Response of Garlic Plants to Chemical, Organic and Bio-fertilizers. 2-Bulb Quality and Storability

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Abstract: This study was carried out on Chinese garlic cultivar 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 from 0 to 4 kg/fed either single or in combinations under sandy soil conditions on garlic bulb quality and storageability. Poultry manure gave the highest value of bulb total carbohydrate followed by farmyard manure, composted cattle manure, mineral fertilizer and the control. The fertilizers showed the same trend concerning bulb dry matter percentage except control treatment which was higher than mineral fertilizers. Mineral fertilizer gave the greatest nitrate content followed by poultry manure, farmyard manure, composted cattle manure then the control treatment. During storage period, mineral fertilizers recorded the highest weight loss values than control followed by composted cattle manure, farmyard manure, poultry manure. Increasing Rhizobacterin rate from 0 to 4 kg/fed significantly increased bulb carbohydrate and bulb dry matter percentage while nitrate contents and bulb weight loss were decreased with increasing the rate of Rhizobacterin. The interaction between poultry manure with 4 kg Rhizobacterin/fed gave the highest values of total carbohydrate and bulb dry matter, while mineral fertilizers combined with 0 kg Rhizobacterin/fed gave the greatest bulb nitrate content. Bulbs weight loss was the highest with mineral fertilizers with 0 kg Rhizobacterin/fed.

Keywords: Garlic, mineral fertilizer, organic manure, biofertilizer, storageability.

INTRODUCTION

Garlic (*Allium sativum* L.) is one of the most commercially important bulb crops in Egypt which is cultivated 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 which leads to produce clean plant products. In addition, organic manure dose not cause environmental pollution compared with chemical fertilizers. Moreover, the increase demand of 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 improving in ediable part quality and storageability of several crops compared with applying mineral fertilizers. Hossein (2002) reported that organic manure improves onion bulb quality. Cayuely *et al.* (1997) showed that strawberry treated with organic manure had fruits with superior quality. Concerning storageability, Hossein (2002) showed that onion bulbs produced using organic manure recorded less weight loss than those produced using mineral fertilizers. Also, El-Sheikh and Salama (1997) reported that tomato fruits produced from plants fertilized with mineral nitrogen had higher weight loss percentage than that obtained from plants treated with organic manure.

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 contribute 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 Chaudhary 1995 and Bashan and Holguin, 1997).

Some investigators indicate that application of N_2 fixing bacteria (*Azotobacter* and/ or *Azospirillum*) increased concentrations of total carbohydrates proteins, allicin and volatile oils as well as total N and P levels in bulbs of garlic plants (Lewis *et al.*, 1995; Wange, 1998 and Gouda, 2002). Concerning the effect of N-biofertilizers on storability of garlic, in general, there are insufficient information in this respect. However, few studies indicated that garlic treatment with N-biofertiliers (*Azotobacter* or *Azospirillum*) improved keeping quality during the storage period (Lewis *et al.*, 1995 and Wange, 1995 and 1998).

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 Rhizobacterin rates, either single or in combinations on garlic bulbs quality and storageability.

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 garlic bulbs quality and storageability. Chemical and physical characteristics of the experimental soil are shown in Table (1).

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 mhose/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 combination between three types of organic manures (poultry manure, farmyard manure and composted cattle manure) in addition to mineral N, P and K fertilizers treatment and the control (without fertilizers and three levels of Rhizobacterin (0, 2 and 4 kg/fed). Chemical analysis of the used organic manures 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 and added after 30 and 60 days from planting. Uniformed cloves were chosen and soaked in running water for 24h prior to sowing. Rhizobacterin was supplied 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:

1- Bulb quality:

The dried bulbs was finely ground to determine carbohydrate content following the method described by Mazumdar and Majumder (2003) and nitrite content as described by the modified methods of Singh (1988). Also, bulb dry matter percentage was calculated.

2- Storageability:

After curing, random samples (each 10 kg) were taken from every treatment, stored at the normal room conditions and weight loss percentage was recorded every two months during storage period from April to September in 2004 and 2005. The temperature and relative humidity during the storage period are shown in Table (3).

Statistical Analysis:

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

Table (3): Averages monthly air temperature and relative humidity (R.H) in store room during the storage period in 2004 and 2005 seasons.

Month	2004		2005	
	Temp. (°C)	R.H (%)	Temp. (°C)	R.H (%)
April	20.59	53.12	20.84	52.79
May	24.52	54.41	24.26	53.78
June	26.61	55.73	26.92	54.90
July	28.83	55.92	28.84	56.24
August	29.58	58.62	30.04	56.42
September	26.94	58.72	28.14	56.78

RESULTS AND DISCUSSION

1-Bulb Quality

a) Effect of fertilizer type:

Data recorded in Table (4) show that poultry manure gave significantly the highest value of total carbohydrate followed by farmyard manure, composted cattle manure, mineral fertilizers, then the control treatment in both seasons. Concerning bulb dry matter percentage, the fertilizers showed the previous same trend except control which was superior in bulb dry matter percentage than mineral fertilizers.

Regarding bulb nitrate content, results showed that mineral fertilization gave significantly the greatest nitrate content, followed by poultry manure, farmyard manure, composed cattle manure then the control in both growing seasons. Similar results were obtained by El-Sheikh and Salama on tomato, where they reported that chicken manure increased fruit carbohydrate content compared with mineral fertilizers. Furthermore, Mahmoud (2006) indicated that chicken manure significantly recorded high bulb dry matter compared with control (without fertilizers).

b) Effect of Rhizobacterin level:

Data in Table (4) indicate that total carbohydrate and bulb dry matter percentage were significantly increased with increasing the rate of Rhizobacterin from 0 to 4 kg/fed, while nitrate content was significantly decreased with increasing the rate of Rhizobacterin from 0 to 4 kg/fed in both seasons. Concerning bulb nitrate content, the results are in harmony with those of Abd-El-Hady (2003) on garlic.

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

Results in Table (5) show that poultry manure combined with 4 kg Rhizobacterin/fed gave significantly the highest values of total carbohydrate and bulb dry matter. With respect to bulb nitrate content, data show that mineral N, P and K fertilizers combined with 0 kg Rhizobacterin/fed gave significantly the greatest nitrate content in both seasons.

Table (4): Effect of fertilizer type and Rhizobacterin level on bulb quality of garlic during 2003/2004 and 2004/2005 seasons.

Treatment	Total Carbohydrate (%)	Nitrate mg/kg	Bulb dry matter (%)	Total Carbohydrate (%)	Nitrate mg/kg	Bulb dry matter (%)
	(2003-2004)			(2004-2005)		
Fertilizer:						
Control	23.77	17.77	34.66	24.54	19.77	36.02
Composted cattle manure	28.33	32.41	36.07	28.19	34.36	36.90
Farmyard manure	29.24	42.77	37.31	29.14	46.32	38.23
Poultry manure	31.61	47.17	38.51	30.62	52.06	39.14
Minerals (NPK)	26.77	74.19	33.71	26.46	82.54	35.45
LSD %	0.09	8.25	0.03	0.02	8.17	0.06
Rhizobacterin (Kg/fed):						
0	27.26	45.25	35.68	27.24	49.89	36.89
2	27.71	43.55	36.03	27.84	47.29	37.32
4	28.26	39.79	36.44	28.28	44.01	37.50
LSD %	0.06	1.13	0.02	0.01	1.61	0.05

Table (5): Effect of interaction between fertilizer type and Rhizobacterin level on bulb quality of garlic during 2003/2004 and 2004/2005 seasons.

Fertilizer	Rhizo. (Kg/fed)	Total Carbohydrate (%)	Nitrate mg/kg	Bulb dry matter (%)	Total Carbohydrate (%)	Nitrate mg/kg	Bulb dry matter (%)
		(2003-2004)			(2004-2005)		
Control	0	23.22	19.34	34.22	23.64	21.03	35.91
	2	23.79	17.69	34.56	24.58	20.11	36.05
	4	24.50	16.27	35.19	25.40	18.17	36.11
Composted cattle manure	0	27.91	34.77	35.83	27.39	37.81	36.37
	2	28.32	32.40	36.06	28.42	35.88	37.16
	4	28.77	30.05	36.32	28.75	33.53	37.16
Farmyard manure	0	29.01	43.16	36.87	28.80	47.83	37.64
	2	29.25	41.89	37.33	29.11	46.42	38.48
	4	29.46	39.93	37.74	29.52	44.71	38.71
Poultry manure	0	29.98	51.50	38.22	30.26	55.98	39.30
	2	30.57	47.74	38.49	30.66	53.05	39.41
	4	31.28	42.26	38.81	30.93	47.14	39.66
Minerals (NPK)	0	26.17	77.46	33.25	26.13	86.79	35.24
	2	26.83	74.69	33.73	26.44	80.99	35.50
	4	27.30	70.44	34.16	26.81	76.50	35.86
LSD %		0.14	2.54	0.05	0.02	3.59	0.11

2-Storageability

a) Effect of fertilizer type:

Data in Table (6) show the changes in bulbs weight loss percentage during storage period (six months) over time. Data show that mineral fertilizers recorded significantly the highest value of weight loss followed by control, composted cattle manure, farmyard manure and poultry, in both seasons. Similar results were obtained by El-Sheikh and Salama (1997) where they found that tomato fruits produced from plants fertilized with mineral nitrogen had higher weight loss percentage than that obtained from plants treated with chicken manure. Also, the obtained results are in harmony with those of Hossein (2002) on onion.

b) Effect of Rhizobacterin level:

Data presented in Table (6) reveal that weight loss was significantly decreased with increasing the rate of Rhizobacterin from 0 to 4 kg/fed during storage period in both seasons except at 2 months in the second season where no significant differences were detected among Rhizobacterin levels. These results agree with those of Abd-El-Hady (2003). The obtained results may be due to increasing bulb dry matter percentage with increasing the rate of Rhizobacterin from 0 to 4 kg/fed as shown in Table (4).

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

Data in Table (7) indicate that mineral fertilizers with 0 kg Rhizobacterin/fed gave significantly the highest weight loss during storage period in both seasons. In conclusion, the present study showed that organic manures especially poultry manure improved garlic bulb components and storageability and that 4 kg Rhizobacterin/fed was the best rate in this regard

Table (6): Effect of fertilizer type and Rhizobacterin level on bulbs weight loss of garlic over time during 2004 and 2005 seasons.

Treatment	Weight Loss (%)					
	At 2 months	At 4 months	At 6 months	At 2 months	At 4 months	At 6 months
		(2004)			(2005)	
Fertilizer:						
Control	32.23	46.08	51.65	31.55	45.21	49.30
Composted cattle manure	31.06	44.35	49.06	29.84	44.18	47.04
Farmyard manure	28.48	38.55	44.21	27.48	38.36	45.15
Poultry manure	27.45	37.69	43.52	26.83	36.62	43.83
Minerals (NPK)	33.23	47.76	53.19	31.85	46.60	50.47
LSD %	1.70	2.09	1.91	NS	3.95	2.58
Rhizobacterin (Kg/fed):						
0	31.03	43.41	48.93	29.68	43.03	48.05
2	30.51	42.84	48.49	29.59	42.48	47.28
4	29.99	42.41	47.55	29.26	41.07	46.14
LSD %	0.05	0.23	0.28	NS	1.17	1.14

Table (7): Effect of interaction between fertilizer type and Rhizobacterin level on clove traits of garlic during 2004 and 2005 seasons.

Treatment		Weight Loss (%)					
		At 2 months	At 4 months	At 6 months	At 2 months	At 4 months	At 6 months
			(2004)			(2005)	
Fertilizer	**Rhizo. (Kg/fed)**						
Control	0	32.41	46.17	52.00	31.66	45.68	49.35
	2	32.39	46.07	51.73	31.57	45.52	49.29
	4	32.17	45.99	51.22	31.42	44.43	49.25
Composted cattle manure	0	32.09	45.48	50.53	30.77	43.15	49.22
	2	31.22	44.46	49.95	30.24	42.08	48.18
	4	29.87	41.79	46.68	28.51	40.63	47.05
Farmyard manure	0	28.73	39.09	44.41	27.84	38.79	45.70
	2	28.38	38.51	44.22	27.47	38.25	45.11
	4	28.32	38.06	44.00	27.12	37.70	44.64
Poultry manure	0	28.20	38.00	43.81	27.00	37.12	44.33
	2	27.15	37.63	43.60	26.55	36.66	43.81
	4	27.00	37.45	43.15	26.31	36.09	43.35
Minerals (NPK)	0	33.70	48.33	53.90	32.60	47.09	51.66
	2	33.22	47.54	52.94	32.31	46.56	50.01
	4	32.61	47.41	52.28	31.96	46.16	49.74
LSD %		0.12	0.51	0.90	2.06	2.55	2.54

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استجابة نباتات الثوم للأسمدة الكيميائية والعضوية والحيوية.
٢- جودة الأبصال وقدرتها التخزينية

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أجريت هذه الدراسة على نباتات الثوم الصينى خلال موسمى ٢٠٠٣/ ٢٠٠٤ و٢٠٠٤/ ٢٠٠٥ بالمزرعة البحثية لكلية الزراعة – جامعة قناة السويس- بالإسماعيلية لدراسة تأثير ثلاث أنواع من الأسمدة العضوية (سماد الدواجن والسماد البلدى وسماد الماشية المكمور) بالإضافة للمعدل الموصى به من التسميد المعدنى وثلاث معدلات من السماد الحيوي (الريزوبكترين) (صفر و٢ و٤ كيلو جرام/ فدان) تحت ظروف الأرض الرملية على جودة وتخزين أبصال الثوم. أوضحت الدراسة أن سماد الدواجن أعطى أعلى محتوى من الكربوهيدرات والمادة الجافة فى الأبصال يأتى السماد البلدى فى المرتبة الثانية ثم سماد الماشية المكمور ولقد تفوق التسميد المعدنى على الكنترول بالنسبة لمحتوى الأبصال من الكربوهيدرات، بينما تفوق الكنترول على التسميد المعدنى بالنسبة لمحتوى الأبصال من المادة الجافة. كما أوضحت الدراسة أن التسميد المعدنى أعطى أعلى محتوى من النترات يليه سماد الدواجن ثم السماد البلدى ثم سماد الماشية المكمور ثم الكنترول. وخلال فترة التخزين حققت الأسمدة المعدنية أعلى فقد فى الوزن للأبصال ثم الكنترول ثم السماد البلدى ثم سماد الماشية المكمور ثم سماد الدواجن. كما أوضحت الدراسة أن زيادة معدل الريزوبكترين المضاف من صفر – ٤ كيلوجرام/فدان أدى إلى زيادة محتوى الأبصال من الكربوهيدرات والمادة الجافة بينما انخفض محتوى الأبصال من النترات والفقد فى الوزن للأبصال بزيادة معدل الريزوبكترين. أعطت معاملة التفاعل (سماد الدواجن و٤ كيلوجرام ريزوبكترين للفدان) أكبر محتوى للأبصال من الكربوهيدارت والمادة الجافة بينما أعطى التسميد المعدنى و٠ كيلوجرام ريزوبكترين للفدان أعلى محتوى للأبصال من النترات. وخلال فترة التخزين حققت الأسمدة المعدنية وصفر ريزوبكترين للفدان أعلى فقد فى وزن الأبصال.