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Impact of Organic, Mineral and Bio-Fertilization on Broccoli

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ABSTRACT

Two field experiments were conducted at the Experimental Station Farm, Faculty of Agriculture, Mansoura University, Egypt, during 2014/2015 and 2015/2016 seasons to estimate the effect of organic (compost and compost tea), mineral (100%, 75% and 50% from recommended dose of NPK) and bio-fertilization (without, mixture of bacteria with fungi and EM) as well as their interactions on growth, yield and quality of broccoli plants. Data which obtained in this experiment indicated that organic treatments gave the highest means of vegetative growth parameters, total yield and quality of broccoli heads were recorded from plants which fertilized with compost compare to compost tea except total carbohydrates and regarding to mineral fertilization, broccoli plants which fertilized with 75% NPK from recommended dose gave the maximum means of all studied characters in both seasons. Moreover bio-fertilizers, the highest values of all parameters were resulted from plants treated with EM followed by bio-fertilizer mixture treatment in both seasons. It could be recommended that fertilization of broccoli plants with compost (4 ton/fed.), 75% NPK from recommended dose and inoculation with EM (10 ml/plant) in would improve broccoli plants productivity and quality.
Keywords: broccoli, compost, compost tea, EM, *Azotobacter*, *Bacillius*, NPK.

INTRODUCTION

Sprouting broccoli (*Brassica oleracea* L. var. italica) belongs to the family Brassicaceae. Broccoli is grown in a very limited scattered areas in Egypt, while it is widely cultivated in many European and American countries. Broccoli has a great importance, enormous nutritional and medicinal values attributed to being vitamins, minerals, number of antioxidants which decrease the formation of cancer (Goncalves *et al*., 2011).

There are very important studies under Egyptian conditions to establish recommendation for decreasing the quantity of mineral fertilizers which used in large quantities and reduced quality of plants by using organic and bio-fertilization.

Organic fertilizer subject to different reactions, which have their main effects generally on long term and play direct role in plant growth as a source of all necessary macro and micronutrients in available forms and improving physical and chemical properties of soils. The organic manure (such as compost and compost tea) is source of nitrogen and other nutrients, which can minimize the demand of chemical fertilizers, and it has been used for many centuries to increase soil fertility. Moreover, many researchers have mentioned the beneficial effects of organic fertilizer including the increase of hydraulic conductivity, increasing water holding capacity, changes soil pH and reducing the frequency of plant diseases (Tagoe *et al*., 2008 and Hewidy *et al.*, 2015). Meanwhile, Hashem and Abd-Elrahman (2016) showed that liquid organic fertilizers had promotive effect on all growth parameters including the vegetative growth, yield and nutrients content in broccoli plants. Also, Ganesh and Kumar (2016) found that 75% NPK + compost gave the highest plant height, leaves number per plant and yield of onion and cassava.

Mineral fertilizers application is essential for plant growth, development and yield productivity of plants. However, adding huge amount of chemical fertilizers lead to pollution. Mineral nutrition does play an important role in influencing the quality of crops but it is a fact that the soil health deteriorates (Savci, 2012). In the same direction Brahma and Phookan (2006) and Islam *et al. (*2010) mention that increasing phosphorus levels improved the plant growth, yield and head quality of broccoli. Other investigators studied the effect of mineral nitrogen levels on broccoli plant and found clear increments in nitrate accumulation (Zaki *et al*., 2012 and Giri *et al.*, 2013). As well as, Abdel Naby *et al*. (2013) found that the interactions among compost, bio fertilizers (Mixture or EM) and 75% NPK gave superiority for yield and quality of carrot plants.

The healthy agriculture with a minimum pollution requires a conjunctive use of bio fertilizers. Some investigators stated that bio fertilization increased yield of cruciferous and broccoli vegetables (Singh and Singh, 2005 and Howladar *et al.*, 2013). EM is a mixture of beneficial and effective microorganisms that is used as a foliar or soil amendment. It contains selected species of microorganisms, including predominant populations of lactic acid, yeasts, smaller numbers of photosynthetic bacteria, bacteria, actinomycetes and many other types of organisms (Woodward, 2003). In the same direction, Selim *et al.* (2009) noticed that treated broccoli with the bio-fertigation mixture of (*Azotobacter chroccoccum*, *Bacillus megatherium* and *Bacillus circulans)* combined with 100% recommended rate of NPK under drip fertigation tended to increase significantly all vegetative growth parameters, yield and its quality. Muyang *et al*. (2014) on potato reported that plants treated with EM increased vegetative growth parameters and yield.

Therefore, this research aimed to evaluate the response of broccoli to utilization of organic mineral and bio-fertilization as a try to reduce amount of mineral fertilizers and environmental pollution and costs.

MATERIALS AND METHODS

Two field experiments were carried out to study the effect of organic, mineral and bio-fertilization on vegetative growth, head yield and quality parameters of broccoli (*Brassica oleracea* L. var. italic) cultivar "Agasi".

Factorial experiment in strip split plot design was used with 3 replicates for each treatment. The experiment included 18 treatments (2 organic fertilizers, 3 mineral fertilizers and 3 bio-fertilizers).

- **Organic fertilizers:**

a- Compost.
b- Compost tea.

- **Mineral fertilizers:**

a- 100% NPK of recommended dose.
b- 75% NPK of recommended dose.

c- 50% NPK of recommended dose.

- **Bio fertilizers:**

a- Without bio-fertilizer.

b- Mixture of (*Azotobacter chroococcum – Bacillus circulans – Mycrrohiza*).

c- EM.

Seeds were sown in the nursery in foam trays filled with a mixture of peat moss and vermiculite (1:1 volume) on 1st week of September and seedlings were transplanted on 2nd week of October on rows, with 0.7 m width and 5 m length with 0.5 m apart in the two seasons. Each plot included 3 rows thus plot area was 10.5 m2. The physical and chemical properties of the experimental soil are presented in Table1 during the two seasons.

Table 1. Physical and chemical analysis of experimental soil during 2015 and 2016 seasons:

seasons	Mechanical analysis (%)				Texture class	OM (%)	SP	$CaCO_3$ %	EC $dS.m^{-1}$ 1:5	pH (1:2.5)	Available (ppm)		
	Clay Sand	Fine Sand	silt	clay							N	P	K
1st	3.2	27.4	37.8	31.6	Loamy	1.82	45.6	28.2	1.12	8.03	46.7	6.09	265
2nd	3.8	29.2	36.7	30.3	Loamy	1.86	48.4	32.1	1.08	7.98	47.4	5.95	273

SP: saturation percentage OM: Organic matter EC: Electrical conductivity

The recommended doses of mineral fertilizers were: (Ammonium nitrate 33.5 N% at the level of 100 kg N/fed.; calcium super phosphate 15.5% P_2O_5at the level of 50 P_2O_5/fed. and potassium sulphate 48% K_2O at the level of 60 K_2O/fed.). The given doses divided into two equal parts; the first addition was at 21 days from transplanting and the other was at three weeks later in both seasons, except phosphorus fertilizer was added before sowing.

Compost rice straw was added during soil preparation at the rate of 4 tons/fed. , the chemical analysis of compost is presented in Table 2,

Table 2. Chemical analysis of compost:

%			C/N	%		ppm			pH 1:5	EC1:10 $dS-^{1}m$
OM	OC	N		P	K	Fe	Mn	Zn		
75.3	43.8	2.19	20.0	0.32	0.41	28.16	14.05	9.12	6.05	7.14

OM: Organic matter OC: Organic carbon

Compost tea was added at 10 ml/plant three times: the first after two weeks from transplanting and 10 days interval between other times. Preparing compost tea was according to Mostafa *et al.* (2009). Some chemical characteristics of compost tea are shown in Table 3.

Table 3. The chemical composition of compost tea:

Mg L^{-1}						PH	EC $dS.m^{-1}$
N	P	K	Fe	Mn	Zn		
109	16.7	324	17.8	11.9	3.75	6.81	6.33

All inoculants were provided by bio-fertilizer unit, Faculty of Agriculture Ain Shams University. Application mixture of beneficial microorganisms was done by soil inoculation at 10 ml of bio-fertilizers mixture solution to the wet soil at the root absorption zone of each plant twice; after 10 days from transplanting and 10 days later.

EM was obtained from Ministry of Agriculture and added at 10 ml/plant twice at the aforementioned times.

Data recorded:

After 90 days from transplanting ten plants from each treatment were randomly chosen and the following data were recorded:

Vegetative growth characters:

- No. of leaves/ plant.
- Leaves fresh weight (g/plant).
- Main head fresh weight (g/plant).
- Head dry weight percentage.

Head yield and physical head quality:

- Main head yield (ton/fed.).
- Head diameter (cm).
- Head height (cm).

Quality parameters

- Chlorophyll content in broccoli was estimated as the method described by Goodwine (1965).
- Carotenoids were estimated as described by Dubois *et al*. (1956).
- Carbohydrates percentage: It was estimated in head of broccoli plants according to the method described by Hedge and Hofreiter (1962).
- Vitamin C (mg/100g): It was estimated in broccoli heads according to the method reported in AOAC (2000).

Statistical analysis:

Data were statistically analyzed according to the technique of ANOVA for strip split plot design according to Gomez and Gomez (1984). The treatment means were compared using Duncan Multiple Rang Test (Duncan, 1955).

RESULT AND DISCUSSION

Effect of organic fertilization:

Results in Tables 4,5 and 6 show that all measured characters, *i.e.,* No. of leaves, fresh weight of leaves, main head fresh weight, dry matter percentage, head diameter, head height, main head yield, carotenoids, vitamin C and chlorophyll a+b except total carbohydrates of broccoli in both seasons were increased by compost compared with compost tea.

These results can be attributed to the positive impacts of compost on soil physical and chemical properties, where organic matter improved soil drainage, ventilation and increased the soil ability to water retain. It is known that compost is used as a soil amendment, which improves water holding capacity of soils and increases availability of elements such as boron, which consider an essential micronutrient for plants, it is essential for cell wall formation, synthesis of cytokinins, nucleic acid, it facilitates sugar translocation in plants and it influences cell development and

elongation, which in turn enhances vegetable growth parameters and yield. These results are in agreement with those obtained by Jigme *et al.* (2015) and Hashem and Abd-Elrahman (2016) on broccoli plants.

Effect of mineral fertilization:

Regarding to the effect of NPK-fertilization data in the same tables show that fertilization with 75 percentage of recommended dose from NPK gave the highest values of all aforementioned parameters of broccoli.

These results may be due to adding suitable fertilizer dose gave a good chance for the vegetative growth by the positive effect of N, P and K on the biological status, which led to rapid absorption, that improved clearly vegetative growth of plant organs by increasing chlorophyll and carbohydrates formation, increment of photosynthesis rate which reflected on the improvement of aforementioned parameters. These results are in harmony with those obtained by Islam *et al.* (2010) and Giri *et al.* (2013) on broccoli.

`Effect of bio-fertilization:

The same Tables show the effect of bio-fertilization as compared with untreated plants. EM gave the highest values of all parameters mentioned previously and the differences were significantly followed by mixture treatment.

The efficiency of bio-fertilizers may be due to increased activity of bacteria and fungi in reduction of soil pH by secreting organic acids and more solubility and availability of nutrients for broccoli, this lead to more nutrient uptake and high vegetative growth.

Table 4. Number of leaves, weight of leaves, weight of main head, dry matter in broccoli heads as affected by organic, mineral and bio-fertilization as well as their interactions during 2015 and 2016 seasons.

Characters	Number of leaves		Weight of leaves (g)		Weight of main head (g/plant)		Dry matter (%)	
Treatments	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
A- Organic fertilization:								
Compost	58.48	57.33	623.9	613.1	634.5	593.0	13.99	12.62
Compost tea	50.11	48.11	549.9	537.2	545.4	494.7	12.82	12.29
F. test	*	*	*	*	*	*	*	*
B- Mineral fertilization:								
100 %	54.11 b	52.33 b	582.7 b	569.7 b	592.6 b	543.5 b	13.41 b	12.46 b
75 %	57.27 a	55.77 a	616.2 a	607.1 a	630.6 a	576.7 a	13.56 a	12.61 a
50 %	51.50 c	50.05 c	561.8 c	548.7 c	546.7 c	511.3 c	13.25 c	12.30 c
C- Bio fertilization:								
Without	44.72 c	42.55 c	494.0 c	483.8 c	484.8 c	434.6 c	12.94 c	12.03 c
Mix	55.66 b	54.27 b	597.6 b	584.1 b	601.6 b	547.6 b	13.40 b	12.44 b
EM	62.50 a	61.33 a	669.2 a	657.7 a	683.4 a	649.5 a	13.88 a	12.89 a
D- Interactions:								
A × B	*	*	NS	NS	NS	*	NS	NS
A × C	NS	NS	*	NS	*	*	NS	NS
B × C	*	NS	*	*	NS	*	NS	NS
A × B × C	*	*	*	NS	NS	*	NS	NS

Table 5. Head height, head diameter and main head yield/fed. of broccoli as affected by organic, mineral and bio-fertilization as well as their interactions during 2015 and 2016 seasons.

Characters	Head height (cm)		Head diameter (cm)		Main head yield (t/fed)	
Treatments	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
A- Organic fertilization:						
Compost	13.64	13.44	15.81	15.60	5.114	4.742
Compost tea	12.37	12.14	13.58	13.37	4.369	3.957
F. test	*	*	*	*	*	*
B- Mineral fertilization:						
100 %	12.97 ab	12.74 ab	14.66 b	14.40 b	4.742 b	4.347 ab
75 %	13.49 a	13.27 a	15.39 a	15.23 a	5.052 a	4.613 a
50 %	12.55 b	12.37 b	14.04 c	13.82 b	4.429 c	4.088 b
C- Bio fertilization:						
Without	11.78 b	11.61 c	12.57 c	12.32 c	3.935 c	3.476 c
Mix	13.03 a	12.78 b	14.55 b	14.36 b	4.821 b	4.378 b
EM	14.19 a	14.00 a	16.97 a	16.77 a	5.468 a	5.195 a
D- Interactions:						
A × B	NS	NS	*	*	*	*
A × C	*	*	*	*	*	*
B × C	*	*	*	*	*	*
A × B × C	*	*	NS	NS	*	*

Table 6. Total carbohydrates percentage, carotenoids, vitamin-C (VC), and chlorophyll a+b in broccoli heads as affected by organic, mineral and bio-fertilization as well as their interactions during 2015 and 2016 seasons.

Characters	Total carbohydrates (%)		Carotenoids (mg/100 g)		VC (mg/100 g)		Chlorophylls a+b (mg/g F W)	
Treatments	2015	2016	2015	2016	2015	2016	2015	2016
A- Organic fertilization:								
Compost	18.86	19.68	4.47	4.34	167.6	161.2	0.941	0.976
Compost tea	20.73	21.02	3.50	4.25	113.4	114.3	0.876	0.888
F. test	*	*	*	*	*	*	*	*
B- Mineral fertilization:								
100 %	19.79 ab	20.36 b	3.98 b	4.26 b	119.8 c	117.0 b	0.905 b	0.936 a
75 %	19.94 a	20.50 a	4.09 a	4.40 a	120.8 b	180.5 a	0.922 a	0.927 b
50 %	19.65 b	20.19 c	3.87 c	4.23 b	181.0 a	115.7 c	0.897 c	0.934 ab
C- Bio fertilization:								
Without	19.38 c	19.84 c	3.68 c	3.94 c	116.3 c	113.2 c	0.853 c	0.900 c
Mix	19.78 b	20.36 b	3.97 b	4.26 b	182.2 a	116.9 b	0.904 b	0.911 b
EM	20.22 a	20.85 a	4.29 a	4.69 a	123.1 b	183.1 a	0.967 a	0.986 a
D- Interactions:								
A × B	NS	NS	NS	NS	NS	NS	NS	NS
A × C	NS	NS	*	*	NS	NS	NS	NS
B × C	NS	NS	NS	*	NS	NS	NS	NS
A × B × C	NS	NS	NS	*	NS	NS	NS	NS

The increments of vegetative growth by EM addition may be attributed to that EM increases the beneficial microbes in the soil that increase nutrient availability and uptake that increases root hairs and elongation. The improvement in head quality may be attributed to the simulative role of microorganisms on biological activity in the soil resulted in better and balanced nutrition by convert organic nitrogen to mineral nitrogen and play important role in converting phosphorus and potassium fixed form to be ready soluble for plant nutrients uptake this lead to better quality. These results are in harmony with those obtained by Selim *et al.* (2009) and Abou El-Magd *et al.* (2014) on broccoli.

Effect of interactions:

Concerning the effect of interactions among treatments, used, compost + 75 percentage NPK and EM addition gave significant superiority in number of leaves/plant in both seasons, weight of leaves/plant in the first season, head height in both seasons, weight of mean heads in the second season, total yield in both seasons, carotenoid in the second season as show in Fig from 1 to 6. These results are in agreement with those reported by Zaki *et al.* (2012) and Abdel Naby *et al.* (2013).

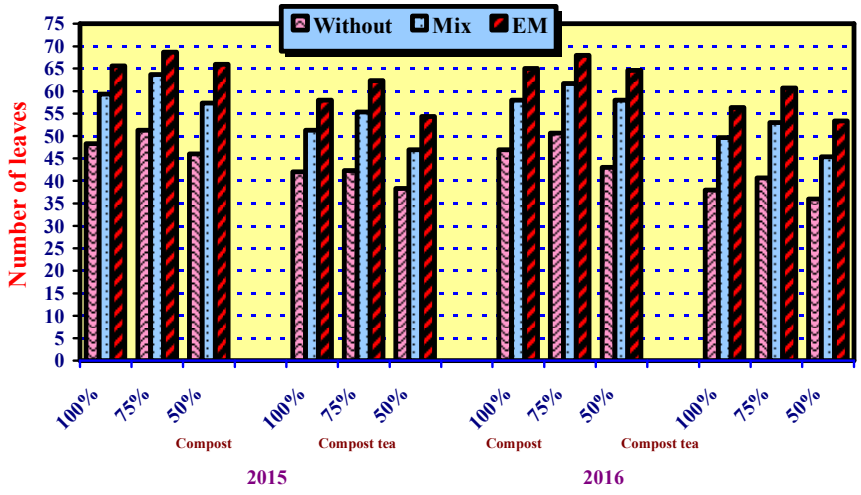

Fig. 1. Number of leaves of broccoli as affected by the interactions among organic, mineral and bio-fertilization during 2015 and 2016 seasons.

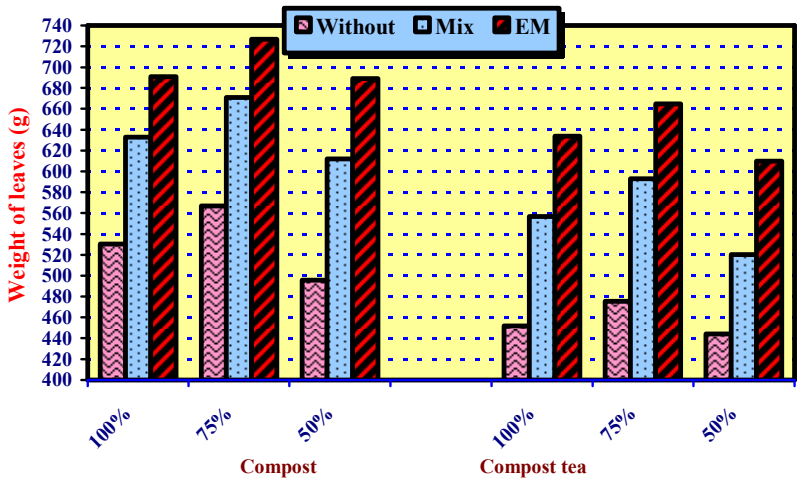

Fig. 2. Weight of leaves (g) of broccoli as affected by the interactions among organic, mineral and bio-fertilization during 2015 season.

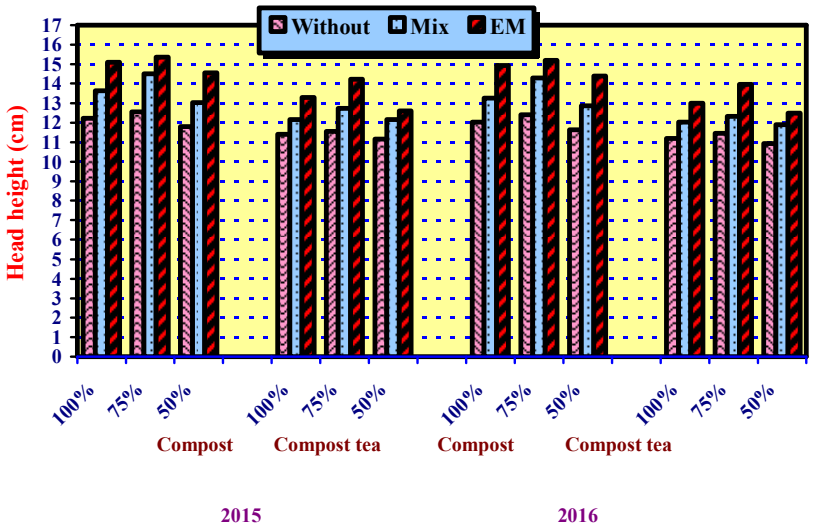

Fig. 3. Head height (cm) of broccoli as affected by the interactions among organic, mineral and bio-fertilization during 2015 and 2016 seasons.

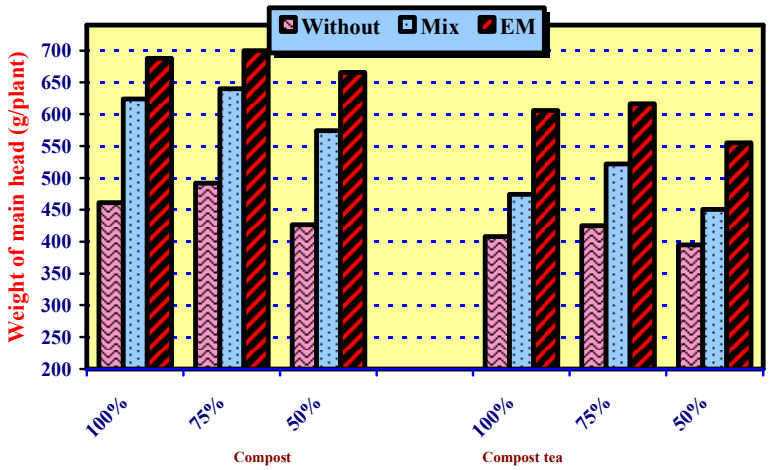

Fig. 4. Weight of main head (g/plant) of broccoli as affected by the interactions among organic, mineral and bio- fertilization during 2016 season.

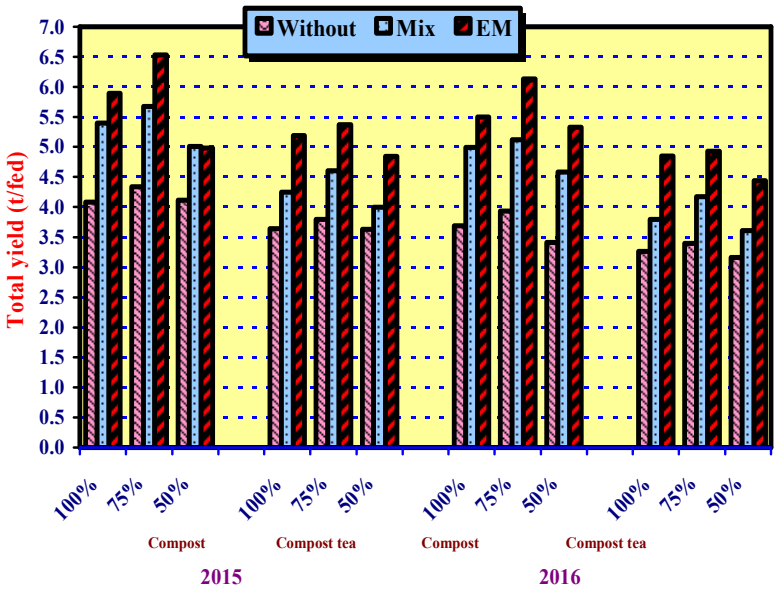

Fig. 5. Total yield (t/fed) of broccoli as affected by the interactions among organic, mineral and bio-fertilization during 2015 and 2016 seasons.

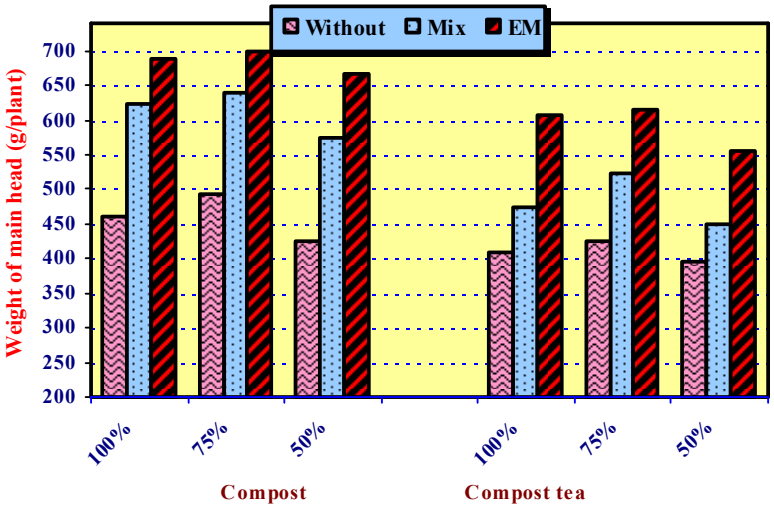

Fig. 6. Carotenoids (mg/100 g) of broccoli as affected by the interactions among organic, mineral and bio-fertilization during 2016 season.

CONCLUSION

Application of organic manures such as compost + 75 percentage NPK from recommended doses + bio-fertilizers as effective microorganisms gave the best vegetative growth, yield and quality moreover decreasing the mineral fertilizer costs, eco-pollution and increasing product quality of broccoli under the similar condition at Dakahlia governorate condition, Egypt.

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تأثير التسميد العضوى والمعدنى والحيوى على البروكولى

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أجريت تجربتان حقليتان بمزرعة كلية الزراعة جامعة المنصورة خلال موسمى 2015/2014 ، 2016/2015 لدراسة تأثير التسميد العضوى (الكمبوست– شاى الكمبوست) والتسميد المعدنى (100% ، 75% ، 50% من الكمية الموصي بها من النتروجين والفوسفور والبوتاسيوم) والتسميد الحيوى (بدون ، مخلوط البكتريا والطحالب ، مركب EM) وكذلك التفاعل بينهما على النمو والمحصول وصفات الجودة لنبات البروكلى صنف أجاسى. وقد اظهرت النتائج التفوق المعنوى لقياسات النمو الخضرى والمحصول وصفات الجودة لنباتات البروكلى عند التسميد العضوى بالكمبوست مقارنة بإستخدام شاى الكمبوست ماعدا محتوي النبات من الكربوهيدرات الكلية. بخصوص تأثير التسميد المعدني فقد تبين أن التسميد بمعدل 75% نتروجين وفوسفور وبوتاسيوم من الكمية الموصي بها قد سببت تفوق معنوي لكل القياسات المدروسة فى كلا الموسمين. وقد أعطي التسميد الحيوي أعلي القيم لكل الصفات المدروسة عند استخدام مركب EM يليه معاملة المخلوط فى كلا الموسمين. من خلال تلك الدراسة يمكن التوصية بتسميد نباتات البروكلى بسماد الكمبوست بمعدل 4 طن / الفدان و التسميد المعدنى بمعدل 75% من الكمية الموصى بها مع التسميد الحيوى باستخدام مركب EM بمعدل 10 مل / النبات للحصول على اعلى انتاجية وصفات جودة.