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# Increasing Application Efficiency of Supplemental Irrigation by Adding the Water in the Root Distribution Zoon

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## ABSTRACT

A new buried irrigation system was applied as supplemental irrigation system, with the goal of enhancing its application efficiency in accordance with climate change challenges and water scarcity through increasing soil moisture content, water saving and Water use efficiency for longest period possible surrounding the root distribution zone to avoid the critical period of rainless and drought and maximizing the olive fruit productivity. The field experiment was conducted in a 5-year-old olive orchard located at Wadi El Raml, Matrouh Governorate. The study extended for two consecutive winter seasons (2018-2020),under semi-arid climate conditions of Egypt. Two main supplemental irrigation system were used: Drip (DI) and buried irrigation (BI) which rely on a perforated pipes under the soil surface depths of 30 and 40 cm. At rates of organic matter 1 and 1.5 Ton.fed-1 were added to the soil. The highest preferable values of soil moisture content, water storage and olive yield productivity obtained from buried supplemental irrigation at depth of 40 cm (BI40cm) and organic matter 1.5 Ton.fed-1,while the lowest values were obtained from non-supplemental irrigated treatment (only rain-fed conditions). Hence, it is recommended that farmers urgently need to apply the supplemental irrigation technique to obtain the desired yield. This study will support the successful usage of the buried supplemental irrigation system to improve soil water storage water use efficiency and enhance yield productivity during rainless period.

***Keywords:*** Supplemental irrigation; moisture content; water storage; water use efficiency; yield.

## INTRODUCTION

Agricultural production reached to almost 70% of the global fresh water extractions (World Bank, 2017). Meanwhile, water is regarded as a necessary component of environmental development (Frone and Frone 2015).Water scarcity and low rainfall affects the agricultural activities in arid and semi-arid regions. Rainfall is characterized by its low value and uneven distribution. Several factors can affect agricultural production, but water is the most important factor, (Oweis and Hachum, 2006). (Rockstrom et al., 2010) Mentioned that by 2050,the world will need an additional 5000 km3/year of water for sustenance to combat the increasing food demands due to population explosion. The productivity of the rainwater can improved significantly when it combined with specific irrigation system, such as supplemental irrigation which can be an efficient technique to cope with the limited water availability (Oweis and Hachum,2012).When the annual rainfall is large, but its pattern includes several inter-seasonal droughts, crops are then exposed to severe loss. This becomes worse if the drought is long and coincides with the period that critically affects the growth of the cultivated crop (Kannan et al., 2010).Supplemental irrigation(SI) could be the most operative solution to mitigate the negative effects of long droughts. Supplemental irrigation is demonstrated as the application of a limited water amounts during the critical stage of crop growth under rain-fed conditions for improving the yield by maintaining minimum soil moisture amount surround the root zone (Nangia and Oweis , 2016).Many researchers have agreed that localized irrigation is considered the best technique over recent decades for protecting soil and enhancing water resources benefits (Muller et al., 2016). Supplemental irrigation is one of the efficient methods for increasing the water use efficiency in the rain-fed agricultural system for complementing the insufficient rainfall to combat with the drawbacks of drought stress (Singh et al., 2010). (Adekalu et al., 2009) Illustrated that using runoff water harvested with supplemental irrigation provides benefits of mitigating the impacts of dry periods, improving and increasing the yield for smallholder farming systems In arid zone. Therefore, the desired goal of this research is to increase the efficiency of supplemental irrigation application and maximize the benefit of it by adding the water directly from the lateral irrigation line to the perforated pipes buried in the root spreading area, so that the soil is fed with water slowly to become more moist for a long period then, increase soil wetting period and maximizing the paramount importance of a drop of water in confrontation of water scarcity challenges.

## MATERIALS AND METHODS

### 1. Study Area Description

The research study was conducted in a five-year-old olive tree orchard, cv Manzanillo at Wadi El-Raml, Matrouh, Egypt, in the Northwestern Coastal Zone (NWCZ).(Latitude: 31 15\ 35\\, N) and (Longitude: 27 09\ 43\\, E). Soil texture is sandy loam (Table.1). Annual rainfall reached 146 and 112.6 mm in the first and second experimental season for 2018/2019 and 2019/2020 respectively, which yearly start from October to April, October to late February is considered a heavy period of rain, while March and April is rainless period, Dry spells begin in the onset summer, all crops suffered from water

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deficit in this period, the orchard used drip irrigation (DI) as a supplemental irrigation in critical period. Buried irrigation (BI) was utilized for increasing the efficiency of supplemental irrigation systems.

**2. Supplemental Irrigation Times Management**

Fixed amount of 120 cubic meters of rainwater previously harvested and stored in a ground tank was used for watering one feddan of olive orchard by supplemental irrigation system during the drought months of June, July and August. Total twelve irrigations was applied, four irrigations each month and one irrigation every week.

**Table 1. Some soil physical properties of the experimental site.**

| Soil Depth Cm | Bulk density | Sand (%) | | Silt | Clay | Texture | Field Capacity (%) |
|---|---|---|---|---|---|---|---|
| | | Coarse | Fine | | | | |
| 0-20 | 1.58 | 52.8 | 24.6 | 12.5 | 9.8 | S.L* | 16.20 |
| 20-40 | 1.62 | 48.3 | 24.3 | 17.3 | 10.1 | S.L* | 19.00 |

**3. Proposed Buried Supplemental Irrigation system**

The buried system was used for optimization of supplemental irrigation and increasing soil moist for the extended period during the most critical water-sensitive stages for olive trees. The system intended to be applied primarily during the growth and productivity stages Coinciding with the cessation of rain. In case of traditional supplemental irrigation water flow directly from the emitter to the soil and evaporates from the surface while a limited amount permeates into the soil and does not benefit the root zone area. In terms of using the buried system by placing perforated pipes inside soil profile around the root zone area which received water from emitters and save it instead of letting it run directly into the soil and lost quickly. Water slowly leaches around the root zone through punched holes in the buried pipes. Water column inside the perforated pipes influenced by gravity and weight, extending the period of moisture and making the most of irrigation and efficiency.

It is worth mentioning that BI system description, two pipes with 4-inch diameter were buried in the soil, the distance between them was 80 cm and the olive tree in the center between them and on a line parallel to the irrigation lines. The pipe is open from the top and shut at the bottom,10 cm length at the bottom end of the pipe were perforated with 9 hole in the side facing the tree, with a distance between them of 2 cm and 4 mm in diameter per hole, as shown in (Fig 1).

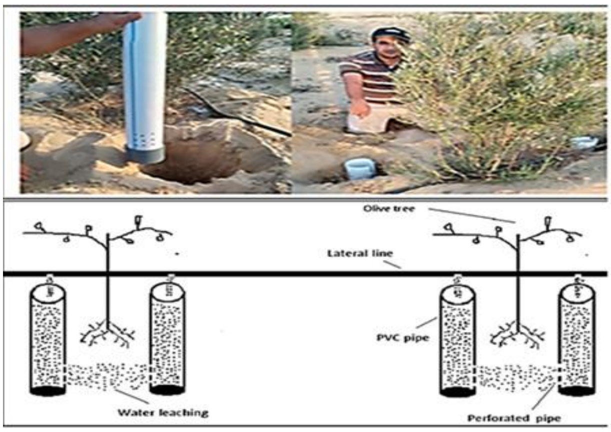


**Fig .1 . Description of buried supplemental irrigation system.**

**4. Experimental Design and Treatments**

The experimental area was divided into two main plot for supplemental irrigation comprised drip irrigation (DI) and buried irrigation (BI).9 irrigation line for olive trees in the field area, in addition to 3 rows of tree as a control treatment which watering depend on only rainfall. The tree spacing was 5×5m. 6 tree in every irrigation line. Split- Split design was used, three replications and 2 tree for every one replication, as shown in (Fig 2 ).

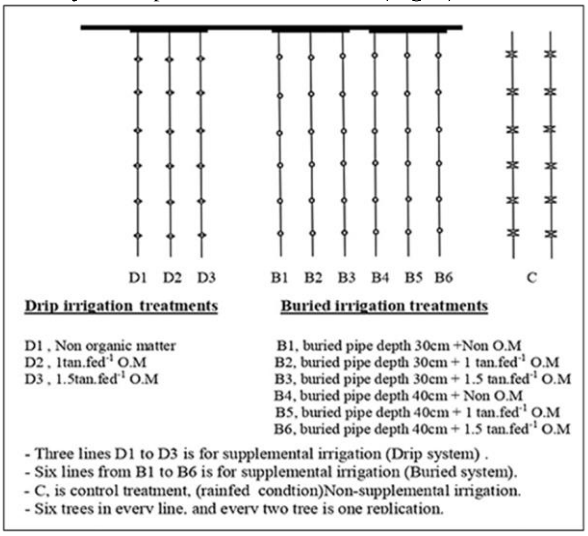


**Fig. 2 . Explaining the experimental treatments design.**

**Field experiment was conducted under the following treatments:**

- Two supplemental irrigation system (DI and buried system, BI ).
- Two depth of buried perforated pipes 30 and 40cm,( $BI_{30cm}$ and $BI_{40cm}$ )
- Three amount of organic matter, Non-(OM), 1 and 1.5 Ton .fed$^{-1}$ .when the organic matter is farmyard manure contains (O.M 12%, 8% moisture, Total nitrogen 0.35%,phosphoric acid 0.45% and Potassium 1.2% ). and traditional treatment was depended on only rainfall water storm.

**5. Soil Infiltration Rate Measurements**

To evaluate the differences in soil infiltration rate after and before adding organic matter, soil infiltration rate was measured by using double ring method according to the following equation, (Philip, 1975).

$$IR = F / T$$

**Where:**

**IR= Infiltration rate, cm.h$^{-1}$.**
**T= time, h.**
**F= cumulative water depth, cm.**

**6. Rain Fall Amount Measurements**

During the winter season rainfall amount for each storm was recorded by a digital automatic rainfall gauge.

**7. Soil Moisture Content Measurements**

After 24h of each rainstorm and every watering by supplemental irrigation, soil samples were taken for measuring moisture content by gravimetric method. It was calculated as the following equation:

$$MC = \frac{Ww - Wd}{Ww} \times 100 \cdot$$

**Where:**

**MC = soil moisture content, (weight %).**
**$W_w$ = wet soil mass, (g).**
**$W_d$ = dry soil mass, (g).**

**7. Soil Water Storage Measurements**

Water storage for all treatments was calculated according to moisture content percentage in soil depth (0-40) cm, which converted to water storage through the soil bulk density and depth. It was calculated by the following equation: ( Tainton *et. al*., 2012).

$$\mathbf{Vw = ( Pv \times A \times D ) /100}\ .$$

**Where :**

**Vw = volume of water stored in soil, $m^3$.**
**Pv = soil moisture content, (v %).**
**A = soil area, $m^2$.**
**D = Soil depth, m .**

**8. Olive Yield Production Measurements**

Olives fruit harvested manually and weighted for every tree ,then The average yield calculated as average , $kg.tree^{-1}$.

**Water Use Efficiency, (WUE)**

Through the olive yield production per feddan which include 133 tree and soil water storage per feddan, WUE was calculated according to the following formula:

$$WUE\ ,\ kg.m^3 = \frac{crop\ \ yield\ ,\ kg.\ fed^{\ -1}}{water\ \ storage\ \ ,\ m^3.\ fed^{\ -1}}$$

## RESULTS AND DISCUSION

**1. Soil Infiltration Rate**

In order to evaluate the effect of adding different amounts of organic matter on the soil's ability to retain water compared with Non-adding, soil infiltration rate was tested for experimented treatments as shown in Figure 3.

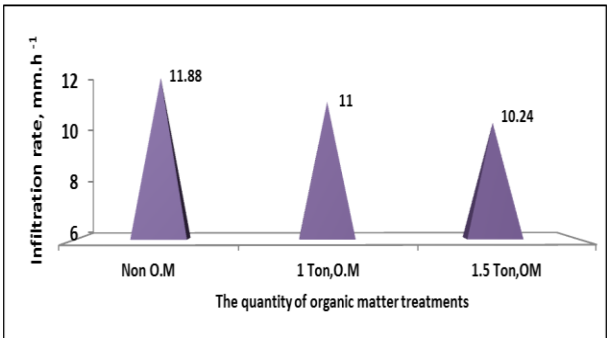


**Fig .3. Effect of organic matter quantity on soil infiltration rate**

Normal soil without adding organic matter recorded the highest value11.88 $mm.h^{-1}$. In contrast, the lowest value occurred with adding the highest quantity of O.M of 1.5 $Ton.fed^{-1}$ which reached to 10.24 $mm.h^{-1}$, while infiltration rate value of 11.00 $mm.h^{-1}$ generated with adding O.M quantity of 1 $Ton.fed^{-1}$. This is Attributed to that the high infiltration rate value of sandy soil make it unable to capture water, while the adding organic matter reduce soil density and thus reduce the infiltration capacity, as it increases the convergence and cohesion of soil particles and colloidal aggregates, which creates capillary pores that hold water and thus decrease soil filtration capacity ,(Salako and Kirchhoff, 2003).

**2. Rainfall Amount**

Rainfall amount and the annual average was illustrated in Table 2 , winter rain spells of season 2018/ 2019 started from October 2018 to March 2019,which reached to 146mm,while season 2019/2020 started from November and reached to 112.6mm.The annual average was129.3mm and the difference between monthly rainfall was observed, the highest event storm was 22.3mm in the end of November 2018 which is considered the highest cumulative rainfall month with total storm of 48.4mm,while the lowest storm was in the second season and recorded 3.00mm in December 2019,the rainiest months was November and February for the first season which recorded three storms for each,11.6 , 14.5 , 22.3 and 19 , 3.6 , 7.4mm respectively, while in the second season, the highest storm was 17mm occurred in February which considered the rainiest accumulative month with total of 31.6mm.

**Table 2. Rain fall data for two winter season and the annual average.**

| Season | | | |
|---|---|---|---|
| 2018 /2019 | | 2019/2020 | |
| Date | Rain fall storm, mm | Date | Rain fall storm, mm |
| 22/10/2018 | 12.7 | 15/11/2019 | 13.00 |
| 27/10/2018 | 7.00 | 19/11/2019 | 5.3 |
| 06/11/2018 | 11.6 | 02/12/2019 | 12.00 |
| 17/11/2018 | 14.5 | 11/12/2019 | 3.6 |
| 26/11/2018 | 22.3 | 16/12/2019 | 9.7 |
| 17/12/2018 | 18.00 | 01/01/2020 | 6.4 |
| 23/12/2018 | 5.7 | 12/01/2020 | 14.5 |
| 11/01/2019 | 13.7 | 23/01/2020 | 5.00 |
| 25/01/2019 | 3.8 | 11/02/2020 | 14.6 |
| 13/02/2019 | 19.00 | 26/02/2020 | 17 |
| 22/02/2019 | 3.6 | | |
| 25/02/2019 | 7.4 | 13/03/2020 | 11.5 |
| 06/03/2019 | 6.7 | | |
| total annual storm | 146 | ----- | 112.6 |
| Annual average | | 129.3 | |

**3. Soil moisture content:**

Annual average of soil moisture content for two winter seasons depth of (10, 30,40cm) under experimental treatments was shown in Figure 4 .Data illustrated that under rain-fed condition treatment (Non- supplemental irrigation ),total soil moisture recorded 54.7% in the end of rainfall season, while applied supplemental irrigation contributed to add moisture to the soil in drought period after rainfall stoppage as follow: buried system ($BI_{40cm}$) with adding organic matter (1.5 Ton O.M) recorded the highest Average value of soil moisture content in soil depth of 40cm compared to the others treatments, while supplemental drip irrigation (DI) in soil depth samples of 10cm recorded the lowest values. Generally there were a differences in soil moist related to the variation of soil depth samples , organic matter amount and the depth of buried pipes. The highest soil moisture content of 12.16, 16.74 and 18.82% was observed for treatment ($BI_{40cm}$) with soil depth samples 10,20,40cm respectively compared to the others treatments in the same soil samples. In the same system of buried irrigation, the effect of buried pipes depth was observed when treatment ($BI_{40cm}$) > ($BI_{30cm}$) in soil moisture content and recorded 12.16, 16.74 and 18.82% > 11.16, 15.3 and 17.78% with soil depth samples of 10, 20,40cm respectively when the organic matter was 1.5 $ton.fed^{-1}$ .the values of moisture contents with adding 1.5 $Ton.fed^{-1}$ was higher than 1 $Ton.fed^{-1}$. The lowest moisture content was recorded in case of drip irrigation , soil depth samples 10cm and non-adding organic matter. Buried irrigation($BI_{40cm}$)with adding organic matter is the optimum adoption for supplemental irrigation because the deepest buried irrigation pipes increased water saving underground and moisture content surround the root zone without any evaporation losses. Organic matter increased soil porosity , pulverization and improved soil properties which asses in soil moisture capture (Zhang *et al*., 2001).

**4. Soil Water Storage**

Data in Figure 5 showed the effect of different applied supplemental irrigation treatments on Average soil water storage after rainfall stoppage. Data illustrated that under rain-fed condition the average rainwater storage in the soil was 366.5 m$^3$.fed$^{-1}$.Buried irrigation system under depth 40cm ($BI_{40cm}$)with adding O.M, 1.5 Ton.fed$^{-1}$ recorded the highest value compared to ($BI_{30cm}$) and Drip irrigation(DI) with values of 106.84, 99.05 and 78.7m$^3$.fed$^{-1}$ respectively, while Non-adding O.M with all systems of supplemental irrigation recorded the lowest values of 51.54, 85.2 and 86.35 m$^3$.fed$^{-1}$ with DI , $BI_{30cm}$ and $BI_{40cm}$ respectively. According to the different results and values, soil water storage increased with increasing buried pipe depth and organic matter amount, because increasing the duration of moisture content in the root zoon far away from the surface and evaporation effects ,and water leaching from perforated pipes was slowly so moist was holding for a long time under soil surface.

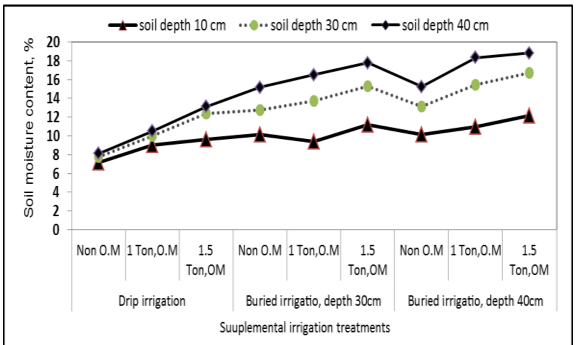

Fig (4) : Effect of different supplemental iriigation treatments on average soil moisture content under three soil depth .

**Fig. 4. Effect of supplemental irrigation treatments on average soil moisture content**

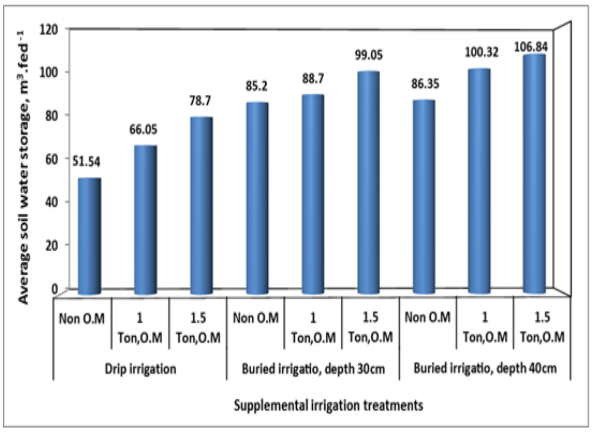


**Fig. 5. Effect of supplemental irrigation treatments on average soil water storage.**

**5. Olive Fruit Production.**

Figure 6 showed that, under different supplemental irrigation treatments the annual average production of olive fruit yield ranged from 11.5 to 24 kg.tree$^{-1}$, and reached to 7.5 kg.tree$^{-1}$ under only rain-fed conditions with non-supplemental irrigation. Results illustrated that the highest production was for treatment $BI_{40cm}$ (24 and 21 kg.tree$^{-1}$) with adding 1.5 and 1 Ton.fed$^{-1}$ of O.M respectively, followed by $BI_{30cm}$ (20.3 and 17 kg.tree$^{-1}$) with O.M 1.5 and 1 Ton.fed$^{-1}$ respectively. In contrast, Yield production with applied DI under the same treatments was less than BI, the lowest values was in case of Non-adding O.M which was 11.5, 14 and 17.2 kg.tree$^{-1}$ with treatments of DI, $BI_{30cm}$ and $BI_{40cm}$ respectively. In generally, applied supplemental irrigation increased the yield and water productivity with proper production inputs and system management (Adary *et al*., 2002). Adding O.M with deeper depth of buried irrigation pipes increased the olive fruit yield. (Hassan *et al.*, 2015) found that Organic matter is the most effective treatment for improving olive yield, this is attributed to soil ability on water irrigation holding and retention which increased the duration period of moist in the root zoon , then increased the olive fruit yield.

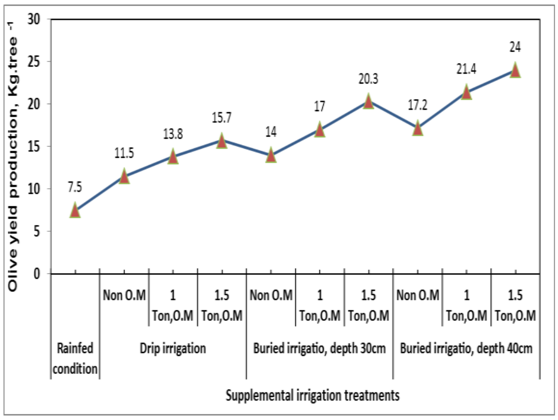


**Fig. 6. Effect of supplemental irrigation treatments on average olive yield production**

**6. Water Use Efficiency (WUE)**

Results of average water use efficiency (WUE) for all treatments are shown in Figure 7. WUE reached to the lowest value of 2.72 kg.m$^{-3}$ under rain-fed conditions. The values of WUE ranged from 3.66 to 6.74 kg.m$^{-3}$ with application of supplemental irrigation under all treatments. Treatment ($BI_{40cm}$) achieved the highest value of 6.74 and 6.10 kg.m$^{-3}$ with adding amount of O.M 1.5 and 1 Ton.fed$^{-1}$ respectively. The effect of buried depth and amount of O.M on WUE was observed, when treatment ($BI_{40cm}$) > ($BI_{30cm}$) which recorded 5.05, 6.10 and 6.74 kg.m$^{-3}$ > 4.12, 7.97 and 5.80 kg.m$^{-3}$ with amount of O.M. Non adding , 1 and 1.5 Ton.fed$^{-1}$ respectively. WUE was low with drip irrigation system compared to BI system.

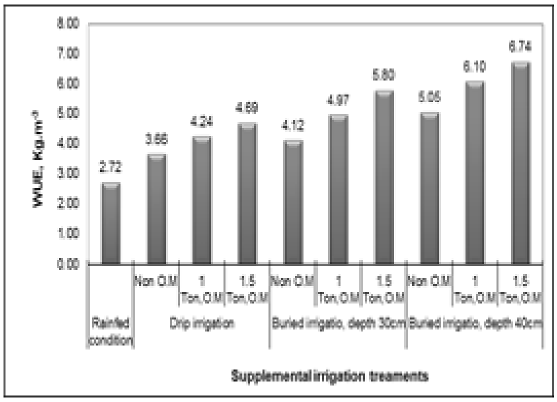


**Fig.7. Effect of supplemental irrigation treatments on average water use efficiency**

In generally increasing the amount of organic matter and applied buried irrigation increase the efficiency of supplemental irrigation system and water saving, this is attributed to the organic matter which increased soil porosity, pulverization and ameliorate field capacity which asses in soil moisture capture. Also located buried pipes in a deeper depth assess on water leaching slowly surround the root zone, decrease losses, so that increase the moisture content and water saving for a long time lead to maximizing the productivity and water use efficiency.

## CONCLUSION

Buried irrigation system was applied in a comparison with Drip irrigation as a supplemental irrigation for olive trees under different treatments. The study aims to determine the best treatments increased soil moisture content, water storage, Water use efficiency and maximize the productivity under critical periods of drought to confront the climate changes and water scarcity. Data indicated that buried supplemental irrigation at a depth of 40 cm ($BI_{40cm}$) with adding organic matter of 1.5 $Ton.fed^{-1}$ achieved the highest value for soil moisture content, water storage, olive yield productivity and water use efficiency which reached to 18.82%, 106.84$m^3.fed^{-1}$, 24$Kg.tree^{-1}$ and 6.74 $kg.m^{-3}$ respectively. Studies support the successful utilization of buried supplemental irrigation system under rain-fed condition and water scarcity for improving water storage and olive productivity to achieve sustainable development in light of the emerging of climate changes challenges.

## REFERENCES


Adekalu, K.O.; J.A. Balogun ; O.B. Aluko ; D.A. Okunade ; J.W. Gowing and M.O. Faborode (2009).Runoff water harvesting for dry spell mitigation for cowpea in the savannah belt of Nigeria Agri Water Manage., 96: 1502–1508.

Adary, A.; A. Hachum ; T. Oweis and M. Pala (2002).Wheat Productivity under Supplemental Irrigation in Northern Iraq. On-Farm Water Husbandry Research Report Series, No. 2. International Center for Agri Res in the Dry Areas (ICARDA)

Frone, D.F. and S. Frone (2015).The Importance Water Security for Sustainable Development in the Romanian Agri-Food Sector. Agriculture and Agricultural Science Procedia., 6: 674-681.

Hassan, S.A.; and M.S. Abou-Rayya (2015).Effect of some bio-fertilizers on leaf mineral content, yield and fruit quality of 'Anna' apple trees grown under Northern Sinai condition. Egypt. J. Appl. Sci., 18 (8): 559-574.

Kannan, N. ; T. Senthivel ; A.J. Rayar and M. Frank. (2010).Investigating Water Availability for Introducing an Additional Crop Yield in Dry Season on Hill Land at. Rubberize, Rwanda. Agric. Water Manage., 97 (5): 623-634.

Muller, T.; C. Bouleau and P. Perona (2016).Optimizing drip irrigation for eggplant crops in semi-arid zones using evolving thresholds. Agri Water Manage 177(2016):54–65

Nangia, V.; and T. Oweis (2016).Supplemental Irrigation: A Promising Climate- Resilience Practice for Sustainable Dryland Agriculture. In: Farooq, M. and Siddique, K., Eds., Innovations in Dryland Agriculture , Springer, Cham, 549-564.

Oweis, T.; and A. Hachum (2012).Supplemental irrigation, a highly efficient water use practice. ICARDA, Aleppo, Syria.

Oweis, T.; and A.Hachum (2006).Water harvesting and supplemental irrigation for improved water productivity of dry farming systems in West Asia and North Africa. J. Agricultural Water Manage ., 80: 57–73.

Philip, J.R. (1975).The theory of infiltration: 4. Sorptivity and algebraic infiltration equation. Soil Sci., 84: 257-264.

Rockstrom, J. ; S. Suhase ; W. Luise ; B. Jeniee ; H. Nuhue ; T. Oweis and Q. Zhu (2010).Managing Water in Rain-fed Agriculture-The Need for a Paradigm Shift. Agricultural Water Manage., 97: 543-550.

Salako, F.K. and G. Kirchhoff (2003).Field hydraulic systems in southwestern Nigeria. Soil Use Manage 19: 340-346

Singh, K.C.; D. Kundu and P.K. Bandyopadhyay (2010).Enhancing agricultural productivity through enhanced water use efficiency. Journal of Agricultural Physics 10:1-15.

Tainton, M. ; R. Drewes ; N. Rethman and C. Donaldson (2012).Radical veld improvement, pasture management in South Africa. University of Natal. Scottsville, South Africa, 355Pp.

World Bank (2017).Water in Agriculture. Understanding Poverty.

Zhang, B. ; Q.G. Zhao ; R. Horn and T. Baumgartl (2001).Shear strength of surface soil as affected by bulk density and soil water content. Soil and Tillage Research 59: 97-106.


# زيادة كفاءة تطبيق الري التكميلي بإضافة المياه بمنطقة انتشار الجذور


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## الملخص


تم إضافة الري المدفون كنظام ري تكميلي يهدف إلى زيادة كفاءة تطبيقه في ظل تحديات التغيرات المناخية وندرة المياه عن طريق زيادة محتوى رطوبة التربة لأطول فترة ممتدة بمنطقة انتشار الجذور لزيادة مخزون التربة من المياه لتجنب الفترات الحرجة من الجفاف وتوقف المطر. تم تطبيق التجربة على حقل زيتون عمر خمس سنوات في وادي الرمل بمحافظة مطروح على امتداد موسمين من 2018 الى 2020. أجريت الدراسة لتحديد أثر نظام الري الدفين على زيادة كفاءة تخزين مياه الري، رطوبة التربة وتحسين انتاجية الزيتون في مرحلة حرجة من عمر النبات وتوقف تساقط المطر. تم استخدام نظامين رئيسيين للري التكميلي ، نظام الري بالتنقيط و نظام الري الدفين الذي يستخدم أنابيب مثقبة تحت سطح التربة بعمق 30 و 40 سم. تمت إضافة المواد العضوية إلى التربة بمعدلات 1 و 1.5 طن / فدان. أوضحت النتائج التي تم الحصول عليها من الدراسة أن أعلى قيم لرطوبة التربة ومعدلات تخزين المياه والانتاجية والتي كانت 18.82 % , 106.84 م3/فدان و 24كجم/ شجرة على التوالي تم الحصول عليها من الري التكميلي المدفون بعمق 40 سم للأنابيب المثقبة مع إضافة المادة العضوية بمقدار 1.5طن / فدان ، بينما كانت اقل القيم مع عدم استخدام نظم الري التكميلي والاعتماد فقط على فترات تساقط الامطار . وبالتالي ، يوصى بأن يحتاج المزارعون إلى تحسين تقنية الري التكميلي للحصول على الانتاجية المطلوبة. ستدعم هذه الدراسة الاستخدام الناجح لتقنية الري التكميلي المدفون لتحسين تخزين مياه التربة وكفاءة استخدام المياه في الظروف الحرجة من الجفاف وندرة المياه لتحقيق التنمية المستدامة في ظل تغيرات مناخية مستجدة.