



Effect of Some Organic Amendments on Lettuce Production under Urban Conditions

M.S.A. Emam, A. M. H. Hawash and Abul-Soud M. A.

Central Laboratory for Agricultural Climate, Agricultural Research Centre, Giza, Egypt.

Received: 20 Jan. 2022

Accepted: 25 Feb. 2022

Published: 01 Mar. 2022

ABSTRACT

Promoting the urban and rural horticulture and top roof garden through reduce the cost of used substrate on the environmental and economic scales to present sustainable horticulture production via applied azolla and vermicompost to the substrate mixtures in pot system. The study conducted out during two successive winter seasons (2019 and 2020) under urban conditions at Central Laboratory for Agricultural Climate (CLAC), Giza, Egypt. The effect of vermicompost and azolla (fresh and dry) as a substrate amendment in different proportions (10 and 20 % v/v) with peat moss: perlite (1:1 v/v) on substrate properties and lettuce yield were investigated. Iceberg lettuce type cv. Robinson F1 hybrid was cultivated in complete randomized blocks design with three replicates. The physical and chemical properties of different substrate mixtures beside vegetative and yield parameters were measured. The obtained results indicated that the top-roof garden application had a positive impact on heat urban island by decreasing the ambient maximum temperature by an average range 2 – 4.5 °C beside the strong contribution in food security and production. Azolla culture and vermicomposting conserved the organic carbon and essential nutrients beside their application as a substrate amendment that presented a significant effect on lettuce yield through enhancing the physical and chemical properties of substrate and support plant nutrition. The implement of vermicompost by different ratio 10 and 20 % led to increase the bulk density, water hold capacity and EC of substrate while increasing the total pore space and air porosity were bone by dry azolla application to substrate. The vegetative growth and yield of lettuce plants improved significantly by dry azolla and vermicompost application as a substrate amendments. The treatment of substrate mixed 20 % vermicompost (v/v) followed by 20 % dry azolla (v/v) recorded the highest vegetative characteristics and yield of lettuce while the lowest gave by standard substrate peat moss: perlite (1:1 v/v). The study is highly recommended sequestrate CO₂ through growing azolla and recycling urban organic wastes via vermicomposting for mitigating greenhouse gases (GHG's) emission and save natural resources as well as achieving sustainable food production through simple substrate culture in top roof garden technique.

Keywords: Azolla, Mitigation, Roof garden, substrate culture, and vermicomposting

1. Introduction

Azolla in symbiosis with cyanobacterium (*Anabaena azollae*) can fix 2-4 kg N ha/day, releasing nutrients and growth-promoting compounds such as gibberellins, cytokinins, auxins, abscisic acid, vitamins, antibiotics, and amino acids into the soil in a readily accessible form for plants (Wagner, (1997); EL-Zeky *et al.*, (2005); EL Shimi *et al.*, (2015); Hanafy and El-Emery, (2018) and Renu Kumari *et al.*, (2018). Bindhu, (2013) stated that Proteins, vital amino acids, vitamins (vitamin A, vitamin B12, Beta Carotene), growth promoter intermediaries, and minerals such as calcium, phosphorus, potassium, ferrous, copper, magnesium, and others are abundant in Azolla. It has a protein concentration of 25-30%, a mineral content of 10-15%, and a combination of amino acids, bioactive compounds, and biopolymers of 7-10%. However, the carbohydrate and lipid content is extremely minimal. As a result, the Azolla serves as a cost-effective and efficient feed substitute for cattle. Its high protein and low lignin content make it easy for livestock to digest. Azolla can serve as good nitrogen supplement to plants (Choudhury *et al.*, 2004). Cyanobacteria inside the azolla can release nutrient into soil in an easily

Corresponding Author: M.S.A. Emam, Central Laboratory for Agricultural Climate, Agricultural Research Centre, Giza, Egypt.

available form to plants (Wagner, 1997). On death and decay Azolla releases nutrients as fresh matter in water (Marwaha *et al.*, 1992). Domínguez, (2004) Said that, the interactions of earthworms and microbes during the preparing of vermicompost from sustainable agriculture organic matter produce a nutrient-dense, microbiologically active organic amendment. It's a finely divided, stabilised peat-like substance with a low C:N ratio, high porosity, and high water-holding capacity, with most nutrients in easily absorbable forms. Abul-Soud *et al.* (2014) revealed that Because of its improved physical qualities, increased microbial and enzymatic activity, and higher amount of accessible nutrients, vermicompost could be utilised as a natural fertilizer with a variety of advantages over chemical fertilisers. Producers accept vermicompost in quantities greater than compost. It's also possible that the growth responses observed are due to hormone-like activity associated with the high levels of humic acids and humates in vermicomposts: there's a good chance that transient plant growth regulators may become adsorbed on humates and act in concert with them to influence plant growth. Some vegetable crops, such as tomatoes, benefit from the addition of vermicompost Atiyeh *et al.*, (2002); Gutiérrez-Miceli *et al.*, (2007); spinach Peyvast *et al.*, (2008); strawberries Singh *et al.*, (2008); and lettuce CoriaCayupán *et al.*, (2009) and Chinese cabbage Wang *et al.*, (2010).

Soilless culture technology could be employed in urban horticulture through a variety of effective techniques, including substrate culture for green roof systems in Egypt (Abul-Soud *et al.*, 2014). (Soilless culture systems (SCSs), the most intensive production method, are based on environmentally benign technology, according to Gruda (2009), and can result in higher yields, especially in places with bad growth circumstances (shortage of available agricultural soil and water). The quality of horticultural products can be improved further by adapting cultural management to the specific cultural system as well as crop demand. As a result, many innovative organic growing media based on renewable basic materials have been tested and are still being tested. Nowadays, the use of SCSs, the materials utilised for SCSs, and the growing media are all changing (Gruda *et al.*, 2005). The substrates' physical, chemical, and biological qualities must be compatible with water and fertilizer availability, climate conditions, and plant requirements.

The study aimed to promote the resilience city principle and small scale urban farm in food security strategy by reduce the cost of used substrate in urban culture while mitigate GHG's and recycle the urban organic wastes through determine the effects of different vermicompost and azolla (fresh and dry) rates mixed with peat moss: perlite, on yield of lettuce grown in pots substrate culture during winter seasons.

2. Materials and Methods

The experiment was conducted in Central Laboratory for Agriculture Climate (CLAC), Dokki, Giza Governorate. Agriculture Research Centre, Ministry of Agriculture and land reclamation, Egypt, during two winter season of 2019 and 2020. This experiment aimed to investigate the environmentally impacts of using azolla and vermicompost as a substrate amendments in substrate pot system under urban condition on yield of lettuce plants.

2.1 Plant material

Lettuce (Iceberg type) Robinson F1 hybrid seeds were sown on the middle of October of 2019 and 2020 in foam trays containing peat moss: vermiculite (1:1 v/v). After three weeks from sowing, lettuce seedlings were transplanted (one seedling per pot) into plastic pots (8 L) filled with different substrate mixtures.

2.2 The Vermicomposting process

The vermicomposting process were done by using Epigieic earthworms *Lumbriscus rubellus* (Red Worm), *Eisenia fetida* (Tiger Worm), *Perionyx excavatus* (Indian Blue) and *Eudrilus eugeniae* (African Night Crawler) were used to convert urban organic wastes (vegetable and fruit wastes + shredded paper) into vermicompost under the study in indoor vermicomposting system according to Abul-Soud *et al.* (2009, 2014 and 2015). The physical and chemical properties of output vermicompost were indicated in Table (2).

Table 1: The chemical composition (%) of the different agricultural wastes.

Raw material	C/N ratio	Macro elements %				
		N	P	K	Ca	Mg
The urban waste	1 : 48	0.56	0.41	0.45	0.32	0.24

Table 2: Physical and chemical properties of vermicompost.

Analysis	Units	Measure	Analysis	UNITS	Measure
B.D	Kg/m ³	715	Fe	ppm	756
O. M	%	48.5	Mn	ppm	152
C/N ratio		1 : 11	Zn	ppm	73
pH		7.46	Cu	ppm	11
EC	dS/m	8.34	Pb	ppm	n.d
N	%	1.34	Cd	ppm	n.d.
P	%	0.89			
K	%	0.94			

Bulk density (B.D) Organic matter (O.M)

2.3 Azolla material

A simple urban azolla production system matched with urban roof conditions was constructed by using wooden frame (1x 2 x 0.25 m) to support black polyethylene sheet (1mm) that constructed as a plastic pool were established to performed reservoir deep water culture system to hold a sufficient amount of water for growing azolla. The basin filled by water till 20 cm to performed real cultivation water volume 0.4 m³. Azolla was fertilized by using vermicompost by the rate of 1 Kg each 10 days to conserve the high growth of azolla. Azolla was harvested partly weekly to keep the good performance of azolla production and to avoid the problem of extreme density. The harvested azolla was dried in open air for 3 to 7 days regarding to the air temperature. The azolla pool was aerated manually daily to guarantee sufficient dissolved oxygen of azolla water for good growth. During the cold days the deep water culture system of azolla was covered by transparent polyethylene sheet (180 micron) to protect azolla and offer suitable temperature for azolla growth while during the warm days the system cover by net to protect azolla from birds and extreme temperature. The physical and chemical properties of azolla were presented in Table (3). The fresh azolla remains after harvesting was collected for solar drying to implement in the current investigation after rubbing handily.

Table 3: Physical and chemical properties of azolla.

Analysis	Units	Measure	Analysis	Units	Measure
B.D	Kg/m ³	47	Fe	ppm	533.12
O. M	%	75.73	Mn	ppm	348.17
C/N ratio		1 : 12.9	Zn	ppm	30.02
pH		7.96	Cu	ppm	26.29
EC	dS/m	5.56	Pb	ppm	n.d
N	%	3.38	Cd	ppm	n.d.
P	ppm	0.96			
K	ppm	1.20			

Bulk density (B.D) Organic matter (O.M)

The physical and chemical properties of vermicompost and azolla were estimated by soil, water and environmental research institute, Agriculture Research Center (ARC), Giza, Egypt.

2.4 Substrate system materials

Plastic pots (8 L) were arranged in four rows to create plant density of lettuce 16 plants per m². Alimantal tables (1 x 2 m) were used to presented micro scale urban farm. Standard substrate peat moss:

perlite (1: 1 v/v) was mixed with the vermicompost and azolla in different proportions and then the pots were filled with different substrate mixtures.

Nutrient solutions pumped via submersible pump (40 watt). Water tanks of 120 L were used in open system of substrate pots culture to avoid the effect of leached water of vermicompost and azolla substrate mixtures on the nutrient solution composition. The nutrient solution used in the experiment was adapted from Cooper (1979). Plants were irrigated by using drippers of 4 L/hr capacity. The fertigation was programmed to work 4 times / day and the duration of irrigation time depended upon the season. The EC of the nutrient solutions was adjusted by using EC meter. The chemical compositions of nutrient solution was illustrated in Table (4).

Table 4: Chemical composition of used nutrient solutions.

Nutrient types	Macro nutrients ppm						Micro nutrients ppm					
	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B	Pb	Cd
Chemical nutrient solution	200	45	300	180	50	3.0	1.00	0.06	0.10	0.25	0.16	0.01

2.5 Treatments

This experiment investigated the effect of mixing azolla (fresh and dry) and vermicompost in different proportions with substrate as substrate amendments through introduced 7 treatments as follow:

- 1- Pet moss 50% + Perlite 50% (P:P)
- 2- Pet moss 45% + Perlite 45% + Vermicompost 10% (PP: Verm.10)
- 3- Pet moss 40% + Perlite 40% + Vermicompost 20% (PP: Verm.20)
- 4- Pet moss 45% + Perlite 45% + Fresh Azolla 10 % (PP : F.Azo 10)
- 5- Pet moss 40% + Perlite 40% + Fresh Azolla 20 % (PP : F.Azo 20)
- 6- Pet moss 45% + Perlite 45% + Dry Azolla 10 % (PP : D.Azo 10)
- 7- Pet moss 40% + Perlite 40% + Dry Azolla 20 % (PP : D.Azo 20)

The experimental design was a complete randomized block design with three replicates. Each replicate consisted of 56 plants.

2.5 Measurements

2.5.1 The physical and chemical properties of substrate

Substrate physical properties i.e. bulk density (B.D), total pore space (T.P.S), water hold capacity % (W.H.C) and air porosity % (A.P) were estimated according to Wilson (1983) and Raul (1996).

The bulk density (*B.D*) was simply measured as dry weight/volume (g/cm^3 or kg/l)

Total pore space (T.P.S) was percentage pore space and the proportion and amount of water and air that was present in pore space.

$$\text{Total pore space} = (1 - \text{bulk density} / \text{true density}) \times 100 \dots \dots \dots (1)$$

Water hold capacity % (W.H.C) is the amount of water present after the substrate in a container has been saturated and allowed to drain.

$$\text{Water hold capacity \%} = ((\text{FW} - \text{DW}) / \text{VB}) \times 100 \dots \dots \dots (2)$$

FW (fresh weight) = weight of substrate after stop draining

DW (dry weight) = dry weight of substrate after 24 hours at a temperature 80 – 90 °C.

Air porosity % (A.P) was the proportion of the volume of substrate (*VB*) that contains air after it has been saturated with water and allowed to drain. Collect the volume of water leached plus the volume of air present after the substrate in a container allowed to drain.

$$\text{Air porosity \%} = \text{T.P.S} - \text{W.H.C} \dots \dots \dots (3)$$

The pH of the substrate mixtures was evaluated using a 1:10 (w:v) double distilled water suspension of each potting mixture that had been mechanically agitated for 2 h and filtered through Whatman no.1 filter paper (Inbar *et al.*, 1993). With a conductance metre standardized with 0.01 and 0.1M KCl, the electrical conductivity of the same solution was measured.

2.5.2 The vegetative and yield characteristics of lettuce

Three samples of each experimental plot after 8 weeks from the transplanting date were selected to measure growth and yield parameters of lettuce (Plant fresh weight (g), head fresh weight (g) (After removing the outer leaves), head volume (cm³), Density (g/cm³) were measured while dry matter percentage were determined after oven-drying the samples of the head lettuce at 70 °C for 48 hours

Mineral analysis (N, P and K), three plants samples of each plot were dried at 70° C in an air forced oven for 48 h and dried plants were digested in H₂SO₄ 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).

2.5.3 The environmental assessment

The calculations of sequestrate CO₂ and the nutrients save via vermicompost and azolla were calculated as follow:

$$\text{Sequestrate CO}_2/\text{ton} = C \% (\text{raw material}) \times 10 \dots\dots\dots(4)$$

$$\text{Nutrient save Kg / ton} = \text{Nutrient \% (after composting)} \times 10 \dots\dots\dots(5)$$

2.6 The statistical analysis

The data was analyzed on a computer using the SAS statistical analysis tool. According to Snedecor and Cochran (1981), variations in means for all attributes were assessed for significance at the 5% level.

3. Results and Discussion

3.1 The environmental impact assessment

3.1.1 The impact of urban agriculture on urban ambient temperature

Clear impact was observed by urban agriculture on urban ambient temperature as Fig. (1) Illustrated. During average maximum temperature of both seasons, urban agriculture contributed strongly in decreasing the air temperature under the cultivation tables by values ranged from 2 to 4.5 °C. On the other hand, the effect of urban agriculture had a slight impact on the minimum air temperature, the urban agriculture table decreased the minimum air temperature by 0.2 to 1.5 °C. The revealed results indicated that the urban agriculture impact on decreasing ambient air temperature increased by increase the air temperature and the opposite is true.

The top-roof garden as an urban agriculture is not just contribute directly in food security and create resilience city Abul-Soud (2015), but also had a positive impact on urban heat island phenome and public health. The impact of decreasing the temperature of urban roof buildings led to decrease the energy use for cooling during the hot days by offering green isolation and direct shading for building roofs as well as decrease the energy of heating during the cold days while protect the roofs from extreme weather events. Regarding to the 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).

The study neglected the direct and indirect impacts of urban cultivation on rooftop through enhancing water, soil and energy use efficiency, reducing the heat urban island, sequestrate air CO₂ via vermicomposting, azolla culture and the cultivation vegetable crops, enhance the nutritional values of fresh vegetables, generate O₂ in addition to reduce, recycle and reuse the urban wastes and etc....

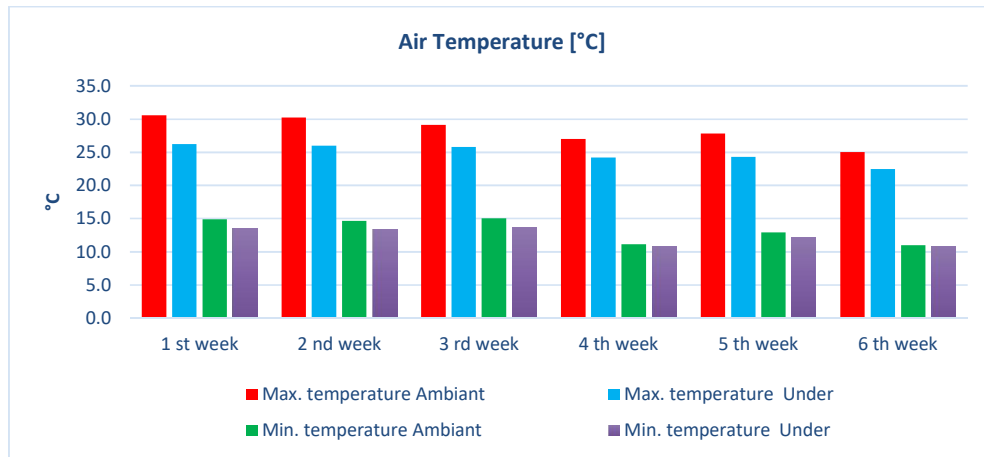


Fig. 1: The impact of top-roof garden system on air temperature.

3.1.2. The environmental impact assessment of vermicompost and azolla

Climate change impacts, extreme weather events, food security were threatened strongly the urbanization activities and extend to the human life. Integrating different technologies such as ecology soilless culture, azolla culture and vermicomposting in urban agriculture (top-roof garden) contributed strongly in creating resilience city (Abul-Soud, 2015).

Organic carbon that sequestered in vermicompost and azolla forms as a substrate amendments was presented in Fig. (2). the revealed results indicated that azolla culture recorded the higher organic carbon than vermicompost regarding to the double process of azolla culture via feeding by vermicompost and its biomass production.

Fig. (3) illustrated that the nutrient saved (Kg/ton) via vermicomposting and azolla culture. There is a clear strong difference between the effect of vermicomposting and azolla culture while azolla culture performed supreme effect because of the double impacts of azolla culture. During the azolla culture, vermicompost as a result of vermicomposting of organic urban waste was used to fertilize azolla and the high capability of azolla on growth, uptake nutrient and concentrated as well as N-fixation presented the supreme impacts of azolla culture on saving the nutrients. On the other hand, the nutrient save (Kg / ton) via using vermicomposting process from non-significant organic sources such as kitchen wastes and shredded newspapers gave good evidences on recycling the urban organic wastes and the application of the output either in food production directly (lettuce) or indirectly (azolla).

The obtained results presented that both of vermicomposting and azolla culture had a positive effect on saving the essential nutrients instead of wasting via aggressive impacts on environmental. The vermicomposting process and azolla culture increased the total N, P, K, Ca and Mg % compared to that of the raw materials while C/N ratio decreased as a result of N fixation, concentrated the nutrients and bulk reduction. At the same time, the heavy metals contents of vermicompost and azolla were in the friendly range.

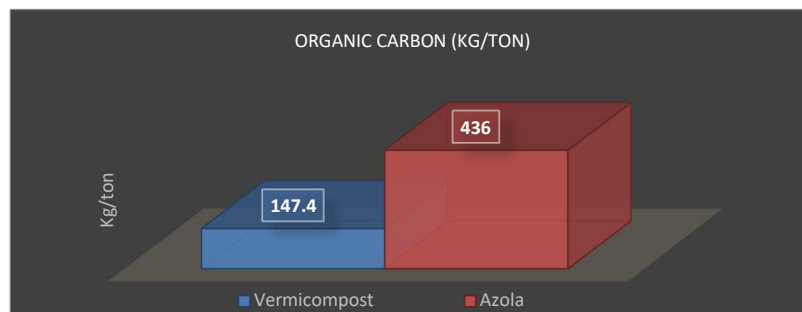


Fig. 2: The effect of vermicomposting and azolla culture on sequester the organic carbon.

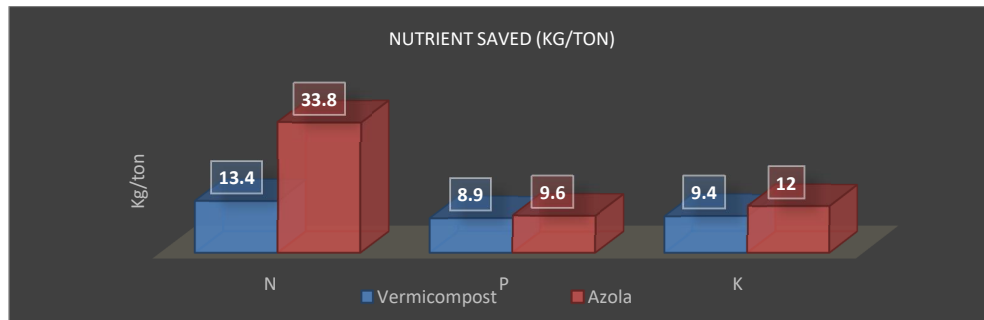


Fig. 3: The effect of vermicomposting and azolla culture on nutrient saved.

3.2. The effect of vermicompost and azolla as substrate amendments on physical and chemical properties of substrate mixtures

Table (5) observed the physical and chemical properties of standard substrate peat moss:

Perlite (1:1 v/v) compared to the different substrate mixtures with different proportions vermicompost and azolla. Vermicompost substrate mixtures recorded the highest values of bulk density (B.D) while increasing the vermicompost and both fresh and dry azolla resulted B.D increment. Total pore space (T.P.S) increased at higher rate with Azolla mixture substrates either fresh or dry compared to vermicompost mixtures. Increasing the mixture proportion of vermicompost, fresh and dry azolla led to increase T.P.S. The increase of water hold capacity (W.H.C) results at the expenses of air porosity (A.P) where there is an inverse relationship. The treatment PP: V20 gave the highest results of B.D, W.H.C while recorded the lowest A.P. The highest T.P.S was recorded by the treatment PP: DA 20.

Table 5: The physical and chemical properties of substrates mixtures.

Substrate	Physical			Chemical		
	B.D g / L	T.P.S %	W.H.C %	A.P %	E.C dS/m ⁻¹	pH (1:10)
Peat : Perlite	140.0	65.2	52.8	12.5	0.43	7.14
PP: Verm10	330.1	70.6	57.1	13.5	1.34	7.83
PP: Verm 20	335.0	72.1	61.4	10.7	1.64	7.77
PP : F.Azo 10	233.0	77.0	57.9	19.1	0.48	7.78
PP : F.Azo 20	252.4	75.3	48.8	26.5	0.50	7.89
PP : D.Azo 10	203.9	81.3	53.8	27.6	0.42	7.95
PP : D.Azo 20	219.3	81.7	55.8	25.9	0.54	7.85

Bulk density (B.D). Total pore space (T.P.S).Water holding capacity (W.H.C).Air porosity (A.P)

Regarding to the chemical properties of different substrate mixtures as Table (5) presented, the obtained data indicated that vermicompost had strong impact on EC while PP: V20 gave the highest EC value of substrate mixtures. On the contrary, azolla presented strong impact on pH of different substrate mixtures. These results are agreed with many studies that investigated the vermicompost potential in horticultural potting substrates in low rate mixture (10 – 30 %) of the substrate (Hashemimajd *et al.*, 2004; Arancon *et al.*, 2003; Arancon *et al.*, 2004b; Abul-Soud *et al.*, 2014 & 2015a,b).

Moreover, regarding the different mixtures, the results matched with Litterick *et al.* (2004), Bachman and Metzger, (2008) and Grigatti *et al.* (2007) who reported that physical, chemical, and biological qualities of the growing media can all be improved by employing organic compost. Due to an increase in the bulk density of the growing medium and a decrease in total porosity and the amount of easily available water in the pots, replacing peat with moderate volumes of vermicompost has good effects on plant growth. When compared to peat-based substrates, such changes in the physical qualities of the substrates may be responsible for greater plant development with lesser dosages of compost and vermicompost.

Generally, many physical and chemical changes had occurred as a result of adding by different proportions vermicompost and azolla, both fresh and dry, to the standard substrate. The real criterion and mirror for these changes will be performed in the vegetative characteristics and yield parameters of lettuce.

3.3 The Effect of vermicompost and azolla as substrate amendments on vegetative and yield parameters of lettuce plant.

Table (6) illustrated the application effects of vermicompost and azolla in different rates as substrate amendments on vegetative and yield parameters of lettuce plant. The revealed results indicated that vermicompost and azolla applications as a substrate amendments had a significant positive impact on No. of leaves, stem diameter (cm), head diameter (cm), fresh plant weight (g) and fresh head weight (g). Increasing the proportion of vermicompost, fresh azolla and dry azolla mixed with standard substrate (peat moss: perlite 1: 1 v/v) led to increase the vegetative and yield parameters of lettuce.

The treatment of mixture substrate P: P + Vermicompost 20 % recorded the highest values of No. of leaves, stem diameter, fresh plant weight and fresh head weight followed by substrate mixture P:P + dry azolla 20 % while the lowest results were given by mixture substrate P:P + fresh azolla 10 % with significant differences among the treatments. The highest records of head diameter was recorded by control substrate (peat moss: perlite 1: 1 v/v) in both seasons. The significant differences among the treatments were true in both seasons.

Table 6: Effect of vermicompost and azolla application as substrate amendments on vegetative and yield parameters of lettuce plant.

Treatments	First season 2019 / 2020				
	No. of leaves	Stem diam. (cm)	Head diam.(cm)	Fresh plant weight (g)	Fresh head weight (g)
Peat : Perlite	32.1 A	2.35 AB	23.4 A	1005.2 C	859.5 D
PP: Verm10	32.3 A	2.38 AB	19.04 C	1350.6 B	1133.1 B
PP: Verm 20	33.2 A	2.62 A	22.39 AB	1509.7 A	1274.1 A
PP : F.Azo 10	26.6 B	2.36 AB	21.21 B	1065.9 C	925.1 C
PP : F.Azo 20	26.7 B	2.19 B	22.32 AB	1139.7 BC	937.7 C
PP : D.Azo 10	31.8 A	2.41 AB	21.91 B	1213.3 BC	969.6 C
PP : D.Azo 20	32.4 A	2.56 A	20.02 C	1308.7 B	1110.8 B
Second season 2020 / 2021					
Peat : Perlite	33.3 A	2.45 AB	23.1 A	988.0 D	852.5 D
PP: Verm10	33.6 A	2.44 AB	18.70 C	1340.6 B	1070.5 BC
PP: Verm 20	34.7 A	2.64 A	21.49 B	1479.0 A	1221.4 A
PP : F.Azo 10	24.9 C	2.18 C	20.39 BC	1018.0 CD	890.5 D
PP : F.Azo 20	27.8 B	2.09 C	19.95 BC	1103.4 C	950.8 CD
PP : D.Azo 10	32.7 AB	2.39 B	22.44 AB	1239.0 BC	1062.5 BC
PP : D.Azo 20	32.8 AB	2.46 AB	22.59 A	1327.5 B	1140.3 B

* Similar letters indicate non-significant at 0.05 levels.

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

Vermicompost presented a strong effect as a substrate amendment regarding to enhance the physical and chemical properties of the substrate as well as supporting the plants by essential nutrients and growth promoters. These results agreed with Abul-Soud (2015) and Abul-Soud *et al.*, (2014 & 2015a, b) that investigated the effect of vermicompost substrate mixtures on spinach, molokhia, lettuce, celery, cabbage, sweet paper, snap bean and strawberry. Increase vermicompost rate in substrate more than 20 % of substrate volume for leafy vegetable crops had a negative effects on the plants growth and yield. Furthermore, plant growth is enhanced through the addition of vermicompost as a substrate amendment. Biologically active metabolites such as plant growth regulators and humates have been discovered in vermicompost materials Atiyeh *et al.*, (2002) and Ferri *et al.*, (2010). Also, many researchers had reported that, vermicompost has considerable potential in horticultural potting substrates in low rate

mixture (10 – 30 %) of the substrate with beneficial effects on plant growth (Arancon *et al.*, 2003; Arancon *et al.*, 2004b; Hashemimajd *et al.*, (2004). The best plant growth responses, with all needed nutrients supplied, were observed when vermicompost made up a small percentage of the total volume of the container medium mixture (10% to 20%), with higher proportions of vermicompost in the plant growth medium not always increasing plant development (AboSedera *et al.*, 2015 ; Abul-Soud (2015).

The application of Azolla in both forms fresh and dry normally used as animal feeder or as a soil amendment in paddy soils and rice field to reduce methane emission. There are so few mentions Omidi *et al.* (2018) about using it as a substrate amendments in pot culture in spite of its high organic matter and nutritional contents that led to positive impact on plant growth and yield. The results of Azolla applications in both forms (fresh and dry) and proportions (10 and 20 %) could be explained by the presence of nutrients in a complex form within the composition of the Azolla tissues, which are not easily accessible to lettuce plants, but rather require time for their decomposition and availability compared to the vermicompost that has a high available nutrients, which explains the improvement in growth about two weeks before harvest. Azolla in dry form with 20 % mixing with control substrate gave the highest records of azola mixture treatments.

3.4 The effect of substrate mixtures on nutrient contents (N, P and K %) of lettuce.

The revealed results of Table (7) demonstrated that the implement of vermicompost and azolla as a substrate amendments had a positive significant impacts on N, P and K (%) contents of lettuce plant. Vermicompost mixtures substrate in general presented the highest significant values of N, P and K contents compared azolla mixture substrates for both of different proportions and forms. Increase the vermicompost rate from 0 (control substrate) up to 20 % led to increase the N, P and K (%) contents of lettuce plant. The mixture substrate treatment P: P + Vermicompost 20 % recorded the highest N, P and K (%) contents while the lowest results gave by control substrate. Vermicompost application as a substrate amendment assisted in encouraging plant growth and yield through increasing the available forms of nutrients (nitrates, exchangeable P, K, Ca and Mg) for plant uptake. Vermicompost contained a large amounts of humic substances which release nutrients relatively slowly and offered better physical, chemical and biological properties for better plant uptake (Muscolo *et al.*, 1999 ; Arancon *et al.*, 2004).

Table 7: Effect of vermicompost and azolla application as substrate amendments on N, P and K (%) contents of lettuce plant.

Treatments	First season 2019 / 2020		
	N (%)	P (%)	K (%)
Peat : Perlite	2.61 D	0.56 C	2.14 D
PP: Verm10	3.33 B	0.76 A	3.33 B
PP: Verm 20	3.85 A	0.81 A	3.87 A
PP : F.Azo 10	3.04 C	0.55 C	2.11 D
PP : F.Azo 20	3.16 BC	0.64 B	2.66 C
PP : D.Azo 10	3.08 C	0.72 AB	2.17 D
PP : D.Azo 20	3.35 B	0.79 A	2.55 C
Second season 2020 / 2021			
Peat : Perlite	2.66 C	0.59 C	2.36 D
PP: Verm10	3.21 B	0.71 B	3.18 B
PP: Verm 20	3.77 A	0.96 A	3.62 A
PP : F.Azo 10	3.10 B	0.60 C	2.26 D
PP : F.Azo 20	3.15 B	0.63 C	2.33 D
PP : D.Azo 10	3.18 B	0.75 B	2.84 C
PP : D.Azo 20	3.68 A	0.77 BC	2.84 C

* Similar letters indicate non-significant at 0.05 levels.

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

The explanation of these results were completely simple regarding to the fact of readily available nutrients in vermicompost for plant uptake such as nitrates, exchangeable phosphorus, potassium, calcium, and magnesium (Edwards and Burrows, 1988; Abul-Soud 2015; Abul-Soud *et al.*, 2014, 2015 (a,b) 2016 and 2017) comparing the compound organic form of nutrients in azolla.

Fresh and dry azolla introduced different impacts on nutrient (N, P and K (%)) contents that drives to suggest recommendation of composting the azolla wastes for using as a substrate amendments to ensure the positive effects and presented the stability and availability of essential nutrients to use as substrate amendment. On the other hand, increasing the azolla proportion from 0 (control substrate) up to 20 % also had a positive effect on N, P and K (%) contents of lettuce plants.

4. Conclusion

The current investigation actually was not for investigating the application of vermicompost or azolla as substrate amendments or concerning the impact of urban horticulture on roofs conditions, food security or even climate change. The study is a serious attempt to create a sustainable ecological loop through recycling the organic urban wastes via vermicomposting and use its output directly as a substrate amendments, as an organic fertilizer for food production or to produce azolla as a an animal feeder (beside the other benefits of reducing CO₂ and methane emissions and etc...) and use the azolla remains as a substrate amendments in producing food such as lettuce. Create resilience city which could mitigate, adapt climate change impacts as well as recycle its organic wastes and matched the demands of food security is a good strategy to eliminate the poverty, hungry, ignorance and malnutrition. Micro - small urban scale farm that include different sustainable and food production activities should be promoted strongly. The economic impact assessment was not included in this study depending the huge priceless benefits of sustainable urban horticulture and the real objectives of the study. More research need for investigating the effects of composting azolla or its remains to use as substrate or substrate amendments in substrate urban horticulture. From the horticulture view point, substrate peat moss: perlite: vermicompost (40: 40: 20 % (v/v)) gave the highest yield of lettuce plants followed by peat moss: perlite: dry azolla (40: 40: 20 % (v/v)).

References

- AboSedera, F.A., Nadia 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. *Annals of Agric. Sci.*, Moshtohor, 53(2): 139-151.
- Abul-Soud, M., 2015. Achieve food security of some leafy vegetables in urban (How to create resilience cities?). *Global Journal of Advanced Research*, 2 (10):1705 – 1722.
- Abul-Soud, M.A., M.S.A. Emam and Abd El-Rahman Noha, G., 2015a. The potential use of vermicompost in soilless culture for producing strawberry. *International Journal of Plant & Soil Scienc*, 8 (5): 1 – 15.
- Abul-Soud, M.A., M.S.A. Emam, A.M.H. Hawash, M.H. Mohammed and Z.Y. Maharik, 2015 b. The utilize of vermicomposting outputs in ecology soilless culture of lettuce. *Journal of Agriculture and Ecology Research*, 5(1): 1-15.
- 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 Journal of Advanced Research*, 2 (12):1832 – 1847.
- 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, *Journal of Advances in Agriculture*, 3 (1): 110-122.
- Abul-Soud, M., M.K. Hassanein, S.M. Ablmaaty, M. Medany and A.F. Abu- Hadid, 2009. Vermiculture and vermicomposting technologies use in sustainable agriculture in Egypt, *Egypt. J. Agric. Res.*, 87 (1):389-403.
- Arancon, N.Q., C.A. Edwards, P. Bierman, C. Welch, and J.D. Metzger, 2004b. Influences of vermicomposts on field strawberries: 1. effects on growth and yields. *Bioresource Technology*, 93: 145-153.

- 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
- Bachman, G.R. and J.D. Metzger, 2008. Growth of bedding plants in commercial potting substrate amended with vermicompost. *Biores. Tech.*, 99: 3155-3161.
- Bindhu K.B., 2013. Effect of Azolla Extract on Growth Performance of *Pisum Sativum*. *International Science Congress Association*, 2(10): 88-90.
- Coria-Cayupán, Y.S., M.I.S. De Pinto and M.A. Nazareno, 2009. Variations in bioactive substance contents and crop yields of lettuce (*Lactuca sativa L.*) cultivated in soils with different fertilization treatments. *Journal of Agricultural and Food Chemistry*, 57(21): 10122-10129.
- Chaoudhury, A.T. and I.R. Kennedy, 2004. Prospects and potentials for systems of biological nitrogen fixation in sustainable rice production. *Biol. Fertile. Soils*, 39: 219-227.
- Cooper, A.J., 1979. *The ABC of NFT*. Grower Books, London.
- Chapman, H.D. and P.F. Pratt., 1961. *Methods of analysis for soil, plant, and water*. University of California, Division of Agric Sci.
- Domínguez, J., 2004. State of the art and new perspectives on vermicomposting research. In: C.A. Edwards (Ed.). *Earthworm Ecology* (2nd edition). CRC Press LLC. P: 401-424.
- EL Shimi, N.M.M, El.H.M. El-Badawy and H.I. Tolba, 2015. Response of sweet pepper plants to some organic and bio-fertilizers and its effect on fruit yield and quality.
- EL-Zeky M.M., R.M. El-Shahat, Gh.S. Metwaly and M. Aref-Elham, 2005. Using of cyanobacteria or Azolla as alternative nitrogen source for rice production, *J. Agric. Sci. Mansoura Unvi.*, 30: 5567-5577.
- 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.
- FAO, 1980. *Soil and Plant Analysis*. *Soils Bulletin* 38/2,250P.
- Gruda, N., 2009. Do soilless culture systems have an influence on product quality of vegetables? *Journal of Applied Botany and Food Quality*, 82:141 – 147.
- Gutierrez-Miceli, F.A, J. Santiago-Borraz, J. Montes Molina, C. Nafate, M. Abdu-Archila, M. OlivaLlaven, R.L. Rincon- Rosales and L. Dendooven, 2007. Vermicompost as a soil supplement to improve growth, yield and fruit quality of tomato (*Lycopersicum esculentum*) *Bioresource Technol.*, 98(15): 2781-2786.
- Gruda, N., M. Prasad, and M.J. Maher, 2005. Soilless culture. In: Lal, R. (ed.), *Encyclopedia of Soil Science*. Taylor & Francis (Marcel Dekker), Inc., New York.
- Hanafy, A. and G.A.E. El-Emery, 2018. Role of azolla pinnata biofertilizer extract in producing healthy tomatoes. *Asian J. Research Biochemistry*, 3(3): 1-8.
- Hashemimajd, K., M. Kalbasi, A. Golchin, and H. Shariatmadari, 2004. Comparison of vermicompost and composts as potting media for growth of tomatoes, *Journal of Plant Nutrition*, 27: 1107-1123.
- Inbar, Y., Y. Chen and Y. Hadar, 1993. Recycling of cattle manure: The composting process and characterization of maturity. *Journal of Environmental Quality*, 22: 875-863.
- 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.
- Marwaaha, T.S., B.V. Singh, and S.K. Goyal, 1992. Effect of incorporation of azolla in Wheat (*Triticum aestivum* var. HD 2329). *Acta Bot. India*, 20: 218-220.
- Omidi, J., S. Abdolmohammadi, M. Bakshipour, and M. Sheykhpour, 2018. Possibility replacement of peat - perlite - sand with Azolla compost in growing media (*Pedilanthus tithymaloides*), 8:13-20.
- Peyvast, G., J.A. Olfati, S. Madeni and A. Forghani, 2008. Effect of vermicompost on the growth and yield of spinach (*Spinacia oleracea L.*). *Journal of Food Agriculture and Environment*, 6: 110-113.

- Raul, I.C., 1996. Measuring physical properties. Rutgers Cooperative Extension. New Jersey Agriculture Experiment Station. New Jersey University.
- Renu, K., V.P. Niteen, R.K. Sawal and S. Sanjay, 2018. Chemical composition and pellet quality of *Azolla pinnata* grown in semi-arid zone of India. *International Journal of Chemical*, 6(3): 2031-2033
- Singh, R., R.R. Sharma, S. Kumar, R.K. Gupta, and R.T. Patil, 2008. Vermicompost substitution influences growth, physiological disorders, fruit yield and quality of strawberry (*Fragaria x ananassa* Duch.) *Bioresource Technology*, 99: 8507-8511.
- 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.
- Wang, D., Q. Shi, X. Wang, M. Wei, J. Hu, J. Liu and F. Yang, 2010. Influence of cow manure vermicompost on the growth, metabolite contents, and antioxidant activities of Chinese cabbage (*Brassica campestris* ssp. *chinensis*). *Biology and Fertility of Soils*, 46: 689-696.
- Wagner, G.M., 1997. *Azolla: a review of its biology and utilization*. *The Botanical Review*, 63(1):1-26.
- 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, G.C.S., 1983. The physic- chemical and physical properties of horticultural substrate. *ActaHort.* No., 150: 19-32.