ISSN2349-0837

Sustainable Urban Horticulture of Sweet Pepper via Vermicomposting in Summer Season

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Abstract

The need for extend the urban horticulture to cover the food security demands, to mitigate CO_2 emissions and avoid the extreme heat waves drive this study to investigate the ability of using soilless culture systems, vermicomposting technology and net cover in producing vegetables in urban area in summer season. The aim of this study was to determine the effect of different vermicompost rates mixed with the standard substrate peat moss: perlite (perlite: peat moss: vermicompost (45:45:10) (Mix.10%), perlite: peat moss: vermicompost (40:40:20) (Mix.20%), perlite: peat moss: vermicompost (35:35:30) (Mix.30%) and perlite: peat moss (50:50 *V/V*) (Control) under three microclimate conditions (plants covered with black net, white net and without cover) on vegetative growth and yield of sweet pepper (*Capsicum annuum* L. cv. Reda) grown in pots culture during summer seasons of 2012 and 2013 at the Central Laboratory for Agricultural Climate, Agricultural Research Center, Dokki, Giza Governorate.

Physical and chemical properties of substrates, vegetative growth and yield characteristics, agrometerological data and mineral contents were determined. The obtained data indicated that vermicomposting could contribute in mitigate CO_2 emission, save the essential nutrients and energy via recycling the urban organic wastes to vermicompost. The physical and chemical properties were affected by vermicompost. The best vegetative growth and yield of sweet pepper were given by (Mix.20%) vermicompost mixture followed by (Mix.10%) and (Mix.30%) vermicompost mixture. There were also significant differences between cover net treatments in affecting vegetative growth and yield of pepper, the white net was superior for producing pepper during the summer season; while the black net gave the lowest plant growth and yield. The best treatment was (Mix.20%) vermicompost mixture with white net cover, while the lowest vegetative growth and yield were obtained by (Control) vermicompost mixture with black cover net during the two tested seasons. These results suggested that vermicomposting and green roof can be used in urban area for producing food instead of incineration the urban organic wastes or imported food from rural area and using white cover net to improve the pepper growth and productivity during summer season.

Keywords: Soilless culture; vermicompost; substrate culture; pots; net color; shading; urban horticulture; vegetative growth and yield of sweet pepper.

Council for Innovative Research

Peer Review Research Publishing System

Journal: JOURNAL OF ADVANCES IN AGRICULTURE

Vol 3, No 1

jaaeditor@gmail.com

www.cirjaa.com

ISSN2349-0837

Introduction

Under climate change impacts and food security needs, urban horticulture should play a vital role in producing the food via using green roof systems and at the same time securing the recycle of urban organic wastes to mitigate CO_2 emissions and save the essential nutrients. Urban horticulture includes all horticultural crops grown for human consumption and ornamental use. Urban horticulture is not just working on producing large variety of vegetables, cereals, flowers, ornamental trees, aromatic vegetables and mushrooms but also fight the climate change impacts, poverty, hungry, malnutrition and illness while help food security, economy and social needs **(FAO, 2012)**.

In recently years some problems in soil culture (such as salinity and unsuitable soil characteristics) and limitation of water resources in many countries, causes to expand soilless culture. Replacing soilless growing systems with soil growing for plants especially for cucumber, pepper, tomatoes and other vegetables cause control of plant nutrition and eliminate of plant diseases that caused by soil **(Olympios, 1995)**.

Utilization of earthworms to break down organic wastes is gaining increasing popularity in different parts of the world. During ingestion, the earthworms fragment the waste substrate, 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, which is obtained as a result of such transformations, is very different from the original waste material, mainly because of the increased decomposition and humification. Compared to their parent materials, vermicompost have less soluble salts, greater cation exchange capacity and increased total humic acid contents **(Atiyeh *et al.,* 2002)**. It is well established that earthworms have beneficial physical, biological and chemical effects on soils and many researchers have demonstrated that these effects can increase plant growth and crop yields in both natural and managed ecosystems **(Edwards *et al.,* 2004)**.

Different organic wastes can be used in vermicompost production by different species of earthworms include urban solid waste **(Alves and Passoni, 1997)**, city leaf litter and food wastes **(Hand *et al.,* 1988; Logsdon, 1994; Singh and Sharma, 2002)**, paper waste **(Gajalakshmi *et al.,* 2002)** and residues of plant decomposition **(Karmegam *et al.,* 1999)**. It is also a sustainable solution for management of organic wastes which are major source of environmental pollution **(Lazcano *et al.,* 2009)**. Possibly due to better physical properties, higher microbial and enzymatic activity and higher content of available nutrients producer acceptance of vermicompost is greater than that of compost **(Tognetti *et al.,* 2005)**. Vermicompost could be used as a natural fertilizer having a number of advantages over chemical fertilizers **(Venugopal *et al.,* 2010)**.

Nevertheless, the organic amendments prepared from different organic wastes (raw material), with different kinds (composting or vermicomposting) and time of process, produce a final product which differs in its quality **(Ranalli *et al.,* 2001)**. Substitution of a range of vermicomposts, produced from cattle manure, pig manure, food wastes, into a commercial soil-less bedding plant growth medium (Metro-Mix 360) in greenhouse experiments; increased the rates of germination, growth and yields of ornamentals, tomatoes and peppers even when all necessary mineral nutrients were supplied **(Atiyeh *et al.,* 2000, 2001, 2002)**. Nutrients in vermicompost are present in readily available forms for plant uptake such as nitrates, exchangeable phosphorus, potassium, calcium and magnesium **(Edwards and Burrows, 1988** and **Orozco *et al.,* 1996)**. Providing that all nutrients are supplied by mineral fertilization, studies show greatest plant growth responses when vermicomposts constituted a relatively small proportion (10–20%) of the total volume of the substrate mixture and with higher proportions of vermicomposts in the mixture not always improving plant growth **(Subler *et al.,* 1998** and **Atiyeh *et al.,* 2000)**.

The frequency and intensity of extreme heat waves as one of the most tangible effects of climate change strongly during the spring and summer seasons in Egypt, encourages the use of net cover to avoid these undesirable effects on various crops, especially in the urban areas. Due to the fact that the tropical fruit trees need a appropriate micro-climate during all its phenological phases, modification of the microclimate by using shade net is necessary at least during part of spring, going through summer up to part of fall **(Abou-Hadid and El-Beltagy, 1992)**. For this reason, two types of shade net that modifies the solar spectrum transmitted was tested in this experiment, allowing their comparison with a white or black shade net, which is regularly used in this cultivation **(Iglesias and Alegre, 2006)**. Low shading netting cover of numerous crops traditionally cultivated un-netted, revealed differential effects of colored nets on the performance of the plant production. The net-covering by itself was found to mitigate extreme climatic fluctuations, reduce heat and wind stresses and improve canopy vitality. Most responses depend on the chromatic properties of the protecting net. These nets can be used outdoors as well as in greenhouses. They can provide physical protection affect environment **(Wilson and Rajapakse, 2001)**.

Thus, the aims of this study were determining the ability of vermicomposting in recycling urban organic wastes and use its output as an organic substrate to enhance the physical and chemical properties of substrate in pots culture and its effect on the sweet pepper growth and yield, beside investigating the efficiency use of proper cover net on sweet pepper plants during summer season.

2. Materials and Methods

This study was carried out in the experimental station at the Central Laboratory for Agricultural Climate (CLAC), Agriculture Research Center (ARC), Egypt, during summer seasons of 2012 and 2013.

Plant material:

Sweet pepper (*Capsicum annuum* L. cv. Reda) seeds were sown on 15th and 17th May of 2012 and 2013, respectively, in polystyrene trays. After the fifth true leaf stage (26 and 29 June 2012 and 2013, respectively), the sweet pepper seedlings were transplanted into black plastic pots (25 cm height and 20 cm width). Each pot contained one plant. The final plant spacing was 50 cm in the row.

The vermicomposting process:

The epigiec earthworms Lumbriscus Rubellus (Red Worm), Eisenia Fetida (Tiger Worm), Perionyx Excavatus (Indian Blue) and Eudrilus Eugeniae (African Night Crawler) were used. Indoor system of vermicomposting was used in this investigation for producing the vermicompost. Fife holed plastic boxes (40 x 40 x 60 cm) were established as indoor system of vermicomposting. Each holed plastic box had 250 g of epigiec earthworms to begin the study. Worm diameter: 0.5 – 5 mm and worm length: 10 – 120 mm.

Mixing the different raw materials: kitchen wastes (vegetables, fruits, foods, breads, tea, eggshells wastes) + shredded newspaper and paper (Sh. P) in the rate of 4: 1 (*v/v*), respectively, was done before feeding earthworm. The final mix of raw materials soaked in water for 0.5 to 1 hour to make sure it is not any drier before feeding the worms. Worms should be avoiding the thermophilic stage (increase temperature above 35 ^{o}C cause the death of earthworms in vermicompost systems) through control the feeding rate of earthworm. The epigiec earthworm consume as much as their weight of different wastes, the feeding rate of earthworm was 90% of the earthworm weight. The use of newspaper, cardboard and any fiber material used as a bulk and water agent should not over than 25% of processing waste. The vermicompost was collected gradually when the plastic box filled up to 90% of its volume. Before harvesting the vermicompost, the earthworms were fasting for 3 days to give them the opportunities to re-eat the cast and to avoid non composted wastes. After 3 months, chemical composition of vermicompost, average weight of 100 earthworms (g), the biomass of earthworm (g) and the average vermicompost output (Kg)/system were estimated. The composition of the different organic wastes presented in **Table (1)**. The feeding of earthworm was done every day. Moisture content was in the range of 60 – 70%**.**

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

Raw material	C/N ratio	Macro elements, %				
		N	P	K	Ca	Mg
Kitchen wastes	50.2	0.59	0.44	0.56	0.98	0.62
Sh. P	169	0.02	0.01	0.00	0.19	0.01
The mix	76.5	0.54	0.38	0.49	0.73	0.55

System materials:

Growing pots were filled with 10 liters of the substrate mixtures. The pots were arranged in 3 rows over aluminum tables (1 x 2 x 0.6 m); every table was contained 20 pots. The distance between each two plants was 0.3 m. The aluminum tables were supported with stainless steel wire to install the shade net such as the tunnel. The height of the tunnel was 0.75 m. Each table was representing one replicate.

Nutrient solution **(El-Behairy, 1994)** was pumped via submersible pump (110 watt). Water tanks 120 L were used in open system of substrate culture. Plants were irrigated by using drippers of 2 l/hr capacity. The fertigation was programmed to work 4 times/day and the duration of irrigation time depended upon the season. The irrigation scheduled was programmed by using digital timer (one minute) to determine the schedules and operation time of irrigation depend on calculated ET under open field conditions. The EC of the different nutrient solutions were adjusted by using EC meter to the required level (2.5 dS.m^{-1}).

The investigated treatments:

Two factors were investigated under the study. First, four different substrate mixtures perlite: peat moss: vermicompost (45:45:10 V/V/V) (Mix.10%), perlite: peat moss: vermicompost (40:40:20 V/V/V) (Mix.20%), perlite: peat moss: vermicompost (35:35:30 V/V/V) (Mix.30%) and perlite: peat moss (50:50 V/V) (Control) combined with three cover treatments (white net, black net and without cover) as a second factor.

The measurements:

The following measurements were performed for three labeled-plants per replication for each treatment at the end of growing seasons. Plant height (cm) was measured as distance from the level of upper side of growing pot to the highest point of plant stem fortnightly at the end of every season. Number of leaves per plant was determined by counting the leaves at the end of every season. Total fruit weight was calculated by the summation of all the fruit pickings per plant during the season. Total plant dry matter (leaf, stem and root) was determined after drying the plant samples in an oven at

ISSN2349-0837

70 ^{o}C at the end of every season. Total nitrogen was determined by 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 photometrically using Flame photometer as described by **(Chapman and Pratt, 1961)**.

The physical and chemical properties of different substrates mixtures were estimated according to **(Wilson, 1983** and **Raul, 1996)** as follows:-

- The bulk density (BD) is simply measured as dry weight/volume ($g.cm^{-3}$ or $kg.L^{-1}$).
- Total pore space (TPS) is the percentage pore space and the proportion and amount of water and air that is present in pore space.

Total pore space = (1 – bulk density/ true density) x 100

- Water holding capacity % (WHC) is the amount of water present after the substrate in a container has been saturated and allowed to drain.

Water holding capacity % = ((FW- DW)/ VB) x 100

Where:

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

DW (dry weight) = dry weight of substrate after 24 hours at a temperature 80 – 90 ^{o}C.

- Air porosity % (AP) is 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.

Air porosity % = TPS – WHC

- The pHs 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 h and filtered through Whatman no.1 fillter paper. The same solution was measured for electrical conductivity with a conductance meter that had been standardized with 0.01 and 0.1 M KCl.

All the other agriculture practices of sweet pepper cultivation were in accordance with the standard recommendations for commercial growers by Agriculture Research center (ARC), Ministry of Agriculture, Egypt.

The experimental design was split plot with 3 replicates where cover net and control were assigned as main plots and substrate mixtures allocated as subplots. Analysis of the data was done by computer, using SAS program for statistical analysis and the differences among means for all traits were tested for significance at 5% level **(Snedicor and Cochran, 1981)**.

3. Results and Discussion

3.1 The effect of vermicomposting proccess on the urban organic wastes

The results in **Table (2)** showed that the vermicomposting proccess increased the total N, P, K, Ca and Mg % of the vermicompost as 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 were in the friendly range lower than the commercial composts in the Egyptian market. Vermicomposting is defined as a low cost technology system for processing organic wastes **(Hand *et al.,* 1988)**.

Fig. (1) showed that the nutrient saved (Kg/ton) via vermicomposting of urban organic wastes. The obtained results presented that vermicomposting had a positive effect on saving the essential nutrients instead of loosing these nutrients through an ordinary treatments (incineration or burial) of urban organic wastes. The nutrient save (Kg/ton) via using vermicomposting proccess 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. Needless to say that the most important point of utilizing vermicomposting was mitigating the CO_2 emissions from the different used of organic wastes through sequestration of the organic carbon into substrate and organic nutrient solution forms that could be utilize in ecology soilless culture of different vegetables led to more mitigation of CO_2 emissions. However, the determined calculation measured the organic carbon of organic wastes used in this study that treated by vermicomposting and produced in vermicompost was estimated by 765 Kg per each ton of urban organic wastes instead of incineration. Also, vermicomposting contribute in save energy, cost and environmental of transport the urban organic wastes that contained about of 55- 60% of organic wastes.

ISSN2349-0837

Table (2): The chemical composition of macro nutrients (%) and heavy elements (ppm) of vermicompost after vermicomposting.

	Macro nutrients, %					
Vermicompost	C/N ratio	N	P	K	Ca	Mg
	16.7	0.98	0.46	0.81	0.78	0.59
	Heavy elements, ppm					
		Pb	Ni	Cd	Co	
		11.3	8.31	0.49	2.09	

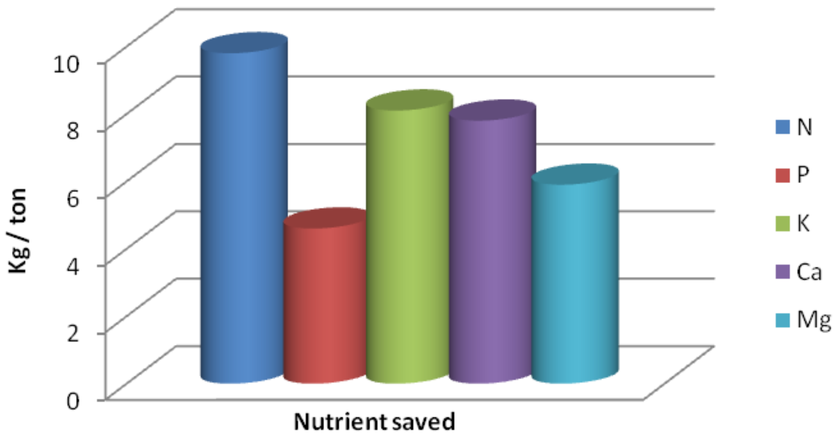

Fig. (1): The nutrient saved (Kg/ton) via vermicomposting of urban organic wastes.

The results in **Table (3)** illustrate the vermicomposting output of the urban organic wastes after 3 months. The revealed data showed that increase the worm biomass after 3 months about 13.5 times through the vermicomposting process. The increase of worm biomass led to increase the amount of treated urban organic wastes gradually to reach around 2100 g daily (= 90% of worm biomass) instead of 225 g in the beginning. The average total output (Kg/system) reach to 68.2 Kg of vermicompost that produced from about 105 Kg of urban organic wastes. These results indicated the high efficiency of vermicomposting in processing the urban organic wastes on different scales **(Sherman, 2000** and **Aalok *et al.*, 2008)**.

Table (3): The vermicomposting output of the urban organic wastes after 3 months.

Vermicomposting	Average weight (g /100 worms)	Average worm biomass (g)	The total organic wastes (Kg / system)	Average total output (Kg / system)
Output	40.2	3385	105	68.2

3.2 The physical and chemical properties of different substrate mixtures

The results of physical and chemical properties of different vermicompost mixtures are presented in **Table (4)**. The results demonstrated that there was a significant increase in the bulk density (kg.L^{-1}) and air porosity (AP %), EC and pH with increasing VC mixture proportion from 0 to 30%. The highest BD and AP were recorded by vermicompost mixture 30%.

On the other hand, the data in **Table (4)** illustrate that increasing the rate of vermicompost from 10 to 20% led to increase the total pore space (TPS %) and water holding capacity (WHC %), while increasing the rate up to 30% had a negative effect on TPS and WHC. Vermicompost mixture 20% gave the highest TPS and WHC. The control substrate recorded the lowest value of BD and WHC. These results could be explained by referring to the physical and chemical properties of vermicompost that had high BD, TPS and WHC. The main benefit of high BD is helping the sweet pepper plant for stand stable and avoid break it down instead of lower BD as a direct effect.

Regarding to the chemical properties (EC and pH), the obtained data indicated that increasing the rate of vermicompost led to increase EC and pH of different mixtures as a result of high contents of nutrients of vermicompost **(Atiyeh *et al.,* 2001 and 2002; Orozco *et al.,* 1996; Tognetti et *al.,* 2005** and **Venugopal *et al.,* 2010)**.

Table (4): The effect of vermicompost rates on physical and chemical properties of different mixtures and control.

	Physical				Chemical	
Substrate mixtures	*BD* *Kg.L^{-1}*	*TPS* *%*	*WHC* *%*	*AP* *%*	EC dS.m^{-1}	pH
Mix. 10%	0.263 C	63.75 D	54.5 C	9.3 D	1.03 C	7.6 C
Mix. 20%	0.318 B	72.75 A	62.5 A	10.3 C	1.76 B	7.8 B
Mix. 30%	0.410 A	69.50 B	55.0 B	14.5 A	2.38 A	7.9 A
Control	0.140 D	65.25 C	52.8 D	12.5 B	0.45 D	7.6 C

3.3 Climatic data

The average maximum weekly temperatures for the different treatments showed that the use of nets influence on temperature **(Figs. 2, 3 and 4)**. Temperatures tended to be lower under the white and black net covers (1- 3°C), due to the lower interception of radiation than open field. Use of white and black nets reduces light intensity by about 600-1200 foot candle and increase relative humidity by 2-5%. Similar results were reported by **(Al-Helal and Abdel-Ghany, 2010** and **Abdrabbo *et al*., 2013)**, indicating that the influence of nets upon maximum temperatures. **(Elad *et al*., 2007)** found a moderate decrease in maximum temperatures associated with the use of shade nets. **Stamps (2008)** reported a moderate decrease (<2°C), while **Gu *et al*. (2002)** did not find any clear temperature effect associated with the use of nets and only noted that maximum. Moreover, using net cover led to decrease maximum air temperature in comparison with open field, the lowest maximum temperature was gained by black net. Maximum temperatures tended to be lower under the black net by 3°C in comparison with open field, while Average relative humidity increased by the use of all net colors by 4-8% compared to open field **(Shahak *et al.,* 2004** and **Abdrabbo *et al*., 2013)**. **Campen and Bot (2003)** explained the ventilation phenomenon. The pressure difference over the openings was one of the driving forces for ventilation, which could be either due to the wind outside the greenhouse or due to the temperature difference over the openings. At lower wind speed, which was true under present case, mainly the buoyancy effect contributes in ventilation **(Retamales *et al.,* 2008)**.

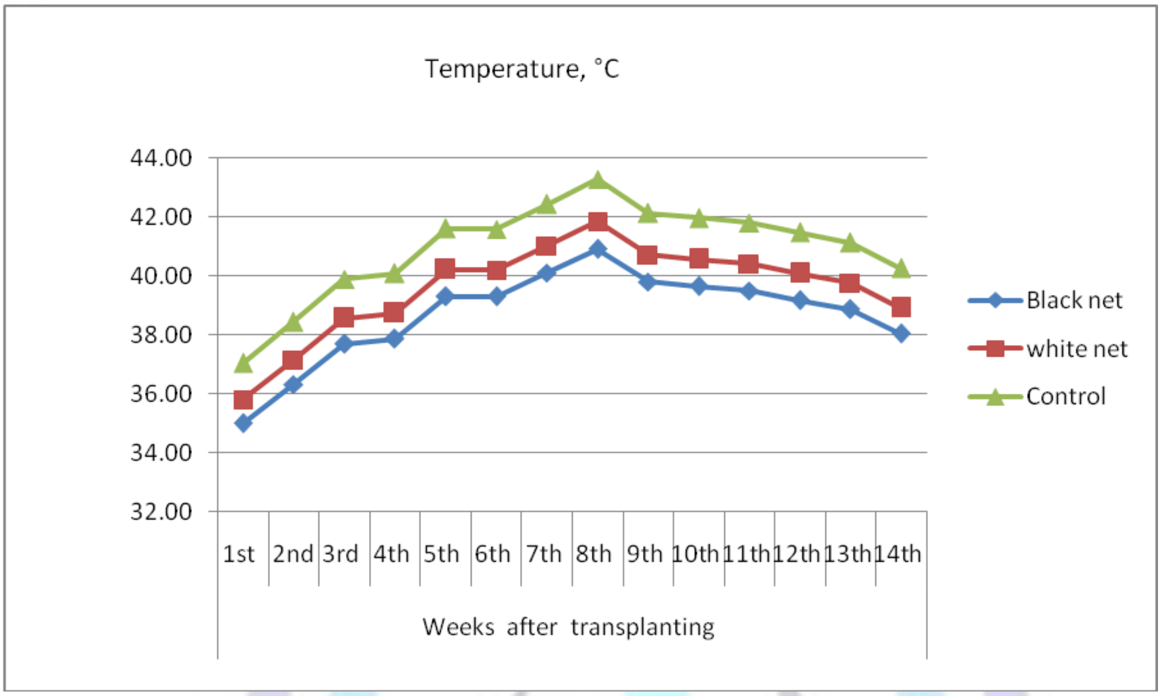

Fig. 2: Weekly average air temperature under different treatments (°C) during the two studied seasons 2012 – 2013.

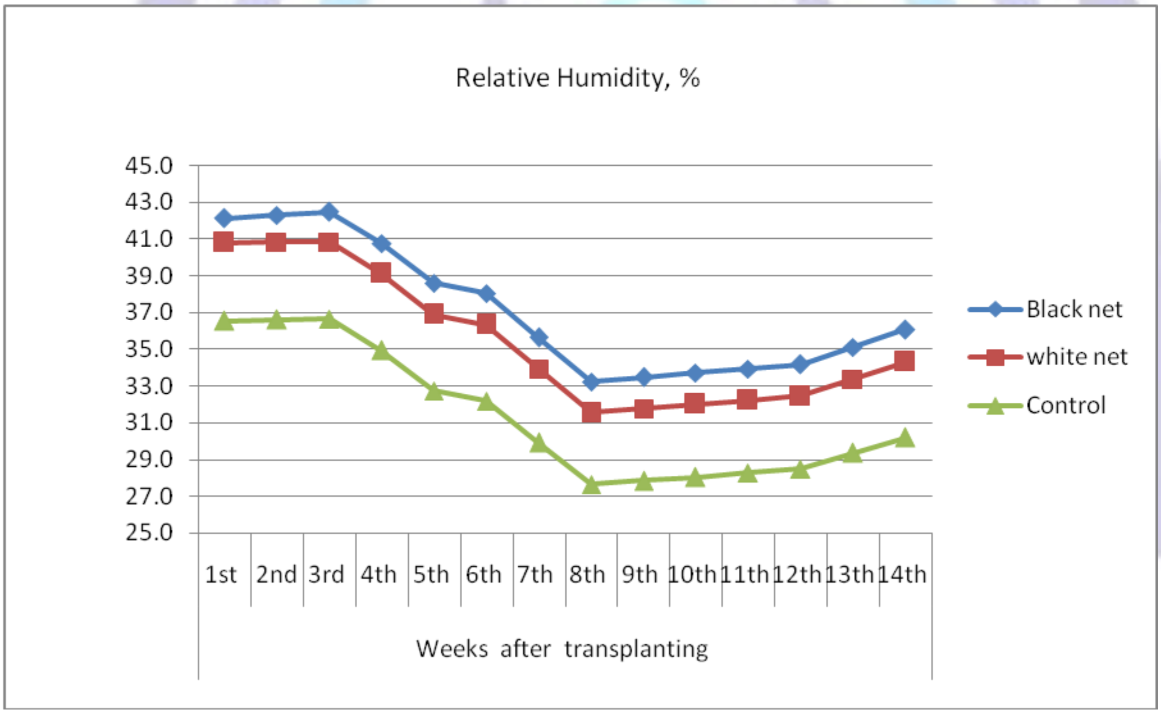

Fig. 3: Weekly average relative humidity under different treatments (%) during the two studied seasons 2012 – 2013.

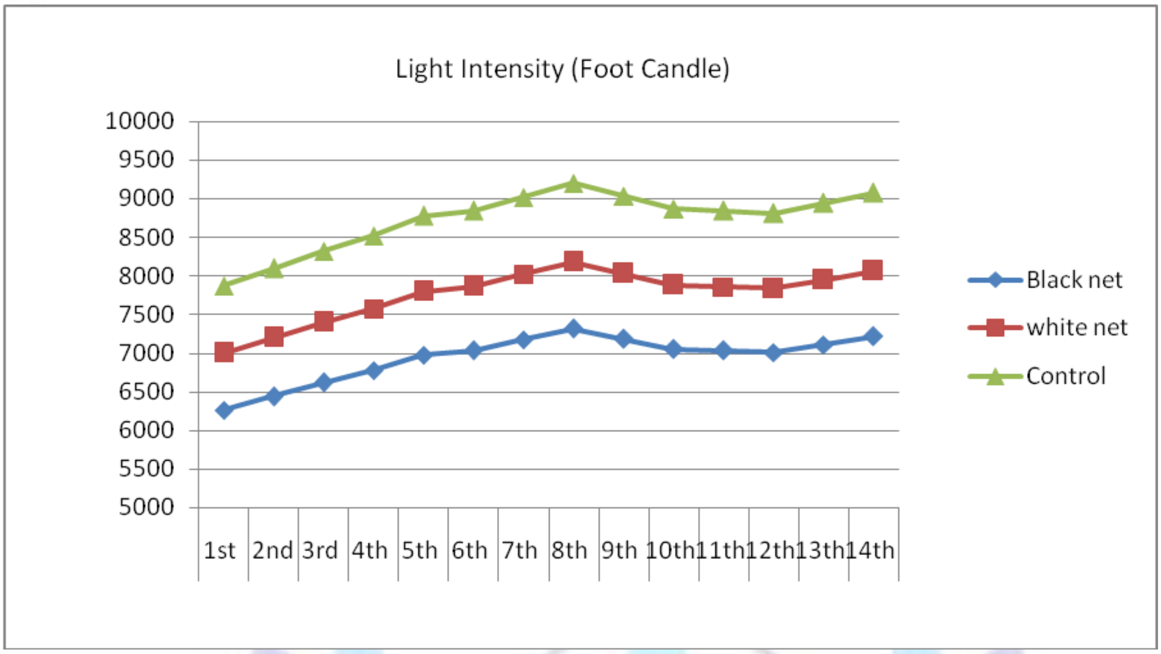

Fig. 4: Weekly average light intensity (foot-candle) under different treatments during the two studied seasons 2012 – 2013.

3.4 The effect of cover and vermicompost mixtures on vegetative growth

The effect of different net covers on pepper vegetative growth characters of different net covers and soilless are presented in **Table (5)**. Regarding the effect of different net covers, data showed that using black cover increased plant height significantly, followed by white net cover treatment. The lowest plant height was obtained by without net cover treatment during the two studied seasons. Number of leaves, fresh and dry weights per plant took different trend, the highest number of leaves, fresh and dry weights were obtained from white net cover followed by without cover treatment.

The highest plant height was obtained by (Mix.20%) and (Mix.30%) treatments; while the lowest plant height was obtained by (Control) mixture. Number of leaves, fresh and dry weights per plant took different trend, Vegetative growth under different mixture indicated that (Mix.20%) had the highest vegetative growth followed by (Mix.10%) and (Mix.30%) without significant difference between them with pepper. The lowest vegetative growth was obtained by (Control) mixture.

Regarding the interaction effect between different net covers and mixture, data illustrated that the highest plant height were obtained by black shading with (Mix.20%) followed by black net cover with (Mix.30%). The highest number of leaves, fresh and dry weight was obtained by white net cover with (Mix.20%). On the other hand, the lowest number of leaves, fresh and dry weight was obtained by using black net cover treatment with (Control) mixture during the two tested seasons. Similar results were found by **(Abou-Hadid and El-Beltagy, 1992)** who found that vegetative growth of the plants under protection was bigger than those plants grow under open field conditions. The improved vegetative growth evidenced as number of leaves and stem diameter per plant under the protection levels may be due to the favorable weather conditions, *i.e*. increase in relative humidity, lower maximum temperature and light irradiance, higher minimum temperature and finally lower wind speed in comparison with open field conditions **(Al-Helal and Abdel-Ghany, 2010)**. Other possibility was increasing plant ability to uptake water and nutrients which ultimately accelerated the rate of vegetative growth under greenhouse conditions. **Gu *et al.* (2002**) reported that the superiority of tomato plants under greenhouse cover net maybe because it led to diffuse light and then increase radiation use efficiency, yields (both at the plant and ecosystem level), and even be a factor affecting plant growth. **Nissim-Levi *et al*. (2008)** added that shade netting increases light scattering but does not affect the light spectrum has been shown to increase branching, plant compactness and total leaf area per plant. The colored shade net can also increase light scattering by 50% or more and this alone may influence plant development and growth. On the other hand, black net reduce radiation reaching crops underneath. Obviously, the higher the shade factor in dark net color, the more radiation will be blocked. Reductions in radiation resulting from netting will affect the climatic conditions under net and will reduce the plant growth **(Stamps, 2008)**.

Moreover, referring to the different mixtures the results agreed with those reported by **Litterick *et al.* (2004)** who found that using organic compost can improve the physical, chemical and biological properties of a soil or of a growing medium. Physical properties of soil improve mainly due to the high organic matter content. It enhances soil structure, thereby increasing porosity, water holding capacity and infiltration. In addition, **Abd El-Kawy (2003)** found that using manure in soilless culture improve plant growth and yield under Egyptian conditions. Replacement of peat with moderate amounts of vermicompost produces beneficial effects on plant growth due to the increase on the bulk density of the medium, and to the decrease on total porosity and amount of readily available water in the pots **(Bachman and Metzger, 2007** and **Grigatti *et al*., 2007)**. Such changes in the physical properties of the substrates might be responsible for the better plant growth with the lower doses of compost and vermicompost as compared to the peat-based substrate. Furthermore, plant growth enhanced through the addition of vermicompost to a potting substrate or as a soil amendment. In addition, biologically active metabolites such as plant growth regulators and humates have been discovered in vermicomposted materials **(Atiyeh *et al.*, 2002)**.

3.5 The effect of cover and vermicompost mixtures on yield

The effect of different treatments on pepper yield was presented in **Table (6)**. Referring the effect of different net covers, data showed that using white net cover increased fruit weight and number of fruits per plant significantly, followed by without net cover (control) comparing with black net cover.

Regarding the effect of different mixtures on pepper yield, data showed that the highest number of fruits and fruits weight per plant was obtained by (Mix.20%) followed by (Mix.10%) and (Mix.30%) due to the high content of nutrients and organic matter of vermicompost. The lowest yield weight and number of fruits per plant was obtained by (Control) mixture during the two tested seasons. The content of vermicompost from essential nutrients could be resulted in increasing the yield; while the high rate of vermicompost (30%) decrease the yield as results of high EC and pH. The greatest plant growth responses and largest yields have usually occurred when vermicompost constituted only a relatively small proportion (10 – 20%) of the total volume of a greenhouse container medium mixture **(Subler *et al.,* 1998** and **Atiyeh *et al.,* 2000)**.

Regarding the interaction effect between different net covers and vermicompost mixtures, data showed that white net cover combined with (Mix.20%) increased yield significantly, followed by white net cover combined with (Mix.30%). The lowest yield was obtained by black net cover with (Control) mixture during the two tested seasons. The highest yield production under greenhouse cover net may be due to proper light distribution, which creates favorable conditions for plant growth, photosynthesis and metabolites translocation. Other possibility was increasing available water and nutrients uptake which ultimately accelerated the rate of vegetative growth and yield **(Abdrabbo, 2013)**. The increasing total yield under net maybe due to the plants don't suffer from the heat stress under the net, the plants has good vegetative growth, better pollination and finally higher yield **(Safia *et al.,* 2002)**.\

3.6 The effect of cover and substrate mixtures on mineral contents

According to the effect of different treatments on pepper, data in **Table (7)** showed that using white net cover led to increase N, P and K % contents of sweet pepper plants significantly, followed by free cover treatment, while the black net gave the lowest values because of the negative effect of high shading.

Regarding the effect of different mixtures on N, P and K percentage, data showed that there were significant differences between treatments during the two tested seasons. The highest N, P and K percentage were obtained by B mixture as normal results of applying vermicompost in the potting substrate. The high proportion of vermicompost 30% caused negative impact of sweet pepper’s mineral contents and that could be explained via the high EC and pH of substrate mixture.

The interaction effect between covers net and mixtures, data showed that white net cover combined with (Mix.20%) gave the highest N, P and K%. The lowest N, P and K% proceeded by black net cover with (Control) mixture. The obtained results agreed with those of **Kinet and Peet (1997); Safia *et al.* (2002)** and **Sato *et al.* (2006)** who concluded that cover the plants with white net led to improve the nutrient content more than white cover and open field. The general characteristic of the vermicomposts was that they have high electrical conductivity, indicating that they cannot be used individually as a substrate for growing plants, but as a component of the potting mixture. When mixing vermicomposts with peat and perlite, nutrient content decreased due to the dilution and kept nutrients within acceptable, or optimal, ranges for growing plants **(Tognetti *et al.,* 2005)**. Differences in growth responses were attributed to differences in nutrient content of potting mixes. Although, the present study was focused more on effects of vermicomposts on plant growth rather than on causes leading to these effects, the results indicated that availability of nutrients is an important factor influencing plant growth **(Lazcano *et al.,* 2009)**. But, changes in physical and biological properties of the substrate could also be responsible for observed differences **(Tringovska and Tsvetanka, 2012)**.

4. Conclusion

While the main target of this study is develop ecology urban horticulture under Egyptian conditions for helping the society in improving the life style, also the study provides some technical information. Vermicomposting can be applicable method for recycling urban organic wastes with high efficiency use. Vermicomposting presented an environmental method for producing organic substrate to improve physical and chemical properties of substrate culture in urban horticulture. Modifying urban horticulture under Egyptian conditions via vermicomposting and green roof for producing food instead of incineration the urban organic wastes or imported food from rural areas and to mitigate CO_2 emissions. This study suggests mixture of perlite:peat moss:vermicompost (40:40:20 V/V/V) and cover the plants with white net to have the best production under soilless conditions during the summer season. More studies should be done on vermicomposting of different urban organic wastes and using more net colors beside special studies on environmental, economic and energy impacts of urban horticulture and vermicomposting under climate change conditions.

5. Acknowledgment

This study was promoting by the activities of "Integrated environmental management of urban organic wastes using vermicomposting and green roof (VCGR) project" funded by Science and Technology Development Fund, Egypt, by providing the vermicompost.

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Table (5): Effect of different vermicomposting mixtures and covers on vegetative growth characteristics of sweet pepper in substrate culture.

Net cover treatments	First season (Summer 2012)					Second season (Summer 2013)				
	Mix. 10 %	Mix. 20 %	Mix. 30 %	Control	Mean	Mix. 10 %	Mix. 20 %	Mix. 30 %	Control	Mean
	Plant height (cm)									
Black	52.3 e	67.0 a	61.0 b	44.6 g	56.3 A	55.5 e	71.0 a	64.0 b	44.6 g	59.6 A
White	44.6 g	58.6 c	53.6 de	42.3 h	49.8 B	47.2 g	62.2 c	56.8 de	42.3 h	52.8 B
Without	39.8 i	54.1 d	47.8 f	39.8 i	45.4 C	42.2 i	57.4 d	50.7 f	38.6 i	47.2 C
Mean	45.6 C	59.9 A	54.2 B	42.3 D		48.3 C	63.5 A	57.4 B	43.6 D	
	No. of leaves									
Black	67.3 cd	81.6 b	64.3 d	39.3 f	63.2 B	71.6 cd	86.6 b	68.3 d	41.6 f	67.1 B
White	68.0 cd	88.0 a	73.3 c	51.6 e	70.2 A	72.0 cd	93.0 a	77.6 c	54.6 e	74.3 A
Without	57.6 e	73.3 c	64.6 d	37.0 f	58.2 C	61.0 e	77.6 c	68.6 d	39.0 f	61.5 C
Mean	64.3 B	81.0 A	67.4 B	42.6 C		68.2 B	85.7 A	71.5 B	45.1 C	
	Plant fresh weight (g)									
Black	177. e	363 d	240 d	161 e	210 C	188 g	279 e	252 f	171 g	222 C
White	394 b	442 a	356 c	265 d	364 A	428 b	468 a	378 c	281 e	388 A
Without	350 c	393 b	347 c	241 d	333 B	388 c	417 b	347 d	256 ef	352 B
Mean	307 B	366 A	314 B	222 C		335 B	388 A	326 B	236 C	
	Plant dry weight (g)									
Black	18.6 f	30.3 e	30.6 e	19.0 f	24.6 C	19.7 e	32.1 d	32.4 d	20.1 e	26.1 C
White	42.0 bc	47.3 a	36.0 d	32.6 de	39.5 A	44.8 b	50.3 a	38.2 c	34.6 cd	41.9 A
Without	40.6 c	44.3 b	33.3 de	31.3 e	37.4 B	43.5 b	46.9 ab	34.7 cd	33.2 d	39.6 B
Mean	33.7 B	40.6 A	33.3 B	27.6 C		36.0 B	43.1 A	35.0 B	29.3 C	

Table (6): Effect of different vermicomposting mixtures and covers on yield of sweet pepper in substrate culture.

Net cover treatments	First season (Summer 2012)					Second season (Summer 2013)				
	Mix. 10 %	Mix. 20 %	Mix. 30 %	Control	Mean	Mix. 10 %	Mix. 20 %	Mix. 30 %	Control	Mean
	Yield / plant (g)									
Black	435 g	542 f	423 i	383 i	446 C	531 g	574 e	488 h	406 i	490 C
White	725 b	823 a	682 c	537 f	692 A	769 b	873 a	723 c	570 e	733 A
Without	582 e	743 b	618 d	433 g	594 B	684 d	787 b	655 d	459 f	646 B
Mean	581 B	703 A	574 B	451 C		661 B	745 A	609 C	478 D	
	No. of fruits / plant									
Black	7.90 g	9.80 f	7.61 i	6.90 i	8.10 C	8.38 g	10.4 f	8.15 i	7.39 i	8.59 C
White	13.2 b	14.9 a	12.4 c	9.8 f	12.6 A	13.9 b	15.8 a	13.1 c	10.4 f	13.3 A
Without	10.6 e	13.5 b	11.3 d	7.9 g	10.8 B	11.2 e	14.3 b	11.9 d	8.69 g	11.4 B
Mean	10.5 B	12.7 A	10.4 B	8.2 C		11.2 B	13.5 A	11.1 B	8.69 C	

Table (7): Effect of different vermicomposting mixtures and covers on vegetative growth characteristics of sweet pepper in substrate culture.

Net cover treatments	First season (Summer 2012)					Second season (Summer 2013)				
	Mix. 10 %	Mix. 20 %	Mix. 30 %	Control	Mean	Mix. 10 %	Mix. 20 %	Mix. 30 %	Control	Mean
	N (%)									
Black	1.43 f	2.16 cd	1.80 e	1.23 g	1.65 C	1.52 f	2.29 cd	1.91 e	1.30 g	1.75 C
White	2.16 cd	2.96 a	2.60 b	1.56 f	2.32 A	2.29 cd	3.14 a	2.75 b	1.66 f	2.46 A
Without	2.06 d	2.83 a	2.30 c	1.60 f	2.20 B	2.19 d	3.00 a	2.43 c	1.69 f	2.33 B
Mean	1.88 C	2.65A	2.23 B	1.46 D		2.00 C	2.81 A	2.36 B	1.55 D	
	P (%)									
Black	0.46 e	0.51 d	0.57 c	0.36 h	0.47 C	0.49 d	0.54 c	0.45 d	0.38 e	0.46 C
White	0.52 d	0.78 a	0.64 b	0.40 g	0.58 A	0.55 c	0.85 a	0.68 b	0.48 d	0.64 A
Without	0.51 d	0.76 a	0.44 ef	0.42 fg	0.53 B	0.55 c	0.81 a	0.53 c	0.45 d	0.58 B
Mean	0.49 C	0.68 A	0.55 B	0.39 D		0.53 B	0.73 A	0.55 B	0.44 C	
	K (%)									
Black	2.34 e	2.39 e	2.62 cd	2.14 f	2.37 C	2.48 e	2.53 e	2.77 cd	2.27 f	2.52 C
White	2.056 d	3.21 a	3.00 b	2.34 e	2.77 A	2.71 d	3.40 a	3.18 b	2.48 e	2.94 A
Without	2.64 cd	2.70 c	2.70 c	2.40 e	2.61 B	2.80 cd	2.87 c	2.86 c	2.54 e	2.67 B
Mean	2.52 B	2.76 A	2.77 A	2.29 C		2.66 B	2.92 A	2.93 A	2.43 C	