Zagazig J. Agric. Res., Vol. 44 No. (4) 2017 1259-1276

Horticultural Science

http:/www.journals.zu.edu.eg/journalDisplay.aspx?Journalld=1&queryType=Master

HOW TO SUSTAINE ECOLOGICAL FOOD PRODUCTION UNDER URBAN CONDITIONS

Mohamed Abul-Soud*, M.S.A. Emam, Z.Y. Maharik, M.H. Mohammed and A.M. Hawash

Cent. Lab. Agric. Climate, Agric. Res. Cent., Giza, Egypt

Received: 18/01/2017 ; Accepted: 01/06/2017

ABSTRACT: Sustainable horticulture production, recycling organic wastes, mitigate climate change impacts and greenhouse gas emission and save natural resources under urban and rural areas are a serious issues need to create new strategies. Rooftop garden and vermicomposting technologies performed an integrated strategy to share in achieving resilience city. The study was conducted out during two successive winter seasons (2015 and 2016) under urban conditions at Central Laboratory for Agricultural Climate (CLAC), Giza, Egypt. The study investigated the use and the effect of vermicompost as an amendable substrate in different proportions (10 and 20% *V/V*) with sand: peat moss (1:1 *V/V*) and sand combined with two nutrient solution sources (chemical nutrient solution and vermi-liquid) with two EC levels (1 and 1.5 dS m^{-1}) on lettuce yield under urban condition. Iceberg lettuce type *cv.* Robinson F1 hybrid was cultivated in split split plot design with three replicates. The study aimed to alternate or minimize the use of peat moss by vermicompost and chemical fertilizers by organic source *via* vermi-liquid to provide more sustainable production and mitigate climate change impacts *via* converting urban organic wastes through vermicomposting technology into vermicompost and vermi-liquid. Results revealed that using vermicompost as a substrate amendment combined with different substrates had a significant effect on lettuce yield through enhancing the physical and chemical properties of substrate and support plant nutrition. The use of chemical nutrient solution + EC level 1.5 dS m^{-1} + substrate sand: peat moss: vermicompost ((40: 40: 20% *V/V*) for producing the highest yield of lettuce under the investigation conditions. While for environmentally and safety, vermi-liquid + Ec level 1.5 dSm^{-1} + substrate sand: peat moss: vermicompost (40: 40: 20% *V/V*) was recommended. The study supported the micro and small scale urban farm to match the food security and safety needs *via* using vermicomposting outputs and simple substrate culture in top roof garden technique. Recycling urban organic wastes and mitigating greenhouse gases (GHG's) emission as well as sustainable food production need more efficient efforts and real contribution. Ecology food could be sustained under urban condition.

Key words: Roof garden, vermicompost, vermi-liquid, substrate culture, nutrient solution, small scale urban farm and lettuce.

INTRODUCTION

Under climate change impacts concerning urban and rural areas such as increase of temperature, urban heating island, sharp shortage of water and agricultural land and incompetence in food security especially under urban condition. New and fixable techniques and strategies are needed for reducing the vulnerability to climate change and poverty alleviation, income generation and food security. Urban horticulture should play a vital role in producing the food and reducing the negative climate change impacts via using green roof systems and at the same time securing the recycle of urban organic wastes for mitigate CO_2 emission and save the essential nutrients (Abul-Soud *et al*., 2014). Small scale urban farm could contribute strongly in satisfy the food security and safety needs. Regarding to the

***Corresponding author: Tel.:** +201115115842
E-mail address: abul_soud1@yahoo. Com

limited water resources, available lands and financial resources led to create simple substrate culture for producing vegetables needs could be used on the roof buildings as a small scale urban farm. Urban agriculture via rooftop garden in mega cities offer more flexibility strategy to mitigate climate change impacts and food security (Abul-Soud, 2015).

Soilless culture technology could be used in urban horticulture *via* different successful systems especially substrate culture under Egyptian conditions concerning green roof systems, (Abul-Soud *et al.*, 2014). Gruda (2009) mentioned that soilless culture systems (SCSs), the most intensive production method, are based on environmentally friendly technology, which can result in higher yields, even in areas with adverse growing conditions (shortage of available agricultural soil and water). An adaptation of cultural management to the specific cultural system, as well as crop demand can further result in the improvement of the quality of horticultural products. Consequently, a lot of new organic growing media, based on renewable raw materials, were and continue to be investigated. Nowadays, the utilization, nature of materials used for SCSs, and growing media are diverse (Gruda *et al*., 2005). Physical, chemical and biological characteristics of the substrates must correlate with water and fertilizer supply, climate conditions, and plant needs.

A majority of horticulture crops are produced in commercially available substrates. In general, growers want substrates that are consistent, reproducible, available, easy to handle and mix, cost effective, and have the appropriate physical and chemical properties for the crop they are growing (Klock-Moore, 2000), Widely used substrate components include peat moss, pine bark, perlite, vermiculite, sand; *etc.* The need to produce local substrate instead of imported substrates drives many researchers to develop different substrate to play the role of peat moss.

Utilization of epigiec earthworms into vermicomposting system as a bio technique for digesting organic urban wastes to accelerate the rate of decomposition of organic matter, and alter the physical and chemical properties of the material, leading to an effect similar to composting in which the unstable organic matter is oxidized and stabilized aerobically. The final product, named vermicompost, is very different from the original waste material, mainly because of the increased decomposition and humification. Possibly due to less soluble salts, greater cation exchange capacity, better physical properties, higher microbial and enzymatic activity, and higher content of available nutrients producer acceptance of vermicompost is greater than that of compost (Atiyeh *et al.*, 2002; Tognetti, *et al*., 2005; Abul-Soud *et al.*, 2009).

Several studies assessed the effect of vermicompost amendments in potting substrates had a significant impact on growth and yield of a wide range of marketable fruits cultivated in greenhouses (Arancon *et al.*, 2004a), as well as on growth, yields of green gram (*Phaseolus aurus Roxb)* and tomato (Kamergam *et al.*, 1999; Arancon *et al.*, 2004a). The use of simple substrate culture and vermicompost outputs in producing food such as sweet pepper (Abul-Soud *et al.*, 2014), lettuce (Abul-Soud *et al.*, 2015b), spinach, molokhia (Abul-Soud and Mancy, 2015), celery and cabbage (Abul-Soud, 2015), strawberry (Abul-Soud *et al.*, 2015a) through rooftop garden take more consideration last decade under Egyptian conditions.

Vermicompost provides that all nutrients are supplied by mineral fertilization, studies show greatest plant growth responses when vermicompost constituted a relatively small proportion (10 to 20%) of the total volume of the substrate mixture, with higher proportions of vermicompost in the mixture not always improving plant growth (Atiyeh *et al.*, 2000).

Extract during vermicomposting process is known as vermi-liquid (vermicompost extract). Vermicomposting derived liquids contain valuable nutrients that promote plant growth. Substrates that have been used in these liquids production are mainly animal and agricultural waste. (Pant *et al.*, 2009; Gutiérrez-Miceli *et al.*, 2011). Available plant nutrients that present in these liquids are valuable and have the potential to be used as nutrients solution in hydroponics culture. Quaik *et al*. (2012) reported that vermicomposting leachate, this biofertilizer showing promising results in various dilutions.

This study aimed to determine the effects of different vermicompost rates mixed with sand and peat moss, different sources and different EC levels of nutrient solution on yield of lettuce grown in pots culture during winter seasons while promote the small scale urban farm in food security strategy. Investigate the contribution of vermicomposting outputs in sustainable production of vegetables under urban conditions.

MATERIALS AND METHODS

The experiment was carried out in Central Laboratory for Agriculture Climate (CLAC), Dokki, Giza Governorate. Agricultural Research Centre, Ministry of Agriculture and land reclamation, Egypt, during two successive winter seasons of 2015 and 2016. This experiment aimed to investigate the effect of using vermicomposting outputs in substrate culture on yield of lettuce plants. The research was conducted in the open field under urban conditions in substrate culture technique.

Plant Material

Lettuce (Iceberg type) Robinson F1 hybrid seeds were sown on 15th and 17th Oct., 2014 and 2015 winter seasons, respectively in foam trays containing peat moss: vermiculite (1:1 *V/V*). After four weeks from sowing, lettuce seedlings were transplanted into plastic pots (5 l. in volume) (one seedling per pot).

The Vermicomposting Process

The vermicomposting outputs (vermicompost and vermi-liquid) offered *via* integrated environmental management of urban organic wastes using vermicomposting and green roof (VCGR) project, Central Laboratory for Agricultural Climate (CLAC). The vermicomposting process were done by using Epigiec earthworms (worm diameter: 0.5 – 5 mm and worm length: 10–120 mm). *Lumbriscus rubellus* (Red Worm), *Eisenia fetida* (Tiger Worm), *Perionyx excavatus* (Indian Blue) and *Eudrilus eugeniae* (African Night Crawler) converted the different organic wastes into vermicompost under the study in the vermicomposting bed system according to Abul-Soud *et al.* (2009, 2014 and 2015b).

Bed system of vermicomposting was used for producing both of vermicompost and vermi-liquid under the study conditions. Eight beds were established under black net house by digging the soil and mulched with black polyethylene plastic sheet 0.5 mm to perform a bed with length 2.5 m, width 1.2 m and depth 50 cm. A slope 1.5% had been done to collect the vermi-liquid through water bucket. Mixing the different raw materials: horse manure (CM) + vegetable and fruit wastes (VFW) + shredded paper (Sh. P) in the rate of 2 : 2 : 1 (*V/V*), respectively was done by using turning machine (4 hr./3 days) with moisten the mixture. After well mixed done, the final mix soaked in water for 1/2 to 1 hour to make sure it is not drier and put it in lines along the bed. The feeding of earthworm was done every three days and every 21 days the earthworms were fasting for 7 days to give them the opportunities to re-eat the cast and to avoid non composted wastes. Moisture content was adjusted regularly in the range of 60 – 70%.

Treatments

This experiment included 20 treatments resulted from the combinations of two EC levels and two sources of the nutrient solution with five substrate mixtures as follow:

Nutrient sources

Two sources of nutrient have been used in this study as follow:

1. Chemical nutrient solution (CNS)
2. Vermi-liquid (VL)

Electrical conductivity (EC)

1. 1 dS m^{-1}
2. 1.5 dS m^{-1}

Substrate cultures

Five substrate mixtures included vermicompost as substrate amendment as follow:

1. Sand 50% + Pet moss 50% (S:P).
2. Sand 45% + Pet moss 45% + Vermicompost 10% (S: P: V10%).
3. Sand 40% + Pet moss 40% + Vermicompost 20% (S: P: V20%).

4. Sand 90% + Vermicompost 10% (S: V10%).
5. Sand 80% + Vermicompost 20% (S: V20%).

The experimental design was a split split plot design with three replicates. The main plots, subplots and sub-subplots were assigned to nutrient sources, electrical conductivity (EC) and substrates mixes, respectively. Each plot consisted of 10 plants.

System Materials

Plastic pots 5 l. in volume (20 cm diameter × 30 cm length) were used, the pots were filled with different substrates mixtures.

The vermi-liquid was collected through vermicomposting process. The vermi-liquid was filtered by using nets to remove any residues or dust that could cause blocking of drippers before diluted to the desire EC.

Sand was primarily washed with diluted nitric acid to get rid from the undesirable salts, then with running tap water to wash nitric acid compounds from the sand. After sand was getting dry, it mixed with peat moss and vermicompost in different proportions depending on the different treatments under the investigation.

Different nutrient solutions were pumped *via* submersible pump (110 watt). Water tanks of 120 l. were used in open system of substrate pots culture. The nutrient solution used in the experiment was adapted from Cooper (1979) depending on the analysis of the local water by El Behairy (1994). Plants were irrigated by using drippers of 4 l/hr capacity. The fertigation was programmed to work four times/day and the duration of irrigation time depended upon the season. The EC of the different nutrient solutions were adjusted by using EC meter. The chemical compositions of Vermi-liquid and chemical nutrient solution were illustrated in Table 1, and the physical and chemical properties of vermicompost were indicated in Table 2. The physical and chemical properties of vermicompost were estimated by Soil, Water and Environmental Research Institute, Agricultural Research Center (ARC), Giza, Egypt.

Substrates physical properties; *i.e.*, bulk density (BD), total pore space (TPS), water holding capacity (%) (WHC) and air porosity (%) (A.P) were estimated according to Wilson (1983) and Raul (1996). The pH of the potting mixtures were determined using a double distilled water suspension of each potting mixture in the ratio of 1:10 (*W:V*) (Inbar *et al*., 1993) that had been agitated mechanically for 2 hr. and filtered through filter paper No.1. The same solution was measured for electrical conductivity with a conductance meter that had been standardized with 0.01 and 0.1 *M* KCl. The physical and chemical properties of different substrates were illustrated in Table 3.

Measurements

After eight weeks from transplanting date, growth and yield parameters of lettuce; *i.e.*, (Plant fresh weight (g), head fresh weight (g) (After removing the outer leaves), head volume (cm^3) and density (g/cm^3) were measured, while dry matter percentages were determined after oven-drying the samples of the head of lettuce at 70ºC for 48 hours.

Total chlorophyll content was measured by Minolta chlorophyll meter SPAD -502 according to Yadava (1986).

Mineral analysis (N, P and K), plant samples of each plot were dried at 70^{o} C in an air forced oven for 48 hr., and dried plants were digested in H_2SO_4 according to the method described by Allen (1974) and N, P and K contents were estimated in the acid digested solution. Total nitrogen was determined by micro Kjeldahl method according to the procedure described by FAO (1980). Phosphorus content was determined using spectrophotometer according to Watanabe and Olsen (1965). Potassium content was determined photo-metrically using Flame photometer as described by Chapman and Pratt (1961).

The parametric analysis was performed using SAS (Statistical Analysis System) and data were transformed by the technique described by Box *et al.* (1978). The differences among means for all traits were tested for significance at 5 % level according to the procedure described by Snedicor and Cochran (1981).

Table 1. Chemical composition of the different sources of nutrient solutions agricultural

Nutrient type	Macro nutrients ppm					Micro nutrients ppm						
	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Pb	Cd
Chemical nutrient solution	200	45	350	180	50	3.0	1.00	0.06	0.10	0.25	0.16	0.01
Vermi-liquid	128	98	222	111	48.6	0.25	0.04	0.01	0.04	0.21	0.05	ND

part per Moulin (ppm) Non decaled (ND)

Table 2. Physical and chemical properties of vermicompost

Analysis	UNITS		Analysis	UNITS	
BD	Kg/m^3	715	P	(%)	1.27
OM	(%)	33.22	K	(%)	0.59
C/N ratio		1:12.3	Fe	ppm	802
pH		8.17	Mn	ppm	143
EC	dS/m	6.67	Zn	ppm	37.0
N	(%)	1.57	Cu	ppm	14.0
$N-NH_4$	ppm	65	Pb	ppm	9.0
$N-NO_3$	ppm	81	Cd	ppm	ND

Bulk density (BD) Organic matter (OM)

Table 3. The physical and chemical properties of different substrates

	Physical properties				Chemical properties	
Substrate	**BD Kg/m^3**	**TPS (%)**	**WHC (%)**	**AP (%)**	**pH (1:10)**	**EC dS/m^{-1}**
S : P	0.89	60.1	43.2	16.9	6.9	0.35
S: P : V 10%	0.99	54.4	46.8	7.6	7.1	0.53
S: P : V 20%	0.91	58.6	51.5	7.1	7.4	0.79
S: V 10%	1.58	29.4	24.9	4.5	7.7	0.71
S: V 20%	1.53	36.5	31.3	5.2	7.8	0.96

Bulk density (BD). Total poor space (TPS). Water holding capacity (WHC). Air porosity (AP)

RESULTS

Effect of Nutrient Solution Source, EC Level and Substrate Mixtures and Their Combinations on Vegetative Growth and Yield Characteristics of Lettuce

The vegetative and yield characteristics of lettuce plant are illustrated in Tables 4 and 5. The effect of nutrient solution sources, EC levels and substrate mixtures on plant fresh weight (g), head fresh weight (g) and dry matter (%) (Table 4) and on head volume (cm^3), head density (g/cm^3) and total chlorophyll content (spad) (Table 5) were presented.

Concerning the nutrient solution source, results show that using chemical nutrient solution gave the highest values for each of plant fresh weight, head fresh weight, head volume and total chlorophyll content compared to vermi-liquid. On the contrary, vermi-liquid as a nutrient source recorded the highest values of head density. Data of dry matter percentage showed that there was no significant difference between nutrient sources.

Regarding EC level, the EC level 1.5 dSm^{-1} had the highest significant measurements of plant fresh weight, head fresh weight and head volume comparing with 1.0 dS m^{-1}. While using EC level at 1.0 dS m^{-1} recorded the highest significant values of head density, dry matter percentage and total chlorophyll content.

The obtained results of substrate mixtures effect (Tables 4 and 5) indicate that the highest plant fresh weight, head fresh weight and head volume were recorded by sand + peat moss + Vermicompost 40: 40 : 20% (*V/V*),whereas the lowest values of total fresh weight and head fresh weight were obtained by sand + vermicompost (90: 10% *V/V*). Both of sand + vermicompost 10 and 20% recorded the highest dry matter percent and head density results. On the other hand, the lowest records of head volume and the highest total chlorophyll content were recorded by sand + peat moss (1:1 *V/V*). Also, it is clear that sand + peat moss + vermicompost (45: 45:10% *V/V*) and sand + peat moss + vermicompost (40 : 40 : 20% *V/V*) had the lowest values of dry matter percentage. Relative to the head density, the highest result was recorded by sand + vermicompost (90: 10% *V/V*) while plants grown in substrate mixtures sand + peat moss + Vermicompost (45: 45:10% *V/V*) followed by sand + vermicompost (90: 10% *V/V*).

Referring to the interactions between nutrient solution source and electrical conductivity, fertigation with chemical nutrient solution at 1.5 dS m^{-1} gave the highest results of plant fresh weight, head fresh weight and head volume and the lowest head density values, but the highest total chlorophyll content was presented by chemical solution at 1.0 dS m^{-1}. While the highest measures of dry matter percent and head density were recorded by vermi-liquid at 1.0 dS m^{-1}. However, the lowest results of plant fresh weight, head fresh weight, head volume and total chlorophyll content were introduced by vermi-liquid at 1.0 dS m^{-1} and dry matter percent with vermi-liquid at 1.5 dS m^{-1}.

As for the interaction between nutrient solution source and substrate mixtures data show that, sand + peat moss + Vermicompost (40 : 40 : 20% *V/V*) combined with chemical solution performed the highest values of plant fresh weight, head fresh weight and head volume, while the lowest values were presented by sand + vermicompost (90 : 10% *V/V*) combined with vermi-liquid, but gave the highest head density. Moreover, the highest dry matter percentag and the lowest total chlorophyll content were recorded by sand + vermicompost (80: 20% *V/V*) combined with vermi-liquid. Total chlorophyll content, sand + peat moss (1:1 *V/V*) gave the highest values followed by sand + peat moss + Vermicompost (45 : 45 : 10% *V/V)* combined with chemical solution.

The combination effect between electrical conductivity and substrate mixtures showed that lettuce plants grown in sand + peat moss + vermicompost (40:40:20% *V/V*) combined with 1.5 dS m^{-1} gave the highest values of plant fresh weight, head fresh weight and head volume, while the lowest values were recorded by both sand + vermicompost (90: 10% *V/V*) combined with 1.0 dS m^{-1} but had the highest head density records. On the other hand, the highest value of dry matter percentage was recorded with sand + vermicompost (80: 20% *V/V*) combined with 1.0 dS m^{-1} that gave the lowest records of total chlorophyll content. Combination between sand + peat moss (1:1 *V/V*) and EC level 1.0 dS m^{-1} had the highest total chlorophyll content.

Table 4. Effect of nutrient solution source, EC levels and substrate mixtures and their combinations on plant fresh weight, head fresh weight and dry matter percent of lettuce plant

Treatment	First season			Second season		
	Plant fresh weight (g)	Head fresh weight (g)	Dry matter (%)	Plant fresh weight (g)	Head fresh weight (g)	Dry matter (%)
			Nutrient sources			
CNS	663.9 A	476.1 A	6.0 A	703.3 A	512.1 A	6.5 A
VL	320.7 B	203.1 B	6.2 A	341.2 B	222.4 B	6.6 A
			Electrical conductivity (EC)			
1 ds^{-m}	386.8 B	269.0 B	6.5 A	409.8 B	288.6 B	6.9 A
1.5 ds^{-m}	597.8 A	410.2 A	5.7 B	635.2 A	445.8 A	6.1 B
			Substrate mixture			
S: P	462.3 CD	313.9 C	6.3 A	482.8 D	332.5 CD	6.8 A
S: P: V 10%	512.6 B	348.8 B	5.9 B	542.8 B	374.2 B	6.3 B
S: P: V 20%	564.4 A	407.9 A	5.8 B	602.1 A	450.1 A	6.1 B
S: V 10%	444.3 D	301.5 C	6.2 A	471.1 D	325.4 D	6.6 A
S: V 20%	479.1 C	325.8 BC	6.3 A	513.3 C	354.0 BC	6.7 A

Table 4. Cont.

Treatment		First season			Second season		
		Plant fresh weight (g)	Head fresh weight (g)	Dry matter (%)	Plant fresh weight (g)	Head fresh weight (g)	Dry matter (%)
				Nutrient sources × Electrical conductivity (EC)			
CNS	**1 ds^{-m}**	550.6 b	392.2 b	6.1 b	582.7 b	420.9 b	6.5 b
	1.5 ds^{-m}	777.2 a	560.0 a	6.0 b	824.7 a	603.3 a	6.4 b
VL	**1 ds^{-m}**	223.1 d	145.9 d	6.9 a	236.8 d	156.4 d	7.2 a
	1.5 ds^{-m}	418.4 c	260.3 c	5.5 c	445.6 c	288.3 c	5.9 c
				Nutrient sources × Substrate mixture			
CNS	**S: P**	621.0 cd	445.3 bc	6.6 b	646.5 c	470.3 cd	7.1 ab
	S: P: V 10%	690.3 b	477.5 b	6.0 cde	721.7 b	505.8 bc	6.3 cde
	S: P: V 20%	748.0 a	559.2 a	5.9 de	798.5 a	606.2 a	6.3 cde
	S: V 10%	608.0 d	424.5 c	6.1 cd	654.7 c	463.8 d	6.6 cd
	S: V 20%	652.2 bc	474.0 b	5.7 e	697.3 b	514.3 b	6.1 e
VL	**S: P**	303.5fg	182.5 f	6.1 cd	319.2 fg	194.7 g	6.6 bc
	S: P: V 10%	334.8 ef	220.2 e	5.8 de	363.8 e	242.5 f	6.2 de
	S: P: V 20%	380.8e	256.7 d	5.8 de	405.7 d	294.0 e	6.0 e
	S: V 10%	278.5 g	178.5 f	6.3 bc	288.2 g	187.0 g	6.7 bc
	S: V 20%	306.0fg	177.7 f	7.0 a	329.2 ef	193.7 g	7.4 a
				EC level × Substrate mixture			
1 ds^{-m}	**S: P**	396.8 d	274.2 e	7.1 a	416.2 de	291.2 ef	7.6 a
	S: P: V 10%	401.3 d	285.0 de	5.8 bc	421.2 d	302.8 de	6.1 bcd
	S: P: V 20%	429.3 d	316.0 d	5.7 bc	446.2 d	333.2 d	5.9 cd
	S: V 10%	351.2 e	237.0 f	6.8 a	379.0 e	259.2 f	7.2 a
	S: V 20%	355.0 e	233.0 f	7.1 a	386.3 e	256.8 f	7.6 a
1.5 ds^{-m}	**S: P**	527.7 c	353.7 c	5.6 bc	549.5 c	373.8 c	6.0 bcd
	S: P: V 10%	623.8 b	412.7 b	6.0 b	664.3 b	445.5 b	6.4 b
	S: P: V 20%	699.5 a	499.8 a	6.0 b	758.0 a	567.0 a	6.4 bc
	S: V 10%	535.3 c	366.0 c	5.6 bc	563.8 c	391.7 c	6.0 bcd
	S: V 20%	602.7 b	418.7 b	5.5 c	640.2 b	451.2 b	5.9 d

Table 4. Cont.

Treatment			First season			Second season		
			Total fresh weight (g)	Head fresh weight (g)	Dry matter (%)	Total fresh weight (g)	Head fresh weight (g)	Dry matter (%)
			Nutrient sources × Electrical conductivity (EC)×Substrate mixture					
CNS	**1 ds^{-m}**	**S: P**	578.7 e	419.0 f	7.1 b	600.0 ef	440.7 fg	7.7 b
		S: P: V 10%	560.3 ef	412.0 f	5.6 fg	578.3 f	431.3 fg	5.9 g
		S: P: V 20%	608.7 de	444.0 ef	5.6 fg	637.0 e	471.7 ef	5.9 fg
		S: V 10%	505.0 g	341.0 g	6.5 cd	552.3 f	378.3 g	7.0 cd
		S: V 20%	500.3 g	345.0 g	5.6 efg	546.0 f	382.3 g	6.1 fg
	1.5 ds^{-m}	**S: P**	663.3 cd	471.7 de	6.0 def	693.0 d	500.0 de	6.4 defg
		S: P: V 10%	820.3 b	543.0 c	6.4 d	865.0 b	580.3 c	6.8 def
		S: P: V 20%	887.3 a	674.3 a	6.2 de	960.0 a	740.7 a	6.6def
		S: V 10%	711.0 c	508.0 cd	5.7 efg	757.0 c	549.3 cd	6.1 fg
		S: V 20%	804.0 b	603.0 b	5.7 efg	848.7 b	646.3 b	6.0 fg
VL	**1 ds^{-m}**	**S: P**	215.0 j	129.3 l	7.0 bc	232.3 jk	141.7 jk	7.5 bc
		S: P: V 10%	242.3 j	158.0 kl	6.0 def	264.0 j	174.3 jk	6.4 defg
		S: P: V 20%	250.0 j	188.0 jk	5.8 efg	255.3 jk	194.7 j	5.9 g
		S: V 10%	197.3 j	133.0 l	7.1 b	205.7 k	140.0 k	7.4 bc
		S: V 20%	210.7 j	121.0 l	8.6 a	226.7 jk	131.3 k	9.0 a
	1.5 ds^{-m}	**S: P**	392.0 hi	235.7 ij	5.3 g	406.0 hi	247.7 ij	5.7 h
		S: P: V 10%	427.3 h	282.3 hi	5.6 efg	463.7 g	310.7 h	6.1 fg
		S: P: V 20%	511.7 fg	325.3 gh	5.7 efg	556.0 f	393.3 g	6.1 efg
		S: V 10%	359.7 I	224.0 j	5.5 fg	370.7 I	234.0 ij	6.0 fg
		S: V 20%	401.3 hi	234.3 ij	5.3 g	431.7 gh	256.0 i	5.7 g

Chemical nutrient solution (C.N.S), Vermi-liquid (V.L), Nutrient concentration (EC), Sand 50%+50% Pet moss (S:P), Sand 45% + Peat moss 45% + 10% Vermicompost(S:P:V10%), Sand 40% + Peat moss 40% + 20% Vermicompost (S:P:V20%), Sand 90%+10% Vermicompost (S:V10%), Sand 80% + 20% Vermicompost (S:V20%).

Similar letters indicate non-significant at 0.05 levels

* Capital letters indicate the significant difference of each factor ($P<0.05$)

* Small letters indicate the significant difference of interaction ($P<0.05$)

Table 5. Effect of nutrient solution source, EC levels and substrate mixtures on head volume and density and total chlorophyll content of lettuce plant after 8 weeks from transplanting data during 2015and 2016 seasons

Treatments	First season			Second season		
	Head volume (cm^3)	Head density (g/cm)	Chlorophyll (spad)	Head volume (cm^3)	Head density (g/cm)	Chlorophyll (spad)
			Nutrient sources			
CNS	807.1 A	0.62 B	34.6 A	825.7 A	0.64 B	36.1 A
VL	257.9 B	0.87 A	29.3 B	268.7 B	0.91 A	30.9 B
			Electrical conductivity (EC)			
1 ds^{-m}	409.5 B	0.81 A	32.3 A	420.8 B	0.83 A	34.0 A
1.5 ds^{-m}	655.6 A	0.68 B	31.6 B	673.7 A	0.72 B	32.9 B
			Substrate mixture			
S: P	476.5 C	0.77 B	34.5 A	477.4 C	0.82 B	35.8 A
S: P: V 10%	548.3 B	0.67 C	33.2 B	650.5 B	0.69 C	34.7 A
S: P: V 20%	635.0 A	0.71 BC	31.4 C	662.2 A	0.73 C	33.0 B
S: V 10%	446.3 D	0.92 A	31.2 C	463.5 D	0.95 A	32.8 B
S: V 20%	556.7 B	0.67 C	29.6 D	572.5 B	0.70 C	31.1 C

Table 5. Cont.

Treatments		First season			Second season		
		Head volume (cm^3)	Head density (g/cm)	Chlorophyll (spad)	Head volume (cm^3)	Head density (g/cm)	Chlorophyll (spad)
				Nutrient sources × Electrical conductivity (EC)			
CNS	**1 ds^{-m}**	656.7 b	0.63 c	36.1 a	672.6 b	0.65 c	37.9 a
	1.5 ds^{-m}	957.6 a	0.61 c	33.1 b	978.8 a	0.63 c	34.2 b
VL	**1 ds^{-m}**	162.4 d	0.99 a	28.5 d	168.9 d	1.01 a	30.1 d
	1.5 ds^{-m}	353.5 c	0.76 b	30.1 c	368.5 c	0.81 b	31.7 c
				Nutrient sources × Substrate mixture			
CNS	**S: P**	745.3 c	0.65 d	37.4 a	744.2 c	0.68 d	38.5 a
	S: P: V 10%	767.5 c	0.67 d	36.5 a	771.4 c	0.68 d	38.2 a
	S: P: V 20%	919.8 a	0.63 de	33.8 b	956.5 a	0.63 de	35.7 b
	S: V 10%	732.5 c	0.58 de	33.7 b	763.8 c	0.65 de	34.8 bc
	S: V 20%	870.5 b	0.55 e	31.6 c	892.8 b	0.57 e	33.2 cd
VL	**S: P**	207.7 e	0.88 b	31.5 c	210.7 ef	0.95 b	33.1 cd
	S: P: V 10%	329.2 d	0.67 d	30.0 d	349.7 d	0.70 d	31.3 d
	S: P: V 20%	350.2 d	0.78 c	28.9 e	367.9 d	0.83 c	30.4 e
	S: V 10%	160.0 f	1.25 a	28.7 e	163.2 f	1.25 a	30.8 de
	S: V 20%	242.8 e	0.78 c	27.6 f	252.1 e	0.83 c	29.0 e
				EC level × Substrate mixture			
1 ds^{-m}	**S: P**	337.0 h	0.85 b	35.2 a	334.6 g	0.92 b	36.7 a
	S: P: V 10%	555.5 de	0.58 e	33.9 b	554.5 e	0.62 d	35.9 a
	S: P: V 20%	448.8 f	0.78 bc	31.7 cd	471.8 f	0.77 c	33.4 b
	S: V 10%	298.3 h	1.10 a	31.1 d	313.9 g	1.12 a	32.8 bc
	S: V 20%	408.0 g	0.72 cde	29.8 e	429.0 f	0.75 cd	31.3 bc
1.5 ds^{-m}	**S: P**	616.0 c	0.68 de	33.8 b	620.2 c	0.72 cd	34.9 ab
	S: P: V 10%	541.2 e	0.75 cd	32.5 c	566.6 de	0.77 c	33.5 b
	S: P: V 20%	821.2 a	0.63 e	31.1 d	852.6 a	0.70 cd	32.7 bc
	S: V 10%	594.2 cd	0.73 cd	31.3 d	613.1 cd	0.78 c	32.8 bc
	S: V 20%	705.3 b	0.62 e	29.4 e	715.9 b	0.65 d	30.8 c

Table 5: Cont.

Treatment			First season			Second season		
			Head volume (cm^3)	Head density (g/cm)	Chlorophyll (spad)	Head volume (cm^3)	Head density (g/cm)	Chlorophyll (spad)
Nutrient sources × Electrical conductivity (EC) × Substrate mixture								
CNS	**1 ds^{-m}**	**S: P**	529.0 f	0.80 cd	39.4 a	526.3 fg	0.83 c	40.9 a
		S: P: V 10%	881.7 d	0.47 f	39.0 a	868.5 d	0.50 e	40.9 a
		S: P: V 20%	681.0 e	0.67 def	35.9 b	714.0 e	0.67 d	37.9 ab
		S: V 10%	510.0 f	0.67 def	34.2 c	534.6 f	0.73 cd	36.1 bc
		S: V 20%	681.7 e	0.53 f	32.2 d	719.6 e	0.53 de	33.8 cd
	1.5 ds^{-m}	**S: P**	961.7 c	0.50 f	35.4 bc	962.0 c	0.53 de	36.0 bc
		S: P: V 10%	653.3 e	0.87 bc	34.0 c	674.3 e	0.87 bc	35.4 bcd
		S: P: V 20%	1158.7 a	0.60 ef	31.7 de	1199.0 a	0.60 de	33.5 cd
		S: V 10%	955.0 c	0.50 f	33.1 cd	992.9 bc	0.57 de	33.5 cd
		S: V 20%	1059.3 b	0.57 ef	31.0 de	1066.0 b	0.60 de	32.5 d
VL	**1 ds^{-m}**	**S: P**	145.0 j	0.90 bc	31.0 de	143.0 j	1.00 b	32.5 d
		S: P: V 10%	229.3 i	0.70 de	28.9 f	240.5 i	0.73 cd	30.9 de
		S: P: V 20%	216.7 i	0.90 bv	27.4 g	229.6 I	0.87 bc	28.8 e
		S: V 10%	86.7 k	1.53 a	28.0 fg	93.1 j	1.50 a	29.4 de
		S: V 20%	134.3 jk	0.90 bc	27.5 g	138.5 j	0.97 bc	28.9 e
	1.5 ds^{-m}	**S: P**	270.3 i	0.87 bc	32.1 d	278.4 i	0.90 bc	33.7 cd
		S: P: V 10%	429.0 g	0.63 ef	31.0 de	458.8 g	0.67 d	31.7 de
		S: P: V 20%	483.7 fg	0.67 def	30.4 e	506.2 fg	0.80 cd	32.0 de
		S: V 10%	233.3i	0.97 b	29.4 ef	233.3 i	1.00 b	32.2 de
		S: V 20%	351.3 h	0.67 def	27.7 fg	365.7 h	0.70 cd	29.1 e

Chemical nutrient solution (C.N.S), Vermi-liquid (V.L), Nutrient concentration (EC), Sand 50%+50% Peat moss (S:P), Sand 45% + Peat moss 45% + 10% Vermicompost(S:P:V10%), Sand 40% + Peat moss 40% + 20% Vermicompost (S:P:V20%), Sand 90%+10% Vermicompost (S:V10%), Sand 80% + 20% Vermicompost (S:V 20%).

Similar letters indicate non-significant at 0.05 levels

* Capital letters indicate the significant difference of each factor (P<0.05)

* Small letters indicate the significant difference of interaction (P<0.05)

Regarding to the interaction among nutrient solution source, electrical conductivity and substrate mixtures, the obtained date (Tables 4 and 5) indicate that, the highest measures of plant fresh weight, head fresh weight and head volume were recorded by chemical nutrient solution at 1.5 dS m^{-1} combined with sand + peat moss + vermicompost (40:40:20% *V/V*). On the contrary, the lowest values were given by vermi-liquid at EC 1.0 dS m^{-1} combined with sand + peat moss (1:1 *V/V*). Whereas, vermi-liquid at 1.0 dS m^{-1} combined with sand + vermicompost (80: 20% *V/V*) presented the highest results of dry matter percentage and the lowest total chlorophyll content. The lowest dry matter percent was recorded by vermi-liquid at 1.5 dS m^{-1} combined with sand + peat moss (1:1 *V/V*). While the highest value of head density and the lowest head volume were estimated by vermi-liquid at 1.0 dS m^{-1} combined with sand + vermicompost (90: 10% *V/V*) and chemical nutrient solution at 1.5 dSm^{-1} combined with sand + vermicompost (90: 10% *V/V*) recorded the lowest. While chemical nutrient solution at 1.0 dS m^{-1} combined with sand + peat moss (1:1 *V/V*) had the highest results of total chlorophyll content.

Effect of Nutrient Solution Source, EC Level and Substrate Mixtures and Their Combinations on Nutrient Contents (N, P and K %) of Lettuce

The effect of different nutrient sources, electrical conductivity (EC) and substrate mixture on N, P and K content had illustrated in Table 6.

Concerning the effect of nutrient solution sources, results showed that using chemical nutrient solution as a nutrient source gave the highest results of N, P and K contents of head of lettuce, while vermi-liquid gave the lowest results.

Regarding EC level, the 1.5 dSm^{-1} had the highest significant effect of N, P and K contents comparing with 1 dS m^{-1}.

Concerning of substrate mixture effect, the results indicated that the highest N, P and K contents of lettuce head were recorded by sand + peat moss + vermicompost 40: 40: 20% (*V/V*) combining with other substrate mixture. The lowest data of N, P and K contents of head lettuce recorded by sand + vermicompost 90: 10% (*V/V*).

Referring to the interaction between nutrient solution source and electrical conductivity, fertigation of plants with chemical nutrient solution at 1.5 dS m^{-1} gave the highest results of N, P and K contents of lettuce, while the lowest value were recorded with vermi-liquid at 1 dS m^{-1}.

As for the interaction between nutrient solution source and substrate mixtures, results show that, sand + peat moss + vermicompost 40: 40: 20% (*V/V*) combined with chemical solution performed the highest values of N, P and K contents. On the contrary, substrate mixtures by sand + peat moss 50: 50% (*V/V*) followed by sand + vermicompost 90: 10% (*V/V*) combined with vermi-liquid recorded the lowest values of N and K contents while the lowest values of P content were recorded by sand + peat moss 50: 50% (*V/V*) combined with vermi-liquid.

The combination between electrical conductivity and substrate mixtures showed that sand + peat moss + vermicompost 40: 40: 20% (*V/V*) combined with 1.5 dS m^{-1} gave the highest results of N,P and K contents, while sand + peat moss 50: 50% (*V/V*), followed by sand + vermicompost 90 : 10% (*V/V*) combined with 1 dS m^{-1} gave the lowest results of N content, but the lowest values of P and K contents were recorded by sand+ peat moss 50: 50% (*V/V*) when combined with 1 dS m^{-1}.

Regarding to the interaction among nutrient solution source, electrical conductivity and substrate mixtures, data indicate that, the highest value of N content were recorded with chemical nutrient solution at 1.5 dS m^{-1} combined with sand + peat moss + vermicompost 40: 40: 20% (*V/V*), followed by sand + vermicompost 80: 20% (*V/V*) without significant differences. While the lowest value was recorded with vermi-liquid at 1 dS m^{-1} combined with sand + peat moss 50: 50% (*V/V*), followed by sand + vermicompost 90: 10% (*V/V*) without significant differences. The obtained results illustrated that the highest value of P and K contents were recorded with chemical nutrient solution at 1.5 dS m^{-1} combined with sand + peat moss + vermicompost 40: 40: 20% (*V/V*). On the contrary, the lowest values of P and K contents were recorded with vermi-liquid at 1 dS m^{-1} combined with sand + peat moss 50: 50% (*V/V*).

Table 6. Effect of nutrient solution source, EC levels and substrate mixtures on nutrients contents (N, P and k%) of lettuce head after 8 weeks from transplanting date during 2015and 2016 seasons

Treatment	First season			Second season		
	N	P	K	N	P	K
			Nutrient sources			
CNS (Control)	3.06 A	0.70 A	1.21 A	3.30 A	0.67 A	1.27 A
VL	2.59 B	0.54 B	1.10 B	2.83 B	0.52 B	1.14 B
			Electrical conductivity (EC)			
1.0 ds^{-m}	2.73 B	0.57 B	1.11 B	2.59 B	0.55 B	1.15 B
1.5 ds^{-m} (Control)	2.92 A	0.67 A	1.21 A	3.18 A	0.64 A	1.27 A
			Substrate mixture			
S: P (Control)	2.62 D	0.44 E	0.97 E	2.81 D	0.41 E	1.01 E
S: P: V 10%	2.38 C	0.71 B	1.13 C	3.04 C	0.67 B	1.20 C
S: P: V 20%	3.07 A	0.79 A	1.33 A	3.38 A	0.76 A	1.40 A
S: V 10%	2.63 D	0.55 D	1.08 D	2.84 D	0.53 D	1.11 D
S: V 20%	2.98 B	0.61 C	1.27 B	3.25 B	0.59 C	1.13 B

Table 6. Cont.

Treatment		First season			Second season		
		N	P	K	N	P	K
					(%)		
			Nutrient sources × Electrical conductivity (EC)				
CNS	**1 ds^{-m}**	2.92 b	0.65 b	1.18 b	3.16 b	0.61 b	1.24 b
	1.5 ds^{-m}	3.19 a	0.75 a	1.25 a	3.45 a	0.72 a	1.31 a
VL	**1 ds^{-m}**	2.54 d	0.50 d	1.03 c	2.74 d	0.48 d	1.06 c
	1.5 ds^{-m}	2.65 c	0.58 c	1.17 b	2.91 c	0.55 c	1.23 b
			Nutrient sources × Substrate mixture				
CNS	**S: P**	2.78 c	0.48 d	1.10 e	2.97 c	0.46 e	1.15 e
	S: P: V 10%	3.05 b	0.77 b	1.17 d	3.23 b	0.73 b	1.27 cbd
	S: P: V 20%	3.35 a	0.85 a	1.35 a	3.63 a	0.82 a	1.40 a
	S: V 10%	2.80 c	0.65 c	1.15 d	3.07 bc	0.62 d	1.18 de
	S: V 20%	3.30 a	0.75 b	1.30 b	3.62 a	0.72 bc	1.37 ab
VL	**S: P**	2.45 f	0.40 e	0.85 g	2.65 d	0.37 f	0.87 h
	S: P: V 10%	2.60 e	0.65 c	1.10 e	2.85 c	0.60 d	1.13 e
	S: P: V 20%	2.78 c	0.73 b	1.30 b	3.13 bc	0.71 c	1.40 a
	S: V 10%	2.47 f	0.45 d	1.02 f	2.62 d	0.44 e	1.03 f
	S: V 20%	2.67 d	0.47 d	1.23 c	2.88 c	0.46 e	1.28 b
			EC level × Substrate mixture				
1 ds^{-m}	**S: P**	2.57 f	0.42 f	0.95 g	2.78 d	0.38 h	1.00 f
	S: P: V 10%	2.68 e	0.65 c	1.07 e	2.87 d	0.61 c	1.13 de
	S: P: V 20%	2.95 c	0.73 b	1.28 b	3.10 c	0.71 b	1.28 bc
	S: V 10%	2.58 f	0.50 e	1.02 f	2.83 d	0.48 f	1.05 ef
	S: V 20%	2.87 d	0.57 d	1.22 c	3.17 bc	0.54 e	1.28 bc
1.5 ds^{-m}	**S: P**	2.67 e	0.47 e	1.00 f	2.83 d	0.44 g	1.02 f
	S: P: V 10%	2.97 c	0.77 b	1.20 c	3.22 bc	0.72 b	1.27 c
	S: P: V 20%	3.18 a	0.85 a	1.37 a	3.67 a	0.81 a	1.52 a
	S: V 10%	2.68 e	0.60 d	1.15 d	2.85 d	0.58 d	1.17 d
	S: V 20%	3.10 b	0.65 c	1.32 b	3.33 b	0.63 c	1.37 b

Table 6. Cont.

Treatment			First season			Second season		
			N	P	K	N	P	K
			Nutrient sources × Electrical conductivity (EC)× Substrate mixture					
CNS	**1 ds^{-m}**	**S: P**	2.73 e	0.43 f	1.10 e	2.90 de	0.40 gh	1.13 de
		S: P: V 10%	2.83 d	0.70 c	1.13 e	2.97 de	0.68 c	1.23 d
		S: P: V 20%	3.17 c	0.80 b	1.30 bc	3.37 c	0.77 b	1.33 cd
		S: V 10%	2.77 de	0.60 d	1.10 e	3.07 d	0.55 d	1.17 d
		S: V 20%	3.10 c	0.70 c	1.27 c	3.50 bc	0.66 c	1.33 cd
	1.5 ds^{-m}	**S: P**	2.83 d	0.53 e	1.10 e	3.03 d	0.51 e	1.17 d
		S: P: V 10%	3.27 b	0.83 b	1.20 d	3.50 bc	0.78 b	1.30 cd
		S: P: V 20%	3.53 a	0.90 a	1.40 a	3.90 a	0.87 a	1.47 ab
		S: V 10%	2.83 d	0.70 c	1.20 d	3.07 d	0.68 c	1.20 d
		S: V 20%	3.50 a	0.80 b	1.33 b	3.73 ab	0.77 b	1.40 bc
VL	**1 ds^{-m}**	**S: P**	2.40 h	0.40 f	0.80 h	2.67 e	0.36 i	0.87 f
		S: P: V 10%	2.53 g	0.60 d	1.00 f	2.77 e	0.55 d	1.03 e
		S: P: V 20%	2.73 e	0.67 c	1.27 c	2.83 de	0.66 c	1.23 d
		S: V 10%	2.40 h	0.40 f	0.93 g	2.60 e	0.41 g	0.93 ef
		S: V 20%	2.63 f	0.43 f	1.17 de	2.83 de	0.42 g	1.23 d
	1.5 ds^{-m}	**S: P**	2.50 g	0.40 f	0.90 g	2.63 e	0.38 hi	0.87 f
		S: P: V 10%	2.67 ef	0.70 c	1.20 d	2.93 de	0.66 c	1.23 d
		S: P: V 20%	2.83 d	0.80 b	1.33 b	3.43 c	0.76 b	1.57 a
		S: V 10%	2.53 g	0.50 e	1.10 e	2.63 e	0.48 f	1.13 de
		S: V 20%	2.70 ef	0.50 e	1.30 bc	2.93 de	0.50 ef	1.33 cd

Chemical nutrient solution (C.N.S), Vermi-liquid (V.L), Nutrient concentration (EC), Sand: Peat moss (S:P), Sand 45% + Peat moss 45% + 10% Vermicompost (S:P:V10%), Sand 40%+Peat moss 40%+20% Vermicompost (S:P:V 20%), Sand 90%+10% Vermicompost (S:V10%) ,Sand 80%+20% Vermicompost (S:V20%).

Similar letters indicate non-significant at 0.05 levels

* Capital letters indicate the significant difference of each factor ($P<0.05$)

* Small letters indicate the significant difference of interaction ($P<0.05$)

DISCUSSION

Micro and small scale farm could be sustained under urban conditions by using integrated system combined between vermicomposting technology and soilless culture *via* rooftop garden systems. The targets of sustainable urban production extend logically to match the food security demands, fight hungry and meet the strategies of mitigation and adaptation of climate change impacts. Otherwise, minimize the use of peat moss and chemical fertilizers had a great potential on the environmental scale.

Vermicompost had a positive impact as a substrate amendment led to increase the lettuce yield and improve the physical and chemical properties of the substrate and supporting the plants by essential nutrients. Chemical nutrient solution in general gave the higher lettuce yield compared to vermi-liquid. Vermi-liquid didn't match the lettuce nutrient requirements as a nutrient solution and there is a need to improve its composition. The lack of lettuce yield regarding to the use of vermi-liquid could be accepted under the sustainable and food safety needs. The use of sand as a local, available, good physical and chemical properties and unexpansive substrate to reduce the cost and conserve the sustainable production under climate change impacts.

In this respect Al-Redhaiman *et al*. (2005) stated that there were significant influences for different nutrient sources " inorganic source and chicken manure and rabbit manure as a natural organic source" on growth of lettuce plants under hydroponic condition. They noticed that the highest fresh and dry weight of lettuce head was observed with inorganic fertilizer solution, while the lowest values were recorded with chicken manure extract. Abou-El-Hassan *et al*. (2008) and AboSedera *et al.*, (2015) reported that, vegetative growth of vegetable plants was significantly improved with inorganic nutrient solution compared to the other organic different nutrient solution. Huett (1994) investigated the effect of nutrient solution concentrations between 0.4 and 3.6 dSm^{-1} on yield of head lettuce. He reported that the highest yield of head lettuce was obtained from 1.6 dSm^{-1} concentration. Sanguandeekul (1999) investigated the influence of nutrient solution concentration (EC) ranged from 0.5 dSm^{-1} to 3.5 dSm^{-1} and growing season on plant nutrient uptake, growth, yield and market quality of three lettuce cultivars. The results from these studies revealed that yield will be satisfactory with increases in nutrient solution concentration to 1.5 dSm^{-1}

These results agreed with those of Hashemimajd *et al.* (2004), Arancon *et al.* (2003) and Arancon *et al.* (2004b) since, they reported that, vermicompost has considerable potential in horticultural potting substrates in low rate mixture (10 – 30%) of the substrate. Most of these studies confirmed that vermicompost have beneficial effects on plant growth (Chan and Griffiths, 1988; Edwards and Burrows, 1988; Wilson and Carlile, 1989; Buckerfield and Webster, 1998). Vermicompost has considerable potential for substituting peat in horticultural potting substrates. Vermicompost contained large amounts of humic substances which release nutrients relatively slow in the soil that improve its physical and biological properties of soil and in turn rise to much better plant quality (Muscolo *et al.*, 1999; Abul-Soud *et al.*, 2014 and 2015 a and b) reported that the use of vermicompost as a substrate amendments had a significant encouragement impacts on the growth and yield of sweet pepper, snap bean, lettuce and strawberry. The vermicompost contained an essential nutrient for supporting the plant nutrient requirements beside the high organic matter and assist in improve the physical and chemical properties of substrates. These results also agreed with different studies focusing on vermicompost application such as, Arancon *et al.* (2002) on tomato and peas, Arancon *et al* (2004b) on strawberry. Bachman and Metzger (2008) reported that addition of vermicompost in media mixes of 10% VC and 20% VC had positive effects on plant growth of marigold, tomato, green pepper, and cornflower. A consistent trend obtained also indicated that the best plant growth responses, with all needed nutrients supplied, occurred when vermicompost constituted a relatively small proportion (10% to 20%) of the total volume of the container medium mixture, with greater proportions of vermicompost in the plant growth medium not always improving plant growth (Subler *et al* 1998; AboSedera *et al.*, 2015; Abul-Soud, 2015).

Conclusion

The use of vermicomposting outputs (vermicompost and vermi-liquid) in small scale farm in urban and rural areas with simple substrate culture by using minor available area (building roof) could contribute in satisfying the food security and safety beside creating an efficient strategy to mitigate and adapt climate change impacts in urban and rural regions.

This study recommended the use of chemical nutrient solution + Ec level 1.5 dS m^{-1} + substrate sand: peat moss: vermicompost (40: 40: 20% (*V/V*) for producing the highest safety yield of lettuce under the investigation conditions. Enhancing the vermi-liquid composition or modifying it by chemical fertilizers to increase its efficiency as nutrient solution to match the lettuce nutrients requirements needs more research. Small or micro scale urban farm should be integrated in mitigation and adaptation climate change strategy in urban area. Ecology food could be sustained under urban condition.

Acknowledgements

The authors acknowledge the materials support (vermicompost, vermi-liquid and rooftop system) provided by "Integrated environmental management of urban organic wastes using vermicomposting and green roof (VCGR) project" No. 1145, funded by Science and Technology Development Fund, Egypt.

Competing Interests

Authors have declared that no competing interests exist.

REFERENCES

AboSedera, F.A., N.S. Shafshak, A.S. Shams, M.A. Abul-Soud and M.H. Mohammed (2015). The utilize of vermicomposting outputs in substrate culture for producing snap bean. Ann. Agric. Sci., Moshtohor, 53 (2): 139-151.

Abou-El-Hassan, S., U.A. El-Behairy, S.M. Selim and A.F. Abou-Hadid (2008). Effect of compost tea as organic nutrient solution for cantaloupe production grown in nutrient film technique. Egypt. J. Hort., 35: 41-58.

Abul-Soud, M., M.K. Hassanein, S.M. Ablmaaty, M. Medany and A.A.F. Hadid (2009). Vermiculture and vermicomposting technologies use in sustainable agriculture in Egypt, Egypt. J. Agric. Res., 87 (1): 389-403.

Abul-Soud, M.A. (2015). Achieve food security of some leafy vegetables in urban (How to create resilience cities?). Global J. Adv. Res., 2 (10):1705 – 1722.

Abul-Soud, M.A. and A.G.A. Mancy (2015). Urban horticulture of molokhia and spinach environmentally via green roof system and vermicomposting outputs. Global J. Adv. Res., 2 (12):1832 – 1847.

Abul-Soud, M.A., M.S.A. Emam and N.G. Abd El-Rahman (2015a). The potential use of vermicompost in soilless culture for producing strawberry. Int. J. Pl. and Soil Sci., 8 (5): 1 – 15.

Abul-Soud, M.A., M.S.A. Emam, A.M.H. Hawash, M.H. Mohammed and Z.Y. Maharik (2015b). The utilize of vermicomposting outputs in ecology soilless culture of lettuce. J. Agric. and Ecol. Res., 5 (1): 1-15.

Abul-Soud, M.A., M.S.A. Emam, M.A.A. Abdrabbo and F.A. Hashem (2014). sustainable urban Horticulture of sweet pepper via vermicomposting in Summer Season. J. Adv. Agric., 3 (1): 110-122.

Allen, S.E. (1974). Chemical Analysis of Ecological Materials. Black-Well, Oxford, 565.

Al-Redhaiman, K.N., M.Z. El-Shinawy and E.M. Abed El-Moniem (2005). Influence of different nutrient sources on the chemical content and yield of lettuce under hydroponic conditions. Egypt. J. Appl. Sci., 20 (1): 255-266.

Arancon, N.Q., C.E. Edwards, E. Yardim, S. Lee (2002). Management of plant parasitic nematodes by applications of vermicomposts. The Brighton Crop Prot. Conf., Pest and Dis., 2002. Brighton, London. 8 (2): 705–716.

Arancon, N.Q., C.E. Edwards, P. Bierman, C. Welch and J.D. Metzger (2004b). Influences of vermicomposts on field strawberries: 1.

effects on growth and yields. Bioresource Technol., 93: 145-153.

Arancon, N.Q., C.E. Edwards, R.M. Atiyeh and J.D. Metzger (2004a). Effects of vermicompost produced from food waste on the growth and yields of greenhouse peppers. Bioresource Technol., 93: 139-144.

Arancon, N.Q., P. Galvis, C.A. Edwards and E. Yardim. (2003). The trophic diversity of nematode communities in soils treated with vermicompost. Pedobiología, 47: 736-740.

Atiyeh, R.M., S. Lee., C.A. Edwards, N.Q. Arancon and J.D. Metzger (2002). The influence of humic acids derived from earthworms-processed organic wastes on plant growth. Bioresour. Technol., 84: 7–14

Atiyeh, R.M., S. Subler, C.A. Edwards, G. Bachman, J.D. Metzger and W. Shuster (2000).Eects of vermicomposts and composts on plant growth in horticultural container media and soil. Pedobiologia., 44: 579-590.

Bachman, G.R. and J.D. Metzger (2008). Growth of bedding plants in commercial potting substrate amended with vermicompost. Biores. Tech., 99: 3155-3161.

Box, G.E.P., W.G. Hunter and J.S. Hunter (1978). Statistics for Experimenters: an Introduction to Design, Data Analysis, and Model Building. John Wiley and Sons. New York.

Buckerfield, J.C. and K.A. Webster (1998). Worm-worked waste boosts grape yields: prospects for vermicompost use in vineyards. The Australian and New Zealand Wine Industry J., 13: 73-76.

Chan, P.L.S. and D.A. Griffiths. (1988). The vermicomposting of pre-treated pig manure. Biological Wastes, 24: 57-69.

Chapman, H.D. and P.F. Pratt (1961). Methods of analysis for soil, plant, and water. Univ. Calif., Div. Agric. Sci.

Cooper, A.J. (1979). The ABC of NFT. Grower Books, London.

Edwards, C.A. and I. Burrows (1988). The potential of earthworm compost as plant growth media. In: Edwards, C.A. and E. Neuhauser (eds) Earthworms in Waste and Environmental Management. SPB Academic press, The Hague, The Netherlands, 21-32.

El Behairy, U.A. (1994). The effect of levels of phosphorus and zinc in the nutrient solution on macro and micronutrients uptake and translocation in cucumber (*Cucumus sativus* L.) grown by nutrient film technique. Ph.D. Thesis, London Univ., 299.

FAO (1980). Soil and Plant Analysis. Soils Bulletin, 38: 242-250.

Gruda, N. (2009). Do soilless culture systems have an influence on product quality of vegetables. J. Appl. Bot. and Food Qual., 82: 141 – 147.

Gruda, N., M. Prasad and M.J. Maher (2005). Soilless culture. In: Lal, R. (ed.), Encyclopedia of Soil Science. Taylor and Francis (Marcel Dekker), Inc., New York.

Gutiérrez-Miceli, F.A., M.A. Oliva-Llaven, P.M. Nazar, B.J.D. Ruiz-Sesma, Alvarez-Solís and L. Dendooven (2011). Optimization of Vermicompost and Worm-Bed Leachate for the Organic Cultivation of Radish. J. Pl. Nut., 34 (11): 1642-1653

Hashemimajd, K., M. Kalbasi, A. Golchin and H. Shariatmadari (2004). Comparison of vermicompost and composts as potting media for growth of tomatoes. J. Pl. Nut., 27: 1107-1123.

Huett, D.O. (1994). Growth, nutrient uptake and Tipburn severity of hydroponic lettuce in response to electrical conductivity and K: Ca ration in solution. Aust. J. Agric. Res., 45: 252-267

Inbar, Y., Y Chen and Y. Hadar. (1993). Recycling of cattle manure: The composting process and characterization of maturity. J. Environ. Qual., 22: 875-863.

Kamergam, N., K. Alagumalai and T. Daniel (1999). Effect of vermicompost on the growth and yield of green gram (*Phaseolus aurus* Roxb.). Trop. Agric., 76: 143–146.

Klock-Moore, K.A. (2000). Comparison of Salvia growth in seaweed compost and biosolid compost. Compost Sci. Utiliz., 6: 24-28.

Muscolo, A., F. Bovalo, F. Gionfriddo and F. Nardi (1999). Earthworm humic matter produces auxin-like effects on Daucus carota cell growth and nitrate metabolism. Soil Biol. Biochem., 31:1303-1311.

Pant, A.P., T.J. Radovich, N.V.K. Hue, S.T. Talcott and K.A. Krenek (2009). Vermicompost extracts influence growth, mineral nutrients, phytonutrients and antioxidant activity in pak choi (*Brassicarapa cv.* Bonsai, Chinensis group) grown under vermicompost and chemical fertilizer. J. Sci. Food and Agric., 89 (14): 2383-2392.

Quaik, S., A. Embrandiri, P.F. Rupani, R.P. Singh and M.H. Ibrahim (2012). Effect of Vermiwash and Vermicomposting Leachate in Hydroponics Culture of Indian Borage (*Plectranthus ambionicus*) Plantlets. UMT 11th Int. Ann. Symposium on Sustainability Sci. and Manag., 210-214.

Raul, I.C. (1996). Measuring physical properties. Rutgers Cooperative Extension. New Jersey Agric. Exp. Station. New Jersey Univ.

Sanguandeekul, S. (1999). The effect of cultivar, nutrient solution concentration and season on the yield and quality of NFT produced lettuce (*Lactuca sativa* L.): a thesis presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Plant Science at Massey Univ., 1-254.

Snedicor, G.W. and W.G. Cochran (1981). Statistical methods. 7th Iowa State Univ. Press, Iowa, USA, 225-320 .

Subler, S., C.A. Edwards and J.D. Metzger (1998). Comparing composts and vermicomposts. Biocycle., 39: 63–66.

Tognetti, C., F. Laos., M. J. Mazzarino and M. T. Hernandez (2005). Composting vs. vermicomposting: A comparison of end product quality. Comp. Sci. and Utiliz., 13: 6-13.

Watanabe, F.S. and S.R. Olsen (1965). Test of an ascorbic acid method for determining phosphorus in water and $NaHCO_3$ extracts from soils. Soil Sci. Soc. Am. Proc., 29: 677-678.

Wilson, D.P. and W.R. Carlile (1989). Plant growth in potting media containing worm-worked duck waste. Acta. Hort., 238 : 205-220.

Wilson, G.C.S. (1983). The physic- chemical and physical properties of horticultural substrate. Acta. Hort. No., 150: 19-32

Yadava, U.L. (1986). Arpid and non-destructure method to determine chlorophyll in intact leaves. Hort. Sci., 21: 1449-1450.

كيفية الاستدامة البيئية لإنتاج الغذاء تحت ظروف الحضـــــر

محمد أبو السعود - محمد سعد على إمام - زكريا يحى محاريق
محمد حسن محمد - أحمد محمود حواش

المعمل المركزى للمناخ الزراعى - مركز البحوث الزراعية - الجيزة - مصر

فى ظل التأثير السلبى للتغيرات المناخية وخاصة ظاهرة الأحتباس الحرارى وسوء استخدام المخلفات العضوية كان يجب الأتجاة الى تطبيق استراتيجية الزراعة المستدامة فى المناطق الحضرية و ذلك باستخدام نظم الزراعة بدون تربة وناتج كمر المخلفات العضوية باستخدام دود الأرض فى إنتاج محاصيل الخضر فوق الأسطح، تم أجراء الدراسة خلال موسمى الشتاء المتعاقبين ٢٠١٤ - ٢٠١٥ في ظل الظروف الحضرية بالمعمل المركزى للمناخ الزراعى، الجيزة، مصر لدراسة إمكانية استخدام مكمورة دودة الأرض كمحسن للبيئات المستخدمة فى الزراعة وذلك من خلال إضافة مكمورة دود الأرض بنسب مختلفة (١٠ و ٢٠%) مع بيئة الرمل: البيتموس (١: ١ حجما) وبيئة الرمل منفردا وكذلك تأثير استخدام المحلول المغذي الكيماوى وسائل دود الأرض كمصدرين لتغذية النباتات بتركيز ١ و ١.٥ ملليموز والتفاعل بينهما على محصول الخس تحت ظروف المناطق الحضرية، وتم استخدام صنف روبنسون هجين أول فى الزراعة، وقد أظهرت النتائج أن استخدام مكمورة دودة الارض كمحسن لبيئات الزراعية المستخدمة كان له تأثير كبير على محصول الخس وذلك من خلال تحسين الخصائص الفيزيقية والكيميائية لبيئة الزراعة/ وقد أظهرت النتائج أن استخدام المحلول المغذي الكيماوى بتركيز ١.٥ ملليموز+ بيئة الرمل: البيت موس: مكمورة دود الأرض (٤٠ : ٤٠ : ٢٠%) (حجمية/حجمية) أدى إلى الحصول على أعلى محصول من الخس تحت ظروف الدراسة، بينما من الجانب البيئى والصحى تحت ظروف الزراعة فوق الأسطح فى مناطق الحضر يوصى باستخدام سائل مكمورة دود الأرض بتركيز ١.٥ ملليموز مع بيئة الزراعة الرمل: البيت موس: مكمورة دود الأرض بنسبة (٤٠ : ٤٠ : ٢٠%) (حجمية/حجمية).

المحكمـــون:
١- أ.د. محمـــــد الســـــعيد زكـــــــي أستاذ الخضر المتفرغ – كلية الزراعة بمشتهر– جامعة بنها.
٢- أ.د. المتولي عبدالسميع الغمريني أستاذ الخضر المتفرغ – كلية الزراعة – جامعة الزقازيق.