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IMPROVING THE GROWTH, PRODUCTIVITY AND QUALITY OF SPINACH PLANTS (*Spinacia oleracea* L.)

Wafaa A. Fekry[1] and Dalia A.S. Nawar[2]

1. Plant Prod. Dept., Fac. Tech. and Dev., Zagazig Univ., Egypt

2. Hort. Dept., Fac. Agric. Zagazig Univ., Egypt

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ABSTRACT: This study was carried out at Ghazala Experimental Farm, Faculty of Technology and Development, Zagazig Univ., Egypt during winter seasons of 2014/2015 and 2015/2016 to study the effect of N-biofertilizer (Biogein) and NPK mineral fertilizers as soil addition integrated with foliar spray of PK (Agrosol) and some micronutrients (Sterene) on growth, yield and leaves quality of spinach cv. Dash (F_1 hybrid). The interaction between seeds inoculation with biogein and fertilizing plants with 50% RR (recommended rate) of NPK as soil application and spraying with agrosol at 2 g/l and sterene at 10 ml/l, increased plant height, number of leaves per plant, leaf area and total yield/fad., as well as total chlorophyll in leaf tissues, Vitam. C, N, K and Fe contents in leaves, meanwhile, it decreased oxalate contents in leaves. Moreover, this treatment recorded increases in total yield which valued about 56.83 and 49.67% than the treatment with 100% RR of NPK without biogein (control) in the 1st and 2nd seasons, respectively. As for leaves content of nitrate, the interaction between biogein and 50% RR of NPK and sprayed plants with agrosol at 2 g/l recorded the lowest values. It could be concluded that the use of biogein as source of N-biofertilizer and foliar spray of phosphorus and potassium (Agrosol) with 50% RR of NPK mineral fertilizers may save the cost of spinach production and decrease the pollution of the environment, as well as produce healthy food, for human health.

Key words: Spinach, NPK, biogein, micronutrients, growth, yield, nitrate, vitam. C, oxalate contents.

INTRODUCTION

Spinach (*Spinacia oleracea* L.) as an annual leafy popular winter vegetable crops grown in Egypt, it is used as fresh, canned or frozen product. High eating of vegetables is known to have a positive influence of human health. Spinach considered as one of healthy vegetable crops for human consumption. It contains the major vitamins, *i.e.* vitamin C, A and E, minerals such as iron, calcium, potassium, manganese and zinc (Toledo *et al*., 2003). Spinach is a vegetable with a high biological value because it extremely rich in antioxidants compounds, especially Beta-carotene and lutein which both have antioxidant and anticancer properties. The disadvantage of this crop had capable to accumulate NO_3 and oxalates with a high quantity in different parts of plant. (Wang *et al.,* 2002; Jaworska, 2005). These compounds unfavorable because their have hazard effect on human health (Salunkhe and Kadam, 1998).

Leafy vegetables are important in human diet and play a grate role in the nutrient supply of some people, like vegetarians. Yield and nutritive value of these crops were affected by the agricultural practices. One of these leading factors is fertilization. A wrong fertilization for vegetables can produce a nitrate excess in the leaves, beyond the EU regulation limits. Nitrate itself non-toxic, but its metabolites may produce a number of negative health effects (Santamaria, 2006). Cil and Katkat (1995) proposed 700 mg nitrate-N Kg^{-1} as the maximum conentration for leafy and root vegetables.

*** Corresponding author: Tel. :** +201288558805
E-mail address: dnawar73@yahoo.com

NPK mineral fertilizers are applied to supply plants with three major nutrients, nitrogen (N), phosphorus (P) and potassium (K) that the plants need in appropriate proportion and amount (Stolton, 1997) Most farmers are applying intensive and non-rational rate of mineral fertilizers. Mostly, the elements of these fertilizers were losted either by fixed in the soil or leached and pollute the environment.

Application of N, P and K chemical fertilizers to the soil face some problems could be arise, *i.e.,* some nitrogen of the nitrogenous fertilizers is subjected to loss *via* nitrate reduction, denitrification and/or ammonia volatilization. In addition, some N-fertilizers can be leached to the surface underground water, causing an environmental pollution (Attio, 1990). Furthermore, immobilization of phosphorus is the most important problem of phosphorus in the applied fertilizers could be converted to unavailable form for plant absorption (El-Dahtory *et al*., 1989). So, from the economical point of view, the high prices of such fertilizers may increase the production costs of the agricultural crops.

Using mineral fertilizers to spinach plants recorded the best plant growth and yield (Raikova, 2000; Anjana *et al.,* 2006; Gairola and Suryapani, 2009; Popat *et al*., 2009; Ahmadi *et al.,* 2010; Ali *et al.,* 2013) on spinach and Fawzy *et al*. (2012) on sweet pepper.

Biofertilization is a good tool to improve the quantity and quality of leafy vegetable crops yield, particularly spinach. Moreover, it reduce the higher used rates of mineral fertilizers, the cost of crop production and permite for clean environment. *Azotobacter* (Biogein) include as the nitrogen fixing and plant growth promoting microorganisms. The mode of action of this bacteria include fixing N_2, increasing the availability of more soluble nutrients around the roots. It had a positive effect on root and plant growth, beside promoting the other beneficial plant microorganism symbiosis. In this concern, Subba (2001) stated that, in rhizosphere, bacteria had capable to sercrete growth substances and antibiotics, secondary metabolites which influenced seed germination and plant growth. Above of these advantages to the benefits of it, several researchers reported that plant growth and productivity, as well as the quality of yield were increased and improved by treated spinach seed with biofertilizers (Abdel-Fattah *et al*., 2003; El-Assiouty and Abo-Sedera, 2005; Alderfasi *et al.,* 2010). The effect of integrated between chemical fertilizers and biofertilizers are presented in many studies (El-Assiouty and Abo-Sedera, 2005; Popat *et al.,* 2009; Alderfasi *et al*., 2010 ; Ali *et al.,* 2013 on spinach as well as Hosseny and Ahmed, 2009) on lettuce.

This work was carried out to study the effect of biofertilizer (Biogein) and mineral NPK soil application and foliar spray of PK (Agrosol), as well as micronutrients (Sterene) on growth, yield and the quality of leaves of spinach plants

MATERIALS AND METHODS

This work was carried out at Ghazala Experimental Farm, Fac. Tech. and Dev., Zagazig Univ., Egypt, during two winter seasons of 2014/2015 and 2015/2016 to study the effect of nitrogen biofertilizer (Biogein), mineral fertilizers rates and applications, as well as micronutrients on growth, yield and quality of spinach cv. Dash (F_1 hybrid).

The soil texture was clay, with pH 8.1 and 8.2, organic matter 1.5 and 1.7(%), available N 22, 20 ppm; P22,19 ppm and K 332, 323 ppm in the 1st and 2nd season, respectively. This experiment included ten treatments which were the combinations between the two biofertilizer treatments and five integrated with NPK fertilizers applied in soil and foliar spray of PK (Agrosol), as well as micronutrients (Sterene) as follows:

A- Biofertilizer

1- Without biogein.

2- With biogein.

B-NPK (soil application) + foliar spray with agrosol (PK fertilizers) +sterene (micronutrients).

T1: 100% of recommended rate (RR) NPK

T2: 50% RR of NPK + agrosol at 1g/l.

T3: 50% RR of NPK + agrosol at 1 g/l. + sterene at 10 ml/l.

T4: 50% RR of NPK + agrosol at 2 g/l

T5: 50% RR of NPK + agrosol at 2 g/l.+ sterene at 10 ml/l

The experimental design was split plot design with three replicates. Biogein were randomely distributed in the main plots, whereas NPK plus foliar spraying treatments of PK and micronutrients were randomly arranged in the sub-plots.

- Agrosol: it is a commercial compound product by El-Salhia for International Chemicals (El-Salhia El-Gedida, Sharkia Governorate, Egypt), contains 48% P_2O_5 and 31.38% K_2O.
- Sterene: a commercial product, its chemical composition was chelated Fe 2%, chelated Mn 2%, chelated Zn 2% and organic acids 15%.
- Biogein: It is a nitrogen fixing bacteria (*Azotobactor sp*.).

The source of sterene and biogein was produced by the General Organization for Agriculture Equalization Foundation (GOAEF), Ministry of Agriculture, Egypt.

- The source of spinach seeds cv. Dash spinach (F_1 hybrid) was Pinetree Garden Seeds Company (Lowiston RD, New Gloucestor, Cumberland, Me, USA).

Seeds of spinach were sown on 24th November in both growing seasons after inoculation with Biogein (400 g/fad.), and space between hills 10 cm apart on both sides of ridges. Each experimental plot area was 9.6 m^2 consisted of 4 ridges, 0.6 m width and 4 m length.

The recommended rates of NPK mineral fertilizers were as follows phosphorus as 200 kg/ fad., of calcium superphosphate (15.5% P_2O_5), which added during soil preparation, potassium as 70 kg/fad., of potassium sulphate (48-50% K_2O) were added three weeks after seeding, whereas nitrogen as 250 kg/fad., of ammonium sulphate (20.5%N), 50 kg which added during soil preparing and the rest (200 kg) was added in two equal portions, three and five weeks after sowing. Both of agrosol and sterene sprayed two times,(three and five weeks after planting). The other agricultural practices of spinach planting were carried out as commonly followed in the district.

Data Recorded

Plant growth

After 70 days from sowing, ten spinach plants were randomly taken from each experimental plot to record the vegetative growth parameters (plant height (cm), number of leaves, leaf area (cm^2), as well as fresh and dry weight per plant (g). Leaf area was determined according to the method described by Wallace and Munger (1965).

Total yield

Spinach plants were harvested after 70 days after sowing and stems up to 20 cm in length, fresh weight of plants were recorded as ton/fad., and relative yield was calculated.

Leaf chemical composition

Total chlorophyll was measured in fresh leaves by using a non-destructive method with a Spad 502 Chlorophyll Meter designed by Minolta Camera Co. Ltd., Japan.

N, P and K contents were determined according to the methods described by Bremner and Mulvaney (1982), Olsen and Sommers (1982) and Jackson (1970), respectively. Oxalate content was determined according to Human Nutrition Information Service, USDA (1984). However, Nitrate and iron determined according to Chapman and Pratt (1982). Ascorbic acid (mg/100ml juice: it was determined by titration in the presence of 2,6 dichlorophenol – indophenol dye as an indicator against 2% oxalic acid solution as substrate. Ascorbic acid was calculated as mg ascorbic acid/100 ml juice according to the method described by AOAC (1995).

Statistical Analysis

All obtained data were subjected to statistical analysis of variance using SAS 9.2 software (SAS, 2008). Means separation were done using least significant difference LSD (5%) probability level.

RESULTS AND DISCUSSION

Plant Growth and Yield

It is evident from results in Table 1 that inoculation of spinach seeds with biogein had positive effect of spinach plants by increasing the vegetative growth, as well as total and relative yield during the two growing seasons. All plant growth parameters, *i.e.* plant height, number of leaves, fresh and dry weight of plant, as well as leaf area, moreover, total and relative yield were increased by the application with the biofertilizer biogein. There were significant differences in all characters compared to without inoculation with biogein except number of leaves and fresh weight per plant in the 1st season and plant height in the 2nd season.

The superiority of inoculation with biogein might be owe to the role of the bacteria (*Azotobacter*) which exist in the biofertilizer to contributing with some hormone substances, *i.e.* gibberellins, auxins and cytokinins (Cacciari *et al.,* 1989). These phytohormones may stimulate cell division and elongation, as well as development and this consequently reflect on plant growth (Paleg, 1985). Moreover, Subba (2001) reported that *Azotobacter* is an aerobic bacteria, free living in nature and it can capable to produce antibiotics which inhibits the growth of many pathogenic microorganisms that found in the root region thereby maintain the survival of plants. On the other hand, *Azotobacter* as a nitrogen biofertilizer play a positive role in soil fertility through fixing the atmospheric nitrogen and produces plant growth substances in the soil, beside promote a natural available biological system of nutrient mobilization (Venkatashwarlu, 2008). These results were parallel with those reported by Abdel-Fattah *et al.* (2003), El-Assiouty and Abo-Sedera (2005), Alderfasi *et al.* (2010) and Ali *et al.* (2013) on spinach as well as Ahmed *et al.* (2000) and Hosseny and Ahmed (2009) on lettuce.

As for the effect of different rates and applications of NPK and spraying micronutrients, results presented in Table 1 show that there were significant differences in all plant growth features and yield due to the NPK mineral fertilizers applied in soil and spraying P_2O_5 + K_2O (Agrosol) plus the micronutrents (Sterene) in both seasons. The highest values were recorded by used 50% RR of NPK as soil application plus spraying agrosol at the concentration of 2 or 1 g/l, respectively and sterene at 10 ml/l. Moreover, the increase of the leaf area was detected by the treatment of 100% NPK at the recommended rate. Generally, the improvement observed in spinach plant growth may be due to the positive response of plants to NPK as soil dressing and spraying agrosol which contain P_2O_5 and K_2O, as well as applied plants with the micronutrients, *i.e.* chelated Fe, Mn and Zn through spraying sterene (the best form to absorb with plants), especially the treatments were applied in the early stages of spinach plant as a short-life cycle plants. Moreover, the beneficial effect of these elements on number of leaves and leaf area due to the increase of photosynthesis and this consequently resulted to the higher accumulation of assimilates, caused to produce vigor plant growth, and increase the total yield (Shaheen *et al.*, 2012; Nemadodzi, 2015).

The necessity of nitrogen, phosphorus and potassium for spinach growth has been demonstrated by many investigators, since nitrogen, phosphorus and potassium supply were very important and influence vegetative growth, dry matter accumulation as well as nutrient uptake. The stimulative effect of NPK application either in soil or as foliar spray on growth parameters may be attributed to the beneficial effects of N which considered essential element for building up protoplasm, amino acids and proteins which promoting cell division and merstimatic activity, beside, it involved in different biochemical processes related with plant growth (Marschner, 1995). Phosphorus is an essential component of the energy transfer compounds, genetic information system, cell membranes and phosphoproteins (Gardener *et al.,* 1985). Moreover, potassium is triggers activation of enzymes, play a vital role in photosyntehsis and it has an beneficial influence on water consumption (Mengel and Kirkby, 1978). These results are in accordance with those found by Raikova (2000), Anjana *et al*. (2006), Gairola and Suryapani (2009), Popat *et al.* (2009) and Ahmadi *et al.* (2010). They found that supply spinach plants with NPK mineral fertilizers either by added to the soil or

Table 1. Effect of bio and mineral fertilizers rates and applications, as well as micronutrients (sterene) on vegetative growth and total yield of spinach plants during the two seasons of 2014-2015 and 2015-2016

Treatment		Character	2014-2015 Season							2015-2016 Season						
Biofertilizer (Biogein)	Mineral fertilizers and micronutrients		Plant height (cm)	No. of leaves/ Plant	Fresh weight/ Plant (g)	Dry weight/ Plant (g)	Leaf area/plant (cm^2)	Total yield (ton/fad.)	Relative yield (%)	Plant height (cm)	No. of leaves/ Plant	Fresh weight/ Plant (g)	Dry weight/ Plant (g)	Leaf area/plant (cm^2)	Total yield (ton/fad.)	Relative yield (%)
Without			23.33	13.80	43.58	5.94	149.20	5.707	100.00	22.66	11.73	38.72	4.92	138.33	5.827	100.00
With			27.80	14.60	47.56	6.43	159.27	7.086	124.16	24.66	12.73	38.82	5.08	146.67	6.747	115.78
LSD (0.05)			1.03	NS	3.88	0.08	1.510	0.030	-	NS	0.86	NS	0.03	2.34	0.051	-
	T1		25.16	12,16	33.95	4.84	159.33	5.295	100.00	22.50	10.66	30.50	3.96	145.50	5.225	100.00
	T2		23.16	13.00	40.66	5.60	125.33	5.406	101.98	23.50	11.66	30.73	4.18	118.83	5.771	110.42
	T3		25.16	13.66	53.91	6.94	148.50	7.033	132.82	24.16	11.50	46.98	5.99	135.67	6.825	130.62
	T4		23.66	15.33	44.06	6.22	158.67	6.690	131.44	23.33	12.83	34.63	4.56	142.67	6.238	119.38
	T5		30.66	16.83	55.26	7.34	179.33	7.560	142.70	27.33	14.50	51.03	6.30	169.83	7.376	141.10
LSD (0.05)			1.58	1.11	3.96	0.05	4.13	0.042	-	1.69	0.79	4.43	0.04	3.99	0.132	-
	T1		23.33	12.00	36.10	5.13	152.33	5.171	100.00	21.00	10.00	32.13	4.57	142.33	5.100	100.00
	T2		20.66	13.00	37.33	5.30	123.67	4.250	82.15	23.33	11.33	29.26	4.15	117.67	5.216	102.27
Without	**T3**		22.66	12.00	50.83	6.05	131.33	6.356	122.92	22.66	10.33	46.63	5.47	118.67	6.150	120.58
	T4		22.00	15.33	41.20	5.87	163.33	5.750	111.19	22.00	13.00	34.50	4.25	150.33	5.550	108.82
	T5		28.00	16.66	52.46	7.35	175.33	7.010	135.55	24.33	14.00	51.10	6.16	162.67	7.120	139.61
	T1		27.00	12.33	31.80	4.54	166.33	5.419	104.79	24.00	11.33	28.86	3.35	148.67	5.350	104.90
	T2		25.66	13.00	44.00	5.89	127.00	6.563	126.40	23.66	12.00	32.20	4.21	120.00	6.320	124.04
With	**T3**		27.66	15.33	57.00	7.84	165.67	7.710	149.13	25.66	12.66	47.33	6.52	152.67	7.500	147.05
	T4		25.33	15.33	46.93	6.58	154.00	7.630	147.55	24.66	12.66	34.76	4.88	135.00	6.920	135.80
	T5		33.33	17.00	58.06	7.32	183.33	8.110	156.83	30.33	15.00	50.96	6.43	177.00	7.633	149.67
LSD (0.05)			2.24	1.58	5.60	0.07	5.84	0.059	-	2.40	1.11	6.27	0.06	5.65	0.186	-

T1: 100% of recommended rate (RR) of NPK, as soil application

T2: 50% RR of NPK + foliar spray with agrosol at 1g/l

T3: 50% RR of NPK + foliar spray with agrosol at 1g/l and sterene at 10ml

T4: 50% RR of NPK + foliar spray with agrosol at 2g/l

T5: 50% RR of NPK + foliar spray with agrosol at 2g/l and sterene at 10ml

NS : Not Significant

by spraying due to the best plant growth and yield. Foliar application of micronutrients positively affected on vegetative growth and yield of spinach plants and this influence may be attributed to that Zn, Mn and Fe had a vital contribution in several biochemical and physiological processes (Kirkby and Romheld, 2004). In this concern, many investigators reported that Zn is among the necessary element that it interferes with IAA formation and plant regulation (Sillanpaa, 1982) and it causes to activate different enzymes which are needed to chlorophyll synthesis and formation of carbohydrates (Vitosh *et al*., 1994). These results agree with those reported by Abazarian *et al.* (2011), Shaheen *et al.* (2012) and Borowski (2013).

The interaction effect between the two biofertilizer (biogein) treatments and soil application of NPK combined with foliar spray of PK (Agrosol) and micronutrients (Sterene) on the growth of spinach plants, as well as total and relative yield are recorded in Table 1. Obtained results revealed that all plant growth parameters measured and total yield were significantly affected by inoculation spinach seeds before sowing by biogein and fertilized by NPK fertilizers with spraying PK and micronutrients in both growing seasons of study. In this respect, inoculation with biogein and fertilizing plants with 50% RR of NPK as soil addition and spraying plants with agrosol at 2 g/l and sterene at 10 ml/l increased plant height, number of leaves, fresh and dry weight per plant, as well as leaf area. Moreover, there were significant increase in total yield and the increase of relative yield reach up to 156.83 and 149.67% during the two seasons, respectively by the same treatment. These results agree with those demonstrated by El-Assiouty and Abo-Sedera (2005), Alderfasi *et al*. (2010) and Ali *et al.* (2013) on spinach, Fawzy *et al.* (2012) on sweet pepper.

In this respect, obtained results means spraying spinach plants with agrosol as a source of P_2O_5 and K_2O at 2 g/l, as well as sterene at 10 ml/l as a source of micronutrients (Zn, Mn and Fe) with 50% RR of NPK as soil addition may can reduce about 50% of mineral fertilizers application without reducing productivity.

Leaf Chemical Composition

Results in Tables 2 and 3 illustrate that inoculation of spinach seeds with biogein significantly gave higher total chlorophyll and ascorbic acid (Vitam. C) as mg/100 ml juice in leaf tissues than the control treatment (without biogein). Moreover, N, P, K percentage and Fe (ppm) in spinach leaves were increased by the inoculation of seeds with biogein, whereas oxalate and nitrate (ppm) were decreased compared with the uninoculated seeds. These results were true in the two studying seasons.

The stimulative effect of biogen may be due to that it help in the mobilizing of nitrogen fixation from the insoluble to soluble form and this reflected on increased plant growth, the rate of absorption and photosynthesis caused highest accumulation of macro and micro-nutrients in spinach (Alderfasi *et al*., 2010 ; Mahdi *et al.,* 2010). These results are in harmony with those found by Ahmed *et al.,* (2000), Al-Moshileh (2004), Hosseny and Ahmed (2009), Karlidag *et al.* (2009), Revathi (2011) and Fawzy *et al.* (2012).

Results in Table 2 indicate that fertilizing spinach plants with 50% RR of NPK as soil treatment and spraying agrosol at 2 g/l followed by 1 g/l in the second rank and sterene at 10 ml/l due to the highest values of total chlorophyll and Vitam. C in leaf tissues.

Concerning to N and K percentage, as well as Fe (ppm), it is clear in Table 3 that the increased of these elements were produced by the treatment 50% RR of NPK added to the soil and spraying agrosol at 2 g/l plus sterene at 10 ml/l, while oxalate and nitrate (ppm) were increased by added 100% of recommended NPK only to the soil (Table 2). Mean while, the lowest values of each oxalate and nitrate were obtained by applied spinach plants with 50% RR of NPK (soil addition) and foliar spray with agrosol at 2 g/l and sterene at 10 ml/l, for oxalate and without sterene for nitrate. It can be concluded that the improvement in the nutritional values of spinach leaves was obtained by reduce NPK mineral fertilizers used and replace it by spraying agrosol (contain P_2O_5 plus K_2O) and sterene (contain the micronutrients Zn, Mn and Fe), as well as increase Fe content and decrease the content of

Table 2. Effect of bio and mineral fertilizer rates and applications, as well as micronutrients (sterene) on total chlorophyll, vitam. C, oxalate and nitrate contents of spinach leaves during the two seasons of 2014-2015 and 2015-2016

Treatment	Character	2014-2015 Season				2015-2016 Season			
Biofertilizer (Biogein)	Mineral fertilizers and micronutrients	Total Chlorophyll (Spad)	Vitam. C (mg/100 ml juice)	Oxalate (ppm)	Nitrate (ppm)	Total Chlorophyll (Spad)	Vitam. C (mg/100 ml juice)	Oxalate (ppm)	Nitrate (ppm)
Without		48.16	48.69	757.87	647.93	49.66	45.33	736.80	600.40
With		50.18	55.04	743.73	630.87	52.06	52.37	710.00	579.07
LSD (0.05)		3.59	6.02	10.75	2.34	1.24	6.23	23.36	6.97
	T1	44.86	48.38	842.17	717.00	43.70	50.49	808.00	662.33
	T2	44.71	51.16	791.33	648.50	48.80	48.45	763.17	589.83
	T3	52.46	49.93	767.50	688.17	52.32	50.70	733.33	618.67
	T4	49.10	53.34	689.33	565.83	51.86	48.81	676.83	521.67
	T5	54.70	56.36	663.67	577.50	57.62	50.52	635.67	556.17
LSD (0.05)		2.09	3.44	30.41	2.63	2.26	0.43	20.75	3.10
	T1	43.03	45.06	847.67	733.00	41.43	47.22	832.67	673.00
	T2	44.19	49.45	793.33	655.67	51.44	44.31	785.67	598.00
Without	**T3**	51.50	47.88	774.33	695.67	48.50	46.95	735.67	625.67
	T4	48.48	50.36	697.67	571.00	51.36	43.18	684.00	539.33
	T5	53.61	50.70	676.33	584.33	55.58	45.06	646.00	651.67
	T1	46.70	51.70	836.67	701.00	45.96	53.76	783.33	651.67
	T2	45.23	53.18	789.33	641.33	46.16	52.60	740.67	581.67
With	**T3**	53.43	51.99	760.67	680.67	56.13	54.45	731.00	611.67
	T4	49.73	56.33	681.00	560.67	52.36	55.98	669.67	504.00
	T5	55.80	62.03	651.00	570.67	59.66	50.70	625.33	546.33
LSD (0.05)		2.95	9.44	40.83	3.73	3.20	9.23	29.34	4.39

T1:100% of recommended rate (RR) of NPK, as soil application

T2: 50% RR of NPK + foliar spray with agrosol at 1g/l

T3:50% RR of NPK + foliar spray with agrosol at 1g/l and sterene at 10 ml

T4: 50% RR of NPK + foliar spray with agrosol at 2g/l

T5:50% RR of NPK + foliar spray with agrosol at 2g/l and sterene at 10 ml

NS: Not significant

Table 3. Effect of bio and mineral fertilizer rates and applications, as well as micronutrients (sterene) on N, P, K and Fe contents of spinach leaves during the two seasons of 2014-2015 and 2015-2016

Treatment		Character	2014-2015 Season				2015-2016 Season			
			N	P	K	Fe	N	P	K	Fe
Biofertilizer (Biogein)	Mineral fertilizers and micronutrients		(%)	(%)	(%)	(ppm)	(%)	(%)	(%)	(ppm)
Without			2.76	0.309	5.65	257.73	2.67	0.309	5.38	245.80
With			2.88	0.321	5.90	275.13	2.79	0.313	5.69	265.20
LSD (0.05)			0.02	NS	0.07	7.31	0.05	NS	0.07	5.18
	T1		2.71	0.403	5.25	223.67	2.52	0.399	5.06	220.33
	T2		2.65	0.236	5.46	247.83	2.62	0.229	5.20	229.17
	T3		2.89	0.281	5.83	292.33	2.85	0.274	5.68	279.00
	T4		2.82	0.305	6.03	261.83	2.76	0.311	5.76	255.17
	T5		3.05	0.349	6.29	306.50	2.91	0.343	5.98	293.83
LSD (0.05)			0.04	0.054	0.05	3.19	0.03	0.021	0.06	3.00
	T1		2.70	0.395	4.93	216.00	2.51	0.394	4.72	215.33
	T2		2.59	0.235	5.42	233.67	2.52	0.228	5.15	202.33
Without	T3		2.82	0.279	5.72	287.00	2.78	0.273	5.58	276.67
	T4		2.76	0.296	5.95	249.33	2.69	0.318	5.65	246.67
	T5		2.95	0.340	6.22	302.67	2.84	0.333	5.81	288.00
	T1		2.72	0.411	5.57	231.33	2.53	0.405	5.39	225.33
	T2		2.71	0.238	5.50	262.00	2.72	0.230	5.26	256.00
With	T3		2.95	0.282	5.94	297.67	2.92	0.275	5.79	281.33
	T4		2.87	0.315	6.11	274.33	2.83	0.305	5.88	263.67
	T5		3.16	0.358	6.36	310.33	2.98	0.353	6.15	299.67
LSD (0.05)			0.06	0.077	0.07	4.15	0.04	0.030	0.09	4.24

T1:100% of recommended rate (RR) of NPK, as soil application

T2: 50% RR of NPK + foliar spray with agrosol at 1g/l

T3:50% RR of NPK + foliar spray with agrosol at 1g/l and sterene at 10 ml

T4: 50% RR of NPK + foliar spray with agrosol at 2g/l

T5:50% RR of NPK + foliar spray with agrosol at 2g/l and sterene at 10 ml

NS: Not significant

oxalate and nitrate which the higher content of both cause a hazard of human health (Crawford and Glass, 1998). Similar findings were obtained by Hosseny and Ahmed (2009), Popat *et al*. (2009), Marvi (2009), Zahedifar *et al.* (2011), Shaheen *et al.* (2012) and Nemadazi (2015).

The interaction between inoculation with biogein and applied plant with 50% RR of NPK (soil dressing) and spraying with agrosol at 2 g/l and sterene at 10 ml/l increased total chlorophyll and the content of N, K, as well as Fe (ppm) in leaves, whereas the interaction between biogein and 100% RR of NPK, followed by treatment without biogein increased P content in leaves as presented in Table 2. With concern to oxalate and nitrate in spinach leaves, the highest values were obtained by fertilizing plants with 100% of recommended rate of NPK at soil either the exist of biogein or without. As for Vitam. C, the interaction between biogein and applied plants with 50% RR of NPK and spraying with agrosol at 1 or 2 g/l plus sterene at 10 or 20 ml/l increased Vitam. C in leaves. On the same time, the lowest benefit values were recorded by the treatment 50% RR of NPK (soil dressing) and sprayed plants with agrosol at 2 g/l and sterene at 10 ml/l. These means that biogein biofertilizer can be used to a limit extend alongside the mineral fertilizers to produce healthy food for human health.

Conclusion

It could be concluded that the superior interaction treatment concerning plant growth, chlorophyll, total yield/fad., minerals content, as well as spinach leaves quality (reduce the content of oxalate and nitrate, as well as increase Fe) was recorded by inoculation seeds with biogein biofertilizer and fertilizing spinach plants with 50% of the recommended rate (RR) of NPK as soil applied integrated with spraying agrosol at 2 g/l plus sterene at 10 ml/l. Moreover, this application may reduce the mineral fertilizers used (up to 50%), which due to save the high cost, as well as decrease the pollution of the environment and/or to produce healthy food for human health.

REFERENCES

Abazarian, R., M. Azizi, M. Shoor and P. Arvin (2011). Effects of foliar application of zinc on physiological indices and yield of three spinach cultivars in Bojnourd, Iran, Afr. J. Agric. Res., 6 (31): 6572-6574.

Abdel-Fattah, M.A., M.E. Sorial and M.A. Wahb-Allah (2003). Sex expression response of spinach as affected by biofertilizer and GA_3 application and its relation to yield, quality and seed production. J. Agric. Sci. Mansoura Univ., 28 (10): 7357-7393.

Ahmadi, H., V.A. Pour, F. Dashti and A. Shojaeian (2010). Effect of different levels of nitrogen on yield, nitrate accumulation and several quantitive attributees of five Iranian spinach. Ame. Eurasian J. Agric. Environ. Sci., 8 (4): 468-473.

Ahmed, A.H.H., J.F. Mishriky and M.K. Khalil (2000). Reducing nitrate accumulation in lettuce (*Lactuca sativa* L.) plants by using different biofertilizers. ICEHM Cairo Univ., Egypt, 47 (1): 509-517.

Alderfasi, A.A., A.E. Moftah and A.M. Aljuaed (2010). Prospective study in influences of using bio-organic farming system on growth, nitrate, oxalate and ascorbic acid contents in spinach. World Appl. Sci. J. 9 (1): 49-54.

Ali, A.H., M.M. Hafez, A.R. Mahmoud and M.R. Shafeek (2013). Effect of bio and chemical fertilizers on growth, yield and chemical properties of spinach plant (*Spinacia oleracea* L.). Middle East J. Agric. Res., 2 (1): 16-20.

Al-Moshileh, A.M. (2004). Effects of chemical and bio-fertilization on the growth and the chemical constituents of spinach plants. Bull. Fac. Agric., Cairo, Univ., 55:443-458.

Anjana, U.S., M. Iqbal and Y.P. Abrol (2006). Are nitrate concentrations in leafy vegetables within safe limits. Proc. of the Workshop on Nitrogen in Environ., Indust. and Agric., New Delhi, India., 81-84.

AOAC (1995). Official Methods of Analysis of the Association of Offecial Analytical Chemists International. AOAC, Arlington, Virginia.

Attio, M.A. (1990). The biochemistry of urea by decomposition by soil organisms. Ph.D. Thesis, Fac. Agric., Minia Univ., Egypt.

Borowski, E. (2013). Uptake and transport of iron ions (Fe^{+2}, Fe^{+3}) supplied to roots or leaves in spinach (*Spinacia oleracea* L.) plants growing under different light conditions. Acta Agrobotanica, 66 (2): 45-52.

Bremner, J.M. and C.S. Mulvaney (1982). Total nitrogen In: Page, A. L., R. H. Miller, and D. R. Keeney (Eds). Methods of Soil Analysis. Part 2, Ame. Soc. Agron. Madison, WI. USA. 595- 624.

Cacciari, D.L.,T. Pietrosanti, and W. Pietrosanti (1989). Phytohormones-like substances produced by single and mixed diazotrophic cultures of Azospirillum and Arthrobacter. Plant and Soil, 115: 151-153.

Chapman, H.D. and P.F. Pratt (1982). Methods of Plant Analysis, I. Methods of Anaylsis for Soil, Plant and Water. Chapman Publishers, Riverside, California, USA

Cil, N. and A.V. Katkat (1995). Nitrogen fertilizer types and effects of their excess amount on yields, nitrate and mineral composition of spinach. Akalan Soil and Environ. Symposium, 2:156-168.

Crawford, N.M. and A.D.M. Glass (1998). Molecular and physiological aspects of nitrate uptake in plants. Trends Plant Sci., 3 (10): 389-395.

El-Assiouty, F.M.M. and S.A. Abo-Sedera (2005). Effect of bio and chemical fertilizers on seed production and quality of spinach (*Spinacia oleracea* L.). Int. J. Agric. Biol., 7 (6): 947-952.

El-Dahtory, T.M., M. Abdel-Nasser, A. Abdallah and E. El-Mohandes (1998). Studies on phosphate solubilizing bacteria under different soil amendment. Minia J. Agric. Res. and Dev., 11 (2): 935- 950.

Fawzy Z.F., A.M. El-Bassiony, L. Yunsheng, O. Zhu and A.A. Ghoname (2012). Effect of mineral, organic and bio-N fertilizers on growth, yield and fruit quality of sweet pepper. J. Appl. Sci. Res., 8 (8): 3921-3933.

Gairola, S. Umar and S. Suryapani (2009). Nitrate accumulation, growth and leaf S., quality of spinach beet (*Beta vulgaris* Linn.) as affected by NPK fertilization with special reference to potassium. Indian J. Sci. and Technol., 2 (2): 35-40.

Gardener, F.D., R.B. Pearce and R.L. Mitchell (1985). Physiology of crop plants. The Iowa State Univ. Press. Ame., 327.

Hosseny, M.H. and M.M. Ahmed (2009). Effect of nitrogen, organic and biofertilization on productivity of lettuce cv. Romaine in sandy soil under Assiut conditions. Assiut Univ. Bull. Environ. Res., 12 (1):79-93.

USDA (1984). Human Nutrition Information Service. Composition of foods: vegetables and vegetable products. Agric. Handook, 8.

Jackson, M.L. (1970). Soil Chemical Analysis. Prentic Hall, Englewood Ceiffs, NJ.

Jaworska, G. (2005). Content of nitrates, nitrites and oxalates in New Zealand spinach. Food Chem., 89: 235-242.

Karlidag, H., E. Yildirim, M. Turan and M.F. Donmez (2009). Effect of plant growth promoting bacteria on mineral-organic fertilizer use efficiency, plant growth and mineral contents of strawberry (*Fragaria X ananassa* L. Duch.). Ataturk Univ., Ispir Hamza polat vocational school, Dep. Organic Agric., Ispir, Erzurum, Turkey.

Kirkby, E.A. and V. Romheld (2004). Micronutrients in plant physiology: Functions, uptake and mobility. Proc., 543. Int. Fert. Soc.

Mahdi, S.S., G.I. Hassan, S.A. Samoon and H.A. Rather (2010). Biofertilizers in organic agriculture. J. Phytol., 2 (10): 42-54.

Marschner, H. (1995). Mineral Nutrition of Higher Plants. 2nd (Ed.), Academic Press Limited, Text Book.

Marvi, M.S.P. (2009). Effect of nitrogen and phosphorus rates on fertilizers use efficiency in lettuce and spinach. J. Hort. and Forestry, 1 (7): 140-147.

Mengel, K. and E. A. Kirkby (1978). Principles of Plant Nutrition. Int. Potash Inst., PO Box. CH. 3048, Worblaufen Bern, Switzerland.

Nemadazi, L.E. (2015). Growth and development of baby spinach (*Spinacia oleracea* L.) with reference to mineral nutrition. M.Sc. Thesis. Fac. Agric., Univ., South Afr.

Olsen, S.R. and L.E. Sommers (1982). Phosphorus. In: Page. AL, RH Miller and DR Keeney (Eds). Methods of Soil Analysis. Part 2 Ame. Soc. Agron. Madison, WI. USA, 403 - 430.

Paleg, L.G. (1985). Physiological effects of gibberellins. Ann. Rev. Plant Physiol., 16 : 291-322.

Popat, J.R., M. Deshmukh and V.K. Mahorkar (2009). Effect of NPK through foliar application on growth and yield of Indian spinach. Ann. Plant Physiol., 23(2): 201-203.

Raikova, L. (2000). Effect of nitrogen and potassium fertilizer forms on the productivity and nitrate accumulation in spinach. Pochvojnanie Agr. Ekologiya, 35 (1): 24- 28.

Revathi, K. (2011). Impact of biofertilizers on nutrient content and antioxidant activity of spinach beet (*Beta vulgaris*). M. Sc. Thesis, Fac. Agric. Acharya N.G. Ranga Agric. Univ.

Salunkhe, D.K. and S.S. Kadam (1998). Handbook of Vegetable Science and Technology: Production, Composition, Storage and Proc. Marcel dekker, INC, 721.

Santamaria, P. (2006). Nitrate in vegetables: toxicity, content, intake and EC regulation J. Sci. Food Agric., 86:10-17.

SAS (2008). SAS user guides version 9.2, SAS Institute Inc. Cary, North Carolina, USA.

Shaheen, A.M., F.A. Rizk, E.H. Abd El-Samad and Z.S. A. El-Shal (2012). Growth, yield and chemical properties of spinach plants as influenced by nitrogen fertilizer forms and micro-elements foliar application. J. Appl. Sci. Res., 8 (2): 777-785.

Sillanpaa, M. (1982). Micronutrient and the nutrient status of soil. A Global Study. FAO Soil Bull., 98 (FAO Roma).

Stolton, S. (1997). Ecology and Farming. Int. mag. IFOAM, 15:35-37.

Subba, R.N.S. (2001). An appraisal of biofertilizers in India. The Biotechnology of Biofertilizers in S.Kannaiyan (ed.), Narosa Publishing House, New Delhi.

Toledo, M.E.A., Y. Ueda, Y. Imahori and M. Ayaki (2003). L-ascorbic acid metabolism in spinach (*Spinacia oleracea* L.) during postharvest storage in light and dark. Postharvest Biol. Terminol., 28: 47-57.

Venkatashwarlu, B. (2008). Role of bio-fertilizers in organic farming: Organic farming in rain fed agriculture: Central Institute for dry land agriculture, Hyderabad, 85-95.

Vitosh, M.L., D.D. Warncke, R.E. Lucase (1994). Zinc determine of crop and soil sciences. Michigan State Univ. Extension.

Wallace, D. H. and H.M. Munger (1965). Studies of the physiological basis for yield differences. 1-Growth analysis of six dry bean varieties. Crop Sci., 5: 343-348.

Wang, Z.H., Z.Q. Zong, S.X. Li and B.M. Chen (2002). Nitrate accumulation in vegetables and its residual in vegetable fields. Environ. Sci., 23:79-83.

Zahedifar, M., N. Karimian, A. Ronaghi, J. Yasrebi and Y. Emam (2011). Soil-plant nutrient relationship at different growth stages of spinach as affected by phosphorus and manure applications, Commun. Soil Sci. and Plant Anal., 42:1765-1781.

تحسين النمو، الإنتاجية والجودة لنباتات السبانخ

وفاء عادل فكري [١] – داليا أحمد سامي نوار [٢]

١- قسم الإنتاج النباتي – كلية التكنولوجيا والتنمية – جامعة الزقازيق – مصر

٢- قسم البساتين – كلية الزراعة – جامعة الزقازيق – مصر

أجريت هذه الدراسة بمزرعة التجارب كلية التكنولوجيا والتنمية – جامعة الزقازيق بمنطقة غزالة، محافظة الشرقية – مصر خلال الموسم الشتوي لعامي ٢٠١٤/٢٠١٥ و٢٠١٥/٢٠١٦ لدراسة تأثير السماد الحيوي النتروجيني (البيوجين) والأسمدة النيتروجينية والفوسفاتية والبوتاسية المعدنية كإضافة أرضية في تداخلات مع الرش للفوسفور والبوتاسيوم (الأجرسول)، وبعض العناصر الصغرى (الستربن) على النمو والمحصول وجودة الأوراق في السبانخ صنف داش (هجين الجيل الأول)، أدي تلقيح البذور بالبيوجين وتسميد النباتات بمعدل ٥٠% من الموصي به من الأسمدة النيتروجينية والفوسفاتية والبوتاسية كإضافة أرضية، مع رش الأجروسول بمعدل ٢ جم/ لتر والستربن بمعدل ١٠سم/ لتر إلى زيادة طول النبات، عدد الأوراق لكل نبات، مساحة الورقة والمحصول الكلي للفدان، وكذلك الكلوروفيل الكلي بأنسجة الورقة ومحتوى الأوراق من حمض الاسكوربيك والنتروجين والبوتاسيوم والحديد، بينما كان هناك نقص في محتوى الورقة من الأوكسالات، بالإضافة إلى ذلك فقد أدت هذه المعاملة، إلى زيادة في المحصول الكلي تقدر بنسبة ٥٦,٨٣ و٤٩,٦٧% مقارنة بالمعاملة ١٠٠% بالمعدل الموصي به من الأسمدة النيتروجينية والفوسفاتية والبوتاسية بدون إضافة البيوجين (الكنترول) خلال الموسم الأول والثاني على التوالي، وبالنسبة لمحتوى الأوراق من النترات، فقد أدى التداخل بين البيوجين والأسمدة المعدنية النيتروجينية والفوسفاتية والبوتاسية بنسبة ٥٠% من المعدل الموصي به بالإضافة إلى رش الأجروسول بمعدل ٢جم/لتر سجل أقل القيم، نخلص من ذلك إلى أن إستخدام البيوجين كمصدر للنتروجين الحيوي مع رش كلا من الفوسفور والبوتاسيوم (الاجروسول) بالإضافة إلى ٥٠% من المعدل الموصي به من الأسمدة النيتروجينية والفوسفاتية والبوتاسية ربما يؤدى إلى التوفير في تكلفة إنتاج السبانخ مع التقليل من تلوث البيئة بالإضافة إلى إنتاج الغذاء الصحي لصحة الإنسان.

المحكمون :

١- أ.د. عصام أبو الصالحين أستاذ البساتين – كلية التكنولوجيا والتنمية – جامعة الزقازيق.

٢- أ.د. عبدالله برديسي أحمد أستاذ الخضر – كلية الزراعة – جامعة الزقازيق.