WATER MANAGEMENT IN SUBSTRATES CULTURE FOR LETTUCE PRODUCTION

By

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B.Sc. Agric. Sc. (Agricultural Engineering), Ain Shams University, 2010

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ABSTRACT

Ayaa Khalil Moustafa Khalil: Water Management in Substrates Culture for Lettuce Production. Unpublished M. Sc. Thesis, Department of Agricultural Engineering, Faculty of Agriculture, Ain Shams University, 2019.

The experiment was carried out at the Institute of Advanced Studies of Arid lands - Ain Shams University, the experiment was conducted from the 13th of October 2016 to the 28th of November 2016 (47 days). This experimental study was designed to assess the impact of moisture content in substrate on lettuce production by using soil moisture sensors in controlled and closed automatic drip irrigation system.

Experimental layout included a vertical system has been constructed 18 columns formed from white square Styrofoam pots filled with perlite (In-organic substrate)، Two types of lettuce (green and red) lettuce seedlings were planted in the perlite substrate. Three soil moisture content treatments were selected as T_{1} = 60 %, T_{2}= 80 %, and T_{3} = 100% which were controlled by the sensors. Soil moisture controller designed and programed for measuring and controlling soil moisture content in plant media (perlite). The device has been connected to three water-lifting pumps to operate them according to each treatment Solution tank filled with dissolved nutrient elements was used for supplying required water.

The results showed the following: 556.5liters of water was consumed under condition of T_{1} = 60 %, while 697.5 liters and 908.5 were consumed under condition of T_{2}= 80 %, and T_{3} = 100% respectively. And total system production was 72 kg. Lettuce density in order 200 head lettuce/m². Water use efficiency for the System was 26 kg/ m3. The best water use efficiency was 31.50 kg/M ^{3} under (T1).

Keywords: Agricultural engineering, Soilless culture, Perlite substrate, soil moisture sensor, Vertical hydroponics.

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INTRODUCTION

Vegetables play a fundamental role in the human nutrition as source of minerals, vitamins and other antioxidant compounds. Increasing the cultivation and the use of vegetables has potential to improve health care and reduce poverty. Field lettuce was cropped in more than 100 countries with more than 1.15 million ha in 2014. Urea is applied at high rates in lettuce production in Brazil **Gianquinto, et al. 2007 and Fecondini ,et al.2008 ; Mascarenhas, et al. 2008 and FAOSTAT, 2016.**

The universal population is expected to reach 9 billion by 2050, a significant proportion of which will be urban living, requiring a 70% increase in agricultural productivity, FAO estimates that agriculture currently accounts for 70 percent of global freshwater withdrawals**.** The growing water scarcity and the misuse of available water resources are nowadays major threats to sustainable development for most developing arid and semiarid countries of the Mediterranean. But also in increasing the limited available water supply by reducing water losses and by increasing the water use efficiency in the irrigation sector. Avoiding water conflicts among the water user sectors, achieving water security and food security is fundamentally a matter of water use efficient rate in the irrigation sector. The importance of efficiency in water use clearly varies across regions and nations as well as through time **Hamdy, 2007and Mashnik, et al. 2017.**

Vertical farming has been suggested as an engineering solution to increase productivity per area by extending plant cultivation into the vertical dimension, thus improve land use efficiency for crop production **Touliatos and McAinsh, 2016.**

Irrigation improvement project is currently implemented to enhance water distribution and minimize water use. Future water policies include introducing integrated water management approach to increase water use

efficiency and maximize water productivity **Allam and Abdel-Azim, 2007**

Hydroponics is a modern technology involving plant growth on inert media in place of the natural soil, in order to uncouple the performance of the crop from problems associated with the ground**.** Recently particular emphasis was laid on protected cultivation and more specific on cultivation of vegetables and flowers on substrates and soilless cultures (closed systems and open with minimum drainage). New unites with soilless cultivation (mainly perlite, coconut and Rockwool) have been established applying modern greenhouse technology and fully computerized irrigation-fertigation methods. Hydroponic gardening of lettuce became a strategy for sustainably feeding the world's growing population, it used land and water more efficiently than conventional farming and could if the high energy consumption can be overcome through improved efficiency **Savvas, 2003; Polycarpou, et al. 2007** and **Barbosa, et al.2015.**

Technology has started in agriculture, which include all of the processes as crop monitor technology and mobile apps to aid farmers. Most of those technologies could categorize under four key areas: Sensors, Food, Automation and Engineering**.** Building a smart irrigation system using Arduino (a microcontroller) to perform better irrigation systems by increasing the precision of measurements but also by automating decisions. Moisture sensors are particularly suitable for irrigation management in greenhouse soilless production. Identifying the practical effects of substrate water content set-points on crop performance is decisive for successful sensor-based irrigation **AlShrouf, 2017; Casado, et al. 2018 and Montesano, et al. 2018.**

INTRODUCTION

The aim of this research is to study:

1. The effect of using soil moisture sensor on controlling the water consumption for lettuce.
2. Increase productivity of lettuce per area unit by using the vertical system and-closed system to control the addition of nutrient solutions.

REVIEW OF LITERATURE

2.1. Lettuce:

Lactuca sativa is considered as the most important vegetable in the group of leafy vegetables, it is especially important as a commercial crop in Asia, North and Central America, and Europe. China, U.S., Spain, Italy, India and Japan are among the world's largest producers. World production of lettuce for the year 2009 was approximately 24 million metric tons, with a cultivation area of 1 million hectares. Salad -lettuce crops need short time production period, its growing increases in the period between the autumn and spring season **Turhan & Sevgican 1997, Lebeda et al. 2007, Kristkova et al., 2008 and USDA 2011.**

Lettuce is one of the most popular fresh vegetables which is consumed increasingly because of its perception as a healthy food. It was grown in a hydroponic system according to a previously described protocol and it can be harvest in as little as three weeks **Dupont et al. 2000, Waisberg et al. 2004, Tsormpatsidis et al. 2010, and Heredia 2014**.

2.2. Soilless culture:

Schröder& Lieth, 2002 pointed that most hydroponic systems in commercial production use some sort of substrate to create an artificial root zone that is trying to improve water availability for the roots. These production systems consist of: (1) root zone, (2) air part of Plants, (3) irrigation system to supply the feeder solutions for the root area, and (4) drainage system to deal with the flux of the root zone.

Savvas, 2003 studied the effect of water retention and release curves provide excellent information regarding the ability of a substrate to provide air and water to the roots of the plants at different heights of its volume and at different water content regimes.

REVIEW OF LITERATURE

Gruda, 2009 said that soilless culture systems (SCSs) are most intensive production method in today's horticulture industry, are based on environmentally friendly technology, which can result in higher yields, even in areas with adverse growing conditions.

Polycarpou, et al. 2007 mentioned that Soilless culture using locally available substrate materials (perlite, the mixture of perlite + peat, pomace, pine bark etc.) could be the solution. Experimental results so far in terms of yield, quality and water use efficiency are very encouraging. The application of soilless culture in vegetables (tomatoes, cucumber, lettuce, and strawberries) came later due to the low and unpredictable market prices of the products.

Ghehsareh, et al.2012 reported that substrate culture is gaining more importance year-by-year all over the world, Different substrates have several materials which could have direct and/or indirect effects on plant growth and development. Therefore, selecting the best substrate between the various materials is imperative to plant productivity.

Table (1): physical characteristic of some hydroponic soilless media found in UAE market (**AlShrouf, 2017**).

Substrates	Total porosity (V/V)%	Air porosity (V/V)%	WHC (V/V)%	CEC (cmol/kg)	Bulk density (g/cm3)	C/N %
Perlite	66.3	41.1	25.2	0.0	0.13	0.0
Sand	35.6	24.6	11	12	1.45	0.0
Peat	90	13.2	76.8	110.5	0.11	40.12
Rockwool	94.1	10.3	83.8	0.0	0.06	0.0
Coco peat	92	12.2	79.8	138.7	0.16	48.47