COMPOSTED SHRIMP SHELLS CAN SUPPORT GROWTH VIGOR OF EGGPLANT IN MARGINAL LAND

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ABSTRACT

Compost produced from shrimp shells mixed with other botanical wastes as organic soil amendment was examined in a pot experiment for a possible improvement in growth of eggplant in marginal sandy soil. Shrimp shells with rice straw, banana peels, pomegranate peels were recycled in a compost production process and used with *Azotobacter chrococcum* as organic and bio-fertilizer for eggplants in a greenhouse experiment. The obtained results referred to a positive growth promoting effect of the compost product and/or the bacterial inoculum on eggplants. Compost application and bacterial inoculation increased eggplant dry and fresh weight as well as improved the nutritional values of grain, i.e., total carbohydrates, total phenol and total chlorophyll. In addition, soil organic matter was increased in pots received the combined treatment with compost and the bacterial inoculum. Slight changes were recorded in soil pH and EC as a result of organic or biofertilizer application. The examined compost product from shrimp shells might be used with the bacterial inoculum as potential soil amendments in organic farming program.

Key words: agriculture waste, Azotobacter, bio fertilizer, compost, organic fertilizer

INTRODUCTION

Egypt is one of the oldest agricultural countries known in history. Up to now, Egyptian economy is mainly based on agriculture production. The total amount of agricultural wastes produced annually is in the range of 30-35 million tons a year. According to **Abou Hussein *et al.* (2010)**, only 11 million tons of the agricultural wastes are being utilized as animal feed (7 million tons) and as organic manure (4 million tons). Enormous amount of organic wastes are generated from plants, animals and industrial activities in day to day life. One feature of sustainable agriculture is its lower dependence on chemical fertilizers and recycling of on-farm residues to maintain and /or improve soil fertility. Compost produced from agricultural wastes can be used for fertilizing soil and improve growth of the cultivated plants **(Bernal *et al.*, 2009).**

Composting is a biological process occurs under aerobic conditions with adequate moisture and temperature. Composting can be interpreted as the sum of complex metabolic processes performed by different microorganisms that, in the presence of oxygen, use nitrogen and carbon available to produce their own biomass. In this process, additionally, the microorganisms generate heat and a solid substrate, with less carbon and nitrogen, but more stable, which is called compost **(Roman *et al.* 2015).** The composting process is similar to the natural processes of mineralization and humification occurring after incorporating organic residues into cultivated soils. Bio-fertilizers have prodigious potential to improve the plants nutrition by replacing synthetic fertilizers for eco-friendly agriculture. Bio-fertilizers contain plant growth promoting rhizobacteria (PGPR) *viz*; *Azotobacter*, *Azospirillum* and phosphorus solubilizing bacteria i.e., *Pseudomonas* sp. and *Bacillus* sp. having the ability of atmospheric nitrogen fixation and solubilizing the soil phosphates, respectively. Consequently, they fulfill the nitrogen and phosphorus requirement of cereals and also improve the soil fertility. So, utilization of N_2-fixing and phosphate dissolving bacteria as bio-fertilizers has gigantic potential for making use of N_2-gas and the already existing fixed soil phosphorus in crop production without causing any harmful effects on aerial and soil environment **(Yasin, *et al.*, 2012).** Owing to the excessive use of synthetic fertilizers, severe environmental perils are evolved. **Gholami, *et al.*, (2012)** reported that plant-growth promoting rhizobacteria (PGPR) play an important role in plant health and soil fertility. **Zahir, *et al.*, (2005)** revealed that application of L-tryptophan (L-TRP) or *Azotobacter* inoculation alone significantly affected maize crop; however, their combined application produced more pronounced effects as compared with their separate application. Combined application of 10-4 M (L-TRP) and *Azotobacter* significantly increased total nitrogen uptake (40%) compared with an untreated and un-inoculated control.

This study was carried out to produce valuable compost material from shrimp shell wastes in a mixture with rice straw, banana peels and pomegranate peels and to study the effect this compost application compared with a Bio-fertilizer on eggplant growth grown in a low fertile sandy soil.

MATERIALS AND METHODS

Microorganisms:

Azotobacter chrococcum and the fungal strains *Trichoderma harzianum* NRRL13019 and *Phanerochaete chrysosporium* NRRL 6359 kindly provided by the Department of Microbiology, Soil, Water and Environment Research Institute, ARC were used as inocula strains. *Azotobacter chrococcum* were applied as peat based inoculum while the fungal strains were grown on sterilized sorghum grains and applied to the wastes mixture to accelerate the rate of composting.

Soil, plant and waste materials:

The pot experiment was conducted using a sandy soil collected from Giza governorate. The physico - chemical properties of the experimental soil were determined according to **Jakson (1969)** as presented in **Table (1).**

Shrimp shell wastes were collected from the local Giza fish market while rice straw was obtained from Sakha Experimental Station, ARC, and the other waste materials were collected from 6th October Fruit and Vegetable market, Giza.

Composting of Agricultural Wastes:

Shrimp shells with the other waste materials i.e., rice straw, banana peels and pomegranate peels were mixed with cattle dung and aerobically composted in a pile 1m (W) x 1m (L) x 1.5 m(H).The weight of raw materials was calculated according to its carbon and nitrogen contents then ammonium sulfate (20.6% N), was applied to adjust the mixture C/N ratio at 30:1. Equal amounts of rock phosphate and feldspar (1:1) were applied at a rate of 5% from the pile volume as natural sources of P and K applied. fungal *Trichoderma harzianum* NRRL13019 (0.321 g.d.w/100ml) and *Phanerochaete chrysosporium* NRRL 6359 (0.2608 g.d.w/100ml) grown on sorghum were mixed at a ratio of 1:1.was added to the pile at the rate of 5l g per ton of waste mixture before starting the composting process. Wastes were carefully mixed and stacked in 7-layer heaps, moistened to 60% of its water holding capacity and weekly turned to maintain good aeration. The composting process was continued up to 12 weeks. Temperature was daily recorded til the end of maturation period where the pH, EC, and total N, P, K contents were determined at zero time and after, 2, , 4, 6, , 10, 12, weeks of composting. The standard plated count of mesophilic and thermophilic actinomycetes were determined using Jensen medium **(Allen, 1950)** at the same intervals.

Physical determination:

The pH values of compost was determined in compost-water suspension (1:10) using a glass electrode of Orion Expandable ion analyzer EA920 according to **Jodice *et al.* (1982)**, while in case of soil, pH was measured using glass electrode pH meter in soil water suspension (1:2.5) according to **Jackson (1973).** Electrical conductivity (EC) measurements was measured in 1:10 compost : water extract (**Richards, 1954**), using EC meter ICM model 71150 while in case of the soil, EC was determined in 1:5 soil-water extract as described by **Jackson (1973).**

Greenhouse experiment:

The experiment was conducted in the greenhouse of the Dept. environmental Research, ARC during the growing season from Feb., 15^{th} to May15^{th}, 2018. The experimental sandy soil either mixed with the recommended compost dose (1.22 g/ kg soil, inoculated with 10 g/kg soil of peat based inoculum of *Azotobacter chrococcum* or supplied with both compost (1.22 g compost/kg soil) and 10 g bacterial inoculum/ kg soil were distributed in 1 kg plastic pots in triplicates and watered to the field capacity. In each pot, 2 eggplant seedlings (30 day old) were planted. A set of pots containing non treated soil were also included for comparison. Pots were arranged in a completely randomized design and watered to the field capacity after 3-day intervals. Plants were gently uprooted and dried at 60ºC to a constant shoot and root dry weights.

Table1 :Physical and chemical analysis of soil eggplant

Clay	Silt	Course sand	Textural class
1.15	9.98	49.002	Sandy

N (mg/kg)	P (mg/kg)	K(mg/kg)	Fe (mg/kg)	Zn(mg/kg)	Mn(mg/kg)	Cu (mg/kg)
187.2	2.45	128.8	5.3	0.68	0.92	o.27

		Soluble anions (soil past mmolec L^{-1}				Soluble cations(soil past mmolec L^{-1}				
PH	EC	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+	$CaCo_3$ %
7.78	3.80	0	0.4	1.07	0.49	1.09	0.39	0.4	0.06	1.28

Chemical analysis:

Metals contents in compost samples were directly determined by ICP-MS according to **Lindsay and Norvell (1978)**. Total nitrogen was determined in compost, and plant material using Kjeldahl digestion method as reported by **Jackson (1973).** Total phosphorus in compost, and plant material were determined using spectrophotometer (model 670 SUV/VIS Jen way company) in the acid solution of the digested samples using ascorbic acid and mixed reagent as described by **Jackson (1973).** Total potassium in compost and plant material were determined in acid solution of digested samples using flam photometer (model ILAE 201 Fisher Scientific company) as described by **Jackson (1973).**

Plant total hydrolysable carbohydrates were determined in acid hydrolysate using phenol-sulfuric acid method as described by **Dubois *et al*. (1956).** Total phenols were determined by the method of **Singleton and Rossi (1965).** Total chlorophylls were extracted from the sample in an aqueous solution of acetone and determined according to **Ianculov *et al*. (2005).**

RESULTS AND DISCUSSION

Compost Characteristics

From **fig(1)**,Compost pH values ranged between 6.8 and 8 being alkaline at the beginning of the process and tend to be more acidic with time reaching a minimum after 8 weeks of composting. In the maturing phase, the recorded pH approached neutrality then increased over pH 7 in the end-product. The decrease in the compost pH after the heating phase was attributed to active microbial degradation of organic matter and the formation of short chain organic acids mainly lactic acid **(Kiehl, 2002).** Afterwards, these organic acids react with the released bases from organic matter, thus raising again the pH values of the end-product. Miller (1992) determined an optimal range of pH values between 5.5 and 7.5 during the course of composting process. In a similar trend, the EC was gradually increased with time reaching a maximum value of 3.67ds/cm at the final maturing stage. This might be as a result of the release of mineral salts and ammonium ions from the decomposed organic matter as well as the moisture content changes during the heating period **(Silva and Brás, 2016)**.

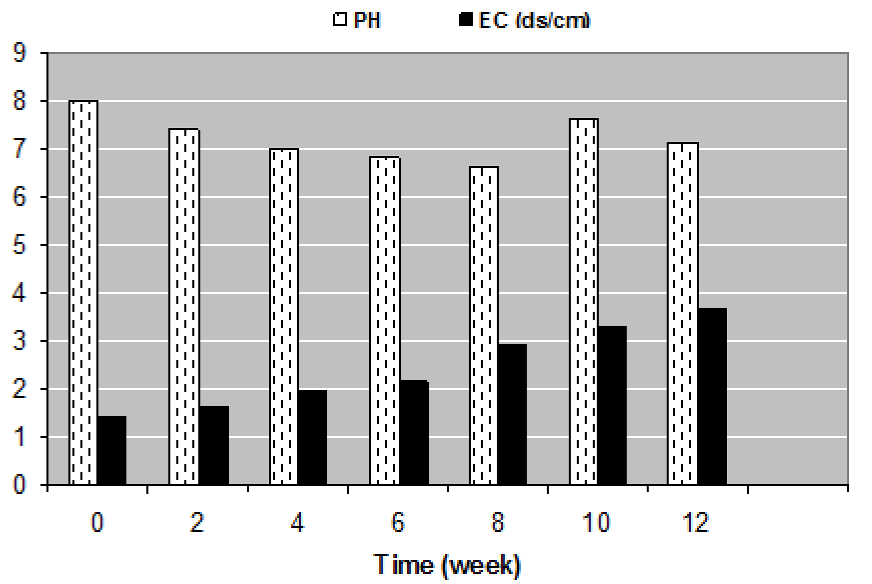

Figure 1: pH and EC (ds/cm) during composting

NPK contents during the composting process:

Data on nitrogen, phosphorus and potassium contents **(Figure, 2)** during the composting period and refer to magnificent increases in the compost N, P and contents by the progress of the composting process reaching its peak at the end of the process. Nitrogen content was as low as 0.7% at the beginning of the process and increased up to 3 folds higher by the end of the process. Data show increases in K and P contents with increasing the composting time. As recommended by **Xie *et al*., (2015),** nitrogen amendment application to the compost substrate mixture at the beginning is a mandatory for triggered microbial degradation, successful process and good quality end product. The increase in compost N-content during composting might be attributed to biomass losses as CO_2. According **Jurado *et al*. (2015)** Nitrogenous fractions in the composted materials could be immobilized, volatilized as NH_3 (during thermophilic phases) or oxidized. This might explain the recorded variations in N-contents along the composting period in this study.

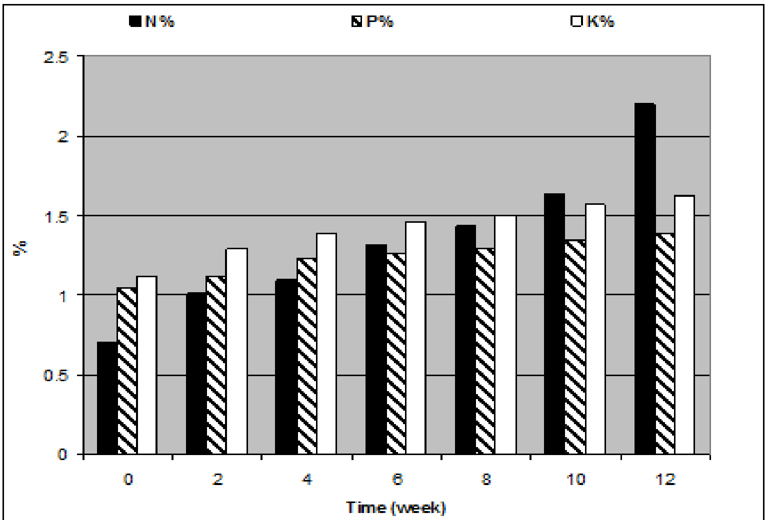

Figure 2: Macronutrients % during composting

Population density of compost Actinomycetes:

Counts of actinomycetes in the compost during mesophilic and thermophilic phase were determined **(Figure 3).** At zero time, mesophilic actinomycetes count was 8.901 log10 CFU/ g compost and decreased during the second week of composting then increased again to reach 7.230 log10 CFU/ g compost by the end of the composting period.

Counts of thermophilic actinomycetes were increased over time during the first week of composting process to reach their maximal value at the fourth week. During the subsequent weeks, counts decreased over time reaching 7.602 log10CFU/ g compost final product. This is in agreement with **Stentiford (1996); Saludes *et al*. (2008) and Rashad *et al*. (2010),** who attributed succession of different microbial communities to variations in temperature during the successive composting phases. During the initial phase of composting, the mesophilic microorganisms developed with resultant increase of temperature (**Stentiford, 1996)** as a result of increasing temperature, counts of mesophilic microorganisms reduced while counts of thermophilic microorganisms increased. By the end of process, the temperature reduced with resultant reduction in counts of the thermophilic microorganisms and dominating the mesophilic microorganisms in the process **(Lim *et al,* 2013)**. Temperature is the major parameter influencing the microbial population, diversity and metabolism rate throughout this process **(Vargas-Garcia *et al*., 2010) (Lei, and Gheynst. 2000).** The microbial profile can be used not only for monitoring the progress of composting, but also reflecting the compost maturity with the detection of specific microorganism, namely *Arthrobacter* sp. **(Ishii *et al*., 2000)**.

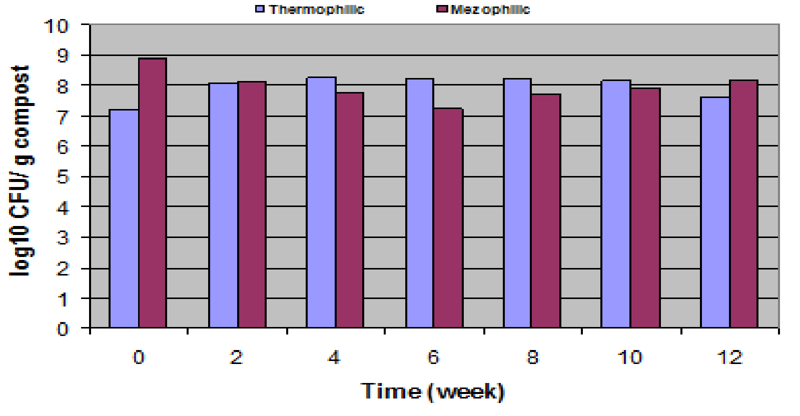

Figure 3: Total counts of actinomycetes during composting

Shrimp shell compost and rhizobacteria for improved eggplant growth in sandy soils:

Heights, fresh and dry weights of eggplant grown in soil amended with compost or inoculated with *Az. chrococcum*, or treated with both are illustrated by **Figures 4 , 5**.

The highest values of eggplant heights, fresh and dry weights were recorded in pots amended with both the compost and the *Az. chrococcum* inoculum followed by those planted in pots supplied with the compost. The minimal values of the three growth parameters were exhibited by control plants. A maximum fresh weight of 22 g/plant and maximum dry biomass of 3.21 g/plant were scored by eggplant grown in soil amended with compost combined with bacterial inoculation. These plants measured 38.33 $cm.plant^{-1}$. The obtained data are in agreement with those reported by **Zahir *et al.* (2005)** and **Mosaad *et al*. (2015)** who **stated that** application of organic and Bio-fertilization improved plant height, dry weight, grain yield of maize plant. Improved plant growth by *Azotobacter* was previously attributed to both fixed nitrogen and plant growth hormones provided by the N_2-fixing bacterium (**Cohen *et al*., 2007; Pedraza *et al*., 2007**). A similar finding was observed by **Hameeda *et al.* (2007)** using rice straw compost applied at a rate of 2.5 t ha^{-1} in sorghum plant. The combined use of organic wastes, biofertilizer and chemical fertilizers is beneficial for improving crop yield; the yields of a number of crops and soil health have been proved **(Mantovi *et al*., 2005).**

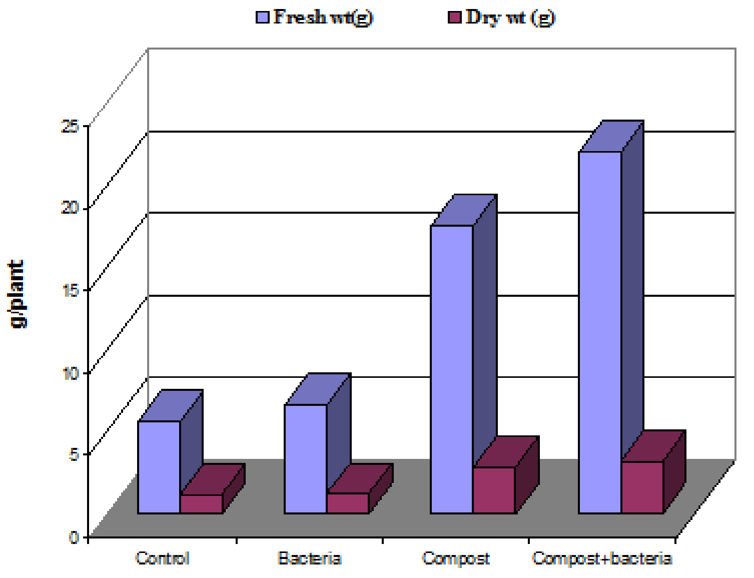

Figure 4: Effect of organic and Bio fertelizer on fresh and dry weight of eggplant

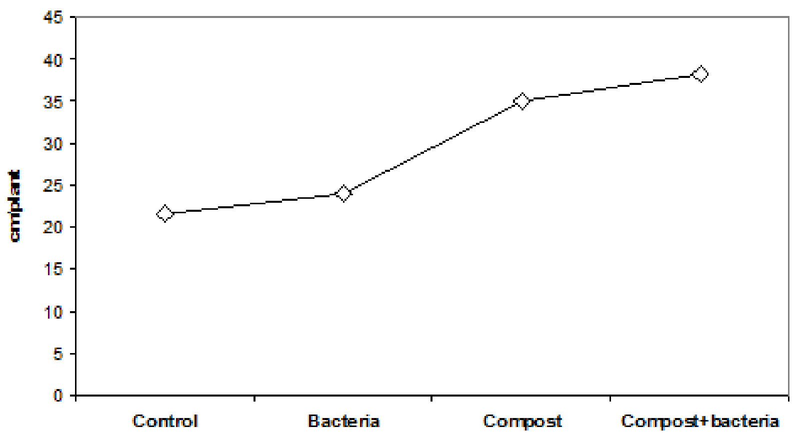

Figure 5: Effect of organic and Bio fertelizer on length of eggplant

Macronutrient contents of eggplant:

Data illustrated by **Figure 6** indicate that maximum N, P and K contents corresponding to 2.63, 0.04 and 1.63%, were recorded with plants grown in soil amended with the compost in combination with bacterial inoculation respectively. Meanwhile control plants showed N, P, K contents of as low as 1.46, 0.02 and 1.19%, respectively. The obtained results are in harmony with those recorded by **Mosaad *et al*. (2015)** regarding improved N, P, K uptake by inoculated maiz plants grown in compost amended soil. **Zahir *et al*. (2005)** revealed that *Azotobacter* inoculation alone significantly affected maize crop however, *Azotobacter* inoculation combined with compost application produced more pronounced effects as compared with their separate application.

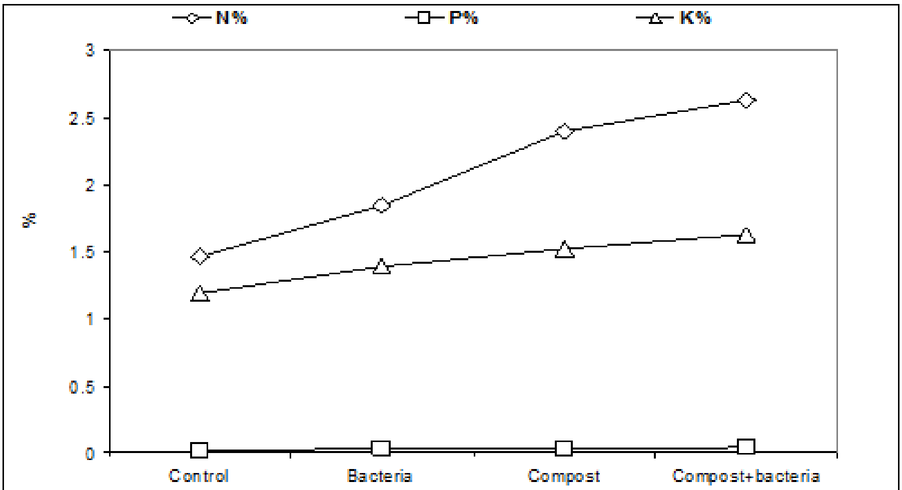

Figure 6: Effect of organic and bio fertilizer on maconurient of eggplant

Total carbohydrates, chlorophyll and phenols in eggplant shoot:

Data on the total hydrolysable carbohydrates% in shoots of eggplant treated with organic or biofertilizer **(Figure 7)** show that control plants contained total carbohydrates of as low as 7.5%. Organic amendment and the bacterial inoculation increased shoot total carbohydrates to 8.2 and 8.1, 10.2% in eggplants, respectively. In parallel with these results, **Ramakrishnan and Selvakumar (2012)** found that *Azotobacter* inoculated plants had the highest carbohydrate contents. Similarity biofertilizer significantly improved sugar concentration in chilli pepper plants **(Selvakumar and Thamizhiniyan, 2011)** and in black gram plants **(Selvakumar *et al*., 2012).**

Data illustrated by **Figure (8)** reveal that maximum shoot chlorophyll was exhibited by inoculated plants grown in compost amended soil followed by non inoculated plants grown with compost amendment and those inoculated without compost application. This is in conformity with **Aslam *et al*., (2011)** and **(Vazin, 2012)** who referred the increased plant chlorophyll to the increased leaf surface area as a result of individual or combined application of biofertilizer and organic amendment. **Farooq *et al*., (2009) and Hussain *et al*.,(2016)** ascribed the improvement in maize plant green pigments to the stabilization of chloroplasts and the scavenging ability of biofertilizers.

Data of the total leave phenols **(Figure 9)** point to a maximum phenol content in inoculated plants grown with compost followed by those treated only with compost then those only inoculated with *Azotobacter* with corresponding amounts approximated 209, 201, 143 and 118 mg. plant^{-1}, respectively. High Phenol content is required for plant defense mechanisms against pathogens and for human nutrition as antioxidants acting **(Prats *et al*., 2000)**.

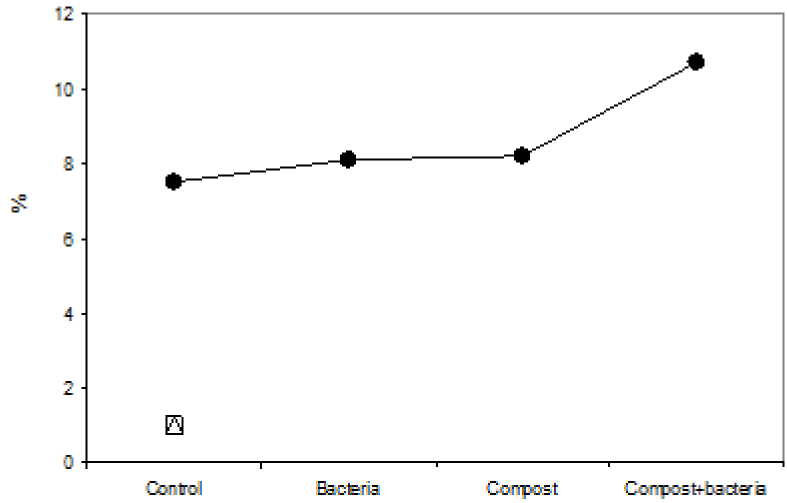

Figure 7: Effect of organic and bio fertilizer on total carbohydrates of eggplant

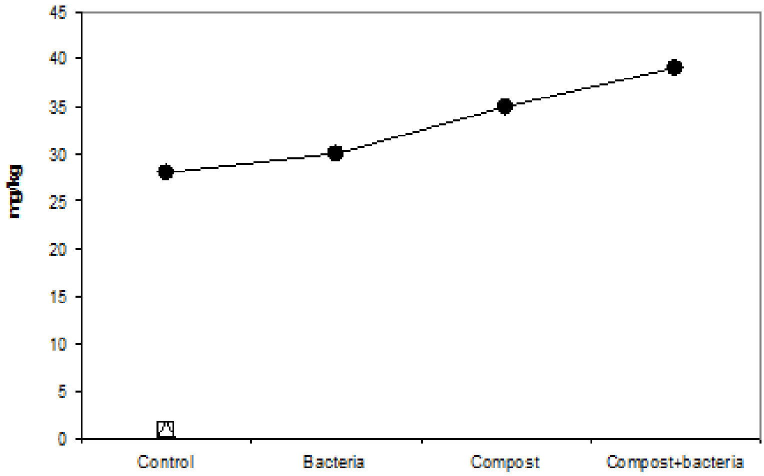

Figure 8: Effect of organic and bio fertilizer on total chlorophyll of eggplant

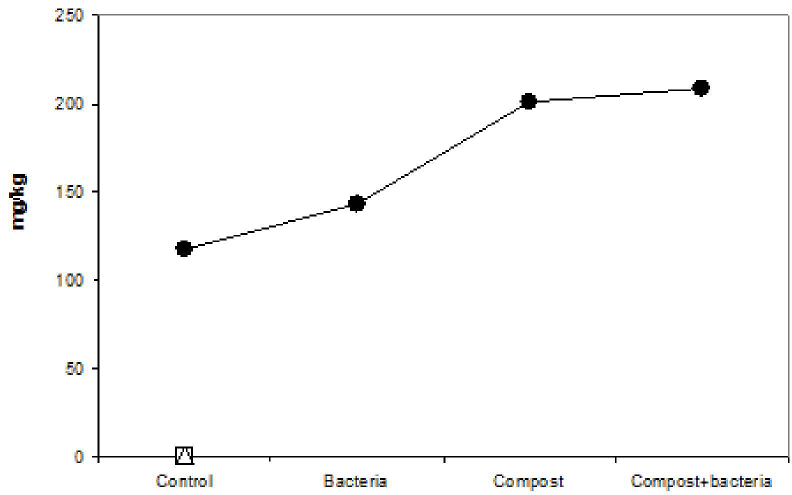

Figure 9: Effect of organic and bio fertilizer on total phenolof eggplant

Effect of composted shrimp shells and inoculation on soil:

Data on soil NPK and organic matter contents as illustrated by **Table 2,** were the highest in pots received bacterial inoculation combined with compost application. Compost application also supported high soil NPK contents of 324, 22.756, 314 and organic matter of 0.7 mg. g^{-1} soil. However, the plain soil contained the lowest NPK and organic contents.

Table 2: Chemical analysis of eggplant soil:

Treatment	PH	EC ds/cm	N (ppm)	P (ppm)	K (ppm)	Organic matter %
Control	7.85	1.158	211.12	22.516	166.87	0.57
Bacteria	7.91	1.32	316.68	22.576	247	0.58
compost	7.87	1.664	324.80	22.756	314	0.70
Compost + bacteria	7.91	1.677	527.80	22.86	347.2	0.87

Conclusion

The combined use of biofertilizer and compost material that produced from shrimp shell wastes in a mixture with rice straw, banana peels and pomegranate peels is more efficient approach in improving the growth, physiology and yield in eggplant that also improved soil bacterial population and soil health.

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كومبوست قشر الجمبري وإسهامه الحيوي في نمو الباذنجان في الأراضي منخفضة القيمة الزراعية

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تم اختبار الكومبوست الناتج من قشر الجمبري الممزوج بالمخلفات النباتية الأخرى وذلك في تجربة أصيصية لتحسين نمو الباذنجان في التربة الرملية منخفضة القيمة الزراعية. تم إعادة تدوير قشور الجمبري مع قش الأرز وقشور الموز وقشور الرمان في عملية إنتاج الكومبوست واستخدامها مع Azotobacter chrococcum كسماد عضوي وحيوي للباذنجان في الصوبة. النتائج المتحصل عليها تشير إلى نمو إيجابي يعززه تأثير منتج الكومبوست و / أو اللقاح البكتيري على الباذنجان. استخدام الكومبوست والتلقيح البكتيري يزيدان الوزن الجاف والطازج للباذنجان بالإضافة إلى قيم الكربوهيدرات الكلية والفينول الكلي والكلوروفيل الكلي. بالإضافة إلى ذلك، تم زيادة المادة العضوية للتربة في الأصص المعاملة بالسماد واللقاح البكتيرى. تم تسجيل تغييرات طفيفة في درجة الحموضة في التربة والتوصيل الكهربى نتيجة لاستخدام التسميد العضوي أو الحيوي.و ادت الدراسة إلى انة يمكن استخدام الكومبوست الناتج من قشور الجمبري مع اللقاح البكتيري كمحسن للتربة العضوية في برنامج الزراعة العضوية.