https://doi.org/10.33261/jaaru.2019.26.2.001 *Association of Arab Universities Journal of Engineering Sciences (2019) 26(2): 1–5*

Association of Arab Universities Journal of Engineering Sciences
مجلة اتحاد الجامعات العربية للدراسات والبحوث الهندسية

# Improvement Water Productivity of Eggplant Under Subsurface Water Retention Technology

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Published online: 30 June 2019

**Abstract—** A study of the evaluation of the water productivity (WP) of eggplant under subsurface water retention technology (SWRT) through membrane sheet installed under the root zone has been conducted in sandy loam soil located in Al-Fahamah Township, Baghdad, during two growing seasons (from January 10th to May 31st, 2017 in a greenhouse and from April 9th to July 10th, 2017 in open field). For this purpose, two treatments plot with membrane sheet and without using membrane sheet were applied for each growing season to determine and compare the effect of water saving membrane on productivity of eggplant. Results showed apparent differences among the water productivities of eggplant in the greenhouse and open field. The WP values of eggplant inside greenhouse for SWRT treatment and control plot were 5640 ID/m3 and 3700 ID/m3, respectively and in open field were 2220 ID/m3 and 1570 ID/m3, respectively. The WP of eggplant for SWRT treatment was more than the control plot inside the greenhouse and in open field by 52 % and 40 %, respectively. The installation of membrane sheet below the soil surface was improved the value of water productivity of eggplant and more saving in applied of irrigation water.

**Keywords—** Subsurface water retention technology, water productivity, eggplant, greenhouse.

## 1. Introduction

The competition for water is growing in various sectors and water is a critical input in agriculture. Water shortage and lack of economically accessible water due to increasing price of production and supply of the resource encouraged researchers to search and increase the production for each unit of water used to increase productivity of water use in agriculture, [5]. Water productivity (WP) can be evaluated at field level, plant level, basin level, and system level, and the value of WP would change with the changing levels of analysis, [6]. In the irrigation regions, the assessment of water uses to assist water stakeholder decisions is increased. Analyzing the water productivity indicator can be assessed the water resources at field, scheme or regional scale, [4]. [8] used WP to assess the irrigation performance between difference systems (solid-set sprinkler, surface and drip irrigation) and crops. in the similar way, [2] apply WP in their study to estimate the quality of water used in irrigation. Water productivity is the benefit derived from the water use, and includes important aspects of water management such as production for semi-arid and arid areas. [1] stated that the WP is used to define the relation between crop produced and the quantity of water involved in crop production. With high increasing populations, improve water productivity is a significant challenge for water shortage areas, especially in regions in the developing and least developed countries, [3]. [10] detect a wide interval in the mean WP values of crops (maize: 1.1-2.7 kg/m3; wheat: 0.6 -1.7 kg/m3; cotton: 0.41-0.95 kg/m3 and rice: 0.6-1.6 kg/m3) and, mentioned reduction water amount by 20 to 40 % may be lead to maintain or increase the crop production. [9] estimated the water productivity indicators for sugar beet, sunflower, fodder maize and wheat in Esfahan, Iran during the growing season 2004-2005 to propose strategies for irrigation management that improved farmer's incomes and water productivity. The experimental results show that the average WP was 0.38 \$.m-3 for sugar beet, 0.06 \$.m-3 for sunflower, 0.5 \$.m-3 for fodder maize and 0.19 \$.m-3 for wheat, and concluded that reduction of irrigated area and deficit irrigation increased water productivity values during the water shortage periods. [7] analyzed in their study water productivity and water use efficiency indicators in Rio Adaja district, Spain for main crops for three years from 2010 to 2013. They concluded that the water productivity for three years in term of (€.m-3) changed among crops but WP for crops such as: onion 4.14, 1.98 and 2.77, respectively, potato 2.79, 1.69 and 1.62 respectively, carrot 1.37, 1.70 and 1.80 respectively and barley 1.21, 1.16 and 0.68 respectively which are the higher values. Additionally, the results show that the deficit application of water has enhanced the WP for most of the crops, especially for onion and potato. The objectives of this study were to estimate the effects of membrane sheet, installed at depth 35 cm below ground surface in a sandy loam soil, on water productivity (WP) of eggplant for two different seasons (inside a greenhouse and open field).

## 2. Materials and Methods

### 2.1 *Experimental Condition and Location of the Field Study*

The experiments were conducted within Al-Fahamah Township, Baghdad, Iraq from month of January 10th to May 31st, 2017 in the greenhouse and from April 9th to July 10th, 2017 in the open field. The experimental work was carried out in two adjacent fields placed at latitude: 33°25' N, longitude: 44°20' E, and altitude: 36 m. Fig. 1 shows a Google map of the study area. The source of water was from a farm reservoir charged continuously from Tigris River. Two soil samples from each field of eggplant were taken at depth (0-50 cm). Analyses of soil sample were conducted at the laboratories of the Agricultural Research Directorate of Ministry of Science and Technology. The goal of the analysis was to identify the physical characteristics of the soil to estimate physical properties and soil texture which involved apparent specific gravity, soil texture, field capacity (FC), and permanent wilting point (PWP). Tables. 1 and 2 present the average values of the physical properties parameters of the soil for the greenhouse and open field, respectively

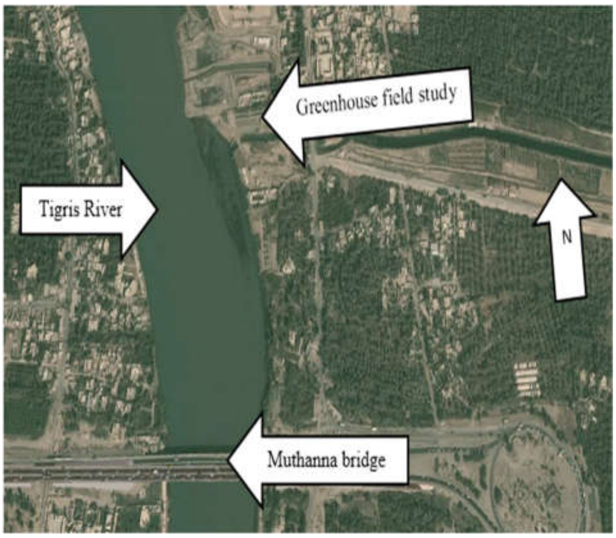


**Figure 1:** Google map for the research site work**.**

**Table 1**: Physical properties of the greenhouse soil.

| Type of the test | Specifications of the soil Average for the depth (0-50 cm) |
|---|---|
| Apparent specific gravity | 1.34 |
| Soil texture | Sandy loam |
| Field capacity (% by volume) | 16.40 |
| Permanent wilting point (% by volume) | 6.90 |

**Table 2:** Physical properties of the open field soil

| Type of the test | Specifications of the soil Average for the depth (0-50 cm) |
|---|---|
| Apparent specific gravity | 1.23 |
| Soil texture | Sandy loam |
| Field capacity (% by volume) | 16.30 |
| Permanent wilting point (% by volume) | 7.40 |

### 2.2 *Treatments, Experimental Design and Crop Material*

The unheated and without ventilated greenhouse was used with dimensions: 8 m in long, 3 m in wide, 1.8 m in high with total area is equal to 24 m2, and the adjacent open field with an area of 27 m2 (9 m in long and 3 m in wide) stretching in an N-S trend. Figs. 2 and 3 show the layout of the field study area of the greenhouse and open field, respectively. Trickle irrigation system was used for both fields. The system consists of two double irrigation lines with extend on the whole length of the field study with pipe diameter of 15 mm. The emitters were spaced at 0.5 mm apart along its total length. The average flow rate for each emitter was 20 ml/min. Eggplant crop (Solanum Melongena L.) was planted at 0.5 m distance between plants apart. Two treatment plots were selected for the research work, treatment plot No. 1 (T1) using membrane sheet installed blow the soil surface and treatment plot No. 2 (T2) without using membrane sheet (control). For each irrigation process, soil water content before irrigation, date, time of applied water and discharge from the emitter were recorded.

**Figure 2**: Field study area of the greenhouse.

**Figure 3**: Field study area of the open field.

### 2.3 *Description of the Subsurface Water Retention Technology (SWRT)*

Subsurface water retention technology (SWRT) consists of subsurface low-density polyethylene membrane of thickness 175μm installed for a half area for each season at depth 35 cm below ground surface with 3:1 (length to height) aspect ratio. The installation of the membrane was done manually and all the excavation work was done by hands, no special machine was used in this process. The width of the membrane was 36 cm with both side heights of 12 cm. Fig. 4 shows the layout of the polyethylene membrane under the soil profile.

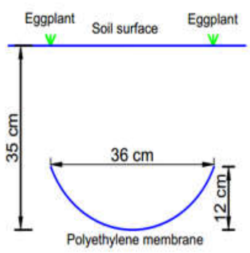


**Figure 4**: Layout of the polyethylene membrane under the soil profile.

## 3. Calculation and Procedure

Water productivity is the value of product over unit of volume of water diverted or consumed. WP was calculated according to the following equation:

$$WP = \frac{Return}{Unit\ of\ water\ consumed} \qquad (1)$$

Return could be including one of the following:

1- Biomass, grain, meat, milk (kg).
2- Income value.
3- Environmental benefits.
4- Social benefits (employment).
5- Energy.
6- Nutrition (protein, carbohydrates, fat).

While unit of water consumed includes information about water (quality, location, time available) and consumed (evaporation, transpiration, quality deterioration). In this study work the water productivity was estimated according to the following:

$$WP(Iraqi/m3) = \frac{Yield\ (kg/m2) \times Market\ selling\ price\ \ (ID/kg)}{Total\ depth\ of\ applied\ water\ (mm)} \qquad (2)$$

## 4. Result and Discussion

The value of return was estimated by multiplying the total of crop yield by the selling price in the market. The WP of eggplant in the greenhouse for treatment plot T1 was more than that in plot T2 by 52 %. Additionally, in the open field the WP in plot T1 was more than that in plot T2 by 40 %. Table. 3 shows the depth of water applied, crop yield and water productivity for eggplant from the greenhouse and from open field of treatment plots T1 and T2. The market selling price was also playing an important factor affecting the value of WP as long the farmer searching for economic issue as a first considered in the cultivated the plant and starting the project. The existing of the membrane sheet within the crop's root zone kept the water, fertilizer and nutrient within the root zone profile and improved the field water use efficiency and then the water productivity parameters. Fig. 5 shows the comparison of the water productivity for eggplant from the greenhouse and from open field of treatment plots T1 and T2.

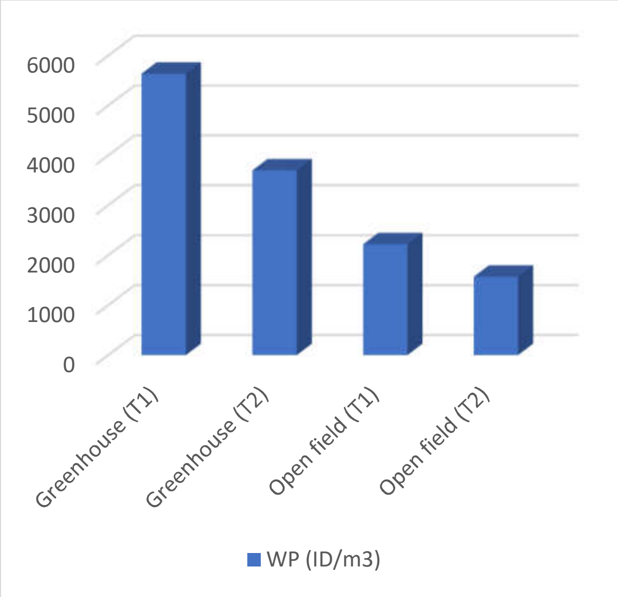


**Figure 5:** Comparison of the water productivity for eggplant from the greenhouse and from open field.

**Table 3:** Depth of water applied, crop yield and water productivity of eggplant for the greenhouse and for open field.

| Present study | Depth of water applied (mm) | Crop yield ($kg/m^2$) | WP* ($ID/m^3$) |
|---|---|---|---|
| Greenhouse (T1) | 617 | 3.48 | 5640 |
| Greenhouse (T2) | 887 | 3.28 | 3700 |
| Open field (T1) | 632 | 1.40 | 2220 |
| Open field (T2) | 883 | 1.40 | 1570 |

* market price selling of the eggplant was 1000 ID/kg (ID = Iraqi Dinars).

## 5. Conclusion

The installation of membrane sheet within crop's root depth was improved the value of the water productivity of eggplant due to the total applied depth which was less amount used in T1 compared with T2 in the greenhouse and in open field. The measured values of WP of eggplant in the greenhouse for SWRT and control plots were 5640 ID/m3 and 3700 ID/m3, respectively and in open field were 2220 ID/m3 and 1570 ID/m3, respectively. The existing of membrane sheet under soil surface improved and accordingly increased the value of WP by 52 % in the greenhouse and by 40 % in open field. Improving WP represents a real challenge in cultivation which may be achieved by increasing the harvest index or by reducing the outflows.appear underneath, flush left. Figures should be at good enough quality.

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# تحسن إنتاجية المياه للباذنجان باستخدام تقنية الاغشية الحافظة للمياه تحت السطح

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نشر في: 31 حزيران 2019

**الخلاصة –** تم اجراء دراسة حقلية لتقييم إنتاجية المياه لنبات الباذنجان باستخدام تقنية الاغشية الحافظة للمياه تحت السطح وذلك بتثبيت غشاء بلاستيكي داخل المنطقة الجذرية في تربة رملية مزيجية في منطقة الفحامة، مدينة بغداد- العراق خلال موسمين زراعيين (من 10 كانون الثاني الى 31 ايار، 2017 داخل البيوت الخضراء ومن 9 نيسان الى 10 تموز، 2017 في حقل مفتوح). لهذا الغرض، فأن نوعيين من المعالجات الزراعية بأستخدام غشاء وبدون استخدام غشاء قد طبقت في كل موسم لغرض حساب ومقارنة تأثير الغشاء الحافظ للمياه على انتاجية المياه للباذنجان داخل البيوت الخضراء وفي حقل مفتوح. اظهرت النتائج ان هنالك فرق واضح في إنتاجية المياه للباذنجان بين المعالجات الزراعية داخل البيوت الخضراء والحقل المفتوح. كانت قيم إنتاجية المياه للباذنجان في المعالجة الزراعية باستخدام الاغشية وبدون الاغشية تساوي 5640 دينار عراقي/م3 و3700 دينار عراقي/م3 على التوالي داخل البيوت الخضراء و2220 دينار/م3 و1570 دينار/م3 على التوالي في الحقل المفتوح. كانت إنتاجية المياه للباذنجان في المعالجة الزراعية بتقنية الاغشية الحافظة للمياه اكثر من المسيطر بحوالي 52% داخل البيوت الخضراء و 40 % في الحقل المفتوح. إن تثبيت الغشاء تحت سطح التربة قد اثبتت تحسن في قيمة انتاجية المياه للباذنجان فضلا عن الاقتصاد في اضافة مياه الري.

**الكلمات الرئيسية –** تقنية الاغشية الحافظة للمياه تحت السطح، إنتاجية المياه، الباذنجان، البيوت الخضراء.