Response of Garlic Plants to Chemical, Organic and Biofertilizers. 1-Plant Growth, Chemical Composition and Yield

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Abstract: This study was carried out during the winter seasons of 2003/2004 and 2004/2005 at the Experimental Farm, Faculty of Agriculture, Suez Canal University, Ismailia Governorate to study the effect of different types of organic manures, in addition to mineral N, P and K fertilization and Rhizobacterin at rates ranged from 0 to 4 kg/fed either single or in combinations, under sandy soil conditions on plant growth, leaves chemical composition, yield and its components, bulb and clove characters of Chinese garlic cultivar. Mineral fertilizers gave significantly the highest values of plant length, number of leaves per plant; both fresh and dry weight of leaves; N, P and K contents of leaves; yield of bulb> 5cm, total yield, both weight and diameter of bulb, neck diameter and clove weight. The second treatment recorded positive increase in the previous parameters was poultry manure followed by farmyard manure then composted cattle manure. The control (without fertilizers) recorded the least parameters. Increasing Rhizobacterin rate from 0 to 4 kg/fed significantly increased plant length, leaves number per plant, dry weight of leaves per plant, N, P, K, Mn, Fe and Zn contents in leaves; yield of bulbs> 5 cm; total yield; both weight and diameter of bulb; neck diameter and clove weight. The interaction between mineral NPK fertilization and 4 kg Rhizobacterin/fed gave significantly the highest values of plant length, leaves number per plant, both fresh and dry weight of leaves per plant, N, P and K contents of leaves, yield of bulbs> 5cm, total yield, both weight and diameter of bulb, neck diameter and clove weight.

Keywords: Garlic, organic manure, mineral and bio-fertilizer.

INTRODUCTION

Garlic (*Allium sativum* L.) is one of the most commercially important bulb crops in Egypt for both local consumption and export. It is commonly used as a spice or condiment as well as for many medical purposes. Organic manures must be added to improve the chemical and physical properties of the soil, reducing soil pH and Ec, increasing soil organic matter content. Soils of high organic matter are recognized as fertile, because of constantly release of nutrients during the time of decomposition (Balba, 1973 and Salem 1986). In addition, organic manures increase the population and activity of micro-organisms in the soil (Parr, 1975 and Mervat and Dahdoh, 1995). Fisher and Richter (1984), Borin *et al.* (1987) and Browaldh (1992) reported that organic manure is a rich and slow release fertilizer, its usage leads to produce clean plant product. Also, organic manure dose not cause environmental pollution compared with chemical fertilizers. Moreover, the increased demand for organic products has also been an incentive for producers in sub-tropical countries to start organic production for export. Many investigators reported that applying organic manures caused an improvement in vegetative growth and yield of bulb crops compared with applying no organic fertilizers. Mohamed and Gamie (1999) reported that application of organic manure has a considerable effect on increasing both plant length and number of leaves per plant; N, P and K contents of leaves and total yield of onion. In this connection, Arenfalk and Hagekjaer (1995) showed that chicken manure has a favorable effect on total yield of leek. In other plant species, organic fertilizers increased the growth and yield of tomato (Steffen *et al.*, 1995 and El-Sheikh and Salama, 1997); cow pea (Abd-El-Fattah and Saleh, 1999); cucumber (Abou-Hadid *et al.*, 2001).

Soil micro-organisms can play an important role in increasing soil fertility and plant development via N_2-Fixation and releasing certain nutrient elements (P, Fe, Zn, Mn, and K) in addition to contributing with some phytohormons such as gibberellins, auxins and cytokinines (Tien *et al.*, 1979 and Bouton *et al.*, 1985). Moreover, Rhizobacterin have beneficial function, improve water status and N-asimilation in plant cell, produce amino acid e.g., glutamine, aspartine, histamine and serine as well as increase nitrate reductase activity and antifungal compounds (Alexander, 1982; Aggarwal and Chauhary 1995 and Bashan and Holguin, 1997). Inoculation of garlic cloves with Rhizobacterin has a favourable effect on vegetative growth (Abd-El-Hady, 2003), nutrients uptake (Wange, 1998; Lewis *et al.*, 1995; Mhendran and Kumar, 1996 and Gouda 2002) yield and its components (Lewis *et al.*, 1995; Mahenran and Kumar, 1996; Gomez and Munoz, 1998 and Abd-El-Hady, 2003). Since most of the soils in Ismailia and Sinai are sandy in texture and poor in organic matter and have low nutrient contents, the addition of organic manures and N-biofertilizers is necessary. However, little information is available to guide grower on efficient utilization of organic manure fertilizers and N-biofertilizers. Therefore, the aim of this study was to investigate the effect of different types of organic manure in addition to mineral N, P and K fertilization and rate of Rhizobacterin as biofertilizer, either single or in combinations on garlic plant growth, leaves chemical composition, yield and its components, bulb and clove traits.

MATERTIALS AND METHODS

Two field experiments were conducted on Chinese garlic plants during the winter seasons of 2003/2004 and

2004/2005 at the Experimental Farm, Faculty of Agriculture, Suez Canal University, Ismailia Governorate to study the effect of different types of organic manures; mineral N, P and K fertilizers and the inoculation with Rhizohacterin on plant growth, leaves chemical composition, yield and its components of garlic plant (Chinese cultivar) under sandy soil conditions.

Table (1): The physical and chemical analysis of the experimental soil

Properties	Values 2003/2004	Values 2004/2005
Sand	94.84 %	95.88 %
Silt	3.37 %	2.21 %
Clay	1.79 %	1.91 %
Texture	Sandy	Sandy
pH	8.05	8.11
Ec	2 mmhose/cm	1.98 mmhose/cm
Organic matter	0.77 g/kg	0.75 g/kg
Available N	4.45 ppm	4.51 ppm
Available P	3.47 ppm	4.97 ppm
Available K	10.25 ppm	10.02 ppm

The experimental design was a split-plot with four blocks. The main plots were presented as type of fertilizer, while Rhizobacterin levels were distributed in the sub-plots. The experiment included 15 treatments which were the combinations among three types of organic manures (poultry manure, farmyard manure and composted cattle manure) in addition to mineral N, P and K fertilizers and the control (without fertilizers) and three levels of Rhizobacterin (0, 2 and 4 kg/fed). Chemical analysis of the used organic manure is shown in Table (2). The fertilizers were applied according to their content of total nitrogen. Organic fertilizers and mineral fertilizers contained 120 kg N/fed. The sub-plot area was $15m^2$ (1/280 feddan) which contained 5 rows, each 5m long and 0.6m wide. The treatments were combined as follows:

Fertilizer		Rhizobacterin rate
Control	+	0 kg/fed
Control	+	2 kg/fed
Control	+	4 kg/fed
Composted Cattle manure	+	0 kg/fed
Composted Cattle manure	+	2 kg/fed
Composted Cattle manure	+	4 kg/fed
Farmyard manure	+	0 kg/fed
Farmyard manure	+	2 kg/fed
Farmyard manure	+	4 kg/fed
Poultry manure	+	0 kg/fed
Poultry manure	+	2 kg/fed
Poultry manure	+	4 kg/fed
Mineral fertilizers	+	0 kg/fed
Mineral fertilizers	+	2 kg/fed
Mineral fertilizers	+	4 kg/fed

Ammonium sulphate (20.5 % N) was used as a source of mineral nitrogen and applied in four equal doses at planting, 30, 60 and 90 days after planting. Phosphorus and potassium were added in the form of calcium superphosphate (15.5 % P_2O_5) and potassium sulphate (48 % K_2O) at the rates of 90 kg P_2O_5 and 96 kg K_2O/fed respectively. Calcium super phosphate and organic manures were added at the time of soil preparation. Potassium sulphate was equally divided after 30 and 60 days from planting. Uniformed cloves were chosen and soaked in running water for 24h cloves were treated with Rhizobacterin immediately before planting. Cloves were treated with gum material and dipped for 5 minutes in paste of carried based inoculant mixed with wet soft duste (1-5 ratio).

Rhizobecterin inoculum is commercial N-biofertilizer locally produced by the General Organization for Agriculture Equalization Fund (GOAEF), Ministry of Agriculture, Egypt. It contains live cells of efficient bacteria (70 % *Azotobacter* + 30 *Azospirillum*) which are capable to N_2 fixation in the soil.

The planting was carried out during the first week of October for both seasons of study. The cloves were hand planted at 10cm apart on two sides of each row. Furrow irrigation was applied every 3 days. The other normal agricultural treatments for growing garlic plants were practiced.

Table (2): The chemical analysis of the used organic manures.

Organic manures characters	Poultry manure		Farmyard manure		Composted cattle manure	
	2003/2004	2004/2005	2003/2004	2004/2005	2003/2004	2004/2005
Weight of m^3 (kg)	512	508	600	604	748	755
Moisture percentage	59	54	57	59	36.2	36.9
pH	6.5	6.6	7.5	7.5	7	7.4
Ec (mmhose/cm)	5.9	5.7	14.7	14.4	12	12.2
Organic carbon %	33	32	8.1	7.8	18.89	18.93
Organic matter %	63.4	63.31	29.09	25.04	32.57	34.13
Total nitrogen %	2.98	3.15	0.74	0.73	1.27	1.23
C/N ratio %	1:10.7	1:10.7	1:16.8	1:16.3	1:15.6	1:15.4
Total phosphorus %	0.15	0.14	0.52	0.51	0.47	0.49
Total potassium %	0.81	0.83	0.85	0.87	0.80	0.86
Ferrous mg/kg	175	171	644	652	155	150
Manganese mg/kg	245	253	136	139	598	564
Copper mg/kg	96	99	12	13	36	37
Zinc mg/kg	113	115	112	109	67	65
Application rate (kg/fed)	8948	8910	32004	32876	15544	15779

Data Recorded:

The following data were recorded during the plant growth period and during harvesting.

1-**Vegetative growth character:** Five plant from each sub-plot were randomly taken at 120 days after planting and the following data were recorded: plant length, leaves number per plant and both fresh and dry weight (after oven dried for 72 hr at 70°C) of leaves per plant.

2-**Leaves chemical composition:** The dried leaves were finely ground, wet digested and total nitrogen was determined according to Bremner and Mulvaney (1992). Phosphorus was estimated colorimetrically according to Olsen and Sommers (1982). Potassium was also determined flame photometrically due to the methods described by Jackson (1970). Manganese, zinc and iron were determined using an atomic absorption spectrophotometer as described by Pag *et al.* (1982).

3-**Yield and its components:** At harvesting time, all plants of each sub-plot were harvested, weighted after curing for 3 days and converted to record the following characters: Total yield, yield of bulb> 5cm and yield of bulb< 5 cm in diameter.

4-**Bulbs characters:** A random samples (10 bulbs) were taken from each sub-plot at harvesting to determine:

Bulb weight and diameter, neck diameter and bulbing ratio (Mann, 1952)

$$\text{Bulbing ratio} = \frac{\text{bulb neck diamter (cm)}}{\text{bulb diamter (cm)}}$$

5-**Cloves traits:** All cloves of chosen bulbs of each sub-plot were used to determine: Clove weight, number of cloves per bulb and clove circles per bulb.

Statistical Analysis:

All obtained data were subjected to statistical analysis of variance and the least significant difference (L.S.D) was calculated as mentioned by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

1) Vegetative Growth Characters:

a) Effect of fertilizer type:

Data recorded in Table (3) show that mineral NPK fertilizers gave significantly the highest values of plant length, leaves number per plant and both fresh and dry weight of leaves per plant in both seasons. The second treatment with increase in the previous parameters was poultry manure followed by farmyard manure then composted cattle manure as compared with the control.

The obtained results are in harmony with those of Hossein (2002) on onion concerning plant length, leaves number and fresh weight of leaves per plant. Similar results were obtained by Gliesman *et al.* (1996) who reported that strawberry leaves number per plant decreased in the organic production compared with conventional system. Also, similar results were obtained by El-Banna and Abd-El-Salam (2000) on potato where they found that using mineral nitrogen fertilizer was effective on vegetative growth parameters than farmyard manure. Moreover, the obtained results are in harmony with those of Abd-El-Mouty *et al.* (2000) on squash and El-Mansi *et al.* (2004) on pea where they found that chicken manure gave better plant growth expressed as length of plant and number of leaves per plant than cattle manure.

Furthermore, Mahmoud (2006) reported that applying chicken manure significantly increased onion plant height compared with the control (without fertilizers). The observed enhancement effect on plant growth with the mineral fertilizers compared with organic manures may be due to rapid availability of nutrients (N, P and K) for garlic growth period. The improvement of vegetative growth with chicken manure compared with the other organic manure may be inputted to rapid decomposition of chicken manure throughout garlic growth period.

b)Effect of Rhizobacterin level:

Data in Table (3) indicate that plant length, leaves number per plant and dry weight of leaves per plant

were significantly increased with increasing Rhizobacterin levels from 0 to 4 kg/fed in both seasons except dry weight of leaves per plant in the first season. Concerning fresh weight of leaves per plant, there were no significant differences among Rhizobacterin levels in both seasons.

The obtained results coincided with those of Wange (1998) concerning plant length and Abd-El-Hady (2003) regarding plant height and number of leaves per plant.

The enhancement effect on vegetative growth of garlic plants due to use of Rhizobecterin may be inputted to improvement soil fertility via N_2 fixation and releasing certain nutrient elements (P, Fe, Zn, Mn and K) and to contributing some hormones such as gibberellins, auxins and cytokinins (Tien *et al.*, 1979, Bouton *et al.*, 1985 and Cacciar *et al.*, 1989). These phytohormones may stimulate the cell elengation and division in plant, hence plant growth (Paleg 1985). Moreover, Rhizobacterin have beneficial effects on plant by confirm plant root growth and function, improve water status and N-assimiplation in plant cells, produce amino acid e.g., glutamine, aspartain, histamine and serine as well as increase nitrate reductase activity and antifungal compounds (Alexander, 1982; Aggarwal and Chaudhary, 1995 and Bashan and Holguin, 1997).

c) Effect of interaction between fertilizer type and Rhizobacterin level:

Data in Table (4) reveal that the combination of mineral fertilizers with 4 kg Rhizobacterin/fed gave significantly the highest values of plant length, leaves number per plant and both fresh and dry weight of leaves per plant in both growing seasons.

Table (3): Effect of fertilizer type and Rhizobacterin level on vegetative growth characters of garlic during 2003/2004 and 2004/2005 seasons.

Treatment	Plant length (cm)	Leaves number/ plant	Fresh weight of leaves/ Plant (g)	Dry weight of leaves/ Plant (g)	Plant length (cm)	Leaves number/ plant	Fresh weight of leaves/ Plant (g)	Dry weight of leaves/ Plant (g)
	(2003-2004)				(2004-2005)			
Fertilizer:								
Control	34.35	5.54	54.67	4.12	33.41	6.41	62.98	4.79
Composted cattle manure	46.17	8.59	80.37	8.51	51.92	10.01	95.83	9.92
Farmyard manure	54.13	9.73	107.00	9.60	57.98	10.66	118.94	10.46
Poultry manure	58.87	10.61	133.53	11.29	60.79	11.22	139.23	11.23
Minerals (NPK)	64.97	11.42	170.60	11.83	69.79	12.01	179.48	12.54
LSD %	5.06	0.74	20.79	1.63	3.79	0.84	16.84	1.23
Rhizobacterin (Kg/fed):								
0	48.88	8.81	106.15	8.97	53.21	9.82	115.84	9.58
2	51.69	9.12	110.09	8.94	54.59	10.03	119.16	9.79
4	54.52	9.61	111.46	9.30	56.24	10.34	122.87	9.99
LSD %	0.01	0.07	NS	NS	0.23	0.34	NS	0.03

Table (4): Effect of interaction between fertilizer type and Rhizobacterin level on vegetative growth characters of garlic during 2003/2004 and 2004/2005 seasons.

Treatment		Plant length (cm)	Leaves number/ plant	Fresh wt. of leaves/ Plant (g)	Dry wt. of leaves/ Plant (g)	Plant length (cm)	Leaves number/ plant	Fresh wt. of leaves/ Plant (g)	Dry wt. of leaves/ Plant (g)
		(2003-2004)				(2004-2005)			
Fertilizer	**Rhizo. (Kg/fed)**								
Control	**0**	29.76	5.16	52.31	3.94	31.57	5.99	60.66	4.55
	2	32.17	5.31	53.05	3.95	33.01	6.43	63.73	4.78
	4	41.13	6.18	58.64	4.35	35.64	6.81	64.55	4.84
Composted cattle manure	**0**	43.32	7.91	81.37	7.93	49.11	9.82	98.80	9.88
	2	47.54	8.53	84.39	8.46	52.62	10.00	99.00	9.90
	4	47.67	9.35	98.67	9.13	54.02	10.20	99.70	9.97
Farmyard manure	**0**	50.92	9.63	104.95	9.42	55.80	10.49	113.44	10.21
	2	54.34	9.68	107.57	9.68	58.00	10.53	116.11	10.45
	4	57.12	9.87	108.49	9.71	60.13	10.97	119.22	10.73
Poultry manure	**0**	58.20	10.25	127.76	10.16	60.44	11.10	137.38	10.99
	2	58.49	10.68	133.72	10.66	60.93	11.22	139.75	11.18
	4	59.93	10.89	139.11	11.04	61.00	11.35	143.88	11.51
Minerals (NPK)	**0**	62.22	11.10	164.34	11.56	69.11	11.70	174.57	12.22
	2	65.93	11.38	171.74	11.98	69.85	11.96	179.57	12.57
	4	66.77	11.77	175.73	12.27	70.42	12.37	184.29	12.83
LSD %		0.02	0.19	16.27	1.55	0.95	0.11	4.61	0.07

Leaves Chemical Composition:

c) Effect of fertilizer type:

Data recorded in Tables (5 and 7) show that mineral fertilizers gave significantly the highest N, P and K contents of leaves followed by poultry manure, farmyard manure, composted cattle manure and the control treatment, in both seasons. With regard to Mn, Fe and Zn contents of leaves, poultry manure gave significantly the highest uptake of Mn, Fe and Zn followed by farmyard manure, composted cattle manure, mineral fertilizer and the control, in both growing seasons respectively. Similar results were obtained with onion by Mallanagouda *et al.* (1995) and Mahmoud (2006) where they reported that plants from plots treated with the recommended rates of NPK exhibited higher uptake of N, P and K than those fertilized with organic manure. Moreover, El-Mansi *et al.* (2004) indicated that application of chicken manure increased pea N, P and K contents compared with application of farmyard manure.

b) Effect of Rhizobacterin level:

Data obtained in Tables (5 and 7) reveal that N, P, Mn, Fe and Zn contents of leaves significantly increased with increasing level of Rhizobacterin from 0 to 4 kg/fed in both seasons except P uptake in the first season where there were no significant differences among Rhizobacterin levels. Regarding K content in leaves, no significant differences among Rhizobacterin levels were detected in both seasons. Similar results were obtained by El-Rewainy and Abd-Alla (2005) on strawberry, where they reported that inoculation with *Azospirillum brasilense* increased P, Fe and Zn contents in leaves compared with the uninoculated (control) treatment.

Table (5): Effect of fertilizer type and Rhizobacterin level on leaves chemical composition of garlic during 2003/2004 season.

Treatment	N (%)	P (%)	K (%)	Mn mg/kg dry matter	Fe mg/kg dry matter	Zn mg/kg dry matter
Fertilizer:						
Control	2.241	0.334	1.854	16.32	163.06	19.22
Composted cattle manure	2.366	0.360	2.086	17.78	176.86	27.94
Farmyard manure	2.668	0.389	2.135	21.13	204.51	34.88
Poultry manure	2.948	0.405	2.310	22.62	329.72	37.64
Minerals (NPK)	3.704	0.468	3.227	16.43	162.92	19.50
LSD %	0.032	0.015	0.376	2.06	13.62	4.13
Rhizobacterin (Kg/fed):						
0	2.698	0.380	2.253	18.29	193.80	26.62
2	2.782	0.387	2.356	18.82	207.98	27.44
4	2.876	0.395	2.358	19.46	226.73	29.46
LSD %	0.023	NS	NS	0.01	3.00	0.05

Table (6): Effect of interaction between fertilizer type and Rhizobacterin level on leaves chemical composition of garlic during 2003/2004 season.

Treatment		N (%)	P (%)	K (%)	Mn mg/kg dry matter	Fe mg/kg dry matter	Zn mg/kg dry matter
Fertilizer	**Rhizo. (Kg/fed)**						
Control	**0**	2.230	0.306	1.806	16.09	160.22	18.81
	2	2.242	0.311	1.835	16.31	163.39	19.33
	4	2.251	0.325	1.921	16.55	165.74	19.53
Composted cattle manure	**0**	2.264	0.349	1.941	16.70	173.62	25.08
	2	2.409	0.361	1.949	17.44	174.18	26.13
	4	2.493	0.370	2.035	19.21	182.77	32.61
Farmyard manure	**0**	2.518	0.381	2.054	20.83	190.05	33.25
	2	2.601	0.389	2.126	21.11	201.12	35.17
	4	2.884	0.396	2.224	21.45	222.36	36.27
Poultry manure	**0**	2.915	0.401	2.248	21.60	285.12	36.75
	2	2.947	0.405	2.329	22.71	330.44	37.03
	4	2.981	0.408	2.353	23.55	360.27	39.15
Minerals (NPK)	**0**	3.629	0.461	3.215	16.22	160.01	19.21
	2	3.711	0.469	3.218	16.51	164.11	19.53
	4	3.773	0.475	3.248	16.55	164.63	19.77
LSD %		0.048	0.005	0.305	0.03	6.72	0.09

Table (7): Effect of fertilizer type and Rhizobacterin level on leaves chemical composition of garlic during 2004/2005 season.

Treatment	N (%)	P (%)	K (%)	Mn mg/kg dry matter	Fe mg/kg dry matter	Zn mg/kg dry matter
Fertilizer:						
Control	2.157	0.315	1.963	17.59	175.77	19.49
Composted cattle manure	2.373	0.360	2.095	18.58	186.07	29.03
Farmyard manure	2.831	0.396	2.293	20.31	220.50	34.73
Poultry manure	2.931	0.403	2.422	22.38	354.46	35.70
Minerals (NPK)	3.742	0.459	3.296	17.77	123.07	20.52
LSD %	0.138	0.031	0.266	1.66	8.71	3.41
Rhizobacterin (Kg/fed):						
0	2.719	0.378	2.387	18.82	211.18	26.00
2	2.826	0.387	2.410	19.31	225.04	27.99
4	2.875	0.395	2.445	19.84	263.52	29.69
LSD %	0.104	0.004	NS	0.11	2.36	1.20

Table (8): Effect of interaction between fertilizer type and Rhizobacterin level on leaves chemical composition of garlic during 2004/2005 season.

Treatment		N (%)	P (%)	K (%)	Mn mg/kg dry matter	Fe mg/kg dry matter	Zn mg/kg dry matter
Fertilizer	**Rhizo. (Kg/fed)**						
Control	**0**	2.136	0.302	1.922	17.41	172.14	18.54
	2	2.153	0.310	1.962	17.65	175.66	19.71
	4	2.181	0.333	2.004	17.71	179.51	20.23
Composted cattle manure	**0**	2.203	0.340	2.051	17.92	180.73	26.96
	2	2.411	0.365	2.083	18.81	186.17	28.95
	4	2.504	0.374	2.150	19.33	191.30	31.18
Farmyard manure	**0**	2.676	0.392	2.277	19.94	200.28	32.31
	2	2.786	0.397	2.283	20.07	212.51	35.90
	4	2.801	0.400	2.320	20.92	248.72	35.98
Poultry manure	**0**	2.841	0.401	2.403	21.30	329.37	36.20
	2	2.966	0.403	2.429	22.17	355.05	38.21
	4	2.985	0.404	2.435	23.66	378.95	39.37
Minerals (NPK)	**0**	3.513	0.455	3.281	17.54	173.40	19.33
	2	3.615	0.459	3.293	17.87	195.81	20.51
	4	3.699	0.462	3.315	17.90	219.22	21.71
LSD %		0.229	0.008	0.002	0.25	6.46	2.69

c) Effect of interaction between fertilizer type, and Rhizobacterin level:

Data in Tables (6 and 8) indicate that the combination between mineral fertilizers and 4 kg Rhizobacterin/fed gave significantly the highest N, P and K contents of leaves in both growing seasons. Respecting Mn, Fe and Zn uptake, the interaction between poultry manure and 4 kg Rhizobacterin/fed gave significantly the highest Mn, Fe and Zn contents of leaves in both seasons.

2) Yield and its Components:

a) Effect of fertilizer type:

Data in Table (9) reveal that mineral fertilizers gave significantly the highest values of yield of bulbs < 5cm diameter, yield of bulbs> 5cm and total yield. The second fertilizer with positive effect on the previous characters was poultry manure then farmyard manure then composted cattle manure followed by control in both seasons. Similar results were obtained by Mallanagouda *et al.* (1995) on garlic where they reported that plants from plots treated with mineral N, P and K fertilizers exhibited higher total yield than farmyard manure. Furthermore, the obtained results agree with those of Arenfalk and Hagelskjaer (1995) on leek, those of Mohamed and Gamie (1999), Hossein (2002) and Mahmoud (2006) on onion.

Respecting the effect of different organic manure on the total yield, the obtained results agree with those of Abd-El-Mouty *et al.* (2000) on squash where they reported that chicken manure gave higher yield than cattle manure. The observed enhancement on garlic yield with the mineral fertilizers compared with organic manures may be attributed to the increase in leaves growth which in turn increase the synthesis and

translocation of carbohydrates to storage organs (Aggarwal and Choudhary, 1995) and to N, P and K uptake (Tables 5 and 7).

b) Effect of Rhizobacterin level:

Data in Table (9) indicate that yield of bulbs < 5cm, diameter, yield> 5 cm diameter and total yield were significantly increased with increasing level of Rhizobacterin from 0 to 4 kg/fed in both seasons. 2 kg Rhizobaterin/fed increased total yield by 1.72 % and 2.44 % and 4 kg Rhizobaterin/fed by 3.62 % and 6.53 % over control, in the first and second seasons, respectively. The obtained results are in correspondence with those of Lewis *et al.* (1995), Mahendran and Kumar (1996), Gomez and Munoz (1998) and Abd-El-Hady (2003) on garlic. The increase in total yield due to use of Rhizobacterin may be attributed to the increase in garlic vegetative growth (Table 3) and nutrients uptake (Tables 5 and 7).

c) Effect of interaction between fertilizer type and Rhizobacterin level:

Data recorded in Table (10) show that mineral fertilizers combined with 4 kg Rhizobacterin/fed gave significantly the highest values of yield> 5 cm and total yield in both seasons. Concerning bulbs yield< 5 cm diameter, composted cattle manure with 4 kg Rhizobacterin/fed gave significantly the highest yield< 5 cm in the first season while the combination between composted cattle manure and 0 kg Rhizobacterin/fed gave significantly the highest yield< 5cm in the second season.

Table (9): Effect of fertilizer type and Rhizobacterin level on yield and its components of garlic during 2003/2004 and 2004/2005 seasons.

Treatment	Yield < cm (Ton/Fed)	Yield > cm (Ton/Fed)	Total Yield (Ton/Fed)	Yield < cm (Ton/Fed)	Yield > cm (Ton/Fed)	Total Yield (Ton/Fed)
	(2003-2004)			(2004-2005)		
Fertilizer:						
Control	1.241	1.838	3.102	1.097	2.404	3.398
Composted cattle manure	2.733	2.476	5.320	2.211	3.688	5.903
Farmyard manure	1.411	4.391	5.802	2.165	4.217	6.382
Poultry manure	1.391	6.208	٧.599	2.167	6.373	8.206
Minerals (NPK)	2.306	6.931	9.321	2.422	7.890	10.283
LSD %	0.415	0.901	0.911	0.407	0.732	0.979
Rhizobacterin (Kg/fed):						
0	1.898	4.077	6.025	2.070	4.686	6.636
2	1.853	4.282	6.202	2.952	4.955	6.798
4	1.699	4.748	6.459	2.015	5.102	7.069
LSD %	0.143	0.060	0.072	0.046	0.055	0.039

Table (10): Effect of interaction between fertilizer type and Rhizobacterin level on yield and its components of garlic during 2003/2004 and 2004/2005 seasons.

Treatment		Yield < cm (Ton/Fed)	Yield > cm (Ton/Fed)	Total Yield (Ton/Fed)	Yield < cm (Ton/Fed)	Yield > cm (Ton/Fed)	Total Yield (Ton/Fed)
		(2003-2004)			(2004-2005)		
Fertilizer	**Rhizo. (Kg/fed)**						
Control	**0**	1.162	1.691	2.853	0.895	2.225	3.120
	2	1.257	1.815	3.072	1.057	2.477	3.324
	4	1.305	2.009	3.314	1.240	2.510	3.750
Composted cattle manure	**0**	3.177	1.978	5.155	2.485	3.116	5.601
	2	3.152	2.224	5.376	2.094	3.957	6.051
	4	2.202	3.227	5.429	2.054	3.992	6.056
Farmyard manure	**0**	1.475	4.181	5.656	2.094	4.009	6.103
	2	1.411	4.134	5.725	2.029	4.110	6.139
	4	1.347	4.677	6.024	2.373	4.531	6.904
Poultry manure	**0**	1.426	5.815	7.241	2.220	6.257	8.477
	2	1.403	6.162	7.565	2.147	6.362	8.509
	4	1.345	6.648	7.993	2.133	6.499	8.632
Minerals (NPK)	**0**	2.383	6.720	9.155	2.556	7.658	10.214
	2	2.375	6.896	9.271	2.432	7.867	10.299
	4	2.294	7.244	9.538	2.366	7.969	10.335
LSD %		0.319	0.134	0.161	0.108	0.120	0.093

4- Bulb Characters

a) Effect of fertilizer type:

Data in Table (11) show that mineral fertilizers recorded significantly the highest values of bulb weight and diameter. The second treatment which increases the previous parameter was poultry manure then farmyard manure followed by composted cattle manure and the control in both seasons.

Concerning neck diameter, mineral fertilizer treatment gave significantly the greatest neck diameter followed by poultry manure, farmyard manure, composed cattle manure and the control in the first season. With respect to bulbing ratio, the same data in Table (11) show that the control and composted cattle manure gave significantly the highest bulbing ratios followed by farmyard manure, poultry manure and mineral N, P and K fertilizers in the second season. The obtained results are in harmony with those of Hossein (2002) on onion. In addition, Mahmoud (2006) revealed that chicken manure significantly increased onion fresh weight of bulb compared with the control (without fertilizers).

b) Effect of Rhizobacterin level:

Data in Table (11) indicate that both bulb weight and diameter in both seasons and neck diameter in the first season were significantly increased with increasing rate of Rhizobacterin from 0-4 kg/fed. Similar results were obtained by Ali and Abd-El-Mouty (2001) and Abd-El-Hady (2003) respecting bulb diameter.

c) Effect of interaction between fertilizer type and Rhizobacterin level:

Data in Table (12) reveal that mineral fertilizers with 4 kg Rhizobacterin/fed gave significantly the highest values of both bulb weight and diameter and neck diameter in both seasons except neck diameter in the second season. Regarding bulbing ratio, poultry manure with 4 kg Rhizobacterin/fed gave significantly the highest value of bulbing ratio in the first season, while control with 4 kg Rhizobacterin/fed gave the highest value in the second one.

Table (11): Effect of fertilizer type and Rhizobacterin level on bulb characters of garlic during 2003/2004 and 2004/2005 seasons.

Treatment	Bulb weight (g)	Bulb diameter (cm)	Neck diameter (cm)	Bulbing ratio	Bulb weight (g)	Bulb diameter (cm)	Neck diameter (cm)	Bulbing ratio
	(2003-2004)				(2004-2005)			
Fertilizer:								
Control	22.53	3.54	0.73	0.205	25.49	3.67	0.88	0.241
Composted cattle manure	39.83	4.17	0.86	0.205	44.27	4.43	1.03	0.241
Farmyard manure	43.21	4.75	0.99	0.209	47.86	4.96	1.05	0.211
Poultry manure	56.87	5.15	1.09	0.214	64.05	5.30	1.09	0.206
Minerals	69.90	6.18	1.28	0.207	77.12	6.50	1.12	0.172
LSD %	5.56	0.46	0.02	NS	7.32	0.42	NS	0.002
Rhizobacterin (Kg/fed):								
0	44.52	4.58	0.94	0.205	50.27	4.78	1.00	0.212
2	46.44	4.77	0.99	0.207	51.48	5.00	1.03	0.216
4	48.44	4.93	1.05	0.212	53.52	5.14	1.06	0.213
LSD %	0.79	0.06	0.01	NS	0.52	0.04	NS	NS

5- Clove Traits

a) Effect of fertilizer type:

Data in Table (13) show that mineral fertilizer treatment gave the highest value of clove weight followed by poultry manure, farmyard manure then composted cattle manure while the control treatments gave the lowest values. The previous trend was found in both growing seasons. Conversely, the control treatment gave the highest values of number clove circles per bulb followed by composted cattle manure, farmyard manure, poultry manure, and mineral fertilizers, in both seasons. Concerning number of cloves per bulb, poultry manure gave the greatest number of cloves per bulb followed by composted cattle manure, farmyard manure, control and mineral fertilizers.

b) Effect of Rhizobacterin level:

Data in Table (13) indicate that clove weight was significantly increased with increasing rate of Rhizobacterin from 0 to 4 kg/fed while number of cloves in the second season and clove circles per bulb in the first season were decreased with increasing the rate of Rhizobacterin from 0 to 4 kg/fed.

The obtained results agree with those of Lewis *et al.* (1995), and Abd-El-Hady (2003). The positive effect of biofertilizer on clove weight may be explained on the bases of well known role of N_2 fixation bacteria in improving photosynthesis process and this in turn increased translocation of synthesized carbohydrates to storage organs (Aggarwal and Chaudhary, 1995).

Table (12): Effect of interaction between fertilizer type and Rhizobacterin level on bulb characters of garlic during 2003/2004 and 2004/2005 seasons.

Treatment		Bulb weight (g)	Bulb diameter (cm)	Neck diameter (cm)	Bulbing ratio	Bulb weight (g)	Bulb diameter (cm)	Neck diameter (cm)	Bulbing ratio
		(2003-2004)				(2004-2005)			
Fertilizer	**Rhizo. (Kg/fed)**								
Control	**0**	21.39	3.46	0.69	0.198	23.40	3.50	0.74	0.211
	2	23.03	3.51	0.71	0.203	24.93	3.64	0.89	0.245
	4	24.84	3.69	0.79	0.215	28.13	3.88	1.02	0.263
Composted cattle manure	**0**	38.56	3.81	0.83	0.218	42.01	4.05	1.05	0.259
	2	40.21	4.23	0.84	0.199	45.38	4.51	1.01	0.224
	4	40.72	4.54	0.90	0.198	45.42	4.73	1.02	0.216
Farmyard manure	**0**	41.70	4.68	0.99	0.211	45.77	4.75	1.02	0.215
	2	42.93	4.75	0.98	0.207	46.04	5.01	1.06	0.212
	4	45.16	4.83	1.01	0.209	51.78	5.12	1.06	0.207
Poultry manure	**0**	54.18	5.02	1.05	0.209	63.58	5.26	1.07	0.203
	2	56.48	5.16	1.09	0.212	63.82	5.27	1.08	0.205
	4	59.94	5.28	1.17	0.221	64.74	5.37	1.11	0.209
Minerals	**0**	68.62	6.01	1.36	0.189	76.61	6.35	1.12	0.176
	2	69.55	6.19	1.34	0.216	77.24	6.57	1.12	0.170
	4	71.53	6.33	1.36	0.215	77.51	6.59	1.13	0.171
LSD %		1.78	0.14	0.05	0.001	1.16	0.09	NS	0.001

c) Effect of interaction between fertilizer type and Rhizobacterin level:

Data in Table (14) illustrate that mineral fertilizers treatment with 4 kg Rhizobacterin/fed gave significantly the highest value of clove weight while the poultry manure with 0 kg Rhizobacterin/fed gave significantly the highest values of number of cloves and clove circles per bulb in both seasons. Respecting number of clove circles per bulb, control with 0 Rhizobacterin gave the highest number of clove circles per bulb in both seasons. In conclusion, the present study demonstrated that mineral NPK fertilization gave greater garlic growth, nutrients uptake and yield. Poultry manure was the best organic manure concerning plant growth nutrients uptake and total yield. Also, the study showed that 4 kg Rhizobacterin/fed was the best Rhizobacterin level.

Table (13): Effect of fertilizer type and Rhizobacterin level on clove traits of garlic during 2003/2004 and 2004/2005 seasons.

Treatment	Clove weight (g)	No. of cloves/bulb	No. of clove circles/bulb	Clove weight (g)	No. of cloves/bulb	No. of clove circles/bulb
	(2003-2004)			(2004-2005)		
Fertilizer:						
Control	2.79	7.75	5.68	2.99	7.92	5.77
Composted cattle manure	4.15	9.03	5.17	4.38	9.57	5.15
Farmyard manure	4.97	8.10	4.43	5.22	8.58	4.18
Poultry manure	5.82	9.39	4.12	6.27	9.70	4.22
Minerals (NPK)	8.59	7.27	3.31	9.13	7.87	3.26
LSD %	0.89	0.66	0.32	0.79	0.32	0.59
Rhizobacterin (Kg/fed):						
0	4.97	8.56	4.67	5.24	8.99	4.56
2	5.25	8.32	4.55	5.58	8.63	4.54
4	5.57	8.55	4.41	5.98	8.56	4.45
LSD %	0.08	0.34	0.02	0.07	0.10	NS

Table (14): Effect of interaction between fertilizer type and Rhizobacterin level on clove traits of garlic during 2003/2004 and 2004/2005 seasons.

Treatment		Clove weight (g)	No. of cloves/bulb	No. of clove circles/bulb	Clove weight (g)	No. of cloves/bulb	No. of clove circles/bulb
		(2003-2004)			(2004-2005)		
Fertilizer	**Rhizo. (Kg/fed)**						
Control	0	2.66	7.54	5.83	2.91	7.46	5.90
	2	2.81	7.69	5.76	2.95	7.92	5.77
	4	2.90	8.02	5.44	3.10	8.37	5.63
Composted cattle manure	0	3.78	9.61	5.32	3.90	10.13	5.51
	2	4.32	8.74	5.11	4.51	9.39	5.00
	4	4.35	8.75	5.07	4.73	9.20	4.93
Farmyard manure	0	4.72	8.33	4.61	4.92	8.82	4.56
	2	4.92	8.09	4.44	5.22	8.27	4.52
	4	5.27	8.08	4.25	5.53	8.66	4.46
Poultry manure	0	5.44	9.36	4.19	5.92	10.20	4.31
	2	5.82	9.16	4.11	6.33	9.51	4.25
	4	6.19	9.06	4.05	6.57	9.39	4.11
Minerals (NPK)	0	8.24	7.75	3.40	8.56	8.36	3.52
	2	8.37	7.74	3.31	8.88	8.08	3.15
	4	9.16	7.26	3.22	9.96	7.17	3.11
LSD %		0.18	0.75	0.05	0.15	0.23	0.77

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إستجابة نباتات الثوم للأسمدة الكيميائية والعضوية والحيوية.
١ ـ نمو النباتات والتركيب الكيميائي والمحصول

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أجريت هذه الدراسة على نباتات الثوم الصينى خلال موسمى ٢٠٠٤/٢٠٠٣ و ٢٠٠٥/٢٠٠٤ بالمزرعة البحثية لكلية الزراعة – جامعة قناة السويس – الإسماعيلية لدراسة تأثير ثلاث أنواع من الأسمدة العضوية (سماد الدواجن والسماد البلدى وسماد الماشية المكمور) بالإضافة للتسميد المعدنى وثلاث معدلات من الريزوبكترين (صفر و٢ و٤ كيلو جرام/ فدان) تحت ظروف الأرض الرملية على نمو النباتات والمحتوى الكيميائى للأوراق والمحصول ومكوناته وصفات الأبصال والفصوص.

أوضحت الدراسة أن التسميد المعدنى أعطى أعلى القيم لكل من طول النبات وعدد الأوراق للنباتات وكلا من الوزن الطازج والجاف للأوراق للنبات والممتص من النيتروجين والفوسفور والبوتاسيوم ومحصول الأبصال ذات قطر أكبر من ٥ سم والمحصول الكلى وكلا من وزن وقطر البصلة ووزن الفص. يأتى سماد الدواجن فى المرتبة الثانية لكل الصفات السابقة. السماد الثالث هو السماد البلدى ثم سماد الماشية المكمور ثم الكنترول.

كما أوضحت الدراسة أن زيادة معدل الريزوبكترين المضاف من صفر - ٤ كجم أدى إلى زيادة طول النبات وعدد الأوراق للنبات والوزن الجاف للأوراق للنبات ومحتوى الأوراق من النيتروجين والفوسفور والبوتاسيوم والمنجنيز والحديد والزنك ومحصول الأبصال ذات قطر أكبر من ٥ سم والمحصول الكلى ووزن البصلة وقطر العنق ووزن الفص.

أعطت معاملة التفاعل (التسميد المعدنى مع إضافة ٤ كجم ريزوبكترين/ فدان) أعلى القيم لكل من طول النبات وعدد الأوراق للنبات وكلا من الوزن الطازج والجاف للأوراق للنبات ومحتوى الأوراق من النيتروجين والفوسفور والبوتاسيوم ومحصول الأبصال ذات قطر اكبر من ٥ سم والمحصول الكلى ووزن البصلة وقطر العنق ووزن الفص.