Egyptian Journal of Horticulture

https://ejoh.journals.ekb.eg/

جمعية الفلاحة البساتين المصرية
THE EGYPTIAN HORTICULTURE SOCIETY

Sustainable Ecology Strawberry Production Via Different Soilless Culture Techniques Under Urban Conditions

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THIS study was conducted at Central Laboratory for Agriculture Climate (CLAC), Agriculture Research Center, Dokki, Giza, Egypt during two successive seasons of 2018/2019 and 2019/2020 under open field urban conditions. The study investigated the effect of using as well as the efficiency of different soilless culture techniques including substrate culture systems; container, pots and horizontal bags beside two systems of nutrient film technique (NFT); vertical A shape and flat in a close system on vegetative growth and production of strawberry plants grown under open field conditions in urban area. Standard substrate used in all systems was peat moss: perlite (1:1 *v/v*). Planting densities differed regarding each used soilless system specifications.

Illustrated that, used substrate systems gave the highest vegetative growth characteristics, yield parameters, N, P and K contents of strawberry leaves as well as the highest water and power use efficiencies compared to NFT systems. The ecology sustainable agriculture of strawberry under urban conditions could achieved by implement substrate culture in general. Amongst substrate culture systems container system recorded the highest vegetative growth characteristics but the highest yield was attained by bags system . All substrate systems had the highest values of N, P and K contents of strawberry leaves compared to NFT systems. The study recommended that bags substrate system which recorded the highest yield per m^2 (average 15.2 kg/m^2), average PUE (2.4 kg/kw) and WUE (43.7 kg/m^3) with an economic value followed by container system under urban conditions could be used for producing strawberry sustainably and ecologically.

Keywords: Soilless culture Techniques, Urban areas, Water use efficiency (WUE), Power use efficiency (PUE), Strawberry, Climate change and food security.

Introduction

Generally, strawberry plants are cultivated under open field conditions and low-tunnels in commercial farms as a high profit yield (Karlsson and Werner, 2011, Demchak and Hanson, 2013). The price of strawberry in the early season is expensive while the shelf life of strawberry fruits is short. Special procedures, managements and transactions are highly required for profitability producing strawberry commercially. Producing strawberry under urban conditions as a self-production will reduce the yield waste while neglect the unmarketable yield. The contribution of urban horticulture for producing strawberry as well as leafy vegetables create more resilience city for climate change negitive impacts.

Urban horticulture had a good sounds concerning sustainability, food security, climate change impacts and environmentally. The dramatic increase of population and urbanization led to rise the food demand while the aggressive exhaustion or shortage of natural resources and climate change impacts (currently and expected) created the driving forces to pay more attention

for sustainable urban horticulture (Abul-Soud 2015). Micro-scale farms (urban farms) may play a vital role in the near future to provide food and to address the impact of climate change on agricultural production, especially under conditions of urban expansion and population increase. The urban soil cultivation performed many environmental risks due to contamination effect of trace and heavy elements in urban soils (Sharma et al., 2009, Temmerman et al., 2009, Nabulo et al., 2010, Säumel et al., 2012 and McBride et al., 2014). plus human health risk assessment of vegetables consumed from contaminated urban soil and foodborne pathogens (Sharma et al., 2009, Nabulo et al., 2012, Säumel et al., 2012, Lagerkvist et al., 2013, Nicklett and Kadall, 2013 and Swartjes et al., 2013). The role of urban agriculture in sustainable agriculture production and food security under urban and semi-urban areas were investigated increasingly during the last two decades (Hara et al., 2013, Abul-Soud et al., 2014, Rego 2014, Wertheim-Heck et al., 2014, Abul-Soud & Mancy, 2015, Abul-Soud 2015 and Bvenura & Afolayan 2015).

Soilless culture as a flexible modern technology is a sustainable and environmental production method for production of some crops without soil with reducing the use of hazard agricultural chemicals (fertilizers and pesticides) in addition to increase water use efficiency. Soilless culture could be used on different scales from micro scale (urban farms) up to mega scale (commercial greenhouse farms). Further soilless production system were implement for many centuries to grow crops where no suitable soil exists or where the soil is contaminated in some manner (Raja et al., 2018), while recently extended to the contribution in food production under urban conditions and the expacted climate change negitive impacts. Soilless culture provide the use of different technologies (from simple to smart automation), intensive systems, production area, production methods (open field, urban and greenhouse) and initial investments. Bradley and Marulanda (2000) reported the use of simplified hydroponic technology which reduces the land requirement for crops by 75% or more and water used by 90% with negligible effect on environment.

Paranjpe et al. (2003), Cecatto et al. (2013) and Miranda et al. (2014) investigated the effect of cultivating of different strawberry varieties in different soilless culture systems. Soilless culture

have a beneficial environmental impacts through reducing the used of agriculture chemicals while maximizing the water use efficiency and offer the potential for cultivated poor soils as a sustainable manner. The strawberry yield was higher in soil cultivation method while soilless culture mehtods were superior in the fruit quality. Many researchers studied the strawberry production in different soilless culture systems Paranjpe et al. (2003), Rabeea et al. (2013) and Tredar et al. (2015) under outdoor and greenhouse conditions to avoid the environmental issue of soil fumigation, production problems and climate change impacts while maximizing the water, fertilizer and land use efficiencies as well as the fruit yield and the quality. There were arguments among the scientists concerning the quantity and quality of strawberry yield when grown under soilless culture systems compared to soil cultivation**.** Abul-Soud et al. (2019) provided the relationship between the sustainable agriculture production in hydroponic system and power use efficiency while the power use efficiency in soilless culture play the same important role of water use efficiency in convential soil culture. Soilless culture characterized by high water use efficiency regarding to minimizing the evaporation and prevent precolation and runoff compared to conventional methods of cultivating strawberry that need a hugh requirments of irrigation water (Evon & Seidhom 2009, Létourneau et al., 2015 and Martínez-Ferri et al., 2014).

The current study aimed to investigate the vegetative growth and fruit yield of strawberry plants grown under open field conditions in urban area as affected by different sustainable, environmental and the profitable soilless culture techniques.

Materials and Methods

The study was conducted in the experimental unit of Central Laboratory for Agricultural Climate (CLAC), Agriculture Research Center (ARC), Dokki, Giza, Egypt, during two autumn seasons of 2018/2019 and 2019/2020 in different soilless culture techniques under open field conditions in urban area.

Plant material
Fresh strawberry seedlings (bare roots seedlings) *Fragaria × ananassa* Duch. *cv.* Festival F1 hybrid were cultivated under the experiment conditions. Strawberry seedlings were cultivated at the middle of September in both autumn

seasons of 2018 and 2019 in all different soilless culture systems. Plant density of strawberry varied from 20 to 24 seedlings/m² depending on different specification soilless culture system (Ahmed S. H., 2010, Noha.G.abd-Elrahman 2011, Abul-Soud et al., 2015). Strawberry seedlings cultivated directly in substrate systems (Pot, bag and bed). While in NFT systems (vertical A-shape and Flat), the seedlings cultivated in holed plastic cup (size 11 cm) filled by peat moss + perlite (1 : 1 v/v). Mist system covering all soilless culture systems was operating the first growth month until the middle of October to help the seedlings for better growth and decrease the high temperature impact. Mist system work daily 8 times by digital timer (each time 10 min./hr) for one month in both cultivated seasons.

All other agriculture practices for strawberry cultivation were carried out in accordance with the standard recommendations for commercial strawberry production by Agriculture Research center (ARC), Ministry of Agriculture (MOLAR), Egypt. (Agrecultural Technical Bulltins, 2003).

System materials
Substrate systems
Alumetal tables (0.6 x 1 x 2 m) constructed with steel net (5 x 5 cm) covered by black polyethylene sheet (0.6 mm) to collect the leaching of each system were used. Each alumetal table had a tank with a capacity of 120 L of nutrient solution and located in slope 1 % with drainage PVC pipe for recollecting the drainaged nutrient solution to the tank to presented close system of substrate culture. The nutrient solution was pumped via using submersible pump (40 watt) for each alumetal table. Plants were irrigated by using drippers 4 L/hr. The fertigation schedule was programmed to work during the day 4 - 8 times per day in substrate systems depended upon the season and growth stage via digital timer (each time 10 min./hr). The standard substrate peat moss: perlite (1:1 *v/v*) was used in all substrate systems as follows:

• Pots system, vertical plastic pots (6 L volume) were filled with standard substrate. The pots arranged in four rows (10 pots/row) to performed 40 plants / tables (one strawberry seedling /pot) to presented plant density 20 plants /m².

• Bags system, horizontal polyethylene (0.2 mm thickness) bags (0.25 x 1 m = 35 L volume) were filled with standard substrate. The polyethylene bags holed at the bottom along the bag to allow leaching. The bags arranged in four rows (2 bags/row). Six strawberry seedlings were cultivated in each bags. The final plant density 24 strawberry plants /m².

• Containers system, container was created by using black polyethylene sheet (0.6 mm). The bed system (1 x 2 x 0.15 m) filled by 300 L of standard substrate. The strawberry seedlings cultivated in four rows, the plant distance was 20 cm in the row, 25 cm among the rows to presented plant density 20 plants /m². The container system mulched by silver/black polyethylene sheet (0.2 mm).

Hydroponic systems
Nutrient film technique (NFT) through two systems were implemented. Three metal frames were used to perform A-Shape as a vertical NFT system unit and horizontal system unit. Each NFT system unit (1 x 3 m) had a tank with capacity of 180 L and located in slope 1 % for collecting the drainaged nutrient solution by gravity. The nutrient solution was pumped via using submersible pump (80 watt) for each NFT unit. Plants were irrigated by using polyethylene pipe 4 mm. The fertigation schedule was programmed to work during the day 24 - 30 times per day depended upon the season and growth stage via digital timer (each time 10 min./hr).

• Flat NFT, Five PVC pipes (110 mm) on horizontal scale of metal frame were applied. The plant distance between the plants was 25 cm created plant density 20 strawberry plants / m².

• A-Shape NFT, Three levels of PVC pipes (110 mm) on each side of A-shape metal frames (the width 0.9 and height 1.3 m). The plant distance between the plants was 25 cm created plant density 24 strawberry plants / m².

Chemical nutrient solution (Abul-Soud et al., 2017) were applied as illustrated in Table 1. The electrical conductivity (EC) of nutrient solution for all soilless culture systems was adjusted by using digital EC meter to the required level (2.0 dsm⁻¹).

TABLE 1. The chemical composition of nutrient solution used.

Chemical nutrient solution	Macronutrients (ppm)					Micronutrients (ppm)					
	N	P	K	Ca	Mg	Fe	Mn	Zn	B	Cu	Mo
	180	45	300	170	60	3.0	0.8	0.4	0.5	0.25	0.02

The investigated treatments

The current consists of 5 treaments as follows:

- Pot substrate (Pots), plant density 20 plants/ m2.
- Bag substrate (Bags), plant density 24 plants/ m2.
- Container substrate (container), plant density 20 plants/m2.
- Flat NFT, plant density 20 plants/m2.
- A-shape NFT (A-NFT), plant density 24 plants/m2.

The plant densities of different soilless culture systems were not the same according to the different specifications and the construction of each system. (Ahmed S. H., 2010, Noha.G.abd-Elrahman 2011, Abul-Soud et al., 2015)

The experiments were led in a complete randomized blocks design with 3 replicates.

The measurements
The vegetative and yield characteristics

At 120 days from the transplanting date, the vegatative growth characteristics were measured as follows: No. of leaves/plant, total leaves area (cm2) and No. of crowns/plant. While early and total yield (Kg/plant and Kg/m2), average fruit weight (g)and average No. of fruit/plant. In addition total soluble solids (TSS %) were recorded using hand refractometer (Model HRT 18-T) at the end of both cultivated seasons.

The chemical analysis

Elemental strawberry leaves contents N, P and K were determinded. Three plant samples (15 full expended leaves) were randomly selected from each replicate. Then dried at 70 °C in an air forced oven for 48 h. Dried strawberry leaves samples were digested in mixture of $HClO_4$ and H_2SO_4 acids according to the method described by Allen (1974)**.** Phosphorus and potassium contents were estimated in acid digested solution by colorimetric method (ammonium molybdate) using spectrophotometer (Model T80 douple beam UV/Vis England)and photo-metrically using flame photometer (Model 410 coming England), respectively, as described by Chapman and Pratt, (1961). Whereas, total nitrogen was determined by Kjeldahl (Model UDK139 Italy) method according to the procedure described by FAO (1980).

The environmental and economic study

Water use efficiency (WUE) of different soilless culture systems was calculated regarding

to the average of both two seasons according to FAO (1982) as follows: The ratio of crop yield (Y) to the total amount of irrigation water used for the growth season (IR);

WUE (kg/m^3) = Y (kg) / IR (m^3).

Average water use efficiency and seasonal water consumption were determined at the end of the both two seasons.

Power use efficiency was calculated according to pump power (watt) x operation hours/day (1.33 and 5 hr/day for substrate and NFT systems respectively) x 240 (No. of days/season), while the cost of kw is currently equal 0.55 LE (Abul-Soud et al., 2019).

The power use efficiency (kg / kw / season) = the average yield (kg /m² /seasons) / the average power use / m² / season of both seasons (Abul-Soud et al., 2019).

The economic impact assessment was calculated regarding to standard system area 6 m². The investament cost take in consider the cost of each system (pumps, metal frames, tanks, plastic, substrate, timers and irrigation network) / Annual depreciation rate. The operation cost include the nutrient solution, IPM and power use.

The statistical analysis

Analysis of the obtained data was done by computer, using statistical analysis software program (SAS). The differences among means oftreatments were tested for significance at 5 % level of probability using Duncan's multiple range test according to the method described by Snedicor and Cochran (1981).

Results

The effect of different soilless culture systems on strawberry plant

Vegetative growth characteristics

Data presented in Table 2 showed the effect of different soilless culture systems on vegetative characteristics of strawberry plants grown under open field conditions in urban area during both seasons. The obtained results indicated sharply that substrate systems had a positive significant effect on the vegetative growth characteristics of strawberry plants compared to NFT systems (hydroponic). Container substrate system gave the highest No. of leaves/plant and total leaves area No. of crowns followed by pots substrate system.

On the other hand, the lowest values of No. of leaves/plant and No. of crown was recorded by flat NFT system while the lowest total leaves area was attained by A-shape NFT .

Substrate systems offered better conditions for vegetative growth of strawberry plant by conserve moisture and nutrients as well as root zone temperature compared to hydroponic systems of NFT.

Yield parameters

In general, substrate systems had a superior significant difference on strawberry yield than NFT systems. However, substrate systems recorded the highest significant values of early yield and total yield per plant (g) and per m^2 (kg), respectively, in both cultivated seasons compared to hydroponic systems and these may be due to better vegetative growth characteristics as shown in Fig. 1, 2, 3 & 4. Bags substrate system presented the highest value of early yield per plant (g) and per m^2 followed by container substrate system

while the lowest values were recorded by A-shape NFT as demonstrated in Fig. 1 & 2.

Th results shown in Fig. 3 Indicated that container substrate system resulted the highest values of total yield per plant (g) in both cultivated seasons of 2018/2019 and 2019/2020 followed insignificantly by bags system in the second season only. Pots substrate system, instead of the lowest results of early yield per plant and per m^2, the total yield per plant was strongly increased during the last three months of strawberry growth season.

Regarding to total yield per m^2 (kg), the plant density played a role in change the final results of total yield per m^2. Although container system recorded the highest value of total yield per plant but bags system gave the highest significant total yield per m^2 records in both cultivated seasons followed by container system. Similar results gained by hydroponic systems while flat NFT had the lowest values of total yield per m^2 as illustrated in Fig. 4.

TABLE 2. The effect of different soilless culture systems on vegetative characteristics of strawberry plants grown under open field conditions in urban area during both seasons.

Soilless system	First season 2018/ 2019			Second season 2019 / 2020		
	No. of leaves	Total leaves area (cm²)	No. of crowns	No. of leaves /	Tot. leaves area (cm²)	No. of crowns
Pots	26.3 b	2005.7 b	4.7 ab	32.0 b	2105.0 b	4.3 b
Bags	22.0 c	1737.0 c	4.0 bc	28.0 c	1551.8 c	4.0 b
Container	34.7 a	2641.3 a	5.0 a	35.3 a	2505.2 a	5.0 a
Flat NFT	15.0 d	1450.0 d	3.7 c	16.7 d	1289.5 d	4.0 b
A-shape NFT	15.3 d	1261.7 d	4.0 bc	17.7 d	1200.7 d	4.0 b

Means within each column followed by the same letter are not significantly different (P≤0.05) according to Duncan's multiple range test.
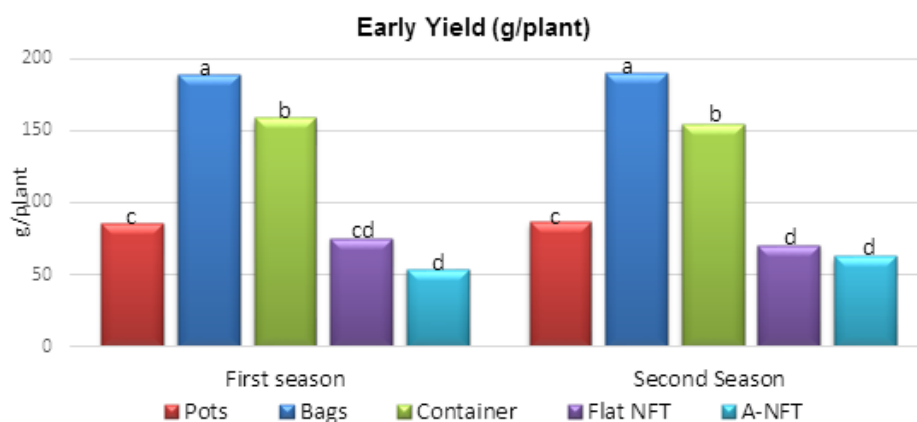

Fig.1. The effect of different soilless culture systems on the early yield (g/plant) of strawberry plants grown under open field conditions in urban area during both seasons

Moreover, Table 3 presented the effect of different soilless culture systems on yield parameters of strawberry plants grown under open field in urban area. Bags substrate system gave the highest values of average fruit weight in both cultivated seasons. In the same respect container system recorded the highest values of average No. of fruit / plant and TSS (%) followed by bags substrate system. Whereas, the lowest records obtained by A-shape NFT system in both seasons of study Achieving significantly between the treatments as shown in Table (3).

N, P and K contents

Substarte culture systems illustrated supereme effect on the N, P and K contents of strawberry leaves. The highest water and nutrient holding capacity of standard substarte peat moss : perlite (1:1 *v/v*) led to an increase of N, P and K uptake compared to NFT systems. Substarte culture systems recorded the highest values of N, P and K contents of strawberry leaves without a significant difference among them, while NFT systems gave the lowest significant values in both cultivated seasons as presented in Table 4.

The Environmental impact assessment of different soilless culture systems

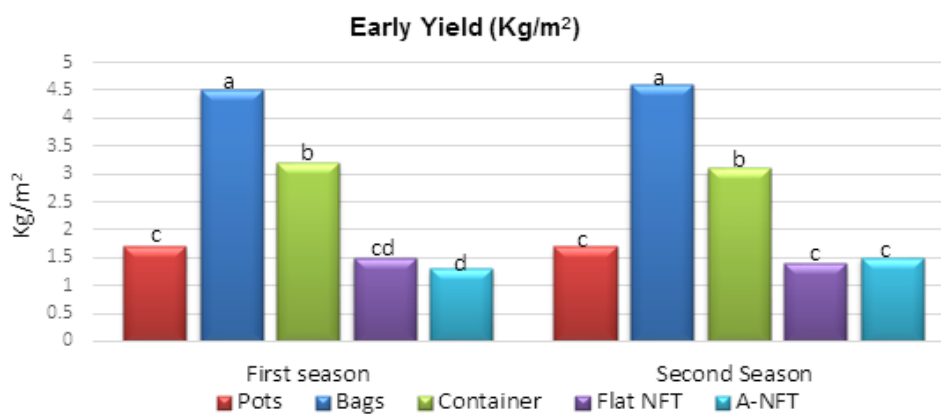*The water use consumption and efficiency*

The average water consumption (L/m²)

Fig. 2. The effect of different soilless culture systems on the early yield (kg/m²) of strawberry plants grown under open field conditions in urban area during both seasons.
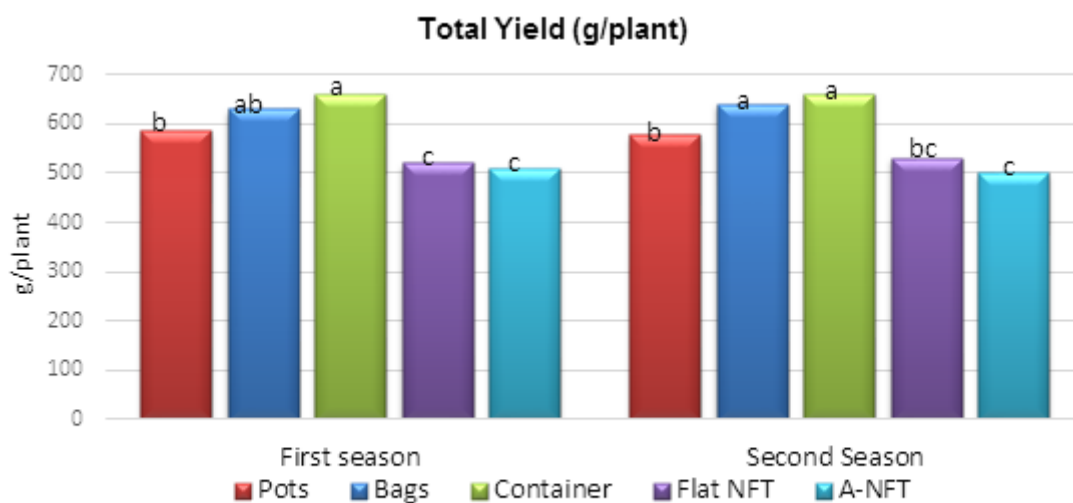

Fig. 3. The effect of different soilless culture systems on total yield (g/plant) of strawberry plants grown under open field conditions in urban area during both seasons.
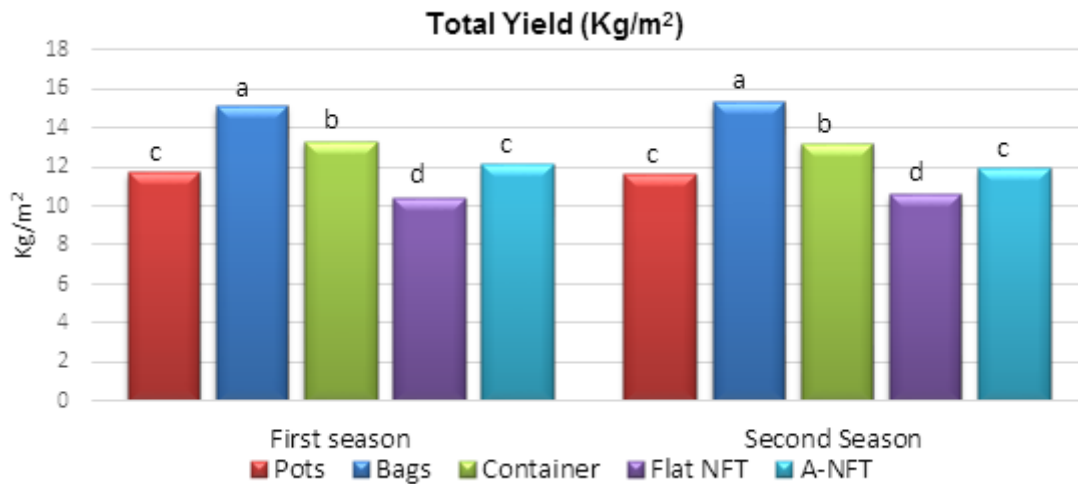
Fig. 4. The effect of different soilless culture systems on on the total yield (kg/m2) of strawberry plants grown under open field conditions in urban area during both seasons.

TABLE 3. The effect of different soilless culture systems on yield parameters of strawberry plants grown under open field conditions in urban area. during both seasons.

Soilless system	First season 2018 / 2019			Second season 2019 / 2020		
	Av. Fruit weight (g)	Av. No. of fruits / Pl.	TSS (%)	Av. Fruit weight (g)	Av. No. of fruits / Pl.	TSS (%)
Pots	17.8 b	32.7 b	5.7 c	17.7 b	36.3 a	5.8 c
Bags	19.3 a	33.7 b	6.1 b	19.3 a	33.3 b	6.4 b
Container	16.7 c	37.3 a	6.6 a	19.1 a	35.0 a	6.7 a
Flat NFT	18.5 ab	32.3 b	5.0 d	18.4 ab	32.0 b	5.2 d
A-shape NFT	16.9 c	30.0 c	4.8 d	17.4 b	28.7 c	5.2 d

Means within each column followed by the same letter are not significantly different (P≤0.05) according to Duncan's multiple range test.

TABLE 4. The effect of different soilless culture systems on N, P and K contents of strawberry leaves grown under open field conditions in urban area during both seasons.

Soilless system	First season 2018 / 2019			Second season 2019/ 2020		
	N (%)	P (%)	K (%)	N (%)	P (%)	K (%)
Pots	2.50a	0.41 a	1.41 a	2.81 a	0.48 a	1.46 a
Bags	2.77 a	0.47 a	1.48 a	2.82 a	0.50 a	1.48 a
Container	2.78 a	0.45 a	1.49 a	2.85 a	0.52 a	1.51 a
Flat NFT	2.31 b	0.39 b	1.39 b	2.35 b	0.40 b	1.38 b
A-shape NFT	2.23 b	0.36 b	1.35 b	2.28 b	0.38 b	1.36 b

Means within each column followed by the same letter are not significantly different (P≤0.05) according to Duncan's multiple range test.

of different soilless culture systems grown strawberry under urban condition during the two cultivated seasons shown in Fig. 5. Container substrate system recorded the highest water consumption value while the lowest value gave by flat NFT as a result of minimizing the evaporation through the used PVC pipes compared to container system and other soilless culture systems.

Referring to the most sustainable agriculture factor, Fig. 6 illustrated the effect of different soilless culture systems on the average of water use efficiency (kg/m^3) of strawberry plants. The highest significant average of water use efficiency demonstrated by bags system as a result of high strawberry yield while pots system gave the lowest average of water use efficiency without significant differences with the rest of soilless systems.

The power use cost assessment and efficiency

Fig. 7 showed the average total power (kw/m^2) consumed by different soilless culture systems for strawberry plants and their average cost (LE/m^2) under urban area during the two
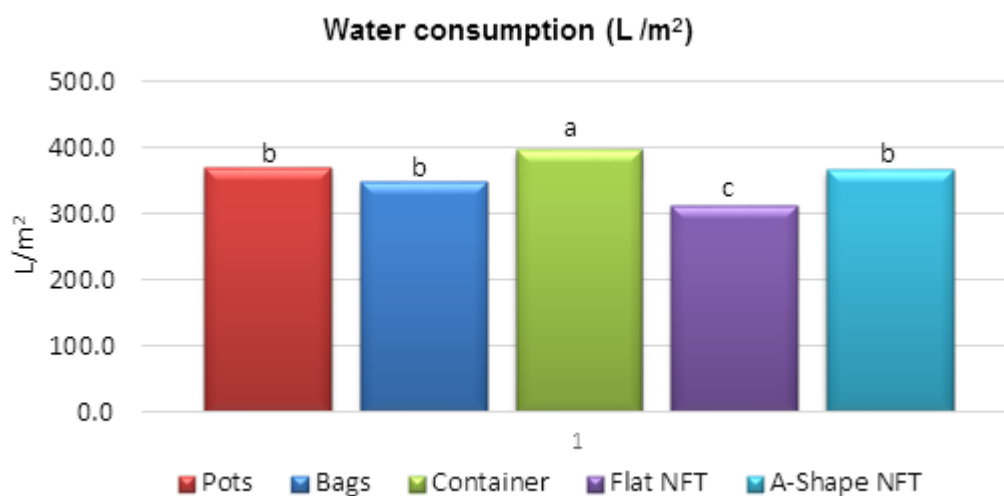

Fig. 5. The average water consumption (L/m²) of different soilless culture systems for strawberry plants grown under open field conditions in urban area during both seasons.
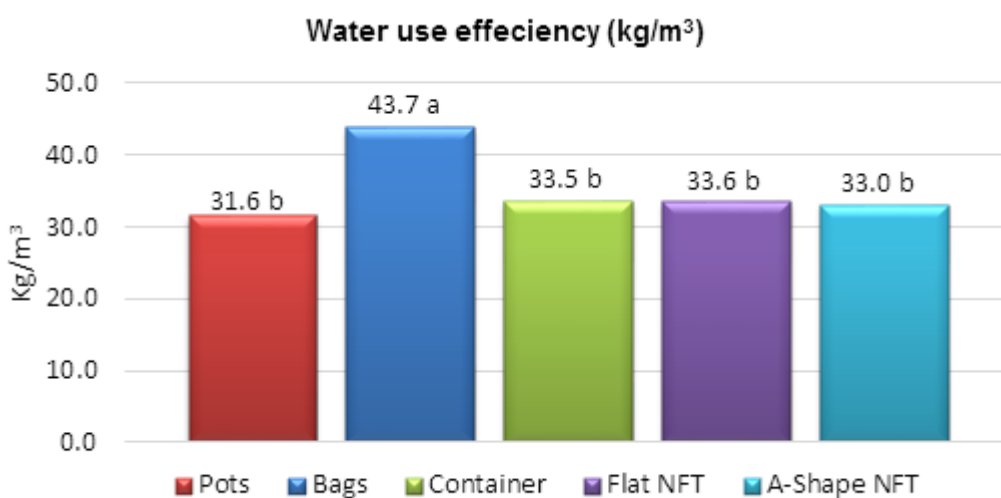

Fig. 6. The average water use efficiency (kg/m3) of different soilless culture systems for strawberry plants grown under open field conditions in urban area during both seasons.

cultivated seasons. The obtained data indicated that both hydroponic systems (Flat and A-shape NFT) consumed more power and higher cost than substrate systems which reflected on the power use efficiency. Hydroponic systems presented the highest values of average total consumed power and power cost during both cultivated seasons. Reducing the power use had not a just economic benefit but also led to increase the sustainable ecology agriculture under urban areas via reduce the environmental pollution and green house gas's (GHG's).

Concerning the average power use efficiency (kg/kw) of different soilless culture systems,

substrate systems had a different direction in the contrary to the previous results which recorded the highest values of average power use efficiency compares to NFT systems. Bags substrate system had the highest significant value of average power use efficiency followed by container system while the lowest values were recorded by flat NFT system followed by A-shape NFT as shown in Fig. 8.

The economic impact assessment

The obtained results shown in Table 5 indicated that the use of different soilless culture systems either substrates or NFT didn't achieve the economic profitable impact of growing
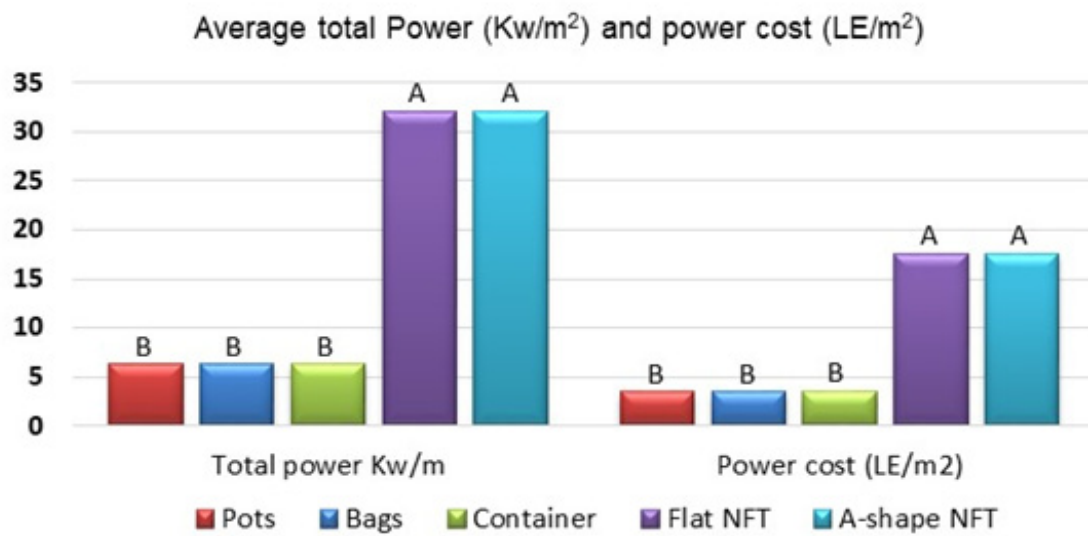

Fig. 7. The average total power (kw/m2) and cost (LE/m2) of different soilless culture systems for strawberry plants grown under open field conditions in urban area during both seasons.
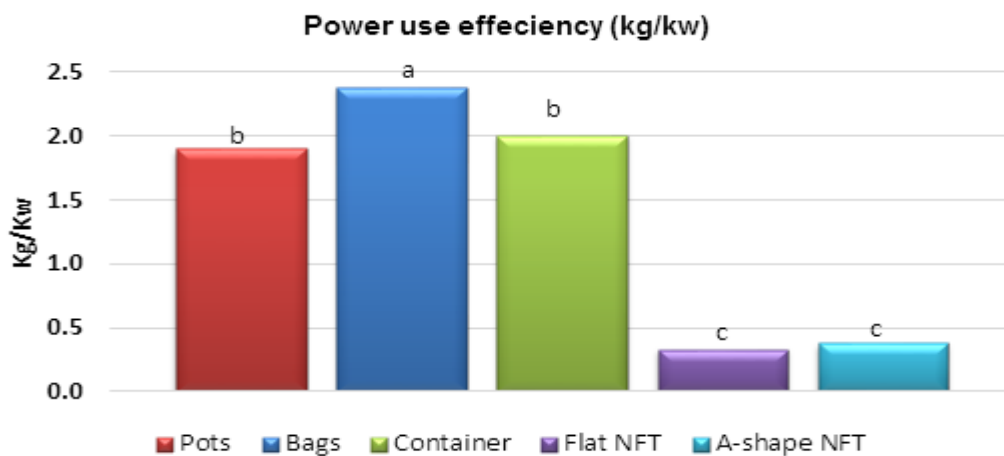

Fig. 8. The average power use effieciency (kg/kw) of different soilless culture systems for strawberry plants grown under open field conditions in urban area during both seasons.

strawberry under open field conditions in urban area except for bags substrate system only.

Bags substrate system yielded the highest net return and net profit regarding to its result of the highest yield although it recorded the highest total cost.

Substrate systems had the highest cost and total cost compared to A-shape NFT system however, it gave the highest operation cost regarding to the nutrient solution and power use cost. The highest investment cost of substrate systems regarding mainly to the high cost of standard substrate and short depreciation period.

Concerning the net profit as presented in Table 5, the lowest values of net profit gained by pots substrate system followed by flat NFT system.

Discussion

Providing the optimum conditions for growth and yield of strawberry plants under open field conditions is not easy while strawberry plant is very sensitive crop. Soilless culture is a method to avoid soil distenfiction, physical and chemical prooperties problems of soil and water shortage while provide optimum conditions for roots and vegetative growth for maximum yield with coserve the envirobmental and sustainable objectives.

The relation between vegetative growth and yield is not always positive relationship. Container substrate system performed the highest vegetative growth characteristics and early and total yield per plant but didn't recorded the highest early and total yield per m2 by the same rate regarding to the lower plant density compared to bags susbstrate system. These results agreed with Hochmuth et al. (1998).

The volume of substrate in substrate systems play a role in increase the vegetative growth, yield, N, P and K contents of strawberry leaves compared to NFT systems. The substrate volume per plant in in substrate systems ranged among pots 6 L, bags 5 L, container 7.5 L while both NFT systems were 0.2 L. The increase of substrate volume led to increase the root zone volume, water and nutrient holding capacities as well as more balance for root zone tremperature and moisture that provide a favorable environment for promoting strawberry root growth leading to an increase in the absorption of nutrients (Kumar & Dey 2011 and Vaughn et al., 2011). El-Behairy et al. (2001) investigated the use of A-shape NFT to produce different vegetable crops included strawberry under open field conditions, the strawberry yield per plant was not satisfied but because of higher plant density compared to soil cultivation, the strawberry yield per area unit became satisfied.

Bags substrate system gave the highest early yield per strawberry plant and per m^2 while the container system recorded the highest total yield per plant. Also, both NFT systems (flat and A-shape) illustrated the lowest early yield per plant and per m^2 comparing to substrate systems but later during the strawberry seasons, the total yield per plant and per m^2 increased dramatically. The soilless culture systems which offer the optimum growth conditions for the bare root strawberry seedlings success to present the highest yield. On the other hand, the need to stable continous strawberry production through the growing season is more importance than the highest yield under urban conditions to offer the food security and accessability.

TABLE 5. The economic impact of strawberry plants grown in different soilless culture systems under open field conditions in urban area.

Soilless system	Average cost and profitable impact (LE / 6 m²)						
	Investment costs	Operation cost	Total cost	Average yield (kg)	Price	Return	Net profit
Pots	242.2	161	403	69.9	5	349.5	**-53**
Bags	237.1	173	410	91.2	5	456	**46**
Container	241.8	167	409	79.5	5	397.5	**-11**
Flat NFT	183.1	172	355	63.1	5	315.5	**-39**
A-shape NFT	191.3	196	387	72.3	5	361.5	**-26**

The management of water irrigation during the strawberry growing season has a great importance not just on strawberry yield. Maximizing water use efficiency under soilless culture systems compared to traditional or even modern irrigation methods contributing to achieve the profitability and environmental sustainability of strawberry production. The minimum evaporation and leaching loss with maximum yield are the most vital factors for maximizing the water use effiency under soilless culture systems (Bradley & Marulanda, 2000, Evon & Seidhom 2009, Létourneau et al., 2015 and Martínez-Ferri et al., 2014).

The use of water pumps with higher capacity in flat and A-shape NFT systems (80 watt) for longer operation time use per day (5 hr / day) compared to different substrate systems (40 watt) and time use (1.33 hr. / day) affected strongly and significantly on power consumption and cost. The less power capacity and operation time combined with higher yield demonestrated the maximum power use efficiency that fulfillment by substrate systems. Abul-Soud et al. (2019) investigated the importance of power consumption and cost in soilless culture systems for performed the environmental sustainability of soilless culture in producing leafy vegetables. Power use effiency is the other face of water use efficency for sustainable food production under urban conditions and climate change impacts.

The study didn't take into account the direct and indirect economic impacts of urban cultivation through conserve water, soil, nutrients and energy, reducing the warm urban island, sequestrate air CO_2 and offer high nutritional values of fresh vegetables.

The economic benefits of urban agriculture was not extended only to food security and safety but also to food accessability by offer the opertunity for poor as well as the rich to access the food at the cricicle periods of strawberry (Abul-soud 2015).

Bags substrate system presented the highest early and total yield per m², power use efficiency, water use efficiency as well as the economic return impact.

Conclusion

The limitation of growing conventional strawberry, environmental issue, higher production cost and climate change impacts presented challenges that urban farming could contributed to face them via using soilless culture systems. Offering food with increasing the water and power use efficiencies are very irresistible for many researchers concerning sustainable urban agriculture.

How to produce strawberry sustainability and ecologically under urban conditions that the current study were provided. The study recommended the use of bags substrate system in producing strawberry to achieved the highest yield with economic and sustainable (water and power) impacts as well as offer stable continous production of strawberry during the growing season.

The need for investigations to develop the use of soilless culture systems espicially reducing the substrtae cost will provide more economic impact for container system. Also, enhence the power use efficiency of NFT systems and increase the plant density (increase the system hieght up to 5 levels and decrease the space among the plants to 15 – 20 cm) while improve the system itself by mixing between substrate and NFT systems should taken in consider and it open a new research area of intesrt.

The change of human behavoir towards the use of power and water under urban conditions is the driving force to promote the resilliance city under climate change impacts through urban agriculture via soilless culture systems and provide food security, safety and accessability. The use of renew energy to provide the power needs is highly neccessry.

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الإنتاج البيئي المستدام للفراولة عن طريق تقنيات الزراعه بدون تربة تحت الظروف الحضرية

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قسم بحوث الاساليب الزراعيه المغلقه ـ المعمل المركزي للمناخ الزراعي ـ مركز البحوث الزراعية ـ القاهرة ـ مصر.

تم اجراء التجربه في المعمل المركزي للمناخ الزراعي (CLAC) ، مركز البحوث الزراعية ، الدقي ، الجيزة، مصر خلال موسمين متتاليين ٢٠١٨/٢٠١٩ و ٢٠١٩/٢٠٢٠ تحت الظروف الحضرية المفتوحة. لدراسة تأثير استخدام وكفاءة تقنيات الزراعه بدون تربة بما في ذلك نظم الزراعه فى البيئات. الحاويات و الأصص والأكياس الأفقية (المخدات الأفقية) بجانب نظامين لتقنية الأغشية المغذية ؛ (مسطح و هرمى الشكل) في نظام مغلق على النمو الخضري وإنتاج نباتات الفراولة المزروعة في الحقول المفتوحة في المناطق الحضرية. البيئة القياسية المستخدمة في جميع الأنظمة هي البيت موس: البيرلايت (١: ١) (حجم / حجم). اختلفت كثافات الزراعة حسب مواصفات نظام الزراعه بدون تربة المستخدم. تم إجراء التجارب في تصميم قطاعات كاملة العشوائية.

اظهرت النتائج المتحصل عليها أن أنظمة البيئات المستخدمة أعطت أعلى صفات النمو الخضري ، معاملات المحصول ، محتويات النيتروجين والفوسفور والبوتاسيوم لأوراق الفراولة وكذلك أعلى كفاءة في استخدام المياه والطاقة مقارنة بأنظمة الأغشيه المغذية. يمكن تحقيق الزراعة البيئية المستدامة للفراولة في ظل الظروف الحضرية من خلال تنفيذ الزراعة فى البيئات بصفه عامه.

من بين أنظمة الزراعه فى البيئات ، سجل نظام الحاويات أعلى خصائص النمو الخضري ولكن أعلى محصول تم تحقيقه بواسطة نظام الأكياس الافقية. احتوت جميع أنظمة الزراعة فى البيئات على أعلى قيم لمحتويات N و P و K لأوراق الفراولة مقارنة بأنظمة الأغشية المغذية. أوصت الدراسة بأن افضل إستخدام لإنتاج الفراولة بشكل مستدام وبيئي هو نظام الاكياس الافقية الذي سجل أعلى إنتاجية لكل متر مربع (بمتوسط ١٥,٢ كجم / م ٢) ومتوسط كفاءة استخدام الطاقة (٢,٤ كجم / كيلو وات) و المياة (٤٣,٧ كجم / م ٣) اعلى قيمة اقتصادية ويتبعه نظام الحاويات في ظل الظروف الحضرية.