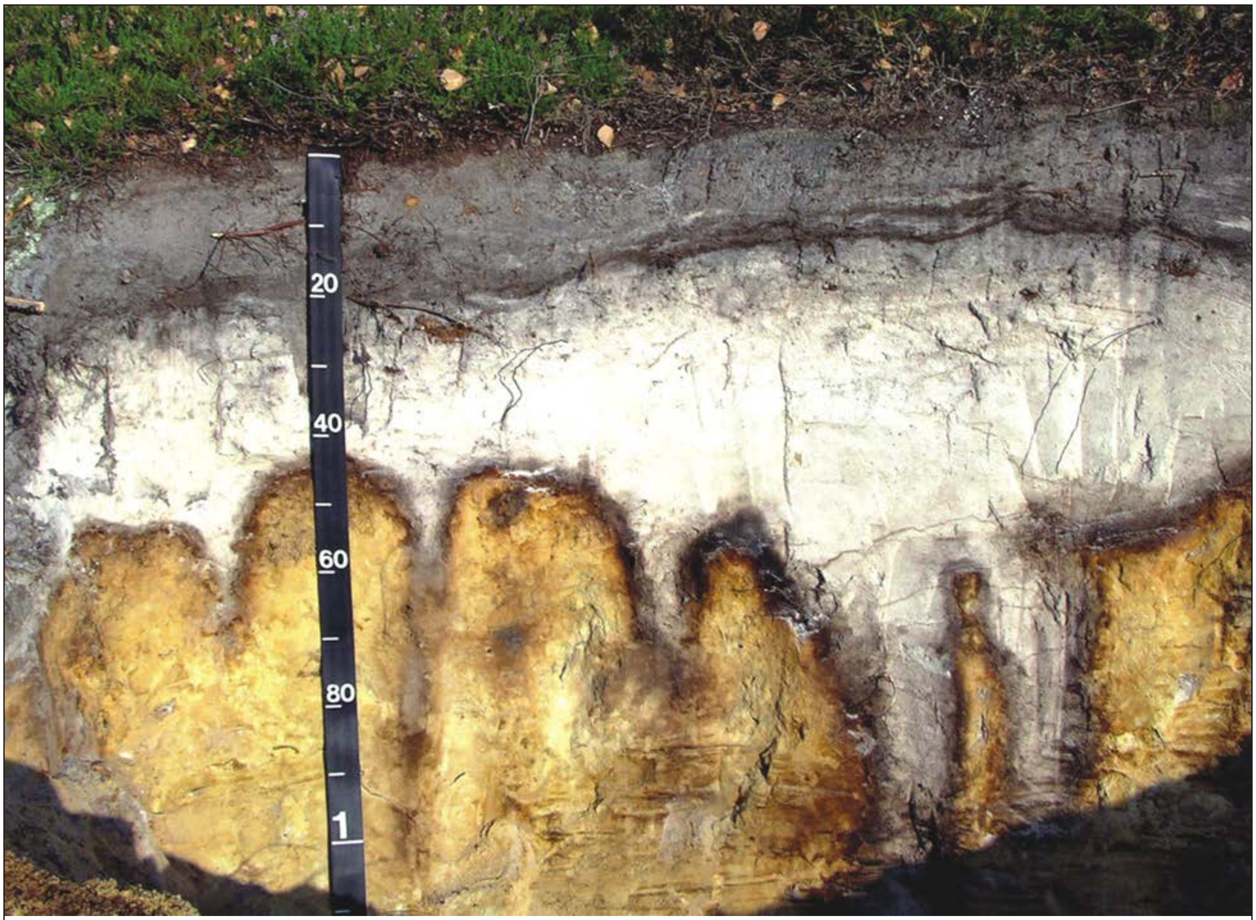

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Effect of Soil Amendments on Growth, Seed Yield and NPK Content of Bottle Gourd (*Lagenaria siceraria*) Grown in Clayey Soil

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ABSTRACT

The application of bio-fertilizers and organic fertilizer is considered a promising alternative for mineral fertilizers to decrease the production costs and environmental pollution with good yield. Hence, the present study aimed to evaluate the benefits of rice straw compost, humic acid and effective microorganism alone or in combination as an alternative to mineral-N fertilizer on the growth, foliar NPK content and yield of the local variety of bottle gourd. The study was carried out at Barramoon experimental farm, Dakahlia Governorate, Egypt, during the two summer seasons of 2012 and 2013. The experiment consisted of eight treatments of soil amendments and NPK fertilizers arranged in a complete randomized blocks design with three replicates. The study's treatments had significant effects on all studied traits in both seasons. The lowest values of these traits were recorded with the 75% recommended dose of NPK fertilizers with humic acid treatment. Whereas, the treatment of 75% recommended dose of NPK fertilizers in combination with rice straw compost, humic acid and effective microorganism had the highest values of foliage dry weight, number of leaves, stem length and number of fruits per plant as well as seeds weight per fruit, 100 seed weight and seed yield per plant and per hectare. So, this treatment could be recommended as an alternative method for bottle gourd fertilization. It might give the chance for increasing NPK-use efficiency and producing satisfactory and good seed yield with keeping the health and safety of human and environment.

Key words: Bottle gourd, effective microorganism, humic acid, *Lagenaria siceraria*, rice straw compost

INTRODUCTION

Bottle gourd seeds are a good source of edible protein and oil. They are an excellent source of essential fatty acids (such as omega 3 and omega 6), antioxidants, vitamins and sterols. They contain the high level of vitamin E, A and C (El-Dengawy *et al*., 2001; Hassan *et al*., 2008; Hegazy and El Kinawy, 2011). They contain the pharmaceutically active compounds used to treat acne, hyper-seborrhea, BHP, hirsutism and alopecia (Piccirilli *et al*., 2007; Prashar *et al*., 2014).

In Egypt, the bottle gourd is planted for the production of seeds that can be used for eating as a snack food or the production of salad oil. However, very little studies have been conducted to evaluate the effect of cultural practices on the growth and seed yield of bottle gourd. Therefore, this study was undertaken to provide data about the optimal fertilization for increasing the seed yield of bottle gourd.

One of the most important factors affecting the productivity of the cucurbits is the use of fertilizers. The Egyptian growers usually apply too much inorganic fertilizers to get high yields. Recently, a great attention has been focused to decrease the applied amounts of chemical fertilizers to decrease the production costs and environmental pollution. The combined application of bio-fertilization and organic fertilizer alongside with mineral fertilizers is increasingly gaining recognition as one of the right practices of addressing low soil fertility, especially in arid regions (Suresh *et al*., 2004; Naeem *et al*., 2006; Vanlauwe *et al*., 2010).

Natsheh and Mousa (2014) found that compost application is the best management for increasing soil fertility, cucumber yield and decrease the cost of N mineral fertilizers.

Singh *et al*. (2012) investigated the suitable combination of organic amendment with doses of chemical fertilizers to enhance the bottle gourd production on nutrient deficient. They found that the application of vermi compost with 50% recommended dose of chemical fertilizer had a significant effect on growth and yield parameters of bottle gourd.

The combined application of organic and inorganic fertilizers improved the soil structure and produced the highest and sustainable crop yield of cucumber. The composted organic wastes can substitute for around 25% of chemical nitrogen fertilizers (Mahmoud *et al*., 2009b).

Depletion of nutrients and poor organic matter contents of Egyptian soils can be replenished by applying rice straw compost to these soils (Mahmoud *et al*., 2009a). The use of rice straw compost as an organic fertilizer, might play a vital role not only in improving physical, biological and chemical properties of the soil, but also in increasing the availability of certain nutrients (Ali *et al*., 2006; Hellal, 2007; Mahmoud *et al*., 2009a). Moreover, the application of humic acid or Effective Microorganisms (EM) to the compost of rice straw gave the greatest results on potato plant growth, yield and chemical composition compared with individual application of compost (Abbas *et al*., 2014).

Humic substances have long a soil conditioner, fertilizer and soil supplement (Nardi *et al*., 2002; Albayrak and Camas, 2005). Humic acid improves soil physical property, ion exchange capacity and water holding capacity. The growth promoting activity of humic substances was caused by plant hormone like material in the humic substances (Zhang and Ervin, 2004; Canellas and Olivares, 2014). It stimulates plant growth by acting on mechanisms involved in cell respiration, photosynthesis, enzyme activities, protein synthesis and nutrient uptake (Nardi *et al*., 2002; Zhang and Ervin, 2004).

The application of humic substances has been reported to improve plant growth and chemical composition and reflected in higher crop yields and quality on watermelon (Salman *et al*., 2005) and squash (El-Masry *et al*., 2014). Moreover, El-Shabrawy *et al*. (2010) found that the soil application of humic acid and inoculated cucumber plants with *Azotobacter* along with 3/4 recommended N chemical fertilizer dose had the highest values of growth, yield and nutritional status of cucumber plants.

Using effective microorganisms is one of the alternatives of nutrient supply. It can enhance the decomposition of organic materials and to improve physical, biological and chemical properties of soils (Higa, 2000; Jusoh *et al*., 2013). EM is a mixed culture of photosynthetic, lactic acid bacteria, yeast, actinomycetes and fermenting fungi. Most of the species in EM inoculants are heterotrophic and need organic sources of carbon and nitrogen for their nutrition. Thus, microbial inoculation has been more effective when applied in combination with organic materials to offer both carbon and nitrogen (Yamada and Xu, 2001; Abou-El-Hassan *et al*., 2014). Moreover, Saeed *et al*. (2015) found that a combination treatment of bio-fertilizer and chemical fertilizer had significant effect and increased the yield and growth traits of cucumber.

Using EM improved growth, nutrient uptake and yield of cucumber (Zaki and Salama, 2006). It also improved the growth of cucumber, pumpkin and squash transplants (Olle and Williams, 2015).

Considering the above facts, the present study was undertaken to investigate the effect of rice straw compost, humic acid and effective microorganism alone or in combination as an alternative to mineral-N fertilizer on the growth, foliar NPK content and yield of the local variety of bottle gourd.

MATERIALS AND METHODS

Experimental site: Two field experiments were performed at Baramoon experimental farm, Dakahlia Governorate, Egypt (latitude 31°04 31" N, longitude 31°37 67" E and altitude 19 m above sea level), where the soil is Clay-loam, during the two summer seasons of 2012 and 2013 to achieve the study objectives.

Some physical and chemical properties of the experimental field soil at the depth of 0-30 cm were determined as described by Page *et al.* (1982) and Klute (1986) and are shown in Table 1.

Experimental design: A randomized complete block design with three replicates was used. Eight treatments were applied as follows: 100% mineral recommended NPK fertilizers (control), 75% NPK with rice straw compost (14.3 t ha^{-1}), 75% NPK with humic acid (3.6 kg ha^{-1}), 75% NPK with Effective Microorganism (EM) at a rate of 48 L ha^{-1}, 75% NPK with rice straw compost (14.3 t ha^{-1}) and humic acid (3.6 kg ha^{-1}), 75% NPK with rice straw compost (14.3 t ha^{-1}) and EM (48 L ha^{-1}), 75% NPK with humic acid (3.6 kg ha^{-1}) and EM (48 L ha^{-1}), 75% NPK with rice straw compost (14.3 t ha^{-1}), humic acid (3.6 kg ha^{-1}) and EM (48 L ha^{-1}).

Each experimental unit area was consisted of two ridges. The ridge was 7 m long and 3.5 m wide with 0.5 m in row spacing.

Treatments and crop management: Recommended levels of N (191 N/ha) P (107 kg P_2O_5/ha) and K (114 kg K_2O/ha) were used as ammonium sulfate (20.6% N), calcium superphosphate (15.5% P_2O_5) and potassium sulfate (48% K_2O), respectively. The mineral NPK fertilizers were applied at two equal doses; one was added after 3 weeks and the other after 6 weeks from planting.

The straw was chopped into 5 cm long pieces, piled, moistened with water and composted in association with a chemical accelerator (7 kg superphosphate and 40 kg ammonium sulfate per ton dry matter), 100 kg fertile soil per ton dry matter and 10% farmyard manure. At the first stage of composting, the EM suspension was sprayed on the raw material amounted 10 L t^{-1} dry matter. During composting (3 months), materials were manually mixed at a week intervals to offer aeration. The moisture content during the composting course was kept at a proper level

Table 1: Some physical and chemical properties of the experimental soil surface layer (at the depth of 0-30) before planting during 2012 and 2013 seasons

	Values			Values	
Properties	2012	2013	Properties	2012	2013
Sand (%)	27.1	26.7	pH* values	7.8	7.6
Silt (%)	31.5	31.8	EC (dSm^{-1})	0.8	0.9
Clay (%)	41.4	41.5	Total N (%)	0.13	0.14
Texture class	Clay-loam	Clay-loam	Available P (ppm)	11.3	11.1
$CaCO_3$	3.1	3.3	Exchangeable K (ppm)	318	309
OM (%)	2.4	2.2			

*pH: 1:2.5 soil extract

Table 2: Some properties of rice straw compost used in 2012 and 2013 seasons

Properties	Values 2012	Values 2013	Properties	Values 2012	Values 2013
N (%)	1.80	1.84	OM (%)	25.4	24.6
P (%)	0.19	0.17	C/N	19.9	20.4
K (%)	0.81	0.83	pH	6.5	6.8
			EC (mmhos cm^{-1})	2.9	2.6

pH 1:10 water extract, EC dS m^{-1}, 1:10 water extract, N: Nitrogen, P: Phosphorus, K: Potassium, OM: Organic matter

Table 3: Effect of mineral NPK fertilizers combined with rice straw compost, humic acid or/and effective microorganism on growth parameters of bottle gourd during 2012 and 2013 seasons

Treatments	Foliage dry weight/plant (g) 2012	Foliage dry weight/plant (g) 2013	No. leaves/plant 2012	No. leaves/plant 2013	Stem length (cm) 2012	Stem length (cm) 2013	Dry matter in leaves (%) 2012	Dry matter in leaves (%) 2013
100% NPK	226.0^{b}	221.7^{c}	57.6^{c}	55.2^{c}	258.0^{c}	255.0^{c}	11.4^{g}	11.5^{g}
75% NPK+RSC	171.0^{de}	165.0^{e}	45.3^{f}	43.6^{f}	285.0^{a}	284.3^{e}	12.4^{c}	12.5^{c}
75% NPK+HA	145.0^{e}	141.0^{f}	38.0^{h}	36.4^{h}	253.0^{f}	247.3^{f}	13.1^{a}	13.3^{a}
75% NPK+EM	158.0^{de}	151.0^{f}	41.2^{g}	40.3^{g}	271.0^{f}	268.0^{f}	12.8^{b}	12.9^{b}
75% NPK+RSC+HA	206.0^{bc}	200.7^{d}	53.5^{d}	50.5^{d}	321.0^{d}	314.0^{d}	11.9^{e}	12.0^{e}
75% NPK+RSC+EM	232.7^{bc}	230.3^{c}	60.7^{b}	58.3^{b}	370.0^{b}	356.0^{b}	11.6^{f}	11.7^{f}
75 % NPK+HA+EM	187.0^{cd}	180.0^{a}	49.4^{e}	47.2^{e}	303.0^{e}	300.0^{de}	12.2^{d}	12.2^{d}
75% NPK+RSC+HA+EM	263.0^{a}	253.7^{b}	64.8^{a}	62.2^{a}	390.7^{a}	377.0^{a}	11.1^{h}	11.2^{h}
LSD (5%)	31.7	30.5	2.6	2.9	15.0	15.8	0.14	0.16

NPK: Nitrogen-Phosphorus-Potassium, RSC: Rice straw compost, HA: Humic acid, EM: Effective microorganisms

(60% by weight) throughout an irrigation (El-Hammady *et al*., 2003; Abdulla, 2007). Some properties of the used compost were determined by using standard methods described by AOAC (1990) (Table 2). Rice straw compost was added to the soil and left two weeks before transplanting.

The properties of the used compost were determined by using standard methods described by AOAC (1990) (Table 2). The rice straw compost was mixed with the soil surface during soil preparation.

Effective microorganisms was obtained from the Ministry of Environmental Affairs, Mansoura, Dakahlia Governorate, Egypt. Humic acid in a solid form as potassium humate (80% humic acid, 11-13% K_2O) was used. Effective microorganisms solution (1:100 dilution of EM in water) and freshly prepared humic acid suspension (3 g L^{-1}) were applied as a soil drench twice before the first and second irrigation.

Seeds of local variety were obtained from Cross Pollinated Vegetables Crops Department., Horticulture Research Institute. Seeds were sown on 8 and 7 April in the 2012 and 2013 seasons, respectively. Two to three seeds were sown per hill and later thin to the best one. The cultural practices were done according to the general program of bottle gourd cultivation.

Data and measurements: At 60 days after planting, a random sample of three plants was taken from each experimental unit to determine the growth parameters (foliage dry weight per plant, number of leaves per plant and stem length).

Eight uppermost fully expanded leaves per plot were randomly cut to measure the dry matter in leaves (%) and N, P and K contents. Total nitrogen was determined by the micro-Kjeldahl method according to Chapman and Pratt (1961). Phosphorus was colorimetrically determined following Jackson (1973). Potassium was determined using a flame photometer as described by Jackson (1973).

At harvest, a random sample of six plants was taken from each experimental unit to study the number of fruits per plant and seed yield per plant (g). Moreover, seeds weight per fruit (g) and

100-seed weight (g) were recorded as the average data of 10 fruits per plot. Seeds were extracted, dried and weighted. Each plot was harvested and seed yield was determined in kg/plot, then it was converted to estimate yield per hectare in kg ha^{-1}.

Data analysis: Data obtained were statistically analyzed according to Snedecor and Cochran (1989). Differences among means were compared using the least significant difference value (LSD).

RESULTS

Vegetative growth characters: The growth parameters of bottle gourd were significantly different due to the different combinations between soil amendments and N, P and K mineral fertilizers in both seasons (Table 3). The highest values of foliage dry weight per plant, number of leaves per plant and stem length were recorded with soil application of 75% recommended dose of NPK fertilizers in combination with rice straw compost, humic acid and effective microorganism followed by 75% recommended dose of NPK fertilizers in combination with rice straw compost and effective microorganism and 100% recommended dose of NPK fertilizers. However, these treatments had the lowest values of dry matter percentage in leaves. On the other hand, 75% recommended dose of NPK with humic acid had the lowest values of foliage dry weight per plant, number of leaves per plant and stem length. It had the highest values of dry matter percentage in leaves. These findings were true in both seasons.

N, P and K concentrations in leaves: The application of soil amendments with 75% recommended dose of NPK fertilizers increased N, P and K content in leaves compared with control 100% recommended dose of N, P and K mineral fertilizers in combination with rice straw compost, humic acid and effective microorganism gave the lowest values (Table 4). Moreover, there are insignificant differences between 100% recommended dose of NPK fertilizers and 75% recommended dose of NPK fertilizers in combination with rice straw compost and effective microorganism treatments. Similar results were recorded in both seasons.

Seed yield and its components: The treatments had significant effects on seed yield and its components in both seasons (Table 5 and Fig. 1). The highest values of number of fruits per plant, seeds weight per fruit, 100 seed weight, seed yield per plant and seed yield per hectare were recorded with the 75% recommended dose of NPK fertilizers in combination with rice straw

Table 4: Effect of mineral NPK fertilizers combined with rice straw compost, humic acid or/and effective microorganism on N, P and K concentrations in bottle gourd leaves during 2012 and 2013 seasons

Treatments	N (%) 2012	N (%) 2013	P (%) 2012	P (%) 2013	K (%) 2012	K (%) 2013
100% NPK	3.49^{f}	3.52^{fg}	0.24^{de}	0.24^{fg}	3.55^{ef}	3.57^{f}
75% NPK+RSC	3.70^{bc}	3.75^{bc}	0.29^{b}	0.30^{c}	3.84^{b}	3.83^{b}
75% NPK+HA	3.82^{a}	3.86^{a}	0.32^{a}	0.34^{a}	3.93^{a}	3.94^{a}
75% NPK+EM	3.75^{ab}	3.80^{ab}	0.30^{b}	0.32^{b}	3.87^{ab}	3.89^{a}
75% NPK+RSC+HA	3.61^{de}	3.64^{de}	0.25^{d}	0.26^{e}	3.67^{d}	3.69^{d}
75% NPK+RSC+EM	3.55^{e}	3.58^{ef}	0.24^{de}	0.25^{ef}	3.61^{e}	3.63^{e}
75% NPK+HA+EM	3.66^{cd}	3.69^{cd}	0.27^{c}	0.28^{d}	3.75^{c}	3.76^{c}
75% NPK+RSC+HA+EM	3.46^{f}	3.45^{g}	0.23^{e}	0.23^{g}	3.50^{f}	3.52^{f}
LSD (5%)	0.07	0.08	0.01	0.02	0.06	0.06

NPK: Nitrogen-Phosphorus-Potassium, RSC: Rice straw compost, HA: Humic acid, EM: Effective microorganisms

Table 5: Effect of mineral NPK fertilizers combined with rice straw compost, humic acid or/and effective microorganism on seed yield of bottle gourd and its components during 2012 and 2013 seasons

	Number of fruits/plant		Seeds weight/fruit (g)		100-seed weight (g)		Seed yield/plant (g)	
Treatments	2012	2013	2012	2013	2012	2013	2012	2013
100% NPK	2.8[a]	2.7[a]	130.0[bc]	129.0[b]	21.1[b]	21.7[b]	361.7[b]	352.4[b]
75% NPK+RSC	2.5[b]	2.4[c]	122.0[de]	121.0[c]	17.0[de]	17.6[cd]	300.9[d]	286.5[e]
75% NPK+HA	2.3[c]	2.2[d]	114.0[f]	110.3[d]	15.2[f]	15.5[e]	266.0[e]	239.0[f]
75% NPK+EM	2.5[b]	2.4[bc]	118.0[ef]	115.0[d]	16.1[ef]	16.3[de]	295.0[d]	276.2[e]
75% NPK+RSC+HA	2.6[b]	2.5[b]	127.0[cd]	128.0[b]	18.3[c]	18.0[c]	330.0[c]	320.3[d]
75 % NPK+RSC+EM	2.6[b]	2.6[b]	134.0[ab]	134.0[ab]	21.5[b]	21.1[b]	352.2[b]	341.9[c]
75 % NPK+HA+EM	2.5[b]	2.5[b]	131.0[bc]	130.0[b]	17.9[cd]	18.4[c]	332.0[c]	325.3[cd]
75% NPK+RSC+HA+EM	2.8[a]	2.8[a]	140.0[a]	139.0[a]	23.6[a]	23.2[a]	391.7[a]	385.4[a]
LSD (5%)	0.14	0.13	6.0	6.9	1.1	1.4	19.2	19.8

NPK: Nitrogen-Phosphorus-Potassium, RSC: Rice straw compost, HA: Humic acid, EM: Effective microorganisms

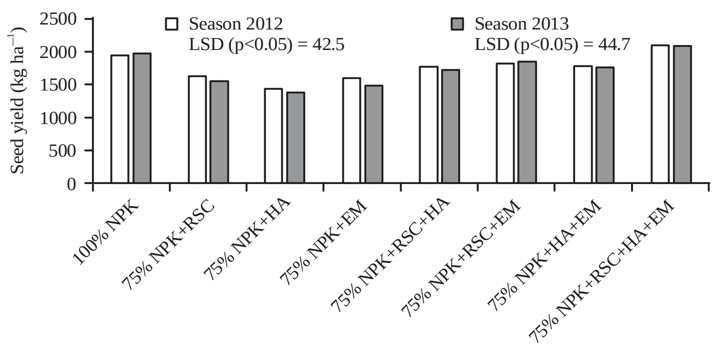

Fig. 1: Effect of mineral NPK fertilizers combined with Rice Straw Compost (RSC), Humic Acid (HA) or/and Effective Microorganism (EM) on seed yield of bottle gourd during 2012 and 2013 seasons

compost, humic acid and effective microorganism treatment. Meanwhile, the lowest values of seed yield and its components were recorded with the 75% recommended dose of NPK fertilizers with humic acid treatment.

Generally, the addition of effective microorganism with rice straw compost led to improve the seed yield and its components as compared to different rice straw compost alone or chemical fertilizer application.

DISCUSSION

The low soil contents for the major nutrients and organic matter (Table 1) indicate the need for soil amendments. The stimulating of vegetative growth by the application of all soil amendments with 75% recommended dose of N, P and K mineral fertilizers may be attributed to their efficiency in providing energy necessary for microorganism activity, supplying the plants with biologically fixed nitrogen, mobilizing the unavailable forms of nutrient elements to available forms and increasing soil fertility and cation exchange capacity (Suresh *et al*., 2004; Naeem *et al.,* 2006; Vanlauwe *et al*., 2010; Abou-El-Hassan *et al*., 2014; Natsheh and Mousa, 2014).

In this respect, Sadek and Youssef (2014) found that compost tea, K-humate and effective microorganism treatments enhanced available nitrogen in soil and soil organic matter and reduced soil pH compared to chemical treatment. Mahmoud *et al*. (2009b) found that the application of compost increased organic carbon, nitrogen and phosphorous in soil more than application of N mineral fertilizers. Compost combined with application of N mineral fertilizers was the best treatment for increasing soil fertility and plant growth (Mahmoud *et al*., 2009b; Singh *et al*., 2012). Abbas *et al*. (2014) showed that the addition of compost of rice straw with mineral N, humic acid or EM had a high significant influence on potato plant growth.

The negative effect of these treatments on dry matter percentage in leaves may be due to the role of soil amendments in increasing of N assimilation by plant (Higa, 2000; Yamada and Xu, 2001), thus, more protoplasm is formed and a more succulent plant results; because protoplasm is highly hydrated (Havlin *et al*., 2005).

Moreover, the higher production of foliage dry weight per plant (Table 3) caused 75% recommended dose of NPK fertilizers in combination with rice straw compost, humic acid and effective microorganism, 75% recommended dose of NPK fertilizers in combination with rice straw compost and effective microorganism and 100% recommended dose of NPK fertilizers treatments may have resulted in a dilution effect in the N, P and K concentrations. This observation has coincided with those reported by Lindani and Brutsch (2012) who found that the application of EM to tomato plants in combination with compost and recommended dose of NP fertilizers led to a decrease in leaf N and P content.

The increase in seed yield and its components with the treatment of 75% recommended dose of NPK fertilizers in combination with rice straw compost, humic acid and effective microorganism might be due to its positive effect on the vegetative growth of bottle gourd plants (Table 3). Consequently, increased translocation of photo assimilates from source to sink tissues (Hu *et al*., 2009) which reflected on increasing reproductive activities and characteristics. These results reflect the accrued benefits of soil amendments in the rhizosphere. Rice straw compost and humic acid improves the physical, chemical and biological properties of the soil and provide the energy necessary for microorganism activity. On the other hand, EM stimulates quick decomposition of organic material and mineralization of nutrients from applied organic matters and enhance the release of nutrients for plant uptake (Rady, 2011; Jusoh *et al*., 2013). These results are in accordance with those reported by Salman *et al.* (2005), Zaki and Salama (2006), Mahmoud *et al.* (2009b), El-Shabrawy *et al.* (2010), El-Masry *et al.* (2014) and Natsheh and Mousa (2014).

CONCLUSION

It could be concluded that, the treatment of 75% recommended dose of NPK fertilizers in combination with rice straw compost, humic acid and effective microorganism is considered a suitable application to improve vegetative growth and seed yield of bottle gourd plants under similar field conditions. Moreover, the application of such materials conserves the environment from chemical pollution hazards.

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