both studied seasons, the interaction treatment ((RP+RK) + (PDB+KSB)) gave the highest significant increases percentage compared to (RD + no inoculation) i.e. 41.9, 239.4, 114.3, 62.5, 202.9 and 89.7% for shoot length, shoot fresh weight, shoot dry weight, plant length, plant fresh weight and plant dry weight, respectively. The lowest increases percentages were due to RP+RK over RD, whereas the increases percentage due to (PDB+KSB) over no inoculation came in between (table, 3).

2. Root Yield Parameters of Table Beet Plant:

Data in Table 4 show that there were significant differences among most of all mineral fertilizer treatments i.e. chemical and natural fertilizers, where the dual soil application of RP+RK achieved the highest values i.e. (262.14and 291.77), (60.19 and 70.28), (17.83 and 21.31) and (7.945 and 9.277) for root fresh weight (g/plant), root dry weight (g/plant), root length (cm), root dry yield (MT/fed), in the first and second grown seasons, respectively.

On the other hand, the sole application of RP had the lowest significant effect on all root yield parameters. It is worth mention that the manufacture chemical fertilizer of P and K at recommended dose (RD) followed the dual soil application of RP+RK concerning their effect on the different studied parameters of root yield.

Significant differences were revealed among most of all the treatments of bio-fertilizers i.e. without inoculation, phosphorus dissolving bacteria (PDB), potassium dissolving bacteria (KSB) and PDB+KSB, concerning their effect on the different yield parameters. The dual soil application of PDB+KSB achieved the highest values i.e. (252.42 and 288.59), (61.51 and 72.84), (17.25 and 20.98) and (8.119 and 9.615) for root fresh weight (g/plant), root dry weight (g/plant), root length (cm)and root dry yield (MT/fed), in the first and second grown seasons, respectively.

The most significant effect interaction treatments on yield and its parameters of table beet plant were the mixed of dual application of P and K mineral natural fertilizer (RP+RK) and biofertilizer (PDB+KSB), whereas the lowest one was the sole application of RP without inoculation of biofertilizer (table, 4).

Through the average of both studied seasons, the interacted treatments ((RP+RK) + (PDB+KSB)) gave the highest increased percentages compared to (RD + no inoculation) i.e. 89.2, 53.4, 46.2 and 53.4% for root fresh weight, root dry weight, root length and root dry yield, respectively. The lowest increased percentages were due to RP+RK over RD, meanwhile the increased percentage due to (PDB+KSB) over no inoculation came in between (table, 5).

Table 3. Average of both studied seasons for the achieved increases percentage in growth parameters of Table beet compared to manufactured fertilizers and/or without biofertilizer inoculation.

Treatments / Growth parameters	(RP+RK) Vs RD	(PDB+KSB) Vs No inoculation	(RP+RK) + (PDB+KSB) Vs (RD + No inoculation)
Shoot length (cm)	14.3	31.1	41.9
Shoot fresh weight (g/plant)	31.8	133.7	239.4
Shoot dry weight (g/plant)	16.5	70.6	114.3
Plant length (cm)	14.0	32.0	62.5
Plant fresh weight (g)	29.2	110.0	202.9
Plant dry weight (g)	14.2	60.8	89.7

Table 4. Effect of natural and bio-fertilizers on root yield parameters of table beet plant grown at two growth seasons.

Season	Season 2016					Season 2017				
*Mineral fertilizer (MF) / **Biofertilizer (BF)	RD	RP	RK	RP+RK	Mean	RD	RP	RK	RP+RK	Mean
Root fresh weight (g/plant)										
Without inoculation	146.30	124.24	137.42	148.05	139.00	152.16	130.82	144.55	159.22	146.69
Inoculation with PDB	234.62	162.85	205.18	275.12	219.44	239.48	169.25	211.51	282.79	225.76
Inoculation with KSB	225.23	159.33	195.04	266.68	211.57	231.48	167.58	202.20	274.00	218.82
Inoculation with PDB+KSB	257.07	177.67	216.23	358.72	252.42	265.24	185.65	252.37	451.08	288.59
Mean	215.81	156.02	188.47	262.14		222.09	163.33	202.66	291.77	
LSD0.05	MF= 19.755 BF= 19.755 MF×BF= 5.6447					MF= 37.298 BF= 37.298 MF×BF= 49.89				
Root dry weight (g/plant)										
Without inoculation	43.54	32.43	40.74	45.91	40.65	49.13	39.87	47.03	51.29	46.83
Inoculation with PDB	55.48	38.47	51.75	63.13	52.21	62.19	52.94	58.11	73.22	61.62
Inoculation with KSB	53.18	36.37	45.33	60.23	48.78	59.08	50.93	55.25	68.64	58.48
Inoculation with PDB+KSB	67.67	47.47	59.41	71.48	61.51	74.01	58.24	71.13	87.98	72.84
Mean	54.97	38.68	49.31	60.19		61.10	50.50	57.88	70.28	
LSD0.05	MF= 1.8079 BF= 1.8079 MF×BF= 0.8218					MF= 3.4198 BF= 3.4198 MF×BF= 5.6811				
Root length (cm)										
Without inoculation	12.00	11.00	11.67	13.33	12.00	14.77	12.52	13.81	15.38	14.12
Inoculation with PDB	16.33	13.67	15.67	19.00	16.17	18.54	14.75	17.64	22.35	18.32
Inoculation with KSB	15.67	13.00	15.33	18.33	15.58	17.52	14.65	16.78	21.07	17.51
Inoculation with PDB+KSB	18.33	14.00	16.00	20.67	17.25	21.28	16.61	19.60	26.42	20.98
Mean	15.58	12.92	14.67	17.83		18.03	14.63	16.96	21.31	
LSD0.05	MF= 1.4157 BF=1.4157 MF×BF= 2.9719					MF= 1.1956 BF= 1.1956 MF×BF= 1.9218				
Root diameter (cm)										
Without inoculation	6.28	2.22	5.74	7.24	5.37	8.84	3.24	7.63	9.57	7.32
Inoculation with PDB	11.05	8.51	10.77	13.20	10.88	12.64	10.30	12.23	15.90	12.77
Inoculation with KSB	10.65	7.47	9.94	12.62	10.17	11.87	9.88	11.61	15.09	12.11
Inoculation with PDB+KSB	12.07	9.50	11.18	16.13	12.22	13.71	11.26	13.04	18.86	14.22
Mean	10.01	6.93	9.41	12.30		11.77	8.67	11.13	14.86	
LSD0.05	MF= 0.5124 BF=0.5124 MF×BF= 0.4446					MF= 0.7678 BF= 0.7678 MF×BF= 0.84				
Root dry yield (MT/fed)										
Without inoculation	5.747	4.281	5.378	6.060	5.366	6.485	5.263	6.208	6.770	6.182
Inoculation with PDB	7.323	5.078	6.831	8.333	6.892	8.209	6.988	7.671	9.665	8.134
Inoculation with KSB	7.020	4.801	5.984	7.950	6.439	7.799	6.723	7.293	9.060	7.719
Inoculation with PDB+KSB	8.932	6.266	7.842	9.435	8.119	9.769	7.688	9.389	11.613	9.615
Mean	7.256	5.106	6.509	7.945		8.065	6.666	7.640	9.277	
LSD0.05	MF=0.2386 BF=0.2386 MF×BF=0.1085					MF= 0.4514 BF= 0.4514 MF×BF= 0.7499				

*RD= recommended dose; 62kgP_2O_5+100kgK_2O/fed as calcium super phosphate (15.5% P_2O5) + potassium sulfate (50%K_2O), RP= 62kgP_2O_5 as rock phosphate & RK=100kgK_2O/fed as rock feldspar. ** PDB; phosphate dissolving bacteria (*Bacillus megaterium*), KSB; potassium soluiblizing bacteria (*Bacillus Coagulans*)

Table 5. Average of both studied seasons for the achieved increases percentage in yield parameters of Table beet compared to manufactured fertilizers and/or without biofertilizer inoculation.

Yield parameters \ Treatments	(RP+RK) Vs RD	(PDB+KSB) Vs No inoculation	(RP+RK) + (PDB+KSB) Vs (RD + No inoculation)
Root fresh weight (g/plant)	26.4	56.5	89.2
Root dry weight (g/plant)	12.3	33.2	53.4
Root length (cm)	16.3	31.0	46.2
Root dry yield (MT/fed)	12.3	33.2	53.4

Mentioned above results are similar to those obtained by Artursson *et al*. (2006) and Marschner *et al*. (2010) who reported that the treatments that inoculated with bacteria, significantly, increased root growth, compared with control. In addition, Abou El Seoud *et al*. (2010) reported that the PDB have a significant effect on root yield of sugar beet.

The previous results are partially in agreement with many authors as follows; Han *et al*. (2005) noticed that application of rock P and K materials with co-inoculation of both bacteria PDB+KSB that solubilize them and might provide faster and continuous supply of P and K for optimal plant growth. Similar results, Han *et al*. (2006) found that combined PDB inoculation with application of rock P consistently increased shoot and root dry weight as compared to control. Furthermore, growth enhancement by bacteria may be related to its ability to produce extensive root length (Sheng and Huang, 2002), improve root development and increase the rate of water and mineral uptake (Alexander, 1997 and Saghir *et al*., 2007). As regarded, Ibrahim *et al*. (2010) discussed the increase in the growth of the biofertilized trees as a result of the ability of *B. megaterium* to produce some growth promoting substances such as IAA, gibberellins and abscisic acid.

Table 6. Effect of natural and bio-fertilizers on yield quality of table beet grown at two growth seasons

Season	Season2016					Season2017				
**Biofertilizer (BF) \ *Mineral fertilize (MF)	RD	RP	RK	RP+RK	Mean	RD	RP	RK	RP+RK	Mean
Root diameter (cm)										
Without inoculation	6.28	2.22	5.74	7.24	5.37	8.84	3.24	7.63	9.57	7.32
Inoculation with PDB	11.05	8.51	10.77	13.20	10.88	12.64	10.30	12.23	15.90	12.77
Inoculation with KSB	10.65	7.47	9.94	12.62	10.17	11.87	9.88	11.61	15.09	12.11
Inoculation with PDB+KSB	12.07	9.50	11.18	16.13	12.22	13.71	11.26	13.04	18.86	14.22
Mean	10.01	6.93	9.41	12.30		11.77	8.67	11.13	14.86	
LSD0.05	MF= 0.5124 BF=0.5124 MF×BF=0.4446					MF= 0.7678 BF= 0.7678 MF×BF= 0.84				
Ascorbic acid (ppm)										
Without inoculation	5.57	6.04	6.12	6.33	6.01	5.71	6.20	6.27	6.49	6.17
Inoculation with PDB	7.61	8.91	9.80	11.64	9.49	7.80	9.14	8.41	11.63	9.24
Inoculation with KSB	7.40	8.63	9.62	10.62	9.07	7.59	8.85	9.22	11.58	9.31
Inoculation with PDB+KSB	8.46	9.28	10.43	12.75	10.23	8.68	9.51	10.72	13.25	10.54
Mean	7.26	8.22	8.99	10.33		7.45	8.43	8.65	10.74	
LSD0.05	MF= 0.569 BF= 0.569 MF×BF= 0.6272					MF= 0.6208 BF= 0.6208 MF×BF= 0.6021				
TSS (%)										
Without inoculation	8.36	8.64	8.93	11.39	9.33	8.57	8.86	9.15	11.34	9.48
Inoculation with PDB	11.41	11.74	13.30	12.46	12.23	11.70	11.40	12.27	13.46	12.21
Inoculation with KSB	11.10	12.01	13.37	13.80	12.57	11.38	12.33	12.46	14.39	12.64
Inoculation with PDB+KSB	12.70	12.93	14.22	14.58	13.61	13.02	12.60	13.31	15.22	13.54
Mean	10.89	11.33	12.46	13.06		11.17	11.30	11.80	13.60	
LSD0.05	MF= 0.5486 BF= 0.5486 MF×BF= 0.835					MF= 0.3925 BF= 0.3925 MF×BF= 0.7525				

*RD= recommended dose; 62kgP_2O_5+100kgK_2O/fed as calcium super phosphate (15.5% P_2O5) + potassium sulfate (50%K_2O), RP= 62kgP_2O_5 as rock phosphate & RK=100kgK_2O/fed as rock feldspar. ** PDB; phosphate dissolving bacteria (*Bacillus megaterium*), KSB; potassium soluiblizing bacteria (*Bacillus coagulans*)

It is also well known that *B. megaterium* produces organic, inorganic acids and CO_2 which lead to increase soil acidity and consequently convert the insoluble forms of phosphorus into soluble ones (Kucey, 1988; Alexander, 1997; Wani *et al*., 2007 and Adesemoye and Kloepper, 2009).

3. Table Beet Yield and Quality Parameters:

Data in Table 6 show that there were significant differences among most of all mineral fertilizer treatments i.e. chemical and natural fertilizers. The dual soil application of RP+RK achieved the highest values i.e. (12.30 and 14.86), (10.33 and 10.74) and (13.06 and 13.60) for root diameter (cm), ascorbic acid (ppm) and TSS (%), in the 1st and 2nd seasons, respectively.

On the other hand, the sole application of RP had the lowest significant effect on all root yield quality parameters. It is worth mention that the manufacture chemical fertilizer of P and K at recommended dose (RD) followed the dual soil application of RP+RK concerning their effect on the different studied parameters of root yield quality.

Significant differences were noticed among most of all the treatments of bio-fertilizers i.e. without inoculation, phosphorus dissolving bacteria (PDB), potassium dissolving bacteria (KSB) and PDB+KSB concerning their effect on the different yield parameters. The dual soil application of PDB+KSB achieved the highest values i.e. (12.22 and 14.22), (10.23 and 10.54) and (13.61 and 13.54) for root diameter (cm), ascorbic acid (ppm) and TSS (%) in the first and second seasons, respectively.

The most significant effective interacted treatments were the mixed of dual application of P and K mineral natural fertilizer (RP+RK) and biofertilizer (PDB+KSB) on all yield quality parameters of table beet plant, whereas the lowest one was the sole application of RP without inoculation of biofertilizer (table, 6).

Through the average of both studied seasons, the interacted treatment ((RP+RK) + (PDB+KSB)) gave the highest increased percentage compared to (RD + no inoculation) i.e. 110.9, 70.5 and 58.0 for root diameter (cm), ascorbic acid (ppm) and TSS (%), respectively. The lowest increased percentage was due to RP+RK over RD, meanwhile the increased percentage due to (PDB+KSB) over no inoculation came in between (table, 7).

The aforementioned results are in agreement with those obtained by Han *et al*. (2006); Sheng and Huang (2002); Alexander (1997) and Saghir *et al*. (2007). Ibrahim *et al*. (2010) mentioned that,the increment of the growth of biofertilizered trees may be due to the ability of *B. megaterium* to produce some growth promoting substances such as IAA, gibberellins and abscisic acid. It is also well known that *B. megaterium* produces organic, inorganic acids and CO_2 which lead to increase soil acidity and consequently convert the insoluble forms of phosphorus into soluble ones (Kucey, 1988; Alexander, 1997; Wani *et al*., 2007 and Adesemoye and Kloepper, 2009).

4. Available Phosphorus and Potassium In Soil

Concerning the available phosphorus and potassium in soil (table, 8) it can be noticed that, there were significant differences among most of all mineral fertilizer treatments i.e. chemical and natural fertilizers, where the mineral chemical fertilizer of P and K at recommended dose (RD) gave the highest significant effects on available P (60.64 and 68.22mgkg^{-1}soil) and K (172.37 and 176.55mgkg^{-1}soil) in the 1st and 2nd seasons, respectively, followed by the dual soil application of p and K mineral natural fertilizers (RP+RK).

The sole soil application of RK gave the lowest values for available P (32.59 and 44.05mgPkg^{-1}soil), while the lowest one for available K (150.77 and 160.38mgkg^{-1}soil) was due to the sole soil application of RK in the 1st and 2nd seasons, respectively. There were no significant differences between both sole soil application of RP and RK in the two studied seasons.

Concerning, their effect on the available phosphorus and potassium in soil, a significant differences among most of all inoculations treatments were noticed. It can be concluded that the dual inoculation (PDB+KSB) showed the highest significant effects on available P (48.23 and 59.97mgkg^{-1}soil) and K (185.95 and 191.54mgkg^{-1}soil) in the 1st and 2nd season, respectively.

The interacted treatment of the dual application of P and K mineral chemical at recommended dose (RD) with the dual application of bio-fertilizers (PDB+KSB) had the most significant effects on available P and K in soil, whereas the lowest one was due to the single application of RK without inoculation of biofertilizer.

In general, a large root surface area is the key importance for nutrient acquisition by roots (Marschner *et al*, 2010). An increase in root surface area can be either an inherent property or deficiency induced, such as P or K deficiency (Abou El Seoud *et al.*, 2010). In this concern, Amer *et al*., (2010) stated that the increase in root surface area of common bean plants inoculated with *B. subtilis* was about 1.6-fold when compared with the common bean plants without inoculation.

Table 7. Average of both studied seasons for the achieved increases percentage in root yield quality of Table beet compared to manufactured fertilizers and/or without biofertilizer inoculation.

Treatments / Some quality parameters	(RP+RK) Vs RD	(PDB+KSB) Vs No inoculation	(RP+RK) + (PDB+KSB) Vs (RD + No inoculation)
Root diameter (cm)	24.6	76.9	110.9
Ascorbic acid (ppm)	43.2	57.2	70.5
TSS%	49.0	53.7	58.0

The obtained significant increases in P and K uptake when P and K were applied to the soil as rock phosphate and feldspar mixed with PDB may be due to that bacteria have been used to convert insoluble rock P and K material into soluble forms available for plant growth through acidification by producing strong organic acids (Nahas *et al*., 1990; Bojinova *et al*., 1997 and Schilling *et al*., 1998).

Similar results were obtained by Han *et al*., (2006) on pepper and cucumber plants and by Abarchi *et al*., (2009) on the legumes, *Mucuna pruriens* (L.) and *Lablab purpureus* (L.).

5. Phosphorus and Potassium Content in Table Beet Plant:

Data in Table 8 indicate that there were significant differences among all soil applications of mineral P and K fertilizers due to their effect on the content of P and K in table beet plant. The P and K mineral chemical fertilizers at recommended dose (RD) showed the highest significant effects on P (0.665 and 0.706%) and K (2.50 and 2.64%) in the 1st and 2nd seasons respectively, followed by the dual soil application of P and K mineral natural fertilizers (RP+RK). On the other hand, the lowest significant effects on P content (0.447and 0.512%) was due to the sole soil application of mineral natural K (RK), whereas the lowest for K content (2.04 and 2.13%) were due to the single soil application of mineral natural P (RP), in the 1st and 2nd seasons, respectively.

Data in Table 8 indicate that there were significant differences among most of all soil applications of all inoculated treatments, where the dual inoculation PDB+KSB showed the highest significant effects on plant content of P (0.610 and 0.659%) and K (2.53 and 2.68%) in the 1st and 2nd seasons, respectively.

It can be concluded that the interacted treatments of the dual application of P and K mineral chemical at recommended dose (RD) with the dual application of bio-fertilizers (PDB+KSB) had the most significant effects on P and K content (%) in table beet plant, whereas the lowest were with the single application of RK without inoculation of biofertilizer (table, 8).

6. Phosphorus and Potassium Uptake by Table Beet Plant:

With respect to P and K uptake by table beet plant it can be concluded from results in Table 8 that the dual soil application (RP+RK) resulted in the highest significant effects on table beet P uptake (0.572 and 0.856gplant^{-1}) and K uptake (2.312 and 3.504gplant^{-1}) in the 1st and 2nd seasons, respectively, followed by the soil application of P and K mineral chemical fertilizers at recommended dose (RD) for P uptake and K mineral natural fertilizer (RK) for K uptake.

The dual inoculation PDB+KSB resulted in the highest significant effects on table beet P uptake (0.629 and 0.914gplant^{-1}) and K uptake (2.608 and 3.734g plant^{-1}) in the 1st and 2nd seasons, respectively.

The most significant effective interacted treatment was the mixed of dual application of P and K mineral natural fertilizer (RP+RK) and biofertilizer (PDB+KSB) on P and K uptake by table beet plant, whereas the lowest one was the sole application of RP without inoculation of biofertilizer.

These results are partially in accordance with those obtained by many authors such as Han and Lee (2005); Han *et al*. (2006); Takano *et al*. (2006); Chen *et al*. (2006); Eweda *et al*. (2007); Jorquera *et al*. 2008; Marschner (2009); Sabannavar and Lakshman (2009) and Marschner *et al*. (2010).

7. The Microbial Densities and Dehydrogenase Activity In The Rhizosphere Of Table Beet:

Regarding to the effect of natural mineral fertilizers compared to chemical one, data in Table 9 indicate that the dual soil application of RP+RK achieved the highest significant values i.e. (127.25 and 138.42), (112.04 and 128.67), (5.28 and 5.59), (101.17 and 108.17), (48.00 and 56.08) and (24.29 and 25.49) for total bacterial counts (cfu $\times 10^{6}$ g^{-1} dry soil), *Bacillus megaterium* density (counts ×103 cfu/g dry soil), *Bacillus Coagulans* density, total nitrifying bacterial count, total thermophilic bacterial count and dehydrogenase activity in the 1st and 2nd seasons, respectively. On the other hand, the sole application of RP had the lowest significant effect on all rhizosphere microbial activity parameters.

Table 8. Effect of mineral natural and bio-fertilizers on available phosphorus and potassium in soil and their content and uptake in table beet plant grown at two growth seasons.

Season	**Season2016**					**Season2017**				
Available P (mg/kg soil)										
***Mineral fertilizer (MF) / **Biofertilizer (BF)**	**RD**	**RP**	**RK**	**RP+RK**	**Mean**	**RD**	**RP**	**RK**	**RP+RK**	**Mean**
Without inoculation	57.17	30.19	29.01	32.64	37.25	61.23	33.81	32.85	42.45	42.59
Inoculation with PDB	59.41	33.07	34.99	44.37	42.96	63.68	46.40	44.80	49.09	50.99
Inoculation with KSB	61.65	32.96	31.79	52.08	44.62	73.39	48.32	46.72	59.12	56.89
Inoculation with PDB+KSB	64.32	36.16	34.58	57.84	48.23	74.56	52.37	51.84	60.37	59.79
Mean	60.64	33.10	32.59	46.73		68.22	45.23	44.05	52.76	
LSD0.05	MF= 3.0278 BF=3.0278 MF×BF= 0.218					MF= 1.6039 BF= 1.6039 MF×BF= 0.2066				
Available K (mg/kg soil)										
Without inoculation	185.39	134.83	138.62	143.25	150.52	202.24	146.41	152.44	155.39	164.12
Inoculation with PDB	189.49	151.68	154.84	168.53	166.14	205.19	158.53	161.90	171.59	174.30
Inoculation with KSB	202.24	151.68	164.31	185.99	176.06	221.09	166.96	175.42	185.39	187.22
Inoculation with PDB+KSB	208.35	164.87	178.86	191.71	185.95	219.09	169.60	183.65	193.81	191.54
Mean	196.37	150.77	159.16	172.37		211.90	160.38	168.35	176.55	
LSD0.05	MF= 4.2088 BF=4.2088 MF×BF= 0.376					MF= 2.877 BF= 2.877 MF×BF= 0.3865				
P concentration% in plant root										
Without inoculation	0.589	0.469	0.425	0.469	0.488	0.632	0.480	0.458	0.501	0.518
Inoculation with PDB	0.687	0.534	0.501	0.567	0.572	0.709	0.567	0.534	0.621	0.608
Inoculation with KSB	0.632	0.523	0.469	0.556	0.545	0.676	0.545	0.501	0.589	0.578
Inoculation with PDB+KSB	0.752	0.545	0.512	0.632	0.610	0.807	0.600	0.556	0.676	0.659
Mean	0.665	0.518	0.477	0.556		0.706	0.548	0.512	0.597	
LSD0.05	MF= 0.0156 BF=0.0156 MF×BF= 0.0017					MF= 0.0139 BF= 0.0139 MF×BF= 0.0019				
K concentration% in plant root										
Without inoculation	2.26	1.79	2.05	2.11	2.05	2.33	1.89	2.11	2.22	2.14
Inoculation with PDB	2.32	2.00	2.11	2.21	2.16	2.36	2.11	2.28	2.34	2.27
Inoculation with KSB	2.42	2.11	2.26	2.26	2.26	2.69	2.22	2.33	2.44	2.42
Inoculation with PDB+KSB	3.00	2.26	2.34	2.51	2.53	3.16	2.30	2.42	2.83	2.68
Mean	2.50	2.04	2.19	2.27		2.64	2.13	2.29	2.46	
LSD0.05	MF= 0.075 BF=0.075 MF×BF= 0.0057					MF= 0.0919 BF= 0.0919 MF×BF= 0.0067				
P plant root uptake (g/plant)										
Without inoculation	0.324	0.321	0.308	0.357	0.328	0.463	0.399	0.393	0.447	0.426
Inoculation with PDB	0.490	0.461	0.468	0.599	0.505	0.698	0.632	0.678	0.938	0.737
Inoculation with KSB	0.434	0.406	0.419	0.561	0.455	0.644	0.583	0.606	0.814	0.662
Inoculation with PDB+KSB	0.641	0.540	0.564	0.771	0.629	0.880	0.760	0.793	1.224	0.914
Mean	0.472	0.432	0.440	0.572		0.671	0.594	0.617	0.856	
LSD0.05	MF= 0.0143 BF=0.0143 MF×BF= 0.0061					MF= 0.0244 BF= 0.0244 MF×BF= 0.033				
K plant root uptake (g/plant)										
Without inoculation	1.243	1.226	1.484	1.609	1.391	1.708	1.574	1.811	1.981	1.769
Inoculation with PDB	1.657	1.728	1.968	2.335	1.922	2.327	2.354	2.895	3.534	2.778
Inoculation with KSB	1.660	1.638	2.022	2.281	1.900	2.565	2.377	2.815	3.375	2.783
Inoculation with PDB+KSB	2.556	2.238	2.577	3.060	2.608	3.446	2.916	3.451	5.125	3.734
Mean	1.779	1.708	2.013	2.321		2.511	2.305	2.743	3.504	
LSD0.05	MF= 0.0443 BF=0.0443 MF×BF= 0.0237					MF= 0.1024 BF= 0.1024 MF×BF= 0.1329				

*RD= recommended dose; 62kgP_2O_5+100kgK_2O/fed as calcium super phosphate (15.5% P_2O5) + potassium sulfate (50%K_2O), RP= 62kgP_2O_5 as rock phosphate & RK=100kgK_2O/fed as rock feldspar. ** PDB; phosphate dissolving bacteria (*Bacillus megaterium*), KSB; potassium soluiblizing bacteria (*Bacillus Coagulans*).

Table 9. Effect of natural and bio-fertilizers on the microbial densities and dehydrogenase activity in the rhizosphere of table Beet grown at two growth seasons.

Season	Season2016					Season2017				
*Mineral fertilizer (MF) / **Biofertilizer (BF)	RD	RP	RK	RP+RK	Mean	RD	RP	RK	RP+RK	Mean
Total bacterial counts (cfu ×10 ^{6} g^{-1} dry soil)										
Without inoculation	85.67	58.00	75.00	98.00	79.17	90.33	62.67	79.67	102.00	83.67
Inoculation with PDB	107.33	91.00	103.00	134.67	109.00	115.67	93.67	108.67	147.67	116.42
Inoculation with KSB	106.00	88.00	104.00	131.67	107.42	114.00	92.67	109.00	144.67	115.08
Inoculation with PDB+KSB	118.00	98.00	110.67	144.67	117.83	124.00	105.67	118.00	159.33	126.75
Mean	104.25	83.75	98.17	127.25		111.00	88.67	103.83	138.42	
LSD0.05	MF= 2.5555	BF=2.5555	MF×BF= 2.8532			MF= 3.5412	BF= 3.5412	MF×BF= 3.4784		
Phosphate dissolving bacteria count (cfu ×10 ^{4} g^{-1} dry soil)										
Without inoculation	57.31	45.00	66.24	72.65	60.30	81.57	54.40	75.67	89.13	75.19
Inoculation with PDB	82.30	51.27	80.54	117.33	82.86	107.47	66.67	99.70	135.13	102.24
Inoculation with KSB	80.21	52.53	82.08	118.55	83.34	106.37	68.30	103.90	137.40	103.99
Inoculation with PDB+KSB	102.57	66.70	99.68	139.64	102.15	128.27	79.20	117.03	153.00	119.38
Mean	80.60	53.88	82.14	112.04		105.92	67.14	99.08	128.67	
LSD0.05	MF= 6.4862	BF=6.4862	MF×BF= 5.0646			MF= 5.3995	BF= 5.3995	MF×BF= 2.927		
Potassium dissolving bacteria count(cfu ×10 ^{3} g^{-1} dry soil)										
Without inoculation	2.71	3.82	3.45	3.97	3.49	3.05	4.11	3.68	4.20	3.76
Inoculation with PDB	3.25	4.60	4.26	5.14	4.31	3.63	4.95	4.52	5.45	4.64
Inoculation with KSB	3.73	5.01	4.62	5.55	4.73	3.87	5.38	4.79	5.78	4.96
Inoculation with PDB+KSB	4.37	5.88	5.58	6.44	5.57	4.58	6.10	5.89	6.94	5.88
Mean	3.52	4.83	4.48	5.28		3.78	5.14	4.72	5.59	
LSD0.05	MF= 0.0502	BF= 0.0708	MF*BF= 0.1417			MF= 0.0399	BF= 0.0782	MF*BF= 0.1410		
Total nitrifying bacterial count										
Without inoculation	53.00	38.00	40.67	59.00	47.67	55.33	43.00	43.67	60.67	50.67
Inoculation with PDB	99.00	58.00	81.00	116.67	88.67	107.33	63.67	97.67	119.00	96.92
Inoculation with KSB	93.33	55.00	82.67	104.67	83.92	108.33	64.33	98.00	120.33	97.75
Inoculation with PDB+KSB	103.33	61.67	86.33	124.33	93.92	112.33	75.33	104.00	132.67	106.08
Mean	87.17	53.17	72.67	101.17		95.83	61.58	85.83	108.17	
LSD0.05	MF= 6.0722	BF=6.0722	MF×BF= 5.3772			MF= 6.2191	BF= 6.2191	MF×BF= 3.8444		
Total thermophilic bacterial count										
Without inoculation	36.33	31.33	34.67	39.00	35.33	42.33	38.33	39.67	48.67	42.25
Inoculation with PDB	46.67	35.33	37.67	50.67	42.58	49.67	41.67	43.00	55.00	47.33
Inoculation with KSB	44.33	35.67	38.33	49.00	41.83	49.33	42.33	43.67	54.33	47.42
Inoculation with PDB+KSB	47.33	36.67	42.00	53.33	44.83	59.67	45.00	50.67	66.33	55.42
Mean	43.67	34.75	38.17	48.00		50.25	41.83	44.25	56.08	
LSD0.05	MF= 1.708	BF=1.708	MF×BF= 2.1954			MF= 1.8396	BF= 1.8396	MF×BF= 2.1284		
Dehydrogenase activity (µg TPF g^{-1} dry soil 24h.)										
Without inoculation	3.79	2.04	2.73	4.64	3.30	4.35	2.27	2.88	5.72	3.80
Inoculation with PDB	15.87	8.16	10.68	28.82	15.88	16.75	8.37	11.77	29.25	16.54
Inoculation with KSB	12.85	6.86	11.21	27.22	14.53	15.82	8.05	12.05	28.31	16.06
Inoculation with PDB+KSB	21.91	9.16	12.25	36.47	19.95	23.17	9.74	13.15	38.67	21.18
Mean	13.61	6.56	9.22	24.29		15.02	7.10	9.96	25.49	
LSD0.05	MF= 3.3422	BF=3.3422	MF×BF= 0.3363			MF= 3.3287	BF= 3.3287	MF×BF= 0.7561		

*RD= recommended dose; 62kgP_2O_5+100kgK_2O/fed as calcium super phosphate (15.5% P_2O5) + potassium sulfate (50%K_2O), RP= 62kgP_2O_5 as rock phosphate & RK=100kgK_2O/fed as rock feldspar. ** PDB; phosphate dissolving bacteria (*Bacillus megaterium*), KSB; potassium soluiblizing bacteria (*Bacillus Coagulans*)

The dual soil inoculation PDB+KSB achieved the highest significant values (117.83 and 126.75), (102.15 and 119.38), (5.569 and 5.879), (93.92 and 106.08), (44.83 and 55.42) and (19.95 and 21.18) for total bacterial count, *Bacillus megaterium* density (counts ×10^3cfu/g dry soil), *Bacillus Coagulans* density **(**counts ×10^3cfu/g dry soil**)**, total nitrifying bacterial count, total thermophilic bacterial count and dehydrogenase activity (µmol/g dry soil /hr.) in the 1st and 2nd seasons, respectively.

It is worth mention that the manufacture chemical fertilizer of P and K at recommended dose (RD) followed the dual soil application of RP+RK concerning, their effect on the different studied rhizosphere microbial activity parameters.

The most significant effective interactied treatment was the mixed of dual application of P and K mineral natural fertilizer (RP+RK) and biofertilizer (PDB+KSB) on all parameters of the microbial densities and dehydrogenase activity in the rhizosphere of table beet, whereas the lowest one was the sole application of RP without inoculation of biofertilizer.

Table 10. Average of both studied seasons for the achieved increases percentage in the microbial densities and dehydrogenase activity in the rhizosphere of Table beet compared to manufactured fertilizers and/or without biofertilizer inoculation.

Treatments / Rhizosphere microbial densities and dehydrogenase activity	(RP+RK) Vs RD	(PDB+KSB) Vs No inoculation	(RP+RK) + (PDB+KSB) Vs (RD + No inoculation)
Total bacterial counts (cfu X 10^6 g^{-1} dry soil)	23.4	36.8	50.2
Phosphate dissolving bacteria count (cfu X 10^4 g^{-1} dry soil)	30.2	45.4	64.1
Potassium dissolving bacteria count(cfu X 10^3 g^{-1} dry soil)	49.0	53.7	58.0
Total nitrifying bacterial count	14.5	54.9	103.2
Total thermophilic bacterial count	10.8	19.2	29.0
Dehydrogenase activity (µg TPF g^{-1} dry soil 24h.)	74.1	287.1	481.0

Table 11. Profitability per fed of *Beta vulgare* var Detrweet root yield (MT/fed) under varying understudied treatments of mineral and bio-fertilizers.

Mineral fertilizers	Biofertilizers	Yield (MT/fed)	Total cost (LE)	Total income (LE)	Net Benefit (LE)	BCR
RD	Without inoculation	6.116	6530	9174	2644	1.40
	Inoculation with PDB	7.766	6580	11649	5069	1.77
	Inoculation with KSB	7.410	6580	11114	4534	1.69
	Inoculation with PDB+KSB	9.351	6630	14026	7396	2.12
RP	Without inoculation	4.772	2350	7158	4808	3.05
	Inoculation with PDB	6.033	2400	9050	6650	3.77
	Inoculation with KSB	5.762	2400	8643	6243	3.60
	Inoculation with PDB+KSB	6.977	2450	10466	8016	4.27
RK	Without inoculation	5.793	3050	8690	5640	2.85
	Inoculation with PDB	7.251	3100	10877	7777	3.51
	Inoculation with KSB	6.639	3100	9958	6858	3.21
	Inoculation with PDB+KSB	8.616	3150	12923	9773	4.10
RP+RK	Without inoculation	6.415	3550	9623	6073	2.71
	Inoculation with PDB	8.999	3600	13499	9899	3.75
	Inoculation with KSB	8.505	3600	12758	9158	3.54
	Inoculation with PDB+KSB	10.524	3650	15786	12136	4.32

*RD= recommended dose; 62kgP_2O_5+100kgK_2O/fed as calcium super phosphate (15.5% P2O5) + potassium sulfate (50%K_2O), RP= 62kgP_2O_5 as rock phosphate & RK=100kgK_2O/fed as rock feldspar. ** PDB; phosphate dissolving bacteria (*Bacillus megaterium*), KSB; potassium soluiblizing bacteria (*Bacillus Coagulans*).

Through the average of both studied seasons, the interacted treatment ((RP+RK) + (PDB+KSB)) gave the highest increased percentage as compared to (RD + no inoculation) i.e. 50.2, 64.1, 58.0,103.2 and 29.0% for Total bacterial counts (cfu × 10^6 g^{-1} dry soil), phosphate dissolving bacterial count (cfu × 10^4 g^{-1} dry soil), potassium dissolving bacterial count(cfu × 10^3 g^{-1} dry soil), total nitrifying bacterial count, total thermophilic bacterial count and dehydrogenase activity (µg TPF g^{-1} dry soil 24h.), respectively. The lowest increased percentages were due to RP+RK over RD of P and K chemical fertilizers, meanwhile the increased percentage due to (PDB+KSB) over no inoculation cleared in between (table, 10).

These results are partially in accordance with those obtained by many authors such as Han and Lee, (2005); Han *et al*., (2006); Takano *et al*., (2006); Chen *et al*., (2006); Eweda *et al*., (2007); Jorquera *et al*., 2008; Marschner, (2009); Sabannavar and Lakshman, (2009) and Marschner *et al*., (2010).

8. Economic Value:

Economic analysis of table beet root yield (MT/fed) under the varying understudied treatments of mineral and bio-fertilizers are shown in Table 11. Data indicated that application of bio-fertilizers either with chemical mineral or natural P and K resulted in higher benefit cost ratio (BCR) due to more income when compared to control (no inoculation). The combination treatment of RP+RK+PDB+KSB gave the maximum total net profit (12236LE) and the maximum total BCR value (4.32) followed by the total BCR values (4.27 and 4.10) for both RP+PDB+KSB and RP+RK+PDB treatments, respectively. The plants without biofertilizer inoculation and 100% chemical PK (RD) resulted in smaller BCR values (1.40) due to lower net benefits (2644LE).

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الملخص العربي

تأثير الأسمدة الطبيعية والحيوية على إنتاجية وجودة بنجر المائدة النامى فى أرض رملية فى واحة سيوة مصر

محمود على محمد السيد، محرم فؤاد عطية، محمد رائف حافظ

أجريت تجربة حقلية على بنجر المائدة صنف (Detrweet cv.) خلال موسمين متتابعين هما في ٢٠١٥/٢٠١٦ و٢٠١٦/٢٠١٧ في مزرعة خيميسة التجريبية التي تقع على خط عرض (29°12' 34.5 N")، وخط الطول (25° 24' 2.56" E)، في محطة بحوث سيوة، مركز بحوث الصحراء، مصر. أجريت التجربة الحقلية بتصميم قطاعات كاملة العشوائية بنظام القطع المنشقة مرة واحدة فكان العامل الرئيسي هو معاملات السماد المعدني (MF) الأربعة وهى ١٠٠٪ من الجرعة الموصى بها (RD) للأسمدة الكيماوية المصنعة للفوسفور والبوتاسيوم (٦٢كجم فو٢أ٥ + ١٠٠كجم بو٢أ لكل فدان)، و٦٢كجم بو٢أ٥ لكل فدان (RP)، ١٠٠كجم بو٢أ لكل فدان (RK)، (RP + RK)، في حين تم تخصيص العامل تحت الرئيسي للمعاملات الحيوية الأربعة وهى بدون تلقيح، التلقيح ببكتيريا ميسرة للفوسفور (PDB)، وبكتيريا مذيبة للبوتاسيوم (KSB)، (PDB + KSB).

أشارت النتائج إلى أن المعاملة الأكثر فاعلية هى معاملة التفاعل بين توليفة أسمدة الفوسفور والبوتاسيوم المعدنية الطبيعية (RP + RK) وتوليفة الأسمدة الحيوية للبكتيريا الميسرة للفوسفور والمذيبة للبوتاسيوم (PDB + KSB) احيث أعطت هذه المعاملة أعلى قيم معنوية لنمو وإنتاجية وجودة محصول بنجرالمائدة والفوسفور والبوتاسيوم سواء الميسر بالتربة أو الممتص بالنبات، وكذلك الكثافة الميكروبية ونشاط الديهيدروجينيز في منطقة إنتشار جذور بنجر المائدة. كما حققت هذه المعاملة أقصى عائد صافي للربح وأعلى نسبة فائدة "BCR" (إجمالى الدخل/ إجمالى التكلفة) حوالى (٤،٣٢) مقارنة بباقى المعاملات الأخرى. وبهذا يمكن الاستنتاج بأن استخدام الأسمدة الطبيعية مثل الصخر الفوسفاتى والبوتاسيومى مع الأسمدة الحيوية الميسرة للفوسفور والمذيبة للبوتاسيوم في التربة الرملية سيزيد من تيسر وامتصاص المغذيات وبالتالى الإنتاجية والجودة فهى تقترب مع ما تحققه الأسمدة الفوسفاتية والبوتاسية المصنعة وقد يفوقها فضلاً عن توفير غذاء آمن للإنسان مع خفض التكاليف، وتقليل التلوث البيئى خاصة في واحة سيوة كمحمية طبيعية.