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Growing broccoli plants in the newly reclaimed soils of Egypt, as affected by different fertilizer sources

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Abstract: Experiments were conducted in sandy soil open field at Nubaria, Egypt using drip irrigation system. The effect of bio, mineral and organic fertilizers and their interactions on the vegetative growth, leaves nutrient content and productivity of broccoli plants were studied. Five treatments of bio-fertilizers were applied using a mixture of nitrogen fixing and phosphorus solubilizing microorganisms (*Aztobacter chroococcum, Bacillus megaterium, Arbiscular mycorrhizea, Bacillus polymyxa*). In addition, four equations of mineral and organic fertilizers were applied. Mixture of *Azotobacter chroococcum* and *Arbiscular mycorrhizea* recorded the highest values of vegetative growth, leaves nutrient content (N, P and K) and total heads yield. Equation of 75% mineral + 25% organic of the recommended fertilizer units exhibited the highest values of vegetative growth, leaves nutrient content and total heads yield as compared to the other treatments. Interestingly, the combined effect of the two mixtures of *Azotobacter chroococcum*+ *Arbiscular mycorrhizea* with 75% mineral+ 25% organic of the recommended fertilizer units recorded the highest values of vegetative growth, leaves nutrient content and broccoli heads yield.
Key words: Broccoli; Bio-fertilizers; Mineral fertilizers; Organic fertilizers.

Introduction

Broccoli (*Brassica oleracea* var. *italic* Plenck) is a widespread international vegetable crop belongs to family Brassicaceae. It is a rich source of vitamin A, vitamin B_2, calcium[1,2] and minerals especially K, S, P, Mg and micro-elements[3]**.** Broccoli has been appointed as anti-cancer source by American Cancer Society[4,5,6].

Plant nutrition is the most important factor affecting the productivity and quality of the crops[7]. Growing broccoli in the newly reclaimed soils faces many problems, such as low soil organic matter content, unreliable rainfall and poor soil nutrients availability. In order to overcome these problems, many farmers used large amounts of mineral fertilizers[8,9]. Application of mineral fertilizers has a negative effect on both environment and human health[8]. Moreover, its continuous use leads to agricultural soil degradation[7]. It is a useful strategy to replace the mineral fertilizer partially with organic or bio-fertilizers. Efficient use of fertilizers can be increased by management practices either using the correct rate of nutrients at the right time or combining mineral and organic fertilizers. Microbial inoculation is a natural, beneficial and friendly ecological solution which may reduce the adverse environmental effects of mineral fertilization[10] and improve the soil fertility status to sustain crop yield[11]**.** Nitrogen fixing- *i.e. Azotobacter chroococcum and Bacillus polymyxa* and phosphorus solubilizing- *i.e. Bacillus megaterium* or *Arbiscular mycorrhizea* microorganisms are widely used as bio-fertilizers. Therefore, this work aims to study the effect of mineral, organic, and bio-fertilizers supplementation

on the vegetative growth, leaves nutrient content and productivity of broccoli plants in the newly reclaimed sandy soil of Egypt.

Materials and Methods

Two field experiments were conducted at National Research Center farm, Nubaria, Beheira Governorate, Egypt during the two successive winter seasons of 2012/2013 and 2013/2014 to study the effect of different fertilizer sources on the vegetative growth, productivity and quality of broccoli heads. Seeds of broccoli cv. Hybrid Marathon were imported from Takii Company, Japan, then sown in foam trays (208 eyes) filled with mixture of 1:1 volume peatmoss: vermiculite (the recommended transplant production media for protected cultivation). Physical and chemical analysis of soil samples took place according to[12] and illustrated in Table (1).

Table (1): Physical and chemical properties of the experimental soil.

	Physical properties									
Season	**Sand%**		**Clay%**		**silt%**		**Texture**			
2012/2013	61.4		4.9		33.7		Sandy			
2013/2014	58.4		3.6		38		Sandy			
	Chemical properties									
			Cations (Meq./L)				**Anions (Meq./L)**			
Season	E.C.(dS/m)	pH	Ca^{++}	Mg^{++}	Na^{++}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
2012/2013	1.55	7.88	6.94	3.4	4.57	1.32	Nil	1.58	1.07	13.58
2013/2014	1.63	7.81	7.41	3.7	4.36	1.37	Nil	1.67	1.23	13.94

Compost was analyzed as shown in Table,2 according to[13]**.** Available phosphorus and available potassium have been evaluated according to[14]. Total nitrogen content was measured according to[13]**.**

Table (2): Chemical analysis of the used compost in the two seasons of the experiment.

Character	**2012/2013**	**2013/2014**
pH	7.80	7.50
E.C. (dSm^{-1})	3.50	4.30
Organic matter (%)	30.50	23.10
Organic carbon (%)	12.20	19.10
Total nitrogen (%)	1.17	1.30
C/N ratio	1:15	1:18
Total phosphorus (%)	0.48	0.75
Total potassium (%)	1.14	0.90

Rock phospahe (20.5% P_2O_5), was used as an organic phosphatic source. Rock phosphate were analyzed at central laboratories sector, the Egyptian mineral resources authority (EMRA), the Ministry of petroleum of Egypt as shown in Tables (3).

Table (3):Chemical analysis of the used rock phosphate.

Content	**(%)**	**Content**	**(%)**
SiO_2	12.8	**Na_2O**	1.12
TiO_2	0.020	**K_2O**	0.050
Al_2O_3	0.350	**P_2O_5**	20.8
Fe_2O_3	1.12	**Cl**	1.56
MnO	0.070	**SO_3**	1.98
MgO	0.610	**L.O.l**	13.6
CaO	44.1		

Ditches of 20 cm width and 20 cm depth were prepared at the every irrigation line. Organic fertilizers (compost and rock phosphate) and calcium super phosphate as well as agricultural sulphur (100 Kg per fed.) were spread through the ditches and covered with sand. Drip irrigation lines were established over the ditches

and soil was irrigated continuously three days before transplanting. Seedlings of 45 days age were transplanted 0.5 m apart on one side of the irrigation line, one transplant besides every irrigation eye. Experimental plot area was 17.5 m^2 containing three rows, each row was 25m length × 0.7 m width.

The bio-fertilizer was kindly supported by Microbiology department Faculty of Agriculture, Ain Shams University, Shoubra El-Kheima, Cairo, Egypt. It contains a mixture of N_2-fixing bacteria *(Aztobacter chroococcum* and *Bacillus polymyxa)* and phosphate dissolving bacteria such *(Bacillus megaterium)* or phosphate mobilizing bio-fertilizer (*Arbiscular mycorrhizea)*. The bio-fertilizers were grown separately in batch cultures to the exponential phase of each micro-organism[15] to get a cell suspension of $4x10^5$; $6x10^6$ and $4x10^6$ cell/g soil, respectively for *Aztobacter chroococcum*, *Bacillus megaterium* and *Bacillus polymyxa* after 6 days incubation period at 28-30°C. *Mycorrhiza was* applied alone by dipping the roots of broccoli seedlings in a liquid suspension of the *mycorrhizae* for a quarter of an hour, directly before transplanting. Other bio-fertilization treatments were applied by injection through irrigation water. Needed horticultural practices of growing broccoli were followed. Nitrogen source of mineral fertilizer (ammonium sulfate 21.5% N) and potassium sulfate (48% K_2O) at a rate of 60 K_2O units/fed were applied through irrigation system allover the growing season and stopped two weeks before harvesting.

2.1. Treatments

2.1.1 Bio-fertilizer treatments:

1- Without: Without bio-fertilizer.
2- Bio. 1*: Aztobacter chroococcum+ Bacillus megaterium.*
3-Bio. 2: *Aztobacter chroococcum+ Arbiscular mycorrhizea*.
4-Bio. 3: *Bacillus polymyxa+ Bacillus megaterium*.
5-Bio. 4: *Bacillus polymyxa+Arbiscular mycorrhizea*.

Bio-fertilizer treatments were added twice, after two and five weeks of transplanting.

2.1.2. Mineral and organic fertilization treatments:

1) - 100 % mineral of the recommended fertilizer units (120 Unit N/faddan and 90 Unit P_2O_5/ fadden).
2) - 75% mineral + 25% organic (of the recommended fertilizer units).
3) - 50% mineral + 50% organic (of the recommended fertilizer units).
4) - 25% mineral + 75% organic (of the recommended fertilizer units).

2.2. Recorded data:

A)- Vegetative growth parameters : A random sample of three plants was taken from each experimental treatment at 45 days after transplanting. Number of leaves per plant, leaf area, total plant fresh and dry weights were recorded.

B)- Total heads yield : All broccoli heads of each plot were harvested at the green mature stage. Primary head yield (main yield of the apical heads), secondary heads yield (side heads yield), the sum was the total heads yield.

C)- Leaves nutrients content : The percentages of nitrogen, phosphorus and potassium in the acid digested samples of dry leaves of broccoli were determined**.** Nitrogen content was determined by the modified micro Kjeldah method[16], phosphorus was determined colorimetrically by NH4-Metavanidate method[16]. Potassium was flame-photometrically estimated[16].

2.3. Experimental design and Statistical analysis: Experimental plots were arranged in a split plot design system with three replicates. Bio-fertilizers treatments were assigned in the main plots, whereas other fertilizer treatments were allotted in the sub-plots. Data were statistically analyzed using Mstatic (M.S.) software. Comparison among different treatments means was made as illustrated by[17]**.**

Results and Discussion

A) Vegetative growth

Effect of bio-fertilization:

Data in Table (4) showed that bio-fertilizers application significantly enhanced vegetative growth and total heads yield compared with the non-inoculated plants. The highest values for number of leaves, leaf area, total plant fresh and dry weights as well as total heads yield were obtained by Bio.2 treatment (*Azotobacter+ Mycorrhiza*) in the two seasons. Increased vegetative growth and total heads yield can be attributed to the role of inoculated microorganisms in reducing soil acidity by secreting some organic acids such as acetic, propionic, succinic and fumaric acids that consequently convert some insoluble nutrients into available soluble forms[18,19]**.** In addition, inoculation of *Mycorrhizae* could improve plant root system, increase the surface area for nutrients absorption from the soil resulted in an increased vegetative growth of broccoli plants[20]**.** Moreover**,** it improves each of soil texture, water-holding capacity and plant disease resistance[21]**.** Some investigators came to similar results**.** The increase in vegetative growth and total heads yield may be due to increase in soil microflora by the addition of bio-fertilization[22]. In addition, treated plants by *Azospirillum brasilense* or *Azotobacter chroococcum* increased vegetative growth characteristics and yields of broccoli plants compared with the non-inoculated plants[23]**.** They added that *Azotobacter chroococcum* was superior in increasing these parameters compared to *Azospirilum* treatment.

Effect of mineral and organic sources:

Results in Table (5) indicated that plants treated with 75% mineral+ 25% organic of the recommended fertilizer units gave the highest vegetative growth, *i.e.* leaves number, leaf area as well as plant fresh and dry weights and total heads yield followed by the level of 100% mineral of the recommended fertilizer units. However, the lowest values were obtained by the level of 25% mineral+ 75% organic of the recommended fertilizer units in both seasons.

The increased vegetative growth and total heads yield of broccoli plants could be referred to the beneficial effect of combined use of mineral and organic fertilizers which mitigate the deficiency of many secondary and microelements in the plants that previously treated with macro elements only for many years without addition of microelements or organic fertilizers. The differences in vegetative growth and yield due to mineral and organic fertilizer equations might be also due to the resulting abundant soluble nutrients which enable plants to absorb more water and nutrients of the soil solution and wider photosynthetic surfaces (leaf number and area) which allows better photosynthetic capacity, more dry matter accumulation in plant tissues and more heads yield. Some investigators came to similar results[24, 25].

Interaction of bio-, mineral and organic fertilizer sources:

Data in Table (6) indicated that number of leaves per plant, leaf area as well as plant fresh and dry weights and total heads yield were significantly affected by the combined effect of bio, mineral and organic fertilizer sources. Applications of Bio.2 with level of 75% mineral+ 25% organic of the recommended fertilizer units resulted in the highest values of all characteristics of the vegetative growth and total heads yield of broccoli plants. The differences between the two treatments Bio.2 with 100% mineral and Bio.1 with 75% mineral+ 25% organic of the recommended fertilizer units did not reach the level of significance. However, the lowest values of vegetative growth parameters and total heads yield were obtained by plants receiving 25% mineral+ 75% organic of the recommended units without bio-fertilizer addition in both seasons.

The increased vegetative growth and total heads yield of broccoli plants may by referred to the combined effect of bio-fertilizer and 75% mineral+ 25% organic which maintains and promotes productivity of the soil by adjustment of soil fertility, increasing the activity of microorganisms leading to more plant nutrient supply and the highest vegetative growth[26]**.** These results agreed with those obtained by[27, 28]**.**

Table (4): Effect of bio-fertilization on vegetative growth and total heads yield of broccoli plants during 2012/2013 and 2013/2014.

Bio-fertilization treatments	Number of leaves/ plant	Leaf area(cm^2)	Total plant fresh weight (g/plant)	Total plant dry weight (g/ 100 g F.W.)	Total heads yield (ton/ fed)
	(2012-2013)				
Without Bio.	10.42 D	363.61 E	405.42 E	21.35 D	3.69 E
Bio. 1	13.25 AB	427.43 D	523.21 B	26.23 B	5.02 B
Bio. 2	13.75 A	496.70 A	562.38 A	28.56 A	5.22 A
Bio. 3	11.92 C	436.40 C	461.09 D	23.88 C	4.65 D
Bio. 4	12.50 BC	442.60 B	483.21 C	25.63 B	4.86 C
	(2013-2014)				
Without Bio.	11.75 D	303.52 E	404.31 D	20.50 D	3.52 D
Bio. 1	13.67 BC	340.36 D	558.75 B	26.59 B	4.80 B
Bio. 2	14.83 A	380.49 A	593.32 A	29.86 A	5.16 A
Bio. 3	13.17 C	352.39 C	500.36 C	24.27 C	4.29 C
Bio. 4	14.00 B	358.56 B	563.51 B	25.91 B	4.68 B

Values followed by the same letter (s) are not significantly different at 5%

Bio. 1, *Aztobacter chroococcum+ Bacillus megaterium;* Bio. 2, *Aztobacter chroococcum+ Arbiscular mycorrhizea*
Bio. 3, *Bacillus polymyxa + Bacillus megaterium;* Bio. 4, *Bacillus polymyxa+ Arbiscular mycorrhizea*

Table (5): Effect of fertilizer equation on vegetative growth and total heads yield of broccoli plants during 2012/2013 and 2013/2014.

Fertilizer equation Treatments	Number of leaves/plant	Leaf area (cm^2)	Total plant fresh weight (g/plant)	Total plant dry weight (g/ 100 g F.W.)	Total heads yield (ton/fed.)
	(2012-2013)				
25% M + 75% O	10.33 C	364.50 D	367.03 C	22.18 D	3.12 D
50% M + 50% O	11.40 B	404.86 C	452.40 B	24.00 C	4.54 C
75% M + 25% O	14.07 A	491.74 A	562.14 A	27.78 A	5.63 A
100%M	13.67 A	472.29 B	566.67 A	26.57 B	5.46 B
	(2013-2014)				
25% M + 75% O	10.80 C	302.28 D	373.57 D	22.71 D	2.43 D
50% M + 50% O	12.07 B	333.50 C	486.99 C	23.83 C	3.65 C
75% M + 25% O	15.87 A	378.33 A	627.34 A	28.04 A	6.03 A
100%M	15.20 A	374.15 B	608.30 B	27.12 B	5.85 B

Values followed by the same letter (s) are not significantly different at 5%

M, Mineral; O, Organic

Table (6): Effect of interaction between bio-fertilization and fertilizer equation on vegetative growth and total heads yield during 2012/2013 and 2013/2014.

Bio-fertilization Treatments	Fertilizer equation	Number of leaves/ plant	Leaf area(cm^2)	Total plant fresh weight (g/plant)	Total plant dry weight (g/ 100 g F.W.)	Total heads yield (ton/fed.)
		(2012-2013)				
Without Bio.	25% M + 75% O	8.33 j	325.57 j	313.09 n	19.10 l	2.31 n
	50% M + 50% O	9.67 ij	352.16 i	374.77 k	20.18 kl	3.26 l
	75% M + 25% O	11.33 f-i	381.17 h	427.95 i	22.18 ijk	4.25 j
	100%M	12.33 d-g	395.53 fg	505.87 g	23.95 hi	4.93 gh
Bio. 1	25% M + 75% O	10.67 ghi	382.13 h	378.78 k	23.24 hij	3.34 l
	50% M + 50% O	12.33 d-g	385.83 gh	504.66 g	25.10 fgh	5.07 g
	75% M + 25% O	15.67 a	471.17 c	612.97 b	29.80 ab	6.00 ab
	100%M	14.33 abc	470.57 c	596.42 c	26.80 b-f	5.69 de
Bio. 2	25% M + 75% O	11.67 e-h	398.51 f	444.97 h	25.40 e-h	3.92 k
	50% M + 50% O	12.67 c-f	470.45 c	528.56 f	27.69 b-e	5.08 g
	75% M + 25% O	16.00 a	560.30 a	639.60 a	31.71 a	6.11 a
	100%M	14.67 ab	557.56 a	636.38 a	29.46 abc	5.76 cd
Bio. 3	25% M + 75%O	10.33 hi	388.18 fgh	340.48 m	21.08 jkl	2.84 m
	50% M + 50% O	10.67 ghi	392.36 fgh	413.13 j	22.24 ijk	4.53 i
	75% M + 25% O	13.00 b-f	485.88 b	552.88 e	27.12 c-g	5.83 bcd
	100%M	13.67 bcd	479.17 bc	537.86 f	25.09 fgh	5.40 f
Bio. 4	25% M + 75%O	10.67 ghi	328.13 j	357.81 l	22.09 ijk	3.18 l
	50% M + 50% O	11.67 e-h	423.49 e	440.90 h	24.81 gh	4.76 h
	75% M + 25% O	14.33 abc	560.16 a	577.27 d	28.08 bcd	5.95 abc
	100%M	13.33 b-e	458.64 d	556.84 e	27.54 d-g	5.54 ef

Values followed by the same letter (s) are not significantly different at 5%

Bio. 1, *Aztobacter chroococcum+ Bacillus megaterium;* Bio. 2, *Aztobacter chroococcum + Arbiscular mycorrhizea*

Bio. 3, *Bacillus polymyxa + Bacillus megaterium;* Bio. 4, *Bacillus polymyxa + Arbiscularmycorrhizea;*

M, Mineral; O, Organic

Table (6): Continued

Bio-fertilization Treatments	Fertilizer equation	Number of leaves/ plant	Leaf area(cm^2)	Total plant fresh weight (g/plant)	Total plant dry weight (g/ 100 g F.W.)	Total heads yield (ton/fed.)
		(2013-2014)				
Without Bio.	25% M + 75% O	9.33 h	274.35 n	255.73 m	17.33 j	1.72 k
	50% M + 50% O	11.00 fgh	299.30 m	410.64 j	18.16 j	3.18 i
	75% M + 25% O	12.33 ef	313.61 l	454.68 h	22.22 i	3.97 g
	100%M	14.33 cd	326.82 ijk	496.19 g	24.30f fgh	5.21 e
Bio. 1	25% M + 75% O	11.00 fgh	261.20 o	404.31 k	24.32 fgh	2.75 j
	50% M + 50% O	12.67 ef	349.19 h	389.05 f	25.14 f	3.88 gh
	75% M + 25% O	16.00 abc	379.09 def	530.41 a	29.51 bc	6.50 a
	100%M	15.00 bc	371.98 f	674.14 bc	27.38 de	6.07 bcd
Bio. 2	25% M + 75% O	12.00 efg	335.51 i	641.40 h	27.12 de	3.30 i
	50% M + 50% O	13.00 de	359.44 g	558.75 e	28.92 cd	4.35 f
	75% M + 25% O	17.67 a	418.53 a	455.09 a	32.35 a	6.66 a
	100%M	16.67 ab	408.49 b	560.88 a	31.03 ab	6.32 abc
Bio. 3	25% M + 75% O	10.33 gh	319.51 kl	683.14 l	21.91 i	1.82 k
	50% M + 50% O	11.67 efg	329.55 ij	674.19 j	22.46 hi	3.29 i
	75% M + 25% O	16.00 abc	384.83 de	593.32 b	27.20 de	6.37 ab
	100%M	14.67 c	375.68 ef	336.74 d	25.49 ef	5.70 d
Bio. 4	25% M + 75% O	11.33 efg	320.81 jkl	412.80 i	22.89 ghi	2.55 j
	50% M + 50% O	12.00 efg	330.04 ij	651.54 f	24.47 fg	3.54 hi
	75% M + 25% O	17.33 a	395.62 c	600.34 a	28.89 cd	6.65 a
	100%M	15.33 bc	387.76 cd	500.36 c	27.40 de	5.97 cd

Values followed by the same letter (s) are not significantly different at 5%

Bio. 1, *Aztobacter chroococcum+ Bacillus megaterium;* Bio. 2, *Aztobacter chroococcum + Arbiscular mycorrhizea*

Bio. 3, *Bacillus polymyxa + Bacillus megaterium;* Bio. 4, *Bacillus polymyxa + Arbiscular mycorrhizea;*

M, Mineral; O, Organic

B)- Leaves nutrients content:

Effect of bio-fertilization:

Table (7) showed that nitrogen, phosphorus and potassium percentages in the tissues of leaves of broccoli plants were significantly enhanced by the application of bio-fertilizer treatment compared with untreated plants. The application of Bio.2 *(Azotobacter+ Mycrrohyzae)* led to the highest values of N, P and K percentages in plant leaves tissues followed by Bio.4 treatment without significant differences in the two seasons. On the contrary, the lowest values were recorded by un-treated plants.

The highest nutrients content in leaves tissues were obtained by Bio.2 (*Azotobacter+ Mycorrhizae*) or Bio.4 (*Bacillus polymyxa+ Mycorrhizae*) treatments may be attributed to the positive effect of microorganisms in increasing availability of these nutrients in the soil solution. Microorganisms reduced rizosphere pH through excretion of some organic acids such as acetic, propionic, succinic and fumaric acids thus convert some insoluble nutrients into available forms[18]**.** Moreover, the inoculation of *Mycorrhizae* may increase the plant roots system and consequently increase the surface area for nutrient absorption from the soil[20]**.** These conditions enables plants to benefit more of the natural resources, *i.e*. light, soil solution and Co_2 absorption leading to more photosynthetic activity which increases N, P and K translocation and increased their content in plant leaves.

Effect of mineral and organic fertilizer sources:

Data presented in Table (8) show that the highest values of nitrogen, phosphorus and potassium percentages in the leaves tissues of broccoli plants were obtained by 75% mineral + 25% organic of the recommended fertilizer units followed by the level of 100% mineral of the recommended fertilizer units without significant differences. While, the lowest values were recorded in the level of 50% mineral+ 50% organic or 25% mineral + 75% organic of the recommended fertilizer units, in the two seasons. The increased nutrients concentrations in leaves tissues could be explained by the increase in nutrients absorption due to the combined effect of mineral fertilizers (more soluble and available to plants) and organic fertilizers (have different dynamics of nutrient availability)[26]**.**

Interaction of bio., mineral and organic fertilizer sources:

Data in Table (9) showed that interaction between bio-, mineral and organic fertilization sources statistically enhanced nitrogen, phosphorus and potassium percentages in leaves tissues of broccoli. The combined effect of Bio.2 with the level of 75% mineral + 25% organic of the recommended fertilizer units or Bio.2 with100% mineral of the recommended fertilizer units led to the highest values of N, P and K percentages in leaves tissues. On the other hand, the lowest values of these nutrients in leaves tissues were recorded by the levels of 25% mineral + 75% organic of the recommended fertilizer units without bio-fertilizer addition in both of the two seasons.

Increases in nutrients content of broccoli leaves tissues may be due to the induced plant roots absorption enhancement. This enhancement is caused by the effect of interaction between bio-fertilization and 75% mineral +25% organic of the recommended fertilizer units consequently more soil fertility was exist[26]**.**

Table (7): Effect of bio-fertilization on leaves nutrient content of broccoli plants during two seasons of 2012/2013 and 2013/2014.

Bio-fertilization treatments	N (%)	P (%)	K (%)
	(2012-2013)		
Without Bio.	2.42 C	0.33 D	2.13 C
Bio. 1	3.68 B	0.54 B	2.87 AB
Bio. 2	4.59 A	0.60 A	2.97 A
Bio. 3	3.38 B	0.45 C	2.69 B
Bio. 4	3.96 AB	0.53 B	2.78 AB
	(2013-2014)		
Without Bio.	2.47 C	0.38 D	1.86 B
Bio. 1	3.79 B	0.51 BC	2.52 A
Bio. 2	5.45 A	0.57 A	2.80 A
Bio. 3	3.60 B	0.46 C	2.40 A
Bio. 4	4.58 AB	0.53 AB	2.56 A

Values followed by the same letter (s) are not significantly different at 5%
Bio.1, *Aztobacter chroococcum+ Bacillus megaterium*; Bio.2, *Aztobacter chroococcum + Arbiscular mycorrhizea*
Bio.3, *Bacillus polymyxa + Bacillus megaterium;* Bio.4, *Bacillus polymyxa + Arbiscular mycorrhizea*

Table (8): Effect of Fertilizer equation on leaves nutrient content of broccoli plants during 2012-2013/2013-2014.

Fertilizer equation	N (%)	P (%)	K (%)
	(2012-2013)		
25% M + 75% O	2.64 B	0.41 B	1.81 B
50% M + 50% O	3.07 B	0.43 B	1.94 B
75% M + 25% O	4.43 A	0.57 A	3.53 A
100%M	4.29 A	0.56 A	3.47 A
	(2013-2014)		
25% M + 75% O	3.33 B	0.41 B	1.57 B
50% M + 50% O	3.68 B	0.43 B	1.68 B
75% M + 25% O	4.62 A	0.57 A	3.25 A
100%M	4.28 A	0.56 A	3.21 A

Values followed by the same letter (s) are not significantly different at 5%
M, Mineral; O, Organic

Table (9): Effect of interaction between bio-fertilization and fertilizer equation on leaves nutrient content of broccoli plants during 2012-2013/ 2013-2014.

Bio-fertilization Treatments	Fertilizer equation Treatments	N (%)	P (%)	K (%)
		(2012-2013)		
Without Bio.	25% M + 75% O	1.71 j	0.26 h	1.38 f
	50% M + 50% O	2.64 ij	0.29 h	1.46 ef
	75% M + 25% O	3.17 g-j	0.35 gh	2.73 c
	100%M	2.56 f-i	0.42 efg	2.95 bc
Bio.1	25% M + 75% O	2.13 g-j	0.47 def	1.94 de
	50% M + 50% O	3.19 e-i	0.48 def	2.12 d
	75% M + 25% O	3.68 bcd	0.62 ab	3.78 a
	100%M	2.96 b-e	0.61 abc	3.66 a
Bio.2	25% M + 75% O	2.74 e-i	0.51 cde	2.09 d
	50% M + 50% O	4.54 c-h	0.52 b-e	2.19 d
	75% M + 25% O	5.99 a	0.70 a	3.81 a
	100%M	4.12 ab	0.65 a	3.77 a
Bio.3	25% M + 75% O	3.10 hij	0.36 gh	1.78 de
	50% M + 50% O	4.37 f-i	0.41 fg	1.90 de
	75% M + 25% O	5.50 c-f	0.55 bcd	3.63 a
	100%M	3.89 c-g	0.50 def	3.43 ab
Bio.4	25% M + 75% O	4.37 f-i	0.44 d-g	1.86 de
	50% M + 50% O	5.50 d-i	0.45 d-g	2.05 d
	75% M + 25% O	3.89 bc	0.62 ab	3.69 a
	100%M	4.57 bcd	0.61 abc	3.53 a

Values followed by the same letter (s) are not significantly different at 5%
Bio.1, *Aztobacter chroococcum+ Bacillus megaterium;* Bio.2, *Aztobacter chroococcum + Arbiscular mycorrhizea*
Bio.3, *Bacillus polymyxa + Bacillus megaterium;* Bio. 4, *Bacillus polymyxa + Arbiscular mycorrhizea;*
M, Mineral; O, Organic

Table (9): Continued

Bio-fertilization Treatments	Fertilizer equation Treatments	N (%)	P (%)	K (%)
		(2013-2014)		
Without Bio.	25% M + 75% O	2.08 j	0.32 f	1.43 c
	50% M + 50% O	2.32 ij	0.36 ef	1.47 bc
	75% M + 25% O	2.62 hij	0.40 ef	2.28 b
	100%M	2.85 g-j	0.43 def	2.29 b
Bio.1	25% M + 75% O	3.15 f-i	0.43 def	1.58 bc
	50% M + 50% O	3.30 e-j	0.48 def	1.73 bc
	75% M + 25% O	4.85 bcd	0.59 abc	3.40 a
	100%M	3.88 d-h	0.58 a-d	3.37 a
Bio.2	25% M + 75% O	4.51 cde	0.47 d-f	1.82 bc
	50% M + 50% O	4.98 bcd	0.48 b-e	1.84 bc
	75% M + 25% O	6.31 a	0.67 a	3.80 a
	100%M	5.98 ab	0.67 a	3.75 a
Bio.3	25% M + 75% O	3.10 f-j	0.38 ef	1.51 bc
	50% M + 50% O	3.48 e-i	0.40 ef	1.64 bc
	75% M + 25% O	3.99 c-g	0.57 a-d	3.24 a
	100%M	3.81 d-h	0.51 b-e	3.22 a
Bio.4	25% M + 75% O	3.78 d-h	0.44 c-f	1.53 bc
	50% M + 50% O	4.32 c-f	0.46 c-f	1.73 bc
	75% M + 25% O	5.32 abc	0.62 ab	3.55 a
	100%M	4.90 bcd	0.61 ab	3.41 a

Values followed by the same letter (s) are not significantly different at 5%
Bio.1, *Aztobacter chroococcum+ Bacillus megaterium;* Bio.2, *Aztobacter chroococcum + Arbiscular mycorrhizea*
Bio.3, *Bacillus polymyxa + Bacillus megaterium;* Bio.4, *Bacillus polymyxa + Arbiscular mycorrhizea;*
M, Mineral; O, Organic

Conclusion

It seems that the integrated application of biological (*Azotobacter+ Arbsicular mycrrohyzae*) with 75% mineral + 25% organic of the recommended fertilizer units on broccoli plants lead to the highest values of vegetative growth, leaves nutrient content and total heads yield.Therefore, the treatment of 75% mineral + 25% organic of the recommended fertilizer units and *Azotobacter + Arbiscular mycrrohizae* was the most favourable treatment with respect to plant growth parameters *i.e.* number of leaves, leaf area, plant fresh weight and plant dry matter. Generally, data of plant growth showed that adding a mixture of biofertilizers (*Azotobacter + Arbiscular mycrrohizae*) can save at least 25% of nitrogen and 25% of phosphorous requirements of broccoli plants.

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