Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

AN AUTOMATED HYDROPONICS SYSTEM USED IN A GREENHOUSE*

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Abstract

In Turkey, the demand of table grapevine rootstocks is increasing day by day since the value of table grapevine rootstocks increase. On the other hand, production of table grapevine does not meet the demands of market since grapevine rootstock production efficiency is low. So, its production efficiency must be increased. Nowadays, hydroponics system is becoming a quite common and alternative method as compared to traditional farming systems of cultivation of soil, because hydroponics systems offer a wide range of advantages such as high capacity of production, high quality of products and also reduce the use of pesticides as compared to the traditional methods of cultivation. Grapevine variety namely, Yalova Cekirdeksizi has been taken in summer growing season and used its green cuttings as living material in this research work. The obtained cuttings were transplanted to different pots in three different time periods (15th of June, July and August in the year 2015). Grapevine rootstocks were placed to the pots having the dimension of 22 cm in width, 72 cm in length and 17 cm in depth. Each pot in the experiment possessed the same amount of fertilizer and the drip irrigation system has been applied. A microcontroller (PIC16F84) device has been used as an automated controller for supplying the water to the experimental trials. The irrigation system has been comprised with three main parts i.e., submersible pump, power suppliers (12 volt DC) and some other connected apparatus. In this experiment, a time based closed loop hydroponics system has been used aimed to test the performance of the automated hydroponics system for the growth of grapevine rootstocks. Consequently, the system took over the all irrigation procedures successfully throughout the entire growing season.

Key words: *automation, drip irrigation, hydroponics, grapevine, green cutting.*

INTRODUCTION

The word hydroponics is derived from two Greek words i.e., 'hydro' and 'ponos' by the meanings of 'water' and 'work', respectively. So, the word hydroponics means to "work with water" described by Catellane and Araujo in 1995. The word "hydroponics" is used for the systems that applied in agriculture for growing plants without soil and irrigate them with a mixed solution of water and chemical fertilizers. Hydroponics systems have recently been used for some research works, especially on the topics of nutrient solutions as well as plant growth, and also commercial cultivation of vegetables and ornamental plants. Thus, hydroponics system is being used quite successfully for this purpose and offering a wide range of advantages such as high quality of agricultural products and reducing the application of pesticides in this sector (Catellane and Araujo, 1995).

Micro irrigation system is practiced as irrigation method in the hydroponics system which is commonly known as drip irrigation. A combination of automation and micro irrigation systems ensure the proper amount of water supplied for growing plants throughout the growing season. It also becomes a cause of energy savings, reduction in labor costs, and controlling the amount of fertilizer, which are some major advantages while adopting automated techniques into micro irrigation systems (Yildirim and Demirel, 2011).

Manually controlled irrigation systems could not supply a proper amount of water because of its mismanagement (Salam et al., 2012). On the other hand, automated irrigation systems provide high crop yield, save the usage of water (Mulas, 1986), facilitate high frequency and low volume irrigation (Abraham et al., 2000), and also minimize the human error (Castanon, 1992). Automated irrigation system is usually designed for ensuring to supply the proper amount of water for growing up the plants throughout the season. Caceres et al. (2007) developed an automated irrigation control tray and activated it with a water level sensing system. Yilidirim and Demirel (2011) developed an irrigation controller and reported

Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

that the most important point in the automated drip irrigation system is the sensor calibration and installation of the soil moisture sensor in the pot.

Many studies have been carried out related to the hydroponics system mainly focusing the planting density while growing the grapevine rootstocks (Maltabar et al., 1977; Mokan, 1979; Bahar, 1996), different cultural practices to the rootstocks (Perstnev, 1979), determination of the most favourable planting season (Maltabar et al., 1977), the application of different hormones (Gromakovskii and Maklakova, 1979; Perstnev, 1979), determine the appropriate ways of irrigation management (Aleksanyan, 1981), and fertilizer application (Suruzhiu, 1979; Suruzhiu and Adamov, 1979), planting depth to the substrates (Adamova, 1980) and suitable temperature in the root region (Suruzhiu, 1981).

There are few published studies about producing grapevine rootstocks in hydroponics in combination with an automated drip irrigation system. The main objective of this experiment is to present the hardware and software of the automated hydroponics system.

MATERIALS AND METHODS

In this research work, Yalova Cekirdeksizi grapevine variety have been taken in the summer growing season used as green cuttings as living material. The obtained green cuttings (3–4 budded) were taken as samples from Dardanelles (Applied Research Center of Canakkale Onsekiz Mart University) and then transplanted for three different times into pots on the 15th of June, July and August in the year 2015. The dimension of each pot has been consisted of 22cm in width, 77cm in length and 17 cm in depth having an overall surface area of 0.17m^2. Each pot possessed two drainage holes with a diameter of 16 mm from the bottom line shown in Fig 1.

The irrigation system is consisted of a water storage tank (200L), containing Hoagland solution described by Hoagland and Arnon in the year 1950. Hoagland solution has been modified by the researchers aimed to regulate the optimum pH and EC levels for the green cuttings of grapevine. This solution has been diluted with water for 3 times to protect the cuttings from high EC levels, because of the continuous supply of nutrient solution to plants through irrigation applications. Nutrient solution has been renewed when its EC level reached to 1.5–1.8 dS/m along with the final formation of the above mentioned solution containing 6.2 pH and 1.0–1.3 dS/m. Submersible pump operating at 12 volt DC has been installed inside the water storage tank. A steel construction was built to keep pots at height of 1.5 m from the ground level of the greenhouse and water storage tank and controller circuit were installed immediately under the pots. Therefore, it made the excess water easiest to return back to the reservoir by the drainage pipes connected to the drainage holes of the pots.

Electrical conductivity of the irrigation water (ECw) has been measured by an EC59 meter (Martini Institute). Pots were irrigated with the same amount of nutrient solution. The required water has been supplied by using Ø16 pipes with drippers (4L/h) at a spacing of 33 cm, with three drippers serving each pot. In the irrigation system, some connection apparatus and also valves were used to integrate all items.

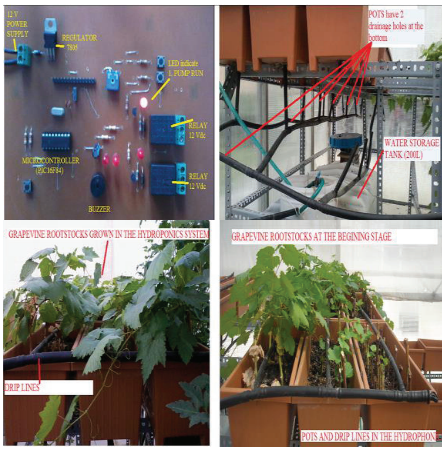

Figure 1. Layout of the experimental components

At the beginning of the experiment, all substrates were filled up to field capacity, then the automated system started irrigation at 4 hours intervals and run the submersible pump only one minute throughout the whole growing season so that this irrigation management kept the soil moisture at the level of field capacity in each substrate since excess water was drained to the reservoir back after each irrigation event. The most important and basic component of the automated hydroponics system was the controller circuit, in which main power supply was 12 V DC, providing power to the controller and also relays, but it was reduced to 5 V dc for microcontroller (PIC16F84) by a regulator of 7805.

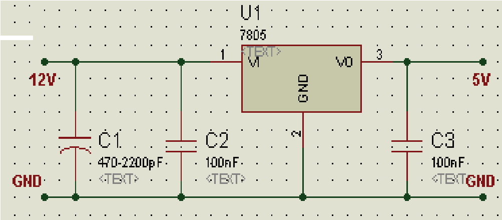

Figure 2. Voltage regulator for the microcontroller

Controller software: the circuit of the automation system is given in Figure 3, showing the all connections between microprocessor, relay and etc. The programme providing the automation in the hydroponics system was simple and basic and also very easy to load into the memory of the microcontroller (PIC16F84).

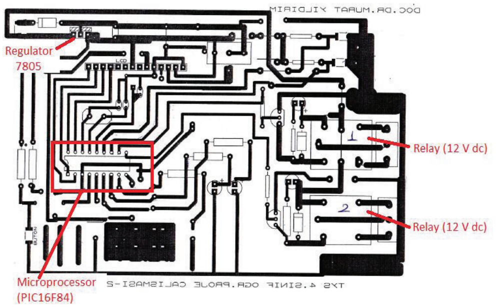

Figure 3. Solder side and components of the circuit.

The programme was written using the PicBasic Pro software programme and in the program the general strategy of the irrigation management was defined to the memory of the microcontroller unit (MCU). After running the system, the MCU repeated the actions throughout the whole growing season. The dosage of water was determined according to the pumping time of water. Some parts of the software is given below.

```
'------------------------------------
'TIME BASED AUTOMATED SYSTEM
'DATE: 25.03.2015
'WRITTEN BY: DR. Murat YILDIRIM
'COMU AGRICULTURAL ENGINERING, IRRIGATION DEPARTMENT, CANAKKALE
'-----------------------------------
P con 0
P1 con 0
P2 con 0
P3 con 0
C0 con 60
*
*
h2 con 117
        @ DEVICE PIC16F84
        DEFINE OSC 4
        i VAR WORD
        k VAR WORD
        TRISA=%00000000
        TRISB=%00000000
        PORTA=0: PORTB=0
        SYMBOL SES=PORTB.2
        SYMBOL BIR=PORTB.5
KTRL:
        SOUND SES, [100,100]
        PAUSE 1000
        GOSUB DELAY
DONGU:
        SOUND SES, [e2, 63, **, 24]
        BIR=1
        FOR i=0 TO 60
        PAUSE 1000
        NEXT i
        BIR=0
        SOUND SES, [100,100]
        k=0
        GOSUB WAITT
        GOTO KTRL
DELAY:
        ****
        RETURN
WAITT:
        k=k+1
        FOR i=0 TO 300
        PAUSE 1000
        NEXT i
        IF k<30 THEN GOTO WAITT
        RETURN
        END
```

Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

RESULTS AND DISCUSSIONS

The irrigation processes have successfully been completed by the hydroponics system according to the strategy defined to the MCU. The microcontroller switched on relaying to pumping water to the root territory only for one minute as described to the memory of the MCU. After that, supplying of water has been stopped to the pump and then waited for 4 hours of interval for the next irrigation session. The system took over the irrigation events successfully for the whole growing season. The system conveys a properly balanced nutrient solution to the plant root area.

It is very easy to construct the controller circuit given in Figure 3 and also having very low cost. It save water and also fertilizer, but the water level in the reservoir must be checked with 2 or 3 week interval or water level sensor should be added to the controller circuit.

Perlite due to its characteristics has more advantages as being used in the hydroponics system as compared with peat and peat+perlite (1:1, v:v). According to the overall results, the Yalova Cekirdeksizi grapevine variety has been successfully developed and would be used for further applications which have been taken from different period of green cuttings.

Usually small producers from small hydroponic systems that own little capita can use this kind of simple automated hydroponics system, this system seems to be more efficient and successful for small farmers.

ACKNOWLEDGEMENTS

The authors would like to thank to the concerned authority of the Department of Horticulture, Canakkale Onsekiz Mart University, since they provide the opportunity to work in the greenhouse.

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