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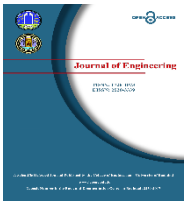

Water Resources and Surveying Engineering

Water Retention Techniques under Crop's Root Zone a Tool to Enhance Water Use Efficiency and Economic Water Productivity for Zucchini

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ABSTRACT

A new technique in cultivation by installing membrane sheet below the crop's root zone was helped to save irrigation water in the root zone, less farm losses, increasing the field water use efficiency and water productivity. In this paper, the membrane sheet was installed below the root zone of zucchini during the summer growing season 2017 in open field. This research was carried out in a private field in Babil governorate at Sadat Al Hindiya Township reached 72 km from Baghdad. Surface trickle irrigation system was used for irrigation process. Two treatment plots were used, treatment plot T1 using membrane sheet and treatment plot T2 without using the membrane sheet. The applied irrigation water, time of irrigation, soil moisture contents before irrigation were calculated and recorded daily for the two treatments plots. Values of crop yield, Field water use Efficiency and economic water productivity were discussed and compared between the plots. The obtained results indicate that field water use efficiency for the two plots, T1 and T2 were: 6.04 and 4.64 kg/m^3, respectively. The increasing value in field water use efficiency (FWUE) of plot T1 comparing with plot T2 was 30.2 %. Additionally, the value of economic water productivity of zucchini crop for plots T1 and T2 was: 20514.1 and 15031.7 ID/m^3, respectively. The increasing value of the Economic water productivity (EWP) of plot T1 comparing with plot T2 was 36.5 %. The value of water saving in plot T1 was 16.7%. The reduction in frequency of irrigation at T1 was 12 %.

Keywords: zucchini, water use efficiency, membrane sheet, and economic water productivity.

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تقنية أحتجاز المياه تحت المنطقة الجذرية للنبات كأداة لتحسين كفاءة استعمال المياه وانتاجية المياه الاقتصادية للكوسا

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مهندس في وزارة الموارد المائية
ماجستير في الموارد المائية

صباح انور المصرف
استاذ مساعد
قسم هندسة الموارد المائية
كلية الهندسة-جامعة بغداد

الخلاصة

التقنيات الحديثة في الزراعة بواسطة تنصيب غشاء تحت الطبقة الجذرية للنبات ساعدت لحفظ ماء الري في المنطقة الجذرية، تقلل ضائعات الري، زيادة كفاءة استعمال المياه وانتاجية المياه. في هذا البحث تم نصب غشاء من البلاستك تحت الطبقة الجذرية لنبات الكوسا خلال موسم النمو الصيفي 2017 في حقل مفتوح. تم انجاز البحث في حقل خاص يقع في محافظة بابل في ناحية سدة الهندية تبعد 72 كم من العاصمة بغداد. استخدم نظام الري بالتنقيط في عملية الري. استخدمت معالجتين زراعتين، المعالجة T1استخدم الغشاء البلاستيكي والمعالجةT2 بدون استخدام الغشاء. ماء الري المطبق، وقت الري، المحتويات الرطوبة قبل الري حسبت وسجلت بشكل يومي للمعالجتين الزراعتين. قيم انتاج المحصول، الكفاءة الحقلية لاستخدام المياه و انتاجية المياه الاقتصادية تم مناقشتها ومقارنتها بين المعالجات الزراعية. النتائج المستحصلة اعطت قيم للكفاءة الحقلية لاستخدام المياه للمعالجة الزراعية الاولى والثانية 6.06 و 4.64 كغم لكل متر مكعب على التوالي و بنسبة زيادة للمعالجة الاولى بمقدار 30.2 %. فضلا عن ذلك فان مقدار انتاجية المياه الاقتصادية للمعالجة الزراعية الاولى والثانية كانت 20514.1 و 15031.7 دينار عراقي لكل متر مكعب وبزيادة في المعالجة الاولى بمقدار 36.5 %. أن قيمة الادخار في استخدام المياه في المعالجة الاولى مقارنة بالمعالجة الثانية كانت 16.7 % و النقصان في عدد فترات الري بمقدار 12 %.

الكلمات الرئيسية: الكوسا، كفاءة استعمال المياه، تقنية الاغشية البلاستكية، انتاجية المياه.

1. INTRODUCTION

In this research will study the effect of installing the membrane sheet of subsurface water retention technology below the root zone on water use efficiency and economic water productivity to squash (zucchini) crops in open field and compered the result with the crops without using subsurface water retention technology to get on the best result in water reduction and increasing of production and this aims more the researcher**. Smucker, et al., 2016,** studied the effect of the membrane sheet installed below the soil surface and under the root zone of the crop on yield and water use efficiency (WUE) of maize. The experiment was conducted inside a greenhouse and lysimeter was constructed. Sandy soil was used cultivated with maize. The results indicated that the soil water content above the membrane sheet was dubled the water holding capacity, increased maize production by 240 % and increasing water use efficiency by 77 %. The economic water productivity (WP) defined as the net return dividing by water applied. The best understanding, calculated and enhancing of WP helped to strengthen of water crisis and response to growth of water scarcity, increasing of production inputs and improving farmer livelihoods **Molden, et al., 2010**. **Isa 2016**, studied the effect of installing the membrane sheet below the root zone on WUE of hot pepper and tomato crops in greenhouses. The experimental sites were located in Diyala and Najaf governorates utilize SWRT treatment plot, organic treatment plots, tillage treatment plots and no tillage treatment plots. The obtained results showed that the value of WUE of hot pepper in Diyala site with SWRT was more than other plots by 233. Additionally, the value of WUE of hot pepper in Najaf site was more than other plots by 165 %. **Amirpour, et al., 2016** investigated the influence of SWRT on soil moisture content, frequency of watering and heat of the soil. SWRT was set up at varies depths in sand texture of soil. The plant which utilized name the maize and utilized straw mulches cultivated on

soil surface and without. The search was carried out in Kerman of Iran during the second month of 2013 to the last of eleventh month of 2014. The water and heat of soil was improved via using SWRT sheet and the irrigation frequency was calculated. Furthermore, SWRT sheet was appeared to be good influence on water retention for plant at all depths. They suggest using SWRT sheet with mulch to improve the condition of sandy texture soil. **Hommadi , 2018,** evaluated the using of the membrane sheet below hot pepper and okra crop's root zone on water use efficiency and water productivity. The experimental work was carried out in two different sites in the growing seasons 2016 and 2017, in Sadat Al-Hindyia, Babylon of Iraq. Surface trickle irrigation system was used in the irrigation process inside the greenhouses. The obtained results indicated that clear increasing values of WUE and WP in the treatment plot with membrane sheet were observed. The value of WUE of hot pepper and okra was more than other plots by an average value of 54 % and 25 %, respectively. Moreover, the economic WP of hot pepper and okra in the plot of membrane sheet was more than other plots by an average value of 89 % and 108 %, respectively.

Salim, 2018 explained in his study work that the field water use efficiency of eggplant was increased when membrane sheet was installed below the root zone of eggplant. The experiment was conducted inside greenhouse and in open field of the growing seasons 2016 and 2017. The research work was located north east of Baghdad. Two treatment plots were used; plot T1 with installing membrane sheet and plot T2 without using the membrane sheet. Sandy loam soil was used. The obtained results showed that FWUE of eggplant in the first and second season by 50 and 41 %, respectively.

The objectives of this study were to improve of utilizing of installing the membrane sheet below the root zone of zucchini on the value of crop yield, field water use efficiency and on the value of economic water productivity.

2. MATERIALS AND METHODS

Field Conditions and Site of the Research Study

The research study was located in Sadat Al Hindiya Township on Sada- Mahawel road, in the Hilla city at Babil governorate 72 Km south of Baghdad. The latitude was equal 32 º 42' 23"N and longitude = 44º 36"E, and altitude: 31m. **Fig. 1** shown the Google map for the site work. Analysis of the soil from the site work was conducted in the laboratory of the Agriculture College in Baghdad University to indicate the physical properties of the soil. The analysis included soil texture, field capacity, wilting point and apparent specific gravity. The soil texture was classified as loamy sand soil for depth ranges 0 to1.0 m. The field capacity was 12.9 % by volume and permanent wilting point was 6.94 % by volume. The apparent specific gravity of loamy sand soil was 1.45 and the allowable depletion of zucchini was taken as 50 % and the maximum effective root zone was 50 cm according to **FAO-56 ,Allen, et al., 1998.**

Figure 1. Google map for the site work.

Treatments, Experimental Design and Crop Material.

Two treatments were utilized: the first treatment plot T1 was utilized SWRT membrane that set partially below soil surface. The second treatment plot T2 without using SWRT. Each treatment area was 8.3 m^2, with total area 30 m^2. The membrane sheet of thickness 100 µm was installed below the soil surface in depth 30 cm under the root zone of crops as U shape with aspect ratio 2:1 (width to height). The set up process of the membrane sheet was carried out by manual work as shown in **Fig. 2**. The cross section through the site work was showed in **Fig. 3.** Zucchini (*Cucurbita pepo L.*) was used in this work planted at a distance of 20 cm. Surface trickle irrigation system was used with emitter spacing equal to 20 cm, therefore each plant provided with one emitter of average flow rate of 32 cm^3/min. Date of seeding the plant was started at May 2017 and the harvest date was mid of August 2017. Electric water pump was used for the trickle system of maximum flow rate equal to 30 l/min with maximum head equal to 30 m and rated at power equal to 0.37 kw (0.5 HP).

Figure 2. Installation process of the polyethylene sheet below the soil surface.

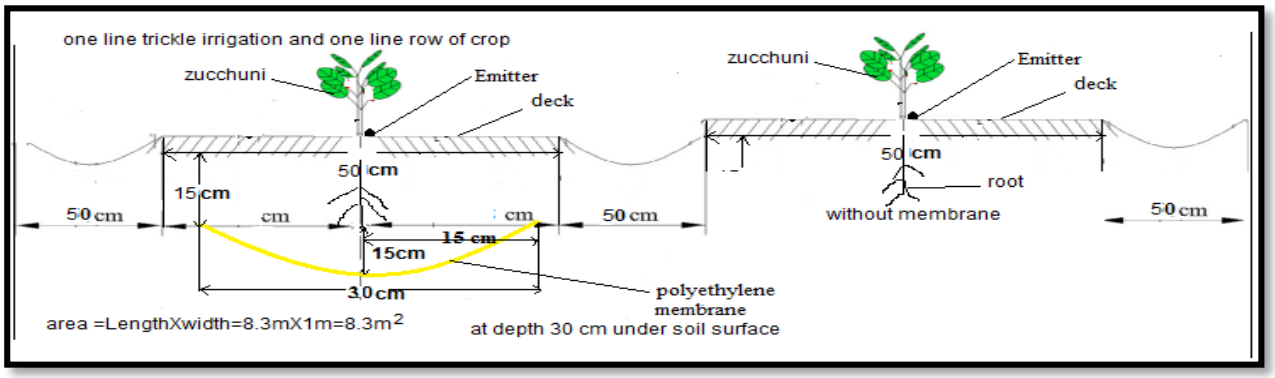

Figure 3 Cross section through the soil deck.

Yield Index, Field Water Use Efficiency (WUE) and Economic Water Productivity (WP)

Yield Index

The summation of production from date of starting harvest till to end of the harvest pickings crop's production was utilize as a total production. The crop yield (kg/m^2) was describing by **FAO, 1982:**

$$Crop\ Yield = \frac{total\ weight\ of\ crop\ (kg)}{total\ area\ of\ crop\ (m^2)} \quad (1)$$

Field Water Use efficiency

Field water use efficiency (FWUE) defines as a result of dividing the crop yield on total depth of applied water. Field water use efficiency (kg/m^3) was applied according to **Naroua, et al., 2014**:

$$FWUE = \frac{crop\ yield(\frac{Kg}{m^2})}{total\ depth\ of\ applied\ water\ (m)} \quad (2)$$

Economic Water productivity

Economic water productivity (EWP) can be defined as a return divided by volume of applied water (m^3). The value of return (in Iraqi Dinars) was equal to crop production multiply by the selling price in the market:

$$E\ W\ P = \frac{\text{Retun}}{\text{volume water applied}(m^3)} \quad (3)$$

3. RESULTS AND THE DISCUSSIONS

Frequency of Irrigation and the Applied Depth of Water

Schedule of irrigation was conducted for the treatments plots through the growing season and when the soil allowable water depletion (AD) reached to 50 % from the available water. Month, depth of applied water and frequency of irrigation of zucchini in treatment plots T1 and T2 for the growing season 2017 were shown in **Table 1**. The total depth of applied water in plots T1 and T2 were 317.8 and 370.5 mm, respectively. Saving in water in plot T1 was 16.7 %. Additionally, total frequency of irrigation in plots T1 and T2 were 25 and 28, respectively, with reduction in number of irrigation in plot T1 by 12 %. Treatment plot T1 was conserving water in the soil root depth higher than T2 due to membrane sheet.

Table 1. Month, depth of applied water and frequency of irrigation of zucchini in treatment plots T1 and T2 for the growing season 2017.

Month	Depth of applied water (mm) in plot T1	Frequency of irrigation in plot T1	Depth of applied water (mm) in plot T2	Frequency of irrigation in plot T2
May	85	8	104.8	9
June	105.58	8	115.05	9
July	127.28	9	150.66	10
Total	**317.8**	**25**	**370.5**	**28**

Crop Yield and Field Water Use Efficiency of Zucchini Crop

The index of crop yield was estimated by the **Eq. 1** for the treatments T1 and T2 were 1.92 kg/m^2 and 1.72 kg/m^2, respectively. The yield for plot T1 was higher than that in plot T2 by 11.6 %. This raising in yield index of the crop in T1 was because of the water and nutrient that were retention in root zone over the membrane sheet. **Table 2** shows the yield index of zucchini crop at month of June and July for plots T1 and T2. Increasing the yield index in plot T1 was 11.6 %. Additionally, the value of field water use efficiency (FWUE) for plots T1 and T2 were estimated by applying **Eq. 2** and to: 6.04 kg/m^3 and 4.64 kg/m^3, respectively. The increasing value in FWUE in plot T1 comparing with plot T2 was 30.2 %. The membrane sheet was assist on saving water, nutrient and pesticides inside root zone and prevention the water from losses by deep percolation process. **Fig. 4** shown the yield index and FWUE values of zucchini crop for plots T1 and T2.

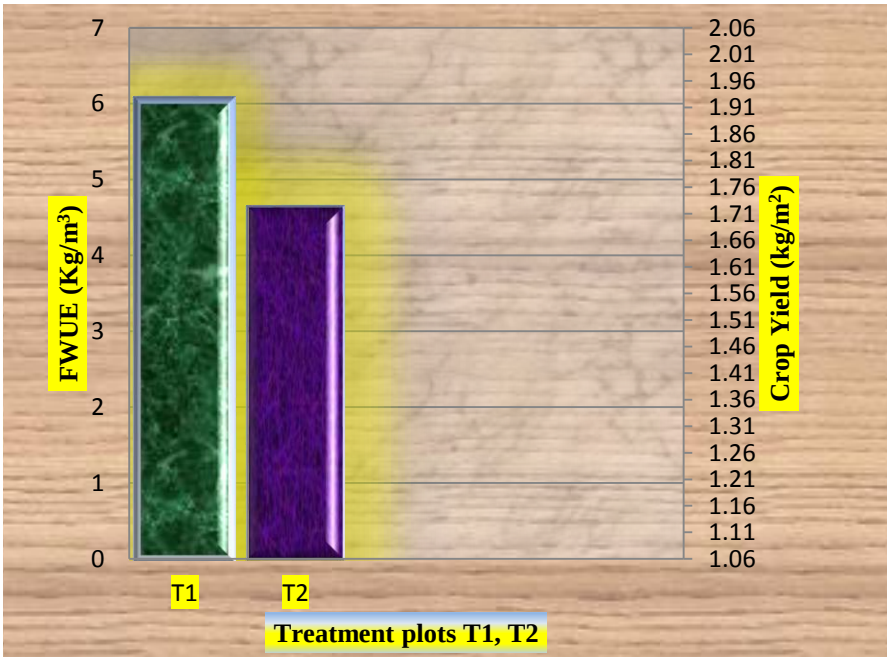

Figure 4 Crop Yield and FWUE values for treatments plots T1 and T2 of zucchini in the growth season 2017.

Table 2. Month and crop yield of zucchini for treatment plots T1 and T2 for the growing season 2017.

Month	Yield for T1 (kg/m^2)	Yield for T2 (kg/m^2)
June	1	0.89
July	0.92	0.83
Total sum	**1.92**	**1.72**

Economic Water Productivity

In this paper economic water productivity (EWP) was estimated by applying **Eq. 3.** The EWP of the treatment plots T1 and T2 was 20514.1 and 15031.7 ID/m^3. **Table 3** shows the production, total selling price, return, applied volume of water and economic water productivity of zucchini for treatment plots T1 and T2. The value of EWP in plot T1 was higher than plot T2 by 36.5 %. Increasing the value of the yield index and decreasing in quantity of applied water was because of the membrane sheet below the root zone that assists on save water, fertilizer and pesticide in root zone. F**ig. 5** shows the comparison in EWP of zucchini between treatments plots T1 and T2 in the growing season 2017. F**ig. 6** shows zucchini at different growing stages.

Table 3. Production, total selling price, return, applied volume of water and economic water productivity for treatment plots T1 and T2.

Parameters	**Plot T1**	**Plot T2**
Production (kg)	15.96	14.25
Average total selling price (ID)	500	500
Return (ID)	7980	7125
Applied volume of water (m^3)	0.389	0.474
Economic water productivity (ID/m^3)	20514.1	15031.7

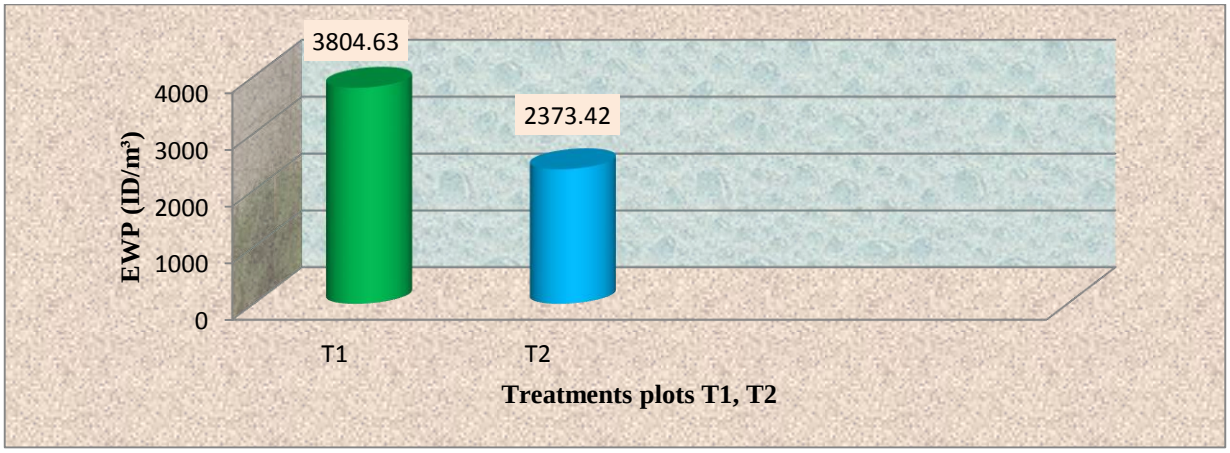

Figure 5. Economic water productivity for treatments T1 and T2 of zucchini in the growing season 2017.

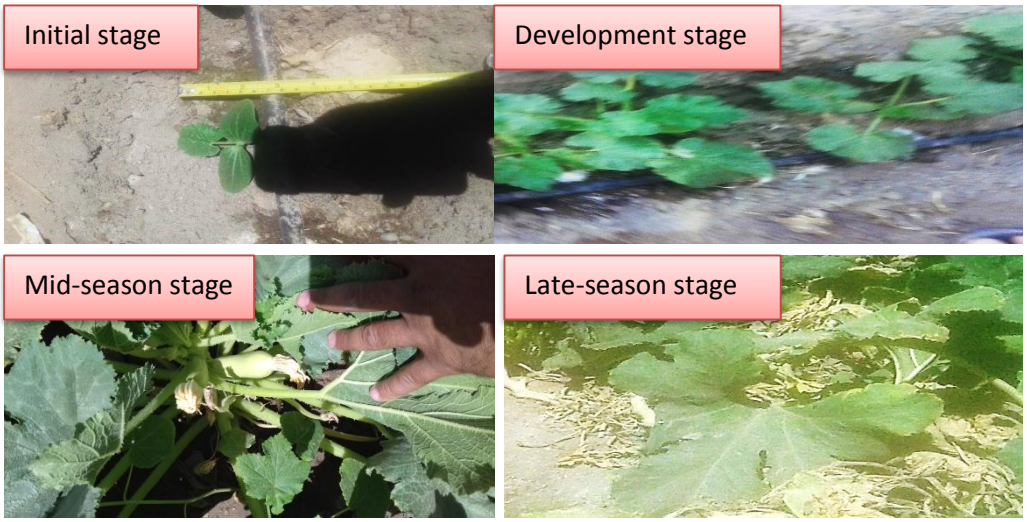

Figure 6. zucchini crop at different growing stages.

4. CONCLUSIONS

Using the membrane sheet below the root zone of the crops was helped on conserving the water and nutrient and assists on reduction the frequency water irrigation and amount of supplied water, resulting high crop yield and field water use efficiency and also the economic water productivity value:

Saving water in plot T1 was 16.7 % comparing with plot 2. Moreover, frequency in irrigation was reduced in plot T1 by 12 %. The crop yield in plot T1 was more than in plot T2 by 11.6 %. Additionally, FWUE in plot T1 was more than in plot T2 by 30.2 %. Accordingly, the value of EWP in plot T1 was more than in plot T2 by 36.5 %.

The increasing value of production and with high selling price of the crop will result high value of the net return, and with less amount of the applied water could be benefit to the farmer as long the farmer looking forward for more income and benefit. The membrane sheet under the soil surface was useful in saving applied water, fertilizer and nutrients. SWRT will be useful in coarse texture soils and with rainy season. Desert area could be changed to green fields.

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NOMENCLATURE

SWRT= subsurface water retention technology.

T1, T2 = treatment plots.

EWP = economic water productivity (ID/m^3).

ID = Iraqi dinar

FWUE = field water use efficiency (kg/m^3).