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Effect of Phosphorus Fertilization and Psb on Garlic Quality under Organic Farming System

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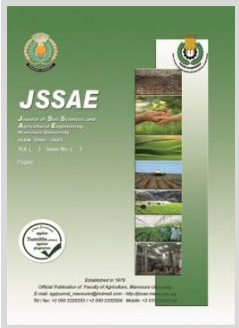

ABSTRACT

The present investigation was undertaken in complete randomized design with three replicates during winter season of 2017/2018 to study the effect of phosphorus fertilization (50, 75 and 100 % from recommended dose), Phosphate Solublizing Bacteria (PSB) and chicken manure on growth criteria , chemical traits, bulb quality and yield of garlic plants. The findings showed that growth criteria such as plant height, No. of leaves, fresh and dry weight of whole plant and its leaves, neck and bulb, yield and its components (number of clovers/bulb, bulb diameter, neck diameter, average cloves and bulb as well as total Mg/fed), chemical content (N, P and K %) and quality parameters (TSS%, total carbohydrates, crude fiber, vitamin C, dry matter, volatile oil and allicin) as well as availability of N, P and K recorded the highest values with plant treated with 75% P fertilization+ PSB +Chicken manure.

Keywords: phosphorus fertilization, PSB, chicken manure and garlic crop

INTRODUCTION

Garlic *(Allium sativum* L.) is consider the second most important bulbous spice crop after onion widely used all over the world. It is widely used in flavoring of food and has health benefits including its antioxidant, anticancer, anti-microbial, and lowering sugar and lipids in blood (Baghalian, 2005). It contains vitamin C, proteins, potassium, calcium, magnesium and other nutrients (Singh *et al.*, 2017). Furthermore, the economic importance of the garlic crop has increased considerably in recent years for local consumption and exportation. So, essential aims for growers are increasing yield and improving bulb quality.

Regarding the productivity , the using organic manures and inorganic fertilizers as combined application to increase vegetable crops yield has importance in ameliorating the yield. using Inorganic fertilizers now a day increases the total cost of cultivation, where bio and organic fertilization is cheap, easily available and ecofriendly, giving quality producer, improving keeping quality, T.S.S. and pungency. It improves the physiochemical properties of the soil, which is very useful for the sustainable crop production as well as soil fertility and productivity (Singh and Ram, 2014).

Phosphorus nutrient plays role in regulating many physiological parameters in the plant that in turn affect the resulted total yield. Phosphorus is the fifth nutrient most extracted by the crop, nevertheless, it is applied in high doses due to its natural deficiency in soils and its strong interaction in the soil that reduce its availability to plants (Vilar *et al.*, 2010). The following review of literature of current knowledge about P, may reflect the studying its mode of action and its role in the production of garlic yield. However, one fact must be put in mind is that, the provided P to the plant or the soil depends largely on the available reservation of this element in the soil, so the negative or the positive results may be due to this quantity or sources stored in the soil (Shaheen *et al.*, 2007). On garlic plant, Stone *et al.*, (2001) found that limited phosphorus led to reduced root growth, foliage growth, bulb quality and yield.

Biofertilizer increases soil fertility and crop yield. Phosphorus biofertilizers causes increase the availability of phosphates for plants grown by solubilization (Gyaneshwar *et al.*, 2002). Addition of phosphorus along with PSB enhanced P absorbtion by plants and yield representing which PSB solubilize phosphates and activate-P in crop plants (Afzal *et al.*, 2013). In this respect, biofertilization technology has substantially minimized the production costs and evades the environmental hazards at the same time.

So, the aim was to study the response of growth, yield and nutritional values of garlic to phosphorus fertilization and phosphate solublizing bacteria (PSB) under chicken manure.

MATERIALS AND METHODS

During the winter season of 2017/2018 afield trails was performed in in complete randomized design (CRD) with three replicates. at the Experimental Farm of El-Mansoura University, Egypt to study the effect of phosphorus addition and phosphate solublizing bacteria (PSB) under chicken manure on growth creteria , chemical traits, bulb quality and yield of garlic (cv. Balady) plants grown on clay loam soil which was analyzed to detriment its physical and chemical characteristics as shown in Table 1 according to Haluschak, (2006).

Table 1. Physical and chemical properties of the experimental site soil.

EC, dSm^{-1} (1:2.5)	pH (1:2.5)	$CaCO_3$	SP	O.M
		%		
62.1	7.96	3.53	1.77	1.77

Particle size distribution (%)				Textural class
Coarse sand	Fine sand	Silt	Clay	Clay loam
2.83	20.01	46.96	30.20	

Available nutrient, ppm			
N	P	K	Mn
62.1	6.81	188.3	

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This experiment included (ten) treatments as follows:

1.Control.
2.50% Phosphorus fertilization from recommended dose.
3.50% P+ Chicken manure(ChM).
4.50% P + ChM+ PSB.
5.75% Phosphorus fertilization from recommended dose.
6.75% P + ChM.
7.75% P + ChM+ PSB.
8.100% Phosphorus fertilization from recommended dose.
9.100% P+ ChM.
10. 100% P+ ChM+ PSB.

Chicken manure as indicated in Table (2) was added at rate of 10 m^3/fed, mineral fertilization as ammonium sulfate (20.5 % N), super phosphate (15 % P_2O_5) and potassium sulfate (48 % K_2O) were used as sources of N, P and K at rate of 200, 150 and 100 kg/fed., respectively. Phosphorus was applied at once time during preparing the soil for planting, whereas nitrogen and potassium added at two equal doses at 60, 75 days of plant old. Bio- fertilization treatments were applied at the time of sowing. The cloves of five cultivars of Balady garlic crop were sown at mid- September in 2017-2018 on one side of the ridges at the distance of 10 cm apart. Each experimental plot area was 12.8 m^2 consisted of four ridges; each was 0.8 m in width and 4 m in length.

After 3 months from planting, samples of garlic plants for vegetative growth characters were measured (plant height, No. of leaves, fresh and dry weights of whole garlic plant and its leaves, neck and bulb). At harvest and after curing period (15 days), the total yields Mg/fed were accounted also D.M%, number of clover, the average bulb, clover and neck diameter were recorded.

Table 2. Chicken manure characteristics.

%						Available (ppm)		SP %	pH
Organic matter	Carbon	Total N	C/N ratio	Total P	Total K	P	K		(1: 5)
57.2	32.08	2.10	15.28	0.50	0.92	13.6	574	156	6.79

Nitrogen, phosphorus and potassium content in tissues of garlic gloves were determined depending on the method which was described by (Mertens, 2005a & b) and Agrilasa, (2002) respectively. However, total carbohydrates (%), and TSS (%) were determined according to Sadasivam and Manickam, (1996), fiber according to (AOAC, 2000), and NO_3-N content ($mg.kg^{-1}$) was determined according to Singh (1988) as well as V.C (mg/100g) according to Mazumdas and majumdas (2003), volatile oil according to (Johnson *et al.*, 2013) and allicin according to (Mansor *et al*., 2016)

At the depth of 0-30 cm, soil samples were randomly taken after garlic harvesting from each plot to determine the available N, P and K $mg.kg^{-1}$ according to Reeuwijk, (2002).

Statistically analyzed of data were performed utilization of CoSTATE Computer Software, depending on Gomez and Gomez, (1984).

RESULTS AND DISCUSSION

1.Vegetative growth characters:

Response of garlic plant growth parameters (plant high, number of leaves, fresh and dry weight of whole plant and its leaves, neck and bulb) to different levels of phosphorus fertilization, PSB under chicken manure are shown in Table (3).

It evident that, addition of all treatments increased all growth parameters comparing with control. The increase of fresh and dry weights of whole garlic plant may be attribute to the increase in size of plant, largest leaves number, heaviest fresh and dry weight of leaves, bulb and neck. Generally, that garlic plant which received its phosphorus requirements as chemical fertilization with PSB under chicken manure as organic farm. The highest mean values of plant growth parameters recorded with using high rates of phosphorus fertilization 75% from recommended dose with PSB under chicken manure.

The impact of phosphorus on growth criteria could be explained major role as a structural part of many components such as nucleic acid and phospholipids. In addition to its important role in energy metabolism. generally, the P element is the main building block of DNA molecules. It has a role in storing energy in the form of ATP and ADP. The phosphorus fertilization ensures that garlic plants will reach their full potential, where phosphorus promotes resistance to root diseases as well as encourages root growth. similar findings are proved by many researchers (Shaheen *et al*., 2007; Mulatu *et al*., 2014; Arif *et al*., 2016 and Mulatu *et al*., 2017).

Table 3. Effect of phosphorus fertilization rates and phosphorus solubilize bacteria under chicken manure on garlic plant growth parameters.

Treatments	Plant height, cm	No. of leaves/plant	Fresh weight (g/plant)				Dry weight (g/plant)			
			Leaves	Neck	Bulb	Total	Leaves	Neck	Bulb	Total
Control	56.56	7.14	6.47	1.11	51.51	59.09	1.63	0.26	12.84	14.72
50% P	59.23	6.99	6.87	1.18	54.67	62.72	1.71	0.29	13.49	15.49
50% P+ChM	68.60	8.00	7.89	1.36	62.95	72.20	1.97	0.34	15.52	17.83
50% P+ChM+PSB	76.93	8.98	8.85	1.50	70.22	80.57	2.21	0.39	17.43	20.03
75% P	62.53	7.20	7.14	1.21	56.53	64.89	1.79	0.29	14.16	16.24
75% P+ChM	71.30	8.58	8.24	1.42	65.33	74.99	2.05	0.33	16.27	18.66
75% P+ChM+PSB	82.45	9.83	9.57	1.63	75.84	87.04	2.39	0.40	18.96	21.74
100% P	65.31	7.80	7.47	1.32	59.27	68.06	1.85	0.32	14.87	17.04
100% P+ChM	74.50	8.80	8.57	1.49	68.30	78.36	2.14	0.35	17.08	19.56
100% P+ChM+PSB	79.44	9.50	9.33	1.61	73.12	84.06	2.33	0.39	18.31	21.04
LSD at 5%	1.75	0.57	0.24	0.06	1.53	1.77	0.06	0.05	0.59	0.64

As for The PSB, treating seeds of garlic increased availability of P in soils, thus improving root growth and plant uptake of all nutrients. It follows from the above, enhancing cell division, which might have helped in the growth of the garlic plant. Also, the bacteria present in the applied biofertilizer leads to secrete some phytohormones i.e. auxins

gibberellic, and cytokines which stimulate cell elongation and division which leads to plant growth. these results are in agreement with obtained results by (Abou El- Magd *et al*. 2014; Zaghloul *et al*., 2016 and Singh *et al*. 2017).

Such an increase in growth parameters as a result of the effect of chicken manure due to it is a source of all nutrients to grown garlic plants. chicken manure is a good natural conditioner to soil texture, also it causes increase availability and uptake of macronutrients such as N, P and K In this regard, photosynthesis is stimulated under soil addition of chicken manure, Abood *et al*., (2013); Sabagh *et al*. (2014); Zakari *et al*., (2014) and Acharya and Kumar (2018) came out to similar conclusions.

2.Garlic yield and its components:

Data presented in Table 4 illustrated that number of clovers/bulb, bulb diameter, neck diameter, average cloves and bulb as well as total yield Mg/fed of garlic plants had a significant variations under all investigated treatments, where the treatment (P 75% + PSB+ ChM) gave the highest values of number of clovers/bulb (22.33), bulb diameter (4.49 cm), neck diameter (1.51 cm), average clover (3.26 g), average bulb (63.05 g) and Yield of bulb after curing (8.34 ton/fed) followed by the treatment (P 100% + PSB + ChM) for yield of number of clovers/bulb (20.33), bulb diameter (4.21 cm), neck diameter (1.40 cm), average clover (3.00 g), average bulb (59.09 g) and yield of bulb after curing (7.07 Mg/fed).

It could be concluded that, the phosphorus fertilizer had a positive influence on the productivity, thus increasing yield criteria of garlic plant. Generally, the enhancement of garlic growth criteria due to P-fertilization reflected on the bulbs yield (Shaheen *et al.*, 2007; Arif *et al.*, 2016; Zaghloul *et al*., 2016and Mulatu *et al*., 2017).

As above mentioned using PSB not only increases the availability of soil nitrogen and phosphorus to plants but also enhances the bulb yield of garlic plants due to the release of vitamins and hormones. Similar findings were also reported by Yadav *et al*. (2005); Zaghloul *et al*., (2016); Vachan and Tripathi (2017).

On the other hand, soil addition of ChM provides all essential and beneficial nutrients as well as organic matter to the soil, thus increasing the crop yields of garlic plants. It also encouraged more photosynthetic activities for higher crop yield. ChM improves texture, structure, aeration, water holding capacity, hummus, buffer action, CEC and microbial activity of the soil, which leads to increase and conserve soil productivity. The results of the present paper are in agreement with the findings of Kabir *et al*., (2011); Abood *et al*., (2013); Zakari *et al*., (2014); Mondal *et al*., (2016) and Acharya and Kumar (2018).

Table 4. Effect of phosphorus fertilization rates and phosphorus solubilize bacteria under chicken manure on garlic yield and its components.

Treatments	No of cloves/bulb	Bulb diameter,cm cm	Neck diameter,cm cm	Average clover weight gm	Average bulb weight gm	Total yield ton/fed
Control	16.33	3.08	1.03	2.08	46.95	4.22
50% P	17.00	3.24	1.09	2.21	48.76	6.43
50% P+ChM	18.67	3.76	1.25	2.63	53.63	7.67
50% P+ChM+PSB	20.33	4.21	1.40	3.00	59.09	7.07
75% P	17.67	3.40	1.12	2.35	50.37	6.72
75% P+ChM	19.33	3.87	1.29	2.73	55.44	7.34
75% P+ChM+PSB	22.33	4.49	1.51	3.26	63.05	8.34
100% P	18.33	3.56	1.21	2.42	51.66	6.94
100% P+ChM	19.67	4.06	1.35	2.87	57.41	7.67
100% P+ChM+PSB	21.33	4.35	1.46	3.12	61.12	8.07
LSD at 5%	1.08	0.11	0.05	0.09	1.07	1.85

3.Chemical content and quality of garlic:

- **N, P and K concentration:**

The nutritional values of garlic bulbs as affected by different treatments under investigation were recorded in Table 5. N, P and K content of garlic bulb tissues increased with plants received all treatments over control.

Table 5. Effect of phosphorus fertilization rates and phosphorus solubilize bacteria under chicken manure on garlic N, P and K concentration.

Treatments	N%	P%	K%
Control	2.15	0.256	1.65
50% P	2.27	0.268	1.76
50% P+ChM	2.62	0.296	2.03
50% P+ChM+PSB	2.93	0.324	2.30
75% P	2.37	0.276	1.83
75% P+ChM	2.72	0.303	2.11
75% P+ChM+PSB	3.14	0.343	2.47
100% P	2.49	0.283	1.94
100% P+ChM	2.85	0.313	2.17
100% P+ChM+PSB	3.05	0.331	2.37
LSD at 5%	0.08	0.006	0.08

Generally, it recorded their peaks with that plants which received (75% P+ ChM+ PSB) comparing with other treatments followed by (100% P+ ChM+ PSB).

- **Quality parameters:**

Data presented in Table 6 revealed that all the quality parameters of garlic (TSS%, NO_3-N, total carbohydrates, crude fiber, vitamin C, dry matter, volatile oil and allicin) obtained significant variations among the treatments, where the treatment of (75% P+ ChM+ PSB) exhibited the better results in terms of all quality parameters. Except NO_3-N with using all treatments found that NO_3-N decreased comparing with control which recorded the highest mean values (108.39) and the lowest one with using (75% P+ ChM+ PSB) which was (86.38).

It could be summarized that, the addition of phosphorus fertilizer at the form of calcium super-phosphate (chemical form) at higher levels gained the best values of chemical constituents in bulbs tissues. This result might be attributed to the chemical phosphorus form is more availability for the garlic plant uptake and also quality parameters. Generally, increasing phosphorus level in rooting area led to an increase in garlic plants uptake, thus increased

the ability of its roots to absorb more nutrients in plant tissues so increase in bulb weight and diameters which reflected on quality parameters. Many investigators had good accordance with that which obtained in this script (Shaheen *et al*., 2007; Mulatu *et al*., 2014 and Arif *et al*., 2016).

From other side, the increase in quality parameters and uptake of N, P and K status might be due to biofertilizers and phosphorus fertilization. Also, it due to higher yield and dry matter accumulation, the crop removed larger quantities of nutrients (NPK) from soils and improved quality parameters. The results are in close harmony to the findings of (Damse *et al.*, 2014; Dhaker *et al.*, 2017 and Singh *et al.*, 2017).

ChM supply macro elements such as N, P and K as well as improve AVAILABILITY of other nutrients, which reflects positively on garlic plants uptake to the nutrients which increased yield and its components as bulb weight and diameters which reflected in quality parameters. Application of ChM encouraged the activity of beneficial microorganisms in the soil. The healthy growth of garlic plants might causes a higher rate of carbohydrate accumulation and enhancing photosynthesis which resulted in increased size of bulbs as indicated by bulb diameter and average bulb weight and ultimately overall yield enhancement of garlic. These findings are also corroborated by (Dhaker *et al*., 2017 and Acharya and Kumar, 2018).

Table 6. Effect of phosphorus fertilization rates and phosphorus solubilize bacteria under chicken manure on garlic quality parameters.

Treatments	TSS%	NO3-N, ppm	T.carbo%	C.fiber%	VC, mg/100g	volatile oil %	DM%	Allicin, mg/g DW
Control	4.98	108.39	39.52	2.94	39.85	0.276	26.55	20.97
50% P	5.11	105.21	40.21	3.14	40.27	0.296	27.21	21.49
50% P+ChM	5.48	99.21	42.34	3.83	41.73	0.344	29.22	23.10
50% P+ChM+PSB	5.88	91.22	44.55	4.43	43.33	0.407	31.25	24.72
75% P	5.21	102.51	40.95	3.39	40.54	0.307	27.91	21.98
75% P+ChM	5.63	95.65	43.15	4.02	42.33	0.367	29.90	23.64
75% P+ChM+PSB	6.17	86.38	45.99	4.75	44.35	0.452	32.65	25.78
100% P	5.33	101.33	41.69	3.63	41.26	0.326	28.56	22.61
100% P+ChM	5.76	93.52	43.89	4.20	42.80	0.385	30.55	24.14
100% P+ChM+PSB	6.03	88.95	45.18	4.57	43.84	0.427	31.88	25.25
LSD $_{at\ 5\%}$	0.09	1.42	0.33	0.15	0.38	0.120	0.24	0.25

4.Soil nutrients availability:

Due to the pattern of mineralization, the combined utilization of organic fertilizers improved the soil properties rather than using only inorganic fertilizers. The build up of available nitrogen, phosphorus and potassium in soil was significantly influenced by application of bio- inoculants (PSB) with any rates of phosphorus fertilization under chicken manure. The results of present investigation revealed that increasing available nitrogen, phosphorus and potassium, and the highest mean values of nitrogen were recorded with 75% P+ChM+PSB, while the highest mean values of phosphorus and potassium realized with 100% P+ChM+ PSB.

Table 7. Effect of phosphorus fertilization rates and phosphorus solubilize bacteria under chicken manure on soil available N, P and K.

Treatments	Available N, ppm	Available P, ppm	Available K, ppm
Control	72.57	6.32	188.30
50% P	75.57	9.52	204.30
50% P+ChM	84.20	10.17	223.37
50% P+ChM+PSB	93.77	10.86	240.60
75% P	78.47	11.75	210.40
75% P+ChM	87.30	12.48	228.67
75% P+ChM+PSB	99.73	13.37	249.27
100% P	81.50	14.10	216.50
100% P+ChM	90.10	15.21	234.50
100% P+ChM+PSB	96.63	16.36	245.43
LSD $_{at\ 5\%}$	2.01	2.54	3.47

Biofertilizers produced various organic acids which solubilize phosphate and other phosphate bearing minerals thereby, increased P availability in soil (Tolanur and Badanur., 2003). Rundala *et al*., (2012) also observed improvement in available nitrogen, phosphorus and potassium in soil due to seed inoculation with PSB. These results are in agreement with findings of Nainwal *et al.*, 2015; Singh *et al.*, 2017 and Talwar *et al*., 2017. The increase in the availability of N, P and K in soil under the treatments having combination of phosphorus fertilizers and chicken manure might be because of increasing organic matter due to application of organic manure, besides reducing losses of nutreints. Similar observations were detected by Nainwal *et al.*, 2015.

CONCLUSION

The present study concluded that fertilizer techniques via.; 75% phosphorus fertilization from recommended dose with PSB under chicken manure as organic manure were found to be the best-combined treatments give the highest marketable and total yield of garlic crop.

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تأثير التسميد الفوسفوري والبكتريا المذيبة للفوسفات على جودة الثوم في ظل نظام الزراعة العضوية

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تم إجراء هذا البحث في تصميم تام العشوائية مع التكرار 3 مرات خلال فصل الشتاء 2018/2017 لدراسة تأثير التسميد الفسفوري (50 و75 و100٪ من الجرعة الموصي بها) والبكتريا المذيبة للفوسفات مع سماد الدواجن على مدلولات النمو والتركيب الكيميائي للنبات والمحصول وجودة الرؤوس لنباتات الثوم (صنف بلدي) النامية في تربة طينية طميية. أشارت النتائج الي أن مدلولات النمو (ارتفاع النبات، عدد الأوراق ، الوزن الطازج والجاف للنبات الكامل وأوراقه ، العنق والرأس) ، المحصول ومكوناته مثل (عدد الفصوص/ الرأس ، قطر الراس ، قطر العنق ، متوسط الفصوص والرؤوس وكذلك المحصول الكلي طن / فدان) ، المحتوى الكيميائي (النسبة المئوية للنيتروجين والفسفور والبوتاسيوم) معايير الجودة (نسبة المواد الصلبة الذائبة ، إجمالي الكربوهيدرات ، الألياف الخام ، فيتامين سي ، المادة الجافة ، الزيت المتطاير ، الأليسين) وكذلك صلاحية النيتروجين والفوسفور والبوتاسيوم بالتربة سجلت أعلى القيم مع النباتات المعاملة بـ 75٪ التسميد الفوسفوري + البكتريا المذيبة للفوسفات + سماد الدواجن.