

# Are Hydroponics of Strawberry in Home Balconies a Promising Economic Technique?

DR. Rida DRAIE

Faculty of Agricultural Engineering, Idleb University, Syria

**Abstract** - Growing vegetables on home balconies is one of the most important techniques of hydroponics, where crops can be grown near the consumer and save time and cost in obtaining and securing them fresh. In this study, we tested the importance of growing strawberry plants on the home balcony, compared to field cultivation. Complete randomized block design was used. Three treatments of local strawberry cultivar (hydroponic in the peatmoss substrate, hydroponic in the perlite substrate and field cultivation in the soil) with three replicates per treatment were adopted. A simplified hydroponics model was designed and a closed nutrient solution system was used. Field plants were irrigated by drip method. Our results indicated that the hydroponics (peatmoss substrate) outperformed field cultivation in most studied traits (fruit length, number of fruits/m<sup>2</sup>, fruit weight, productivity/plant, yield/m<sup>2</sup>). Total production in hydroponics (peatmoss substrate) has tripled in comparison with the field cultivation. Hydroponics in the perlite substrate was delayed from field cultivation (control) in most studied traits, and delayed from hydroponics in the peatmoss substrate in all studied traits. Consequently, hydroponics in the peatmoss substrate on the home balconies is a suitable solution for the production of strawberries.

**Keywords:** Strawberry, Hydroponics, Balconies cultivation, Peatmoss, Perlite, Yield.

## I. INTRODUCTION

Hydroponics is based on crop production away from the traditional medium of agriculture (soil). In this technique, some materials are commonly used to support and maintain the root system. Plant nutrition is secured through a nutritional solution that is added to the culture medium. The materials used as a substrate may be made of either organic materials (peatmoss, hay, tree bark, coconut fiber, crop residue, animal manure, compost) or inorganic materials (sand, gravel, volcanic rock, perlite, Vermiculite, rock wool, expanded clay), (Arzani, 2007; Buchanan and Omaye, 2013).

Rooftops and home balconies cultivation is one of the most important techniques of hydroponics. It is intended to

grow crops of vegetables, fruits, ornamental plants in the spaces inside houses or on balconies or roofs. Where hydroponics can be carried out within civilian communities, away from agricultural fields and soils. This makes hydroponics useful in exploiting new areas that were not originally intended for agriculture. In addition, it is possible to grow vegetable crops close to the consumer (home balcony) and to save time and cost in obtaining and securing them freshly in time of need and in the quantity demanded (Bellows et al., 2003; Schnitzler, 2012).

Most previous hydroponics research has focused on the production of leafy vegetable crops, especially lettuce (Donnell et al., 2011; Coolong, 2012; Selma et al., 2012; Buchanan and Omaye, 2013), and tomatoes (Arias et al., 2000; Borjiet al., 2010; Suvoet al., 2016; Cardoso and Martinez, 2018), and cucumbers (EngindenizandGül, 2009; Mazahrehet al., 2015; Singh et al., 2018). With regard to the production of strawberries in hydroponic systems, current research evidence is insufficient compared to the importance of this crop.

Strawberry (*Fragaria x ananassa* Duch.), is a warm season plant, belonging to the Rosaceae family. It is reported that the origin of the strawberry plant is North America, from which it has spreader to another countries of the world (Homedan and Zedan, 2004; Arizaet al., 2016).The strawberries has a high nutritional value. Fresh fruits contain 85-90% water, 10% sugars, 1% organic acids, 1% fibers, vitamins and minerals. It contains a high percentage of vitamin C and is the richest in iron among fruits and vegetables (Liu and Lin, 2013; Alvarez-Suarez et al., 2014; Jallul and Samra, 2004).Strawberries contain bioactive compounds that promote human health and reduce the incidence of many diseases (Podsedek, 2007; Atmaniet al., 2009), such as the prevention of infections (Liu and Lin, 2013), and oxidative stress (Giampieriet al., 2014), cardiovascular disease (Hannum, 2004; Alvarez-Suarez et al., 2014), diabetes (Da Silva Pinto et al., 2010), cancer (Chen and Li, 2006) and obesity (Zuninoet al., 2012). These health effects have been linked to antioxidant activity such as phenolic compounds, especially ellagitannins (Larrosaet al., 2006) and anthocyanins (Meyers et al., 2003; Andres-Lacuevaet al., 2005; Hartman et al., 2006; West et al., 2007).

The cultivation of strawberries is of great importance, and due to the high sensitivity of the strawberry fruit to the handling and transport operations and the low quality significantly when it touches the soil (in field crops) or exposure to pests and various diseases, hydroponics is the solution to growing this crop.

The type of substrate in hydroponics affects the growth and productivity of the cultivated plants (Tabatabaei and Rezaei, 2006). Coconut fiber is the best substrate for hydroponics because it has good water and nutrient retention capacity (Djedidiet al., 1999). The use of peatmoss alone in aquaculture of plants often shows a lack of nutrients, and mixing it with other organic substances improves plant growth and productivity (Bunt, 1988). The results of Mashhadi-Jafarlooet al., (2009) showed that the highest yield of strawberries was obtained when coconut fiber was singly used. Ercisliet al., (2005) reported that the substrate used in hydroponics had a significant effect on the growth of strawberry plants. The largest growth of the primary root, the aerial vegetation, the number of branches and the leaf area were obtained when using a substrate mixed of peatmoss and coconut fiber in equal proportion. Mousavi (2004), studied the effect of substrate and nutrient solution on the quantitative and qualitative characteristics of pepper in the hydroponic system. He found that the perlite medium caused a significant reduction in total production, economic yield, fruit weight, calcium content, growth indicators, leaf water content and small fruit ratio. Javanpour-Heraviet al., (2005) stated that the substrate which contain a percentage of soil, had a significant effect on most of the quantitative and qualitative traits in tomato fruits. In a study conducted by Ebrahimiet al., (2012) with the aim of determine the effect of the substrate on the productivity and quality of the cultivated strawberries in hydroponic system (the substrates used were: peatmoss + sand + perlite, coconut fiber + perlite, sand + perlite). The results showed that the coconut fiber substrate had significant effects on most growth and productivity factors, such as number of fruits, weight of fruit, total production and the fruit content of vitamin C. Treftz and Omaye, (2015) compared the impact of hydroponics and field agriculture on growth and productivity of strawberry plants. They found that hydroponics outperformed field agriculture in quantity and quality of production. However, there are some difficulties in comparing soil and hydroponics farming systems, because they are fundamentally different; the most reliable method of comparison is to place both systems in ideal growth conditions (Gruda, 2009).

Finally, the aim of this work is to study the importance of hydroponic agriculture of strawberries on the balconies of homes, and determine its impact on productivity and quality of

fruits in comparing to the field agriculture. That is through the establishment of a simple home hydroponic system that can be generalized and used personally.

## II. MATERIALS AND METHODS

### 1) Experiment location

Experiment was carried out in Ariha area of Idlib governorate. It is located at latitude 35.59° north and longitude 36.47° east, rising about 680 m. Rainfall is estimated at about 540 mm per year, with an annual average temperature of 17.4°C.

### 2) Plant material

Local strawberry cultivar was used for the experiment. It is a precocious and productive cultivar.

### 3) Treatments Experimental

Hydroponics was carried out in pipes with a diameter of 3 inches and a length of 175 cm. The pipe is equipped by making 7 holes on the surface of the pipe and the diameter of the hole is 2.5 inches and then installing the pipes on the wall of the home balcony. Planting cups were pierced from below (to facilitate the entry of the nutrient solution into the root zone). The strawberry seedling roots have been washed from the soil, and then put in the planting cups, which were filled with agricultural substrate (peatmoss or perlite).

The cups containing strawberry seedlings and agricultural substrate were placed within the holes of agriculture pipes. The hydroponics system was then operated in a closed circle. A dilute nutrient solution was used (1 mL solution / 1 liter water), and pH was adjusted at 5.5-6.5. The power supply of the pump was provided by the use of a solar cell (250 W) connected to a battery (240 A, 12 V). (Fig. 1).

The strawberry seedlings were planted in the field at distances of 25cm, where the square meter contained 10 plants (Fig. 2). Irrigation of the plants was carried out by drip in rate of 2 L/plant, and it was conducted every two days. All necessary agricultural operations such as control, weeding, etc., were carried out as needed.

The growth and development of the plants were daily observed, and needed measurements were recorded. The fruits were harvested as soon as they were colored and then the necessary measurements were taken on these fruits.



Figure 1: Hydroponics on the home balcony of strawberry plants



Figure 2: Field cultivation of strawberry plants

#### 4) Measured parameters

The following measurements were taken:

- Roots growth.
- Beginning of flowering.
- Beginning of fruition.
- Fruits ripening.
- Number of flowers per plant.
- Number of fruits per plant.
- Fruit set ratio (%).
- Diameter of fruit (cm).
- Length of fruit (cm).
- Weight of fruit (g).
- Weight of fruit per plant (g).
- Number of fruits per m<sup>2</sup>.
- Weight of fruit per m<sup>2</sup> (g).

#### 5) Experimental design

Complete randomized block design was used. Three treatments of local strawberry cultivar (hydroponic in the peatmoss substrate, hydroponic in the perlite substrate and field cultivation in the soil) with three replicates per treatment were adopted. Each experimental block was equal to 1 m<sup>2</sup>. The number of plants in hydroponics was 20 plants/m<sup>2</sup>, while

the number of plants in field agriculture was 10 plants/m<sup>2</sup>. Therefore the total number of plants in the experiment = 3 × (20 + 20 + 10) = 150 strawberry plants.

#### 6) Statistical analysis

All statistical analyzes of the results were executed by the statistical program (Sigma Stat). ANOVA analysis of variance was done to calculate the least significant difference of LSD at the level of significance 5%.

### III. RESULTS

In our study, we applied the hydroponics technique to the local strawberries cultivar in polyvinyl chloride pipes, using two substrate (Peatmoss and Perlite) and cultivating these plants on the home balcony. Then we compared the results of this cultivation with the field control cultivation. Transplanting took place at the beginning of april month 2019. We obtained the following points and the results shown in Table (1).

- Roots began to grow and elongation and appear outside the cups of agriculture after about 15 days of transplanting.
- The flowering began in most plants and in all substrates after about a month of transplanting.
- Fruiting began to grow in both treatments about a week after the bloom.
- Fruits ripening began two weeks after the bloom.

TABLE 1

Results of hydroponics and field cultivars of local strawberry cultivar

Traits	Hydroponics		Control (soil)	LSD 5%
	Peatmoss	Perlite		
Number of flowers per plant	15.9 <sup>a</sup>	11.2 <sup>b</sup>	14.8 <sup>a</sup>	0.8
Number of fruits per plant	10.3 <sup>a</sup>	6.0 <sup>b</sup>	9.25 <sup>a</sup>	0.5
Fruit set ratio (%)	64.8 <sup>a</sup>	53.6 <sup>b</sup>	62.2 <sup>a</sup>	3.6
Diameter of fruit (cm)	2.2 <sup>a</sup>	1.6 <sup>b</sup>	2.1 <sup>a</sup>	0.1
Length of fruit (cm)	2.7 <sup>a</sup>	1.9 <sup>c</sup>	2.3 <sup>b</sup>	0.2
Weight of fruit (g)	9 <sup>a</sup>	4 <sup>c</sup>	7.4 <sup>b</sup>	0.7
Weight of fruit per plant (g)	92.7 <sup>a</sup>	24 <sup>c</sup>	68.1 <sup>b</sup>	4.1
Number of fruits per m <sup>2</sup>	206 <sup>a</sup>	120 <sup>b</sup>	92 <sup>c</sup>	9.3
Weight of fruit per m <sup>2</sup> (g)	1854 <sup>a</sup>	480 <sup>b</sup>	680.8 <sup>b</sup>	85.3

\* Values in the same line with different characters are significantly different

#### 1) Number of flowers/plant

By comparing the average number of flowers of hydroponic strawberries (local cultivar) cultivated in the substrates of peatmoss and perlite and between these cultivated in field (control). There were no significant differences between hydroponics in the peatmoss substrate and the cultivation in field soils, results were 15.9 flowers/plant and 14.8 flowers/plant respectively. While hydroponics in the perlite substrate was delayed by significant differences from other treatments and gave 11.2 flowers/plant (Fig.3).

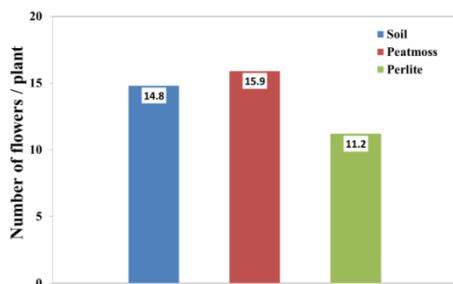


Figure 3: Number of flowers/plant in experimental treatments (LSD5% = 0.8)

2) Number of fruits/plant

As with the number of flowers per plant, the number of fruits of hydroponics plants in the peatmoss substrate (10.3 fruits/plant) and the number of fruits of field plants (9.2 fruits/plant) were close, there were no significant differences between them according to the results of the statistical analysis. While hydroponics plants in the perlite substrate (6fruits/plant) were delayed for both treatments with significant differences (Fig. 4).

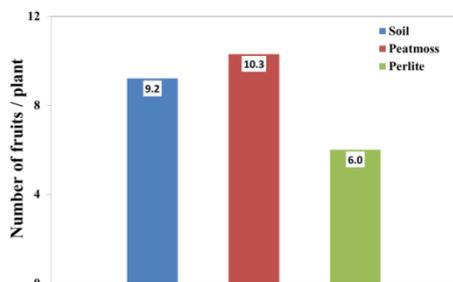


Figure 4: Number of fruits/plant in experimental treatments (LSD5% = 0.5)

3) Fruit set ratio (%)

There were no significant differences in the ratio of fruit set, between hydroponics in peatmoss substrate (64.8%) and field agriculture (62.2%). Also, hydroponics in the perlite substrate (53.6%) was delayed for other treatments (Fig. 5).

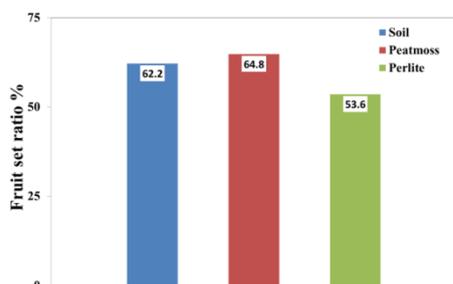


Figure 5: The ratio of fruit set in experimental treatments (LSD5% = 3.6)

4) Diameter of fruit (cm)

The results showed that no significant differences were observed between the diameter of the fruit of the hydroponics plants in the peatmoss substrate (2.2 cm) and the field of cultivation plants (2.1 cm). While the hydroponics plants in the perlite substrate were delayed by the two another treatments (1.6 cm) with significant differences (Fig. 6).

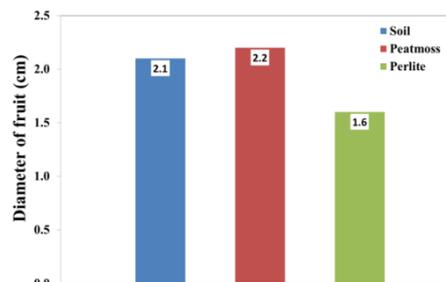


Figure 6: Diameter of fruit in experimental treatments (LSD5% = 0.1)

5) Length of fruit (cm)

Statistical analysis of the results showed that hydroponic plants cultivated in the peatmoss substrate (2.7 cm) were superior to both hydroponic plants cultivated in the perlite substrate (1.9 cm) and field plants (2.3 cm) in the length of fruit. Also, field plants significantly outperformed hydroponics plants cultivated in the perlite substrate in the same trait (Fig. 7).

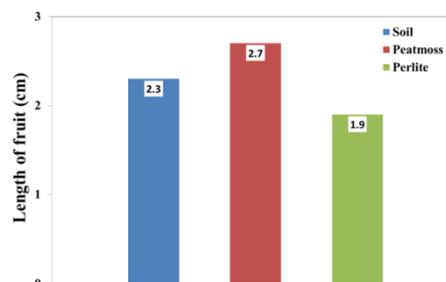


Figure 7: Length of fruit in experimental treatments (LSD5% = 0.2)

6) Weight of fruit (g)

There were significant differences in fruit weight between hydroponics and field cultivation plants. Where hydroponic plants, in the peatmoss substrate (9g) outperformed field farming (7.4g) and hydroponics in the perlite substrate (4g). While the treatment of the control (field) surpassed hydroponics in the perlite substrate with a significant difference. This significant difference between the treatments can be explained by the increase in the length of the fruits, which led to an increase in the weight of the fruit (Fig. 8).

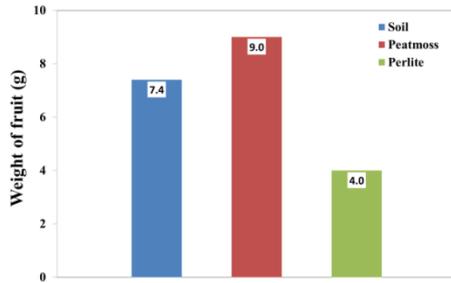


Figure 8: Weight of fruit in experimental treatments (LSD<sub>5%</sub> = 0.7)

7) Weight of fruits/plant (g)

The results showed that there were significant differences between all treatments in total weight of fruits/plant, where the weight of fruits was 92.7 g/plant for hydroponics plants in the peatmoss substrate, 68.1 g / plant for field plants and 24 g / plant for hydroponic plant in perlite substrate (Fig. 9).

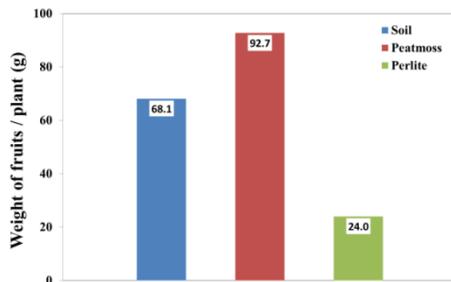


Figure 9: Weight of fruits/plant in experimental treatments (LSD<sub>5%</sub> = 4.1)

8) Number of fruits/m<sup>2</sup>

The results of the study showed a significant superiority of hydroponic plants in the two substrate (peatmoss and perlite) over field plants in number of fruits/m<sup>2</sup> and the results were 206 and 120 fruits/m<sup>2</sup> in hydroponics, respectively, and 92 fruits/m<sup>2</sup> in field. This significant difference can be explained by the agricultural intensification achieved by hydroponics, where 20 plants were cultivated in hydroponics and only 10 in field. Fig. 10 shows the results obtained.

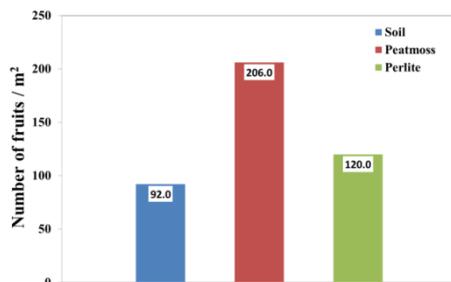


Figure 10: Number of fruits/m<sup>2</sup> in experimental treatments (LSD<sub>5%</sub> = 9.3)

9) Weight of fruits/m<sup>2</sup> (g)

There were significant differences between the treatments in total yield per unit area (total weight of fruits/m<sup>2</sup>). Hydroponics in the peatmoss substrate (1854 g) outperformed field control (681 g) and hydroponics in the perlite substrate (480 g). This superiority is explained by two reasons: First, hydroponic plants (in the peatmoss substrate) outweigh the weight of fruits/plant; the second is the optimal utilization of the unit area, where the number of plants/m<sup>2</sup> is 10 plants in field and 20 plants in hydroponics. Consequently there was superiority in productivity per unit area. Although hydroponic plants (perlite substrate) delayed behind field plants (control) in most studied criteria, the optimal investment rate per unit area and the cultivation of a multiplicity of plants per square meter eventually led to a rate of production close to the results obtained from field plants (control), (Fig. 11).

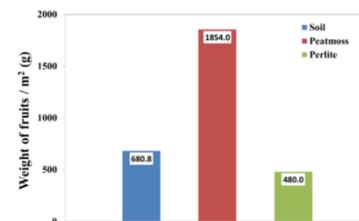


Figure 11: Weight of fruits/m<sup>2</sup> in experimental treatments (LSD<sub>5%</sub> = 85.3)

10) Total costs of hydroponic and field cultivation

Comparing the total costs of both hydroponics and field cultivation shows that these costs are 3.4 times higher in hydroponics (Table 2) than in field agriculture (Table 3). The high cost in hydroponics is mainly due to the cost of supplying the electricity needed to operate the feed pump (which exceeds 75% of the total cost). This cost can be eliminated in field agriculture by placing the water tank at a height sufficient to flow water towards the plants and at the wanted pressure.

TABLE 2

Total Costs of Hydroponics Experiment

Material	Cost (\$)
Nutrient solution	23.08
Agricultural substrate	4.62
Solar panel	96.92
Battery	96.92
Electric drill	9.23
Irrigation pump	4.62
Cultivation pipes (3 inches) with stoppers	15.23
Screws + lashes + connectors + faucets + wires	5.23
Tanks 10 liters + hoses (4 inch) + cultivation cups	7.23
PH meter	5.54
Sensitive balance and metric scale	2.46
Water	0.46
Seedlings	4.62
<b>Total</b>	<b>276.15</b>

**TABLE 3**  
**Total Costs of Field Experiment**

Material	Cost (\$)
Plowing the experimental block	2.31
Organic fertilizer	1.54
Chemical fertilizers (balanced + calcium + microelements)	6.15
Drip hoses	3.08
Irrigation network equipment (taps + couplings + drippers)	1.54
Pesticides	3.08
Pesticide spray pump	9.23
Sensitive balance and metric scale	2.46
Water tank	46.15
Water	1.54
Seedlings	2.31
<b>Total</b>	<b>79.38</b>

#### IV. DISCUSSION

The results of our study to determine the importance of hydroponics and the possibility of investing home balconies in the cultivation of strawberry crop and compare the results with field cultivation. The results showed the superiority of hydroponics (peatmoss substrate) over field cultivation in the most of studied characteristics: fruit length (cm), fruit weight (g), yield/plant (g), number of fruits/m<sup>2</sup> and productivity/m<sup>2</sup> (g). While there was a convergence in the results between them in the characteristics of the number of flowers/plant and the number of fruits/plant, the ratio of fruit set and the diameter of the fruit (cm). In consequence, we got production of hydroponics (peatmoss substrate) three times higher than the production given by field agriculture. Our results are consistent with a large number of studies that have demonstrated the superiority of hydroponics over field agriculture in yield and fruit quality (Gichuhiet *et al.*, 2009; Sgherriet *et al.*, 2010; Selma *et al.*, 2012).

On the other hand, hydroponic in the perlite substrate lagged behind field cultivation in most studied traits (number of flowers and fruits/plant, number of fruits/plant, ratio of fruit set %, diameter and length of fruit (cm), fruit weight (g) and yield/plant (g). While it excelled in the trait of number of fruits/m<sup>2</sup>. The results were converged between the two treatments in total productivity/m<sup>2</sup> without significant differences between them. Consequently, although hydroponic in the perlite substrate was lagging behind the control in the most traits, the net yield/m<sup>2</sup> was close and this underlines the importance of hydroponics and its role in improving productivity even in non-ideal conditions (perlite substrate). At the same time, hydroponic in the perlite substrate was delayed in all the studied traits of hydroponic in the peatmoss substrate, which confirms the inadequacy of this substrate for cultivation of strawberries with hydroponic technology. This finding is consistent with a number of previous studies which have shown that perlite caused a significant reduction in the quantitative and qualitative characteristics of the crop when used in hydroponic (Mousavi, 2004; Ebrahimiet *et al.*, 2012).

The results show that the costs of hydroponics is higher than that of field agriculture (more than 3 times) especially the establishing costs, which accounted for more than 75% of the total cost of hydroponics. This cost was mainly due to the unavailability of a power supply and replacing it with an alternative source (solar panel and electricity storage battery). Our results are consistent with those obtained in previous studies, where the cost of hydroponics increased twice as much as field cultivation of the strawberry crop (Treftzand Omaye, 2015).

As for the length of the production period, it has continued in hydroponics for almost twice as much compared to plants cultivated in soil. The short growth cycle can be justified for field plants due to pest infestation, especially aphids and spiders, despite the use of necessary control systems, as soil cultivation is an appropriate medium for the spread of pests and diseases that are difficult to eliminate. It should be noted that hydroponics can be affected by various pests but can be easily eliminated by replacing the entire nutritional solution if necessary. The long growing season in hydroponics provides a greater income for the farmer and ensures a health product free from the residual effects of the chemicals and pesticides used in the control of land farming. In addition, the crop disease and pest infestation in land farming causes great losses to the farms compared to hydroponics where the morbidity of infection is minimal. Therefore, hydroponic reduces the use of pesticides and thus reduces the costs used in this zone and increases profitability, compared to field cultivation.

Soil in the traditional farming system needs to add fertilizers, sterilization, and drainage system, washing and follow agricultural cycles. Etc. which increases the costs of agriculture in the soil and these costs are not present in hydroponics. Soil cultivation also consumes large amounts of water estimated at 300% of what hydroponic consumes (according to the results obtained). Another important factor to consider when choosing a farming system is labor costs. Soil farming often requires additional costs resulting from the use of labor in tillage, weeding, irrigation and pesticides and spray fertilizers application. Hydroponics needs higher establishing costs than soil cultivation. Which are related to the processing of the farming system, the supply of nutrient solution, the cultivation substrate, the pH controlling equipment, the concentration of elements within the nutrient solution, etc. However, these equipment can be used for several seasons. Hydroponics also requires constant monitoring of the pH of the solution and the concentration of elements in it and any defect may damage the entire culture. In addition, it is necessary to change the nutrient solution frequently, but in soil cultivation there is no need for such precautions

Finally, the results show the great importance of using hydroponics technology and optimizing the unit area, as production can be tripled in the same area and therefore the profitability of hydroponics can cover the establishment costs.

## V. CONCLUSION

Through our study, aimed to clarify the importance of hydroponics and the possibility of investing home balconies in the cultivation of strawberries, we can conclude the following:

1. Hydroponics (peatmoss substrate) outperformed field cultivation in most studied traits (fruit length, number of fruits/m<sup>2</sup>, fruit weight, average yield/plant, yield/m<sup>2</sup>).
2. Total production in hydroponics (peatmoss substrate) has almost tripled from field agriculture (per unit area).
3. Hydroponics in the perlite substrate was delayed from field cultivation (control) in most studied traits (number of flowers/plant, number of fruits/plant, ratio of fruit set, fruit diameter and length, fruit weight, productivity/plant).
4. Hydroponics in the perlite substrate was delayed by hydroponics in the peatmoss substrate in all studied traits.

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