



Effect of compound fertilizers as Foliar Spray with Application Bio-Fertilizers on Growth, Yield and quality of spinach Plants

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ABSTRACT

Two field experiments were completed at particular plantation in Qalyobia Governorate, Egypt through the two sequential winter seasons of 2016/2017 and 2017/2018. The research aimed to research the influence of inoculation soil by bio-fertilizer (Biogein) rates (0, 1 and 2 kg/fad.) with foliar sprinkle with nutrient complex (Aquacool) on growth, yield and leaves specialty of spinach plants cv Balady grown in clay soil conditions. The acquired results specified that, the interaction amidst inoculation soil by high level of N-fixing bacteria (2 kg/fed.) with spray with higher concentration (2 cm/L) of nutrient complex (Aquacool) gave the biggest value of plant height, number of leaves/ plant, leaves fresh and dry weight, total chlorophyll as well as total yield and big contents of the percentage of N, P, K, and protein on leaves tissue.

Keywords: spinach- N-fixing (Biogein) - nutrient complex (Aquacool) – growth - yield - leaves quality

1. Introduction

Spinach (*Spinacia oleracea* L.) is one of the maximum common leafy vegetable crops grown in Egypt. It is utilized fresh or tinned or frozen production. It is lower in calories and a perfect source of vitamin C, vitamin A and minerals particularly iron (Toledo *et al.*, 2003). Spinach is a vegetable with an elevation biological value, extremely wealthy in antioxidants especially when fresh, steamed, or quickly poached (Cho *et al.*, 2008). It is a perfect source of vitamin A, C, E, K, B2, B6, B9, folic acid, minerals (Mn, Mg, Fe, K, Ca, Se), and dietary fiber.

Bio-fertilizers are lower telling, eco-friendly and probable likely to reckon better significance supplement or complement to inorganic fertilizers. Biological fertilizers aside from increasing yield, improving quality also helps in beneficent the nutrient condition of soil. Biological fertilization of plants by N₂ fixing bacteria obtained importance in the different years. The significant impact of bio-fertilizers may be due to the effect of various strain groups such as N-fixer, nutrient motivation microorganisms which support in increasing the availability of minerals and their forms in the composted munitions and improve levels of extractable of macro or micronutrients (El-Karamany *et al.*, 2000). Bio-fertilizer (Biogein) has rising amounts of symbiotic and non symbiotic bacteria answerable for atmospheric nitrogen fixation. Application of bio-fertilizer (Biogein) miniature the desired mineral nitrogen by 25%, increased the availability of different nutrients, promotes the resistance of plants to root disease and reduces the environmental pollution from chemical fertilizer implementation (Fatma Rizk and Shafeek, 2000). It is encouraged plant growth and output of spinach plants was calculated by some investigators (AbdEl-Fattah *et al.*, 2003; El-Assiouty and Abo-Sedera 2005; Alderfasi *et al.*, 2010 and Aish *et al* 2013). In addition, Shinde *et al.* (2018) spotted that, the maximum values of growth characters such as plant height, number of leaves per plant, number of branches per plant and lower days wanted for

maturity were registered with the application of *Azotobacter*. The yield attributes parallel maximum fresh weight of whole plant was registered in treatment of *Azotobacter*.

Now in Egypt, there are considerable foliar fertilizers containing the farthest macro and micro elements generally used to correct any deficiency in soil. Application of micronutrients has an economical function in decreasing the appreciation of the used soluble micronutrients which unfortunately in case of soil application, which modify to forms. So, foliar sprays overcome this question (Hegab *et al.*, 1987). Moreover, Tamilselvi *et al.* (2002) speckled farthest TSS, acidity, ascorbic acid and lycopene contents with the implementation of micronutrients. In addition, Shafeek *et al.* (2013) found that foliar sprinkle with different levels of nutritional compound Stimufol significantly improve the plant growth parameters such as plant height, number of leaves and branches, fresh and dry weight of leaves and branches as well as whole plants also improve pod length, average weight of pod and total yield as ton/fed and it gave the biggest values of the percentage of protein and nitrogen as well as Fe and Mn (mg/g dry weight) of broad bean seeds with privilege by implementation of high level (200 g/fed.). In the same respect, Shafeek, *et al.* (2014) recorded that the bigger plant growth such as number of leaves/plant and net assimilation rate (NAR) and the highest total fruits yield and its components as well as the bigger content of the percentage of N, K and protein of hot pepper fruits tissues were detect with that plants which sprayed by nutritional fertilizers at concentration of 3 L/fed. However, Shafeek *et al.* (2021) found that, sprinkle with high levels (2 cm/L) of nutrient compound (Aquacool) gave the biggest values of plant height, number of leaves/ plant, leaves fresh and dry weight, total roots yield and its components (root weight, length and diameter) as well as highest contents of the percentage of N, P, K, total sugar and vitamin C in root tissue of beet root plants.

2. Material and Methods

Two field experiments were conducted on a private farm in Qalyobia Governorate Egypt during the two growing seasons of 2017 and 2018 in order to study the effect of the addition of different levels of bio fertilizer (Biogein), (0, 1 and 2 kg/fed.) with three foliar application of nutrient compound (Aquacool) (0, 1 and 2.cm/L) and their interactions for influence on plant growth, total yield and chemical properties of spinach leaves cv. Balady. Chemical analysis and physical properties of the experimental soil are shown in Table (1) and Aquacool is a commercial product containing macro nutrients such as N (7%), P (5%), K (5%), Mg (1%) and micro nutrients such as B (0.05%), Fe (0.3%) and S (2.1%) as well as amino acids. Pest control and other agriculture practices were applied as commonly recommended for commercial spinach production by Ministry of Agriculture. The experimental design was split plot with three replicates, where the three levels of bio fertilizer (0, 1 and 2kg/ fed.) were arranged within the main plots, the three levels of nutrient compound fertilizer (0, 1 and 2 cm/L.) were distributed in the sub-plots. Each experiment included 9 treatments with 3 replicates. Each experimental plot area was 10.5 m2 consisted of 5 ridges; each was 0.7 m width and 3 m length.

Seeds of spinach were sown in hills 10 cm apart on one side of the hill, 50 cm apart on the second week of October in both seasons. Three levels of chemical N fertilizer (Ammonium sulphate 20.6% N) were applied to the soil and added in two equal portions (during soil preparing, and one month after seeding as side dressing). Whereas, two levels of bio fertilizer (Biogein) were applied to the soil during preparing it for planting and foliar application of nutrient compound was mixed thoroughly with water and applied at three levels, i.e. 0, 1 and 2 cm/L and divided into two equal portions, first portion was added at 21 days from sowing and the second was added at 36 days from sowing. All recommended rate content of phosphorus as calcium super-phosphate (15% P2O5) which added during soil preparation at rate of 32 units /fed., whereas, potassium sulphate (48% K2O) was added at rate of 48 units/fed. At one month after seeding as recommended by the Egyptian Ministry of Agriculture.

Table 1: The physical and chemical properties of the experimental soil.

Depth (cm)	pH	Texture	Anions (mg/100g soil)			Cations (mg/100g soil)				Total nitrogen
			Ci	P	SO ₄	Na	K	Ca	Mg	
0-15	8.1	Clay	0.52	4.8	2.20	1.50	0.15	9.0	0.50	123
15-30	8.1	loam	0.38	5.6	1.60	1.20	0.07	4.0	0.25	137

Spinach plants with stems up to 20 cm in length, grown from seeding were harvested after 50 days and the fresh weight of plants were recorded as tons/fed. In addition, twenty spinach plants from each experimental plot were randomly taken for measurement of vegetative growth characters (plant length, leaves number, fresh and dry weights of leaves as well as total leaf chlorophyll was measured using Minolta Chlo. Meter (SPHD)-50. The chemical composition of fresh leaves tissue such as total nitrogen was determined according to methods of Chapman and Pratt (1978). In addition, protein percentages were calculated by multiplying nitrogen content by 6.25. However, total phosphorus and/ or total potassium were determined according to John (1970) and Richard (1954), respectively. All the obtained data were statistically analyzed and mean separation was done using the least significant differences (LSD) test at 5% level of probability according to Gomez and Gomez (1984).

3. Results and Discussion

3.1. Plant growth characters:

I. Effect of bio-fertilizer levels:

The data concerning the growth characters are presented in Table (2). The data specific that the implementation of two levels of bio fertilizer (Biogein) has significant influence on the growth parameters such as number of leaves /plant, plant height, fresh and dry weight of leaves and total chlorophyll content compared to without application (control) these true in both seasons. The maximum spinach plant growth i.e. leaf length, Number of leaves /plant, fresh and dry weight of leaves and total chlorophyll were registered in adding bio fertilizer (Biogein) at grade of (2 kg/fed.) pursue by bio fertilizer 1 kg/fed. and without added. However, the minimal spinach plant growth parameters obtained by without bio-fertilizer. The way was 2 kg/fed. bio fertilizer (Biogein) > 1 kg/fed. bio fertilizer > control. These results were correct in the two seasons. It could be complemented that the heaviest and superior values of growth parameters which resulted may be attributed to improving the availability of different nutrients by plant and increasing the resistance of plant to root diseases and decrease the environment pollution by the use of chemical fertilizers (Suba Rao, 1984). The gained results of bio fertilization on growth of spinach plants were in convention with that acquired by (AbdEl-Fattah *et al.*, 2003; El-Assiouty and Abo-Sedera 2005; Alderfasi *et al.*, 2010 and Aisha, *et al.*, 2013).

II. Effect of foliar application of nutrient compound (Aquacool) levels:

Data in Table (2) reported that foliar application of various levels of nutrient compound (Aquacool) significantly improved the growth parameters such as plant height, number of leaves, fresh and dry weight of spinach leaves as well as total chlorophyll content compared to without foliar spraying (Aquacool) (water) in both two growing seasons. However, the maximum suitable influence in this attention was increment Aquacool at foliar application up to (2 cm/L). On the other hand, it significantly improved plant length, number of leaves per plant, fresh and dry weight of leaves and total chlorophyll compared lower concentration of Aquacool (1 cm/L). These results were righting in the two seasons. The superiority of highest concentration of Aquacool up to (2 cm/L) in increasing spinach plant growth may be due to its height contents of macro and micro nutrients. This is probably due to as long as the plants with required nutrients which may one or additional of them were insufficiently supply through the root system. During the last decades, foliar spraying of nutrients has turn out a determined cooperation in crop production to improve plant growth, yield and increase the quality of crop productivity (Roemheld and El-Fouly, 1999). Foliar implementation of nutrients could advanced the nutrient implementation and lower environmental pollution through diminishing the computation of fertilizers added to soil (Abou-El-Nour 2002). The gained result are in good accordance with these which obtained by (El Fouly *et al.*, 2010; Bozorgi *et al.*, 2011; El-Habbasha *et al.*, 2012 ; Shafeek *et al.*, 2013 and 2018).

III. Effect the interaction of bio fertilizer and nutrient compound levels:

In connection with the interaction of bio fertilizer and nutrient compound levels the data in Table (2) specific that, vegetative growth characters of spinach plant was not significantly influenced in two seasons except leaves fresh weight in the first season only. Mostly, in spite of the un-significant reaction, but the gained data reported that the biggest values of plant growth levels were reported when sprayed

by highest level of Aquacool up to (2 cm/L) with high bio-fertilizer (Biogein) (2kg/fed.) compared to the other interaction treatments. These results held completely in the two experimental seasons.

Table 2: Effect of different levels of bio fertilizer and foliar application of nutrient compound on growth characters of spinach plant

Bio fertilizer levels	Aquacol levels (cm/L)	2017 season				
		Plant length (cm)	N. of leaves plant	Weight (g)		Total Chl.
				Fresh	Dry	
Without	0	16.23	6.67	28.67	3.46	30.07
	1	17.55	7.67	32.67	3.87	32.23
	2	19.33	8.67	32.67	4.67	37.50
Mean		17.71	7.67	31.33	4.00	33.27
1 Kg/fed.	0	22.23	9.00	43.67	5.58	40.00
	1	24.57	9.33	46.00	7.27	43.00
	2	26.40	10.00	62.33	8.08	45.67
Mean		24.40	9.44	50.67	6.98	42.89
2 Kg/fed.	0	27.83	10.67	66.67	8.80	48.33
	1	29.27	11.33	72.33	10.60	50.67
	2	32.27	11.67	90.67	11.64	52.33
Mean		29.79	11.22	76.56	10.34	50.44
Average	0	22.10	8.78	46.33	5.94	39.47
	1	23.79	9.44	50.33	7.25	41.97
	2	26.00	10.11	61.89	8.13	45.17
LSD at 5%	Bio	1.37	0.87	4.70	0.43	3.39
	Aquacol	0.49	0.31	1.51	0.40	0.94
	Interaction	NS	NS	2.61	NS	NS
2018 season						
Without	0	17.33	8.00	28.67	3.59	35.00
	1	21.00	9.00	32.67	3.92	38.00
	2	22.67	9.00	37.67	4.46	42.67
Mean		20.33	8.67	33.00	3.99	38.56
1 Kg/fed.	0	24.33	10.00	47.00	5.55	40.00
	1	25.00	11.00	57.33	6.75	46.00
	2	26.67	11.67	64.33	7.84	54.33
Mean		25.33	10.89	56.22	6.71	46.78
2 Kg/fed.	0	25.67	12.33	75.00	8.88	42.67
	1	28.00	12.33	89.00	10.50	45.00
	2	30.00	13.00	93.67	11.54	58.00
Mean		27.89	12.56	85.89	10.31	48.56
Average	0	22.44	10.11	50.22	6.00	39.22
	1	24.67	10.78	59.67	7.06	43.00
	2	26.44	11.22	65.22	7.95	51.67
LSD at 5%	Bio	1.54	1.42	2.44	0.25	2.08
	Aquacol	0.66	0.31	2.71	0.35	2.12
	Interaction	NS	NS	NS	NS	NS

3.2. Total yield and chemical properties of spinach leaves:

I. Effect of bio-fertilizer levels:

The effect presented in Table (3) established that soil inoculation by N-fixing bacteria (Biogein) which was already had high significant stimulating effects on spinach plant growth had a similar suitable activity on its total yield and chemical contents of spinach leaves and grant elevation to stated increases as approach with non pollination of bio-fertilizers. The implementation of bio fertilizer treatments grants the great total leaves yield (ton/fed.) and it's chemical contents of spinach leaves tissues such as (the percentage of N,P,K and total protein) in the two studied seasons. However, the pollination with elevation concentration of bio-fertilizer (Biogein) at 2 kg/fed. significantly increased total yield and its component compare low level (1 kg/fed.). The superiority in total leaves yield per fed. reached 46.978 % and 35.454 % respectively in the first and the second seasons respectively. Usually, the inoculation with bio-fertilizer (Biogein) promotes total yield and chemical contents of spinach leaves. This effect could be attributed to the role of bio-fertilizer that change organic N form to mineral N format, which is more impact by plants. In this attention, El-Kramany, *et al.* (2000) report that the significant effect of bio-fertilizers may be due to the effect of various strain collection such as nitrogen fixers, nutrients actuate microorganisms which help in availability of minerals and improving the levels of extractable N, P, K, Fe, Zn and Mn. The derivation of (AbdEl-Fattah *et al.*, 2003; El-Assiouty and Abo-Sedera 2005; Alderfasi *et al.*, 2010 and Aisha *et al.*, 2013) confirming present results.

Table 3: Effect of different levels of bio fertilizer and foliar application of nutrient compound on total leaves yield and its chemical contents of spinach plant

Bio fertilizer levels	Aquacol levels (cm/L)	2017 season					2018 season				
		Total yield (ton/fed)	%				Total yield (ton/fed)	%			
			N	P	K	Protein		N	P	K	Protein
Without	0	1.4717	1.44	0.31	1.33	9.05	1.4437	1.45	0.37	1.46	9.02
	1	1.5050	1.61	0.34	1.37	10.00	1.4533	1.55	0.40	1.67	10.07
	2	1.7800	1.69	0.39	1.40	10.38	1.7147	1.66	0.43	1.78	10.59
Mean		1.5856	1.58	0.35	1.37	9.81	1.5372	1.55	0.40	1.64	9.89
1 Kg/fed.	0	1.8333	1.74	0.45	1.44	10.73	1.7067	1.72	0.47	1.86	10.90
	1	1.8967	1.87	0.48	1.48	11.21	1.8227	1.76	0.51	1.98	11.69
	2	1.9567	1.96	0.53	1.61	10.90	1.8533	1.86	0.55	2.10	12.27
Mean		1.8956	1.86	0.49	1.51	10.95	1.7942	1.78	0.51	1.98	11.62
2 Kg/fed.	0	2.0433	2.10	0.57	1.66	10.95	1.8900	1.95	0.63	2.24	13.13
	1	2.2333	2.18	0.62	1.71	12.40	2.0000	1.99	0.65	2.17	13.83
	2	2.3067	2.39	0.65	1.82	14.52	2.5333	2.37	0.68	2.34	14.94
Mean		2.0144	2.22	0.61	1.73	14.18	2.1411	2.10	0.66	2.25	13.97
Average	0	1.7828	1.76	0.44	1.48	10.73	1.6801	1.71	0.49	1.85	11.02
	1	1.8783	1.89	0.48	1.52	11.91	1.7587	1.77	0.52	1.94	11.86
	2	2.0144	2.02	0.52	1.61	12.30	2.0338	1.96	0.56	2.07	12.60
LSD at 5%	Bio	0.1459	0.16	0.02	0.09	0.96	0.1828	0.16	0.02	0.07	1.01
	Aquacol	0.1209	0.03	0.01	0.06	0.55	0.1162	0.10	0.01	0.05	0.33
	interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

II. Effect of foliar application of nutrient compound (Aquacool) levels:

Data relative in Table (3) found that foliar sprinkle of various rates of nutritional complex (Aquacool) significantly improved total spinach leaves yield as ton/fed. compared to the untreated treatment (control). However, foliar sprinkle of elevation rates of nutritional fertilizer (2 cm/L.) reported its biggest values on total yield (ton/fed.) of spinach leave (2.0144 and 2.0338 ton/fed.) for 1st and 2nd seasons respectively compared (1.7828 and 1.6801 ton/fed.) for 1st and 2nd seasons respectively by without application control (Table 3). This means that, the chemical composition of spinach leaves expressed as (N, P, K and total proteins %) were influenced by the same degree by total leaves yield in

both seasons. These results are clearly due to the function of micronutrients and the other macro elements in the nutrient compounds simulating the metabolic operation and in turn in plant growth, total yield and leaves quality. Foliar implementation of micronutrients seems to encourage the metabolic operation within the plant over their direct influence on the enzymatic reactions (Peyve, 1969). Moreover, foliar alimentation of a nutrient might have in effect advanced root assimilation of the same nutrient or other nutrients over increasing root growth and improving nutrients uptake (El-Fouly and El-Sayed, 1997). However, the direction of gained results are in good conformity with that of the advanced investigators such as (El Fouly *et al.*, 2010; Bozorgi *et al.*, 2011; El-Habbasha *et al.*, 2012 and Shafeek *et al.*, 2021) of crops.

III. Effect the interaction of bio fertilizer and nutrient compound levels:

The interaction among inoculation soil of bio fertilizer (Biogein) and foliar implementation of nutrient complex had effects on spinach total yield and its leaves contents of the percentage of N, P, K and protein (Table, 3). The great values were registered by using height level of bio-fertilizer at (2 kg/fed.) with foliar sprinkle of nutrient complex (Aquacool) at elevation concentration (2 cm/L). The statistical test of the obtained data registered insignificant in total leaves yield (ton/fed.) and tissues content of spinach leaves of the percentage of N, P, K and total protein in the two growing seasons.

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