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COMPARISON BETWEEN THE TYPES OF HYDROPONICS AND REGULAR CULTIVATION IN THE SOIL AND THEIR IMPACT ON THE GROWTH OF THE LETTUCE CROP

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Abstract: This study aimed compare the morphological properties of lettuce growth in different model of cultivation (soil, cork and water pipes). Samples of lettuce plants were cultivated in three models of cultivation. The first model was regular cultivation in soil, the second model was agriculture using water pipes and the third model was hydroponic using cork. After two months, the properties of each sample, including total length of plant, length of stem to end of leaf, length of root, length of leaves and number of roots. According to the result in this study, length of total plant, root, leaves and stem to end as well as number of leaves and roots were significantly greater in water pipes than in hydroponic with cork and soil, respectively..

Keywords: -

Introduction

Hydroponic systems are cultivation technologies that use nutrient solutions rather than soil substrates. Sometimes natural or artificial media are used, such as peat moss, sawdust, charcoal, rock wool, coco coir, clay granules, gravel, or ceramics to provide physical support for plants (Bhattarai et al., 2008). Hydroponic systems offer a number of benefits, including: the ability to reuse water and nutrients, easy environmental control, and prevention of soil-borne diseases and pests (Lommen, 2007). Since hydroponic production techniques can offer higher yields and higher quality products, the supply of, and demand for, hydroponic systems have dramatically increased in the United States (US) (van Patten, 2011). The commercial hydroponics industry has grown approximately fivefold in the last 10 years, and its global value is currently estimated to be about $8 billion US dollars (Carruthers, 2002).

A large number of hydroponic crops are produced in developed countries to meet consumer demand. For the past several decades, hydroponic research has increased steadily, especially in the topics of improving crop productivity and solving limitations of hydroponic systems. Many different crops have been studied in hydroponic systems, including beans, cucumbers, lettuce, tomatoes, etc. The US and China are the leading two countries generating the most publications about hydroponic plants systems. Majority of the research focused on promoting growth of plants, managing nutrients, and investigating defense system against phytopathogens or response stress from nutrient deficiency, heavy metal, salts, drought, high temperature, and etc. (Carruthers, 2002). Although hydroponics is commonly used for personal gardening, education, and research, most systems have been used for commercial vegetable and cut flower production, i.e., tomatoes, beans, spinach, strawberries, cucumbers, lettuce, gerbera, and rose (Nichols, 2006).

Since hydroponics systems have many benefits, hydroponic systems have been used widely for growing various plants in many different fields and demand for hydroponic produce is increasing. However, treatment of waste water and non-renewable resources that go into hydroponics is an issue. In addition, waterborne diseases can contaminate and spread through the water tubing systems. Species of *Colletotrichum*, *Fusarium*, *Phytophthora*, *Pythium*, and *Phizoctonia* are the common plant pathogens detected in hydroponic systems (Constantino et al., 2013).

This study aimed to compare the morphological properties of lettuce growth in different model of cultivation (soil, cork and water pipes).

1. Literature Review

Hydroponic systems are highly customizable and many modified versions have been used to optimize growing conditions for particular plants. They are divided into two forms depending on whether the nutrient solution and supporting media are reused or recycled; nutrient solution and supporting media in open systems are not reused or recycled whereas, in closed systems, they are reused or recycled (Jensen, 1999). In general, open hydroponic systems may be less sensitive to salinity of the water than closed systems, but closed systems are more cost-effective than open systems (Lippert, 1993).

According to Paulus et al. (2012), for hydroponic lettuce (*Lactuca sativa* L.) cultivation, it is possible to use nutrient solutions prepared with low quality water, or reuse nutrient solutions. The use of alternative sources of water and fertilizers may represent a reduction in production costs in the hydroponic system (Azad et al., 2013), but there is a lack of information on the correct management of the nutrient solution (Bugbee, 2004). Wastewater has the potential to be used as an alternative source of water for hydroponic lettuce cultivation, and there is no damage in terms of production for the culture, as long as a nutritional contribution is made, independent of the time of year.

The deep-water culture and nutrient film technique proved to be promising hydroponic techniques that delivered nutritionally superior and higher yields as compared to the protected soil-based cultivation system. Lettuce (*Lactuca sativa* L.) cultivation under several hydroponic models particularly water culture and nutrient film technique has been extensively studied all over the world. These studies confirm that hydroponic growing systems result in increased leaf yield (Majid *et al.*, 2021).

Six commonly used hydroponic systems are described herein: the wick, drip, ebb-flow, water culture, nutrient film, aeroponic, and window farm model, which has been recently introduced. Firstly, the wick system or passive system is an excellent model for cultivating indoor plants: it is a self-feeding model and does not require a water pump (Fig. 2a). The drip or drip irrigation system has been widely used in commercial system for many years. Water or a nutrient solution in the reservoir is delivered to each plant or pot using a pump with the amount of water for each plant adjusted by an electronic timer (Fig. 2b). The ebb and flow system, that was one of the first commercial hydroponic systems, uses an automatic flood and drain watering technique, in which plants are flooded temporarily and periodically (Fig. 2c). Application of various media around root area is the great strength in the system. The water or nutrient solution in the reservoir ascends to a growth tray via a water pump, accumulates to a certain level, and stays in the growth tray for a set amount of time, providing water and nutrients to the plants (Lee and Lee, 2015).

Moreover, the (deep) water culture system is a simple model, composed of a reservoir, an air stone, a tubing system, an air pump, and a floating platform (Fig. 2d). While, the nutrient film technique system can provide water and nutrient constantly and make oxygen-rich conditions by controlling flow and water depth (Fig. 2e). Water, or a nutrient solution in a reservoir, circulates throughout the entire system; it enters the growth tray via a water pump without a time control, and then constantly flows around the roots (Lee and Lee, 2015).

Another type, aeroponic system, enables even control over the root system delicately and does not require media. Using a high-pressure sprayer with a micro-inject nozzle, water or a nutrient solution is sprayed around the roots by a water pump and provides a highly oxygenated nutrient solution to plants (Fig. 2f). Lastly, hydroponic window farming is an emerging concept in urban agriculture for space-saving and enabling residents to grow vegetables and herbs all year-round in urban settings with an available window. The window farm system is generally a vertical hydroponic system constructed of simple household materials, including plastic bottles, a water reservoir, and a small cale water pump with tubing. Water circulates through the system via an automatic drip configuration using a pump and an electronic timer. The sun supplies natural light, although artificial light may be needed on cloudy days. The vertical window farm system requires much less space than traditional hydroponic systems and provides an alternative method for growing crops in urban environments; an innovation of special interest to people in congested cities (Lee and Lee, 2015).

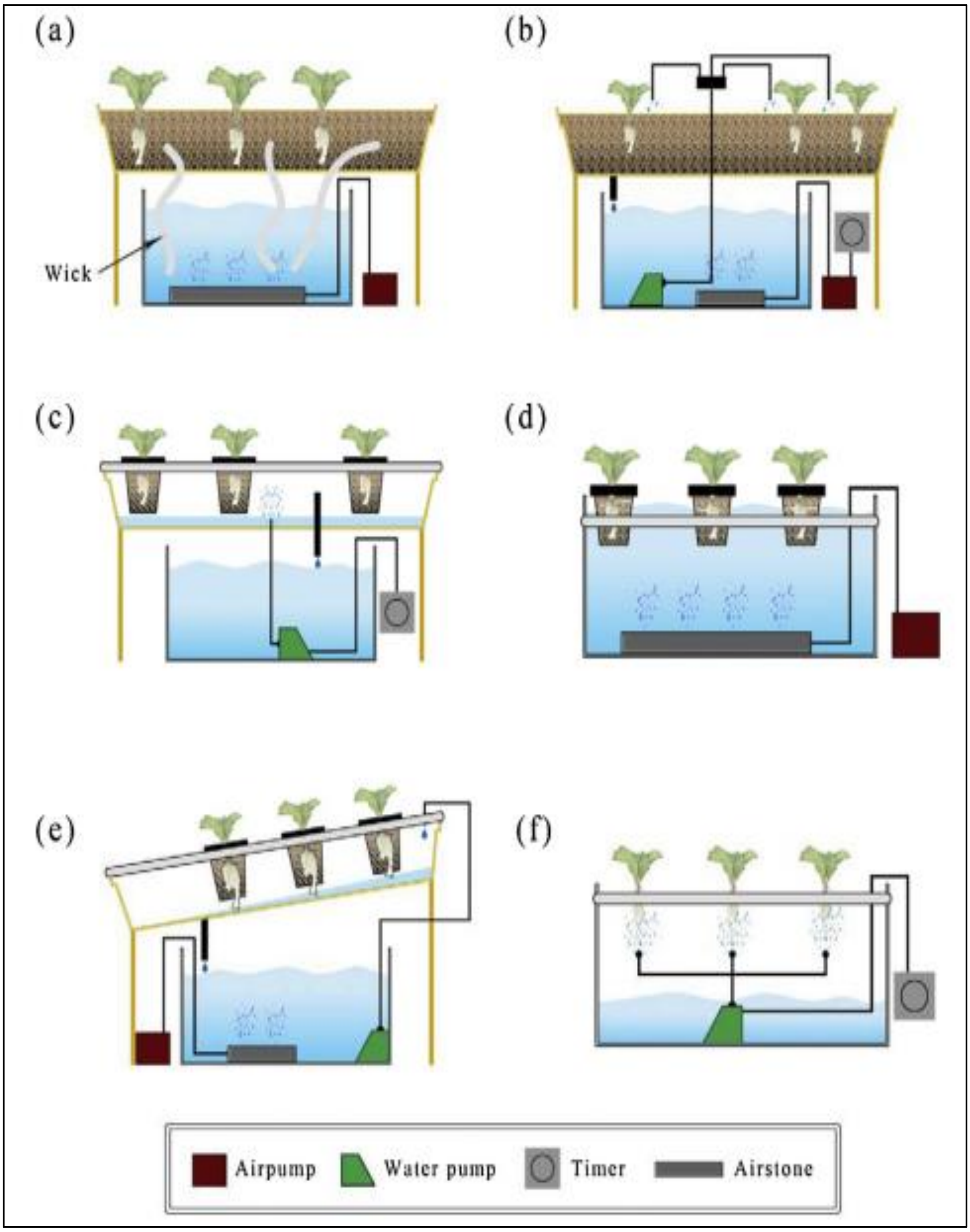

Figure (1-1): Six different types of traditional hydroponic systems. (a) wick system, (b) drip system, (c) Ebb-Flow system, (d) water culture system, (e) nutrient film technique, and (f) aeroponic system.

1.1 Advantages of hydroponics

There are many advantages of hydroponic systems over soil culture systems (Table 1-1) (Lee and Lee, 2015).

Table (1-1): Advantages of hydroponic systems over soil culture systems

Issues	Hydroponic system	Soil Culture
Land usage and effect of environment	Less affected by soil and external factors Indoor system; easy nutrient control; control of the	Unsuitable if soil is contaminated with heavy metal and plant disease; Limited by nutrients in soil; hard to

	environment such as temperature, humidity and lighting time; cultivation all year round everywhere	control external environments; cultivation all year round is limited in certain areas
Labor	Traditional practices are largely eliminated	Cultivating, weeding, watering, tilling and additional practices
Sanitation	Easy handling of medium and all materials and maintaining sanitary conditions	Difficult to sanitize soil and equipment; hard to maintain sanitation conditions consistently
Diseases and pest	Prevent soil-borne diseases; easy to control insects and animals; reducing amount of pesticide usage	Soil-borne diseases; hard to control insects and animals (loss of crop yield)
Water	Efficient water usage; water can be recycled or reused; no nutrient waste due to water runoff; Water goes directly to root areas; possibility of controlling water-holding ability by using different kinds of medium	Inefficient water usage; water cannot be recycled or reused; eutrophicastion of the environment due to run-off; hard to control water-holding capacity
Fertilizers and nutrient solution	Even distribution to crops; efficient use of fertilizers and saving the cost; easy control of pH and amount of nutrient	Uneven distribution to crops (partial deficiency); often use of excessive amount of nutrient; high variation, hard to control pH and amount of nutrient
Quantity and quality of crop	Stable and even amount of production; tomato,14–74 kg per m2; cucumber, 6900 kg per m2; lettuce, 5200 kg per m2; bean, 5 kg per m2; even quality of production	Unstable and uneven amount of production due to pests/soilborne pathogens; tomato, 1.2–2.5 kg per m2; cucumber, 1700 kg per m2; lettuce, 2200 kg per m2; bean, 1.2 kg per m2; uneven quality of production

1.2 The disadvantages of hydroponic system

The disadvantages of hydroponic system are mentioned as follows (Lee and Lee, 2015):

1. High initial setup cost for supplies and continuous replacement cost for maintaining.
2. Generation of waste materials and hydroponic waste solution containing high nutrients.
3. Vulnerable to power outage leading to problems in water or nutrient supply, and witheredness.
4. Easy spread of phytopathogens throughout water tubing systems.
5. Requirement of experts to maintain the systems for optimum production.
6. Needs of nutrients background to controlling amounts of nutrients.
7. Growth of unwanted algae and fungus in nutrient solution.
8. Biofilm build-up in the system interfering nutrient uptake and reducing life span of the system. Not all plants are available for hydroponic systems

Methods

2.1 Materials

The materials that used in this study as follow:

1) Hydroponic solution (water fertilizers represented by chemicals).
2) Lettuce.
3) The hydroponics model with 1 meter long, half a meter wide, and half a meter high.
4) Three pieces of cork with width 25 cm, length 50 cm, and height 30 cm.
5) Lettuce plant anchors in water pipes and corks.
6) Water pump (to circulate water between tubes and get air).

The components of the hydroponic solution were listed in the following Table (3-1):

Table (2-1): The components of hydroponic solution

Component	Percentage (%)
N Natural acid	4 %
N	< 1%
po	< 5%
ko	< 10%
Mannitol	0.48-0.84 %
Laminarin	0.96 – 1.60 %
Alginic acid	1.2 – 2.4%
Protein as amino add	1.25 – 2.3%
Organic matter	5.4 – 6.6 %
Other carbohydrates	1.4%

2.2 Methods

2.2.1 Preparation of studied plant

Lettuce was washed by water in order to remove any contaminate and resides of soil. Lettuce was cultivated in three models, include soil (traditional cultivation), water pipes and cork.

2.2.2 Cultivation in cork

A 1 ml of nutrient solution was added into 10 liters of water in cork tank, where lettuce was cultivated. The experiment should be placed in a warm place covered with a transparent bag to protect it from sunlight and cold weather. The process was monitored for two months until the lettuce was grown in each model.

Figure (2-1): Cultivation of lettuce in cork.

2.2.3 Hydroponic model

A 1 ml of nutrient solution was added into 10 liters of water, where lettuce was cultivated. Water was changed every week with washing the water pipes. The experiment should be placed in a warm place covered with a transparent bag to protect it from sunlight and cold weather. The water pump should be connected to electricity and run for 12 hours. The process was monitored for two months until the lettuce was grown in each model.

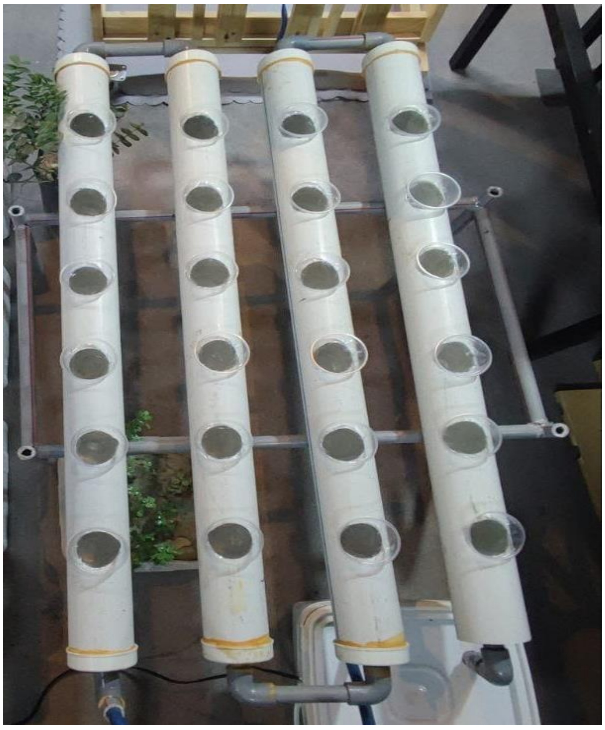

Figure (2-2): Cultivation of lettuce in water pipes (hydroponics).

Result and Discussion

3.1 Results

Samples of lettuce plants were cultivated in three models of cultivation. The first model was regular cultivation in soil, the second model was agriculture using water pipes and the third model was hydroponic using cork.

After two months, the properties of each sample, including total length of plant, length of stem to end of leaf, length of root, length of leaves and number of roots, were measured and mentioned in the following Table (3-1) and Figure (3-1):

Table (3-1): The properties of each sample of lettuce

	total plant length (cm)	The length of the stem to the end of the leaf (cm)	root length (cm)	number of leaves	Leaves length (cm)	number of roots
Agriculture by water pipes	50	30	20	20	18	85
Hydroponics in cork	41	25	18	15	16	70
cultivation in the soil	35	20	18	10	10	60

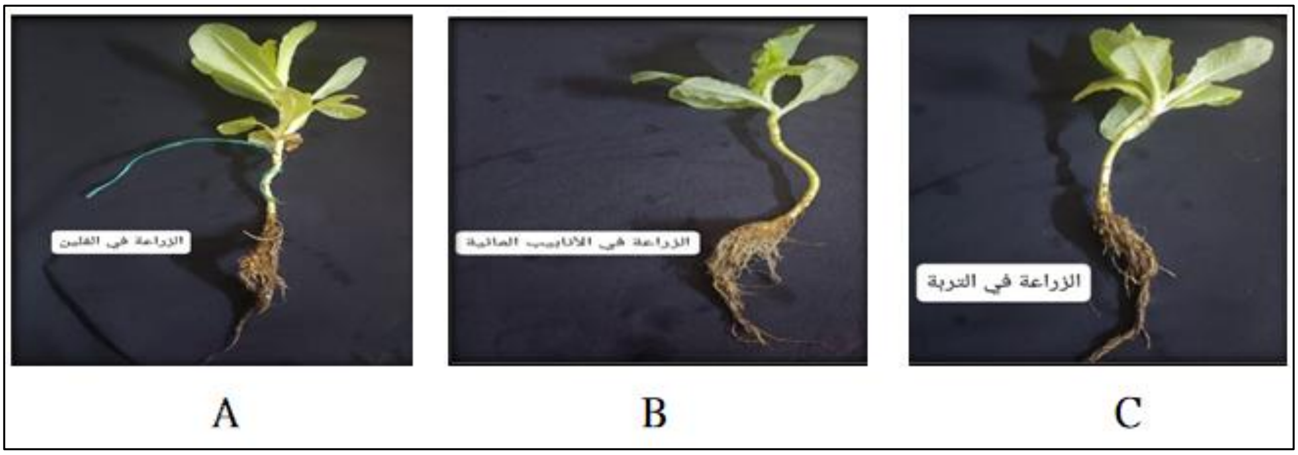

Figure (3-1): Lettuce in (A: Cork, B: Water pipes and C: Soil).

3.2 Discussion

According to the result in Table (3-1), length of total plant, root, leaves and stem to end as well as number of leaves and roots were significantly greater in water pipes than in hydroponic and soil, respectively.

The benefits of hydroponic culture systems have often been stated but rarely are cultivation systems compared directly while trying to control as far as possible environmental variables that may confound comparisons, particularly when comparing crop quality. Different growth environments may impact variables more or less significantly for example warm and cool environments impact vapour pressure deficit and therefore evaporative stress (Lu et al., 2015) and may reduce or exaggerate differences in water use (Leonardi et al., 2000).

Hydroponics perform well, even in areas that are otherwise unsuitable for growing crops due to toxic chemicals or heavy metals contaminating the soil. Indoor hydroponic systems also make it easy to control growth conditions, such as temperature, flow velocity and volume of water, nutrients, relative humidity, and duration of lighting in order to optimize crop production. In addition, plants in hydroponic systems are not easily influenced by climate change; therefore, plants can be cultivated year-round under a wide range of conditions. Further, as the systems operate automatically, they may be expected to reduce labor and several traditional agricultural practices can be eliminated, such as cultivating, weeding, watering, and tilling. Soil-based crops can be exposed and contaminated by many harmful biotic or abiotic compounds, some of which are hard to prevent. However, using hydroponics, most media and other materials can be sterilized by ultraviolet (UV) irradiation, chemical compounds (e.g., alkylating and oxidizing agents), steam, and/or high temperatures (Knutson, 2000). Furthermore, indoor hydroponics are not expected to be infected by diseases common to plants cultivated in soil, thereby reducing or eliminating the use of pesticides and their resulting toxicity. Delivering recycled or used water directly or indirectly to the root area provides a more effective utilization of resources, reduces water loss, and distributes nutrients evenly to each plant. Finally, pH can be easily controlled, according to the plant’s requirements. Because of these advantages, many studies report those hydroponic systems can increase the yield and quality of crops (Lee and Lee, 2015).

Conclusion

In conclusion, the popularity of hydroponic systems has increased significantly, both in personal gardening and agriculture, because of their notable advantages over soil cultures

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