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RESEARCH ARTICLE

AGRICULTURAL WATER MANAGEMENT PRACTICES IN MENA REGION FACING CLIMATIC CHALLENGES AND WATER SCARCITY

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ABSTRACT

Location of Tunisia between the Mediterranean and the Sahara, is an arid country on a major part of its territory. This aridity combined with variability Mediterranean climate makes water a resource both scarce and irregularly distributed in time and space. Tunisia is classified by international organizations as being among the least endowed with groundwater resources countries in the Mediterranean basin. To improve modernization policy in the agriculture sector in Tunisia, essential factors for saving water and for a sustainable development must be followed as providing farmers with the technology they need to maximize the efficiency and rational use of water to optimize the use of water in agriculture. The subsurface irrigation has several advantages in terms of saving the amount of water in a sustainable development that aims to protection of groundwater. The aim of the contrasting water management techniques described in this paper is to minimize spatio-temporal losses. Subsurface irrigation can increase stores water in the root zone, allows limiting losses by evaporation and percolation. It also helps reduce weed growth. Then, we have carried out studies on the following irrigation systems: subsurface drip irrigation system (SDI) and Buried diffusers (BD). The studies consisted of monitoring the water saving of each of these techniques as well as their effects on the profitability of different crops. For example, SDI was used for two treatments full irrigation (T1) and deficit irrigation with 50% of crop Evapotranspiration (T2). Soil water content (SWC) variation was more important at the end of the season due to root uptake and hard climatic condition, treatment T2 had less water stock and best water use efficiency with 10.83 kg/ha than 5.85 kg/ha for T1. While the average values of the SWC are 19.6 ± 2.68; 15 ± 3.81 and 14 ± 3.72% respectively for buried diffuser with full irrigation TD100, deficit irrigation with 50 TD50 and deficit irrigation with 25% TD25.

KEYWORDS

Irrigation system, sustainable development, agriculture sector, water saving, cropping design.

1. INTRODUCTION

In Tunisia, the expansion of irrigated area and the semiarid climate make it compulsory to adopt strategies of water management to increase water use efficiency. Water resources in Tunisia are characterized by scarcity and a pronounced irregularity. By adopting an integrated strategy for the use of water based on scientific and technical studies, we can overcome this problem (Horchani, 2007). Irrigated agriculture is the primary user of the mobilized water in much of the world, commonly using 70% more of developed water supplies, in Tunisia the share of the agricultural sector exceeds 80% (Douh et al., 2013). In recent years, agricultural water has helped meet rapidly rising demand for food and has contributed to the growth of farm profitability and poverty reduction as well as to regional development and environmental protection (Dhaoui, 2013). After several decades of publicly funded surface irrigation, and more recently of privately developed groundwater irrigation, remaining opportunities to harness new resources for agriculture are fewer and more expensive. So, undertaking development of sustainable solutions to 21st century water resource problems become a strategic imperative (Goldhamer, 2007). However, this is combined with some problems relating to water management. Water resources are becoming scarce and the most critical constraint facing the Mena Region is the growing shortage of water resources. Following, the demand for water increases while the availability of resources is decreasing (over-exploitation, mismanagement, contamination, sectoral water-use conflicts, consciousness…). Subsurface drip irrigation (SDI), provide the application of high frequency small irrigation volumes below the soil surface have been increasingly used to enhance water use efficiency. Deficit irrigation has shown successful results with many crops in various countries. Some studies were conducted to assess the effects of deficit irrigation on gross margin and water use efficiency of vegetable crops, such as eggplant, potatoes, tomate and cucumber irrigated with subsurface drip irrigation,

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in a semiarid area of central Tunisia (Douh et al., 2011; Mguidiche et al., 2015; Ghazouani et al., 2016, Mahmoudi et al., 2020). This paper aimed to manage joint future water needs in Mena region. Some integrated approaches must be follow-up, such rehabilitation and development of irrigation systems, Dissemination of new technologies and knowledge, water savings practices.

2. Sustainable Development and Water Saving in Mena Region

Water can pose a serious challenge to sustainable progress but managed efficiently and equitably, it can play a key enabling role in establishment the resilience of social, environmental systems in the light of rapid and irregular changes.

2.1 Sustainable development

The Brundtland Commission defined Sustainable development in the document "Our Common Future "as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". It focused on three pillars of human wellbeing: economic, social and ecological conditions. The basic concept approves putting in place strong measures to spur economic and social development, particularly for people in developing countries, while ensuring that environmental integrity is sustained for future generations (United Nations, 1987). Sustainable development in Agriculture is by far the thirstiest consumer of water globally, rained agriculture is the predominant agricultural production system around the world, and its current productivity is, on average, little more than half the potential obtainable under optimal agricultural management.

By 2050, world agriculture will need to produce 60% more food globally, and 100% more in developing countries. Sustainable development in Ecosystems, probably the most important challenge to sustainable development to have arisen in the last decades is the unfolding global ecological crisis that is becoming a barrier to further human development. Global environmental degradation has reached a critical level with major ecosystems approaching thresholds that could trigger massive collapse. Global planetary boundaries must be respected to protect natural resources (WWAP, 2014).

3. Water Saving in Mena Region

3.1 Rehabilitation and Modernization of Drip Irrigation Systems

Drip irrigation is defined as the slow, even application of low-pressure water to soil and plants using plastic tubing put directly at the plants root zone (Shock et al., 2013). Drip irrigation allows limiting losses by evaporation and percolation. It also helps reduce weed growth. Microirrigation systems are typically designed to wet only the soil zone occupied by plant roots and to maintain this at or near an optimum moisture level, using emitters spaced along drip lines. The obvious advantages of microirrigation include a smaller wetted surface area, reduced evaporation from the soil surface, reduced weed growth, and potentially improved water application uniformity within the crop root zone by better control over the location and volume of application (Hedley et al., 2014).

Therefore, the choice of irrigation system will determine his driving. A drip system is more efficient, but under certain crop like grass and field crops, the spray may be recommended. The drip irrigation has several advantages in terms of saving the amount of water in a sustainable development that aims to protection of groundwater; minimize the diseases, less weeds, less labor, improved productivity, and water use efficiency (Douh et al., 2013; Levidow et al., 2014). But, in Tunisia, Stories of farmers colluding with merchants selling agricultural supplies and employees of the Agriculture Commission to abuse drip irrigation state-run grants are routine in this agricultural city that lacks water. These contributions are meant to encourage farmers both to use cost-effective irrigation methods to help limit water waste and to boost farm income and improve their livelihood (Belhouchette, 2012).

3.2 Dissemination of Technologies and Knowledge

Collaborations across sectors and within the chain of agriculture can contribute to that technology and knowledge useful to reach those who need it most. In this perspective, encouraging partnerships between the public and private sectors because they can effectively share knowledge and facilitate access to inputs. Most suitable partnerships may facilitate the distribution of agricultural inputs, such as seeds and plant protection products, the implementation of agricultural infrastructure, such as irrigation systems and the construction of transport links ensuring water accessibility to the most remote areas. The objective of the technology dissemination was to make better use of the existing irrigation infrastructures and to enhance water resources with rehabilitation and extension measures.

The objective of the project was to make better use of the existing irrigation infrastructures (PPIs and wells) and to enhance water resources with rehabilitation and extension measures. For that, we recommend Setting up consultation mechanisms, encourage technical services adopt an "integrated" and multidisciplinary approach in the agriculture practices. Introduce systems to disseminate information on the actions and results obtained in each sector. Improve adaptation of national extension strategy to local needs and conditions and draw up programs with users rather than based on "national orientations" originating from central agencies. Rethink credit mechanisms to better adapt them to farmers' needs, to the guaranties they can give and to their repayment capacity. Set up a monitoring and evaluation system that will make better use of the capacity.

3.3 Water saving methodologies

Farmers can reduce their water consumption by adopting certain techniques and making the right choice such as: The amount of water varies with climate and species and the degree of evolution of the vegetation. Changes due to climatic factors are essentially variable from one year to the other and have an impact on temperature, wind, humidity, and mainly rainfall. In order not to waste water and to give the plant only what it needs, farmers have to manage their irrigation schedules properly and use advanced techniques for irrigation control using sensors installed either at the soil level to measure water potential or water content, or at the plant level to measure sap flow or stomatal opening, or at the climate level to estimate the reference evapotranspiration of the plant from climate data. The dominant physical quality of the plant is its temperature. The optimum temperature may be about 25°C for most plants during the active season of vegetation.

A supply of very dry water on the land can lead to the phenomena of hydration which may dangerously raise the soil temperature. Thus, the farmer must know the consequences of excessive irrigation. Select crops according to their water consumption and climate: focus on crops that need less water. Collect rainwater. Choosing the right material to reduce water losses, start irrigation when necessary; consider the water content of soil and climatic conditions. Check the equipment to detect leaks and repair them automatically. Training programs that provide farmers with relevant knowledge on local plan essential to apply the techniques most rational in water management optimize the levels of agricultural productivity and farming methods more sustainable. A transformation in the culture of water that affect all those involved in the management of water, namely planners, executive officers as well as the different users. It interests all features that organize water management the technical, legal, institutional, economic, social, cultural, and ecological aspects (Loucks and Beek, 2017; Douh et al., 2018).

3.4 Measures to overcome water scarcity threats

If agricultural water use is adequately managed, and if proper policies are implemented, the effects on agricultural production and rural incomes can be minimized.

3.4.1 Improved irrigation efficiency

Irrigation efficiencies are disappointingly low. Extreme values of as low as 20 percent are encountered in some areas. The efficiency can be amplified through modernization and using advanced technological practices and management techniques. In Cyprus, for example, where pressure buried pipes are used for the conveyance of water the efficiency is higher than 95 percent and the use of sprinkler and drip irrigation has raised the on-farm application efficiency to more than 75 percent. There is a pressing need for training, organizational, technical, and financial assistance that should be extended to both farmers and water organizations to modernize the existing irrigation schemes and implement new irrigation methods thus raising the physical and economic efficiency of water application (Hadjidemetriou, 2010).

3.4.2 Water allocation changes

Provision of water to the different competing demands, even of the same sector, like agriculture, should be governed by the market mechanisms thus yielding maximum benefits and at the same time satisfying equity and sustainability in the societies. This is inherently difficult to achieve because people and even leaders in the region consider water as a free service.

3.4.3 Cropping design changes

In achieving self-sufficiency, the growing of strategic crops such as cereals is promoted in certain areas, olives in other areas in Tunisia. These crops, however, demand a lot of water and are low in cash value. It is prudent in this water short region, to substitute the water-demanding low-cash crops with low water-demanding high-cash crops. Voluntary change of the existing cropping patterns is possible delivered trade and price liberalization of agricultural crops is adopted. It is stressed, however, that agricultural extension services should be provided to the farmers for such a transformation process.

3.4.4 Price of water

Tunisia is facing increasing competition for water among users due to population and economic growth. In managing the demand, the most important and by far most effective tool is to assign to the price of water its true cost including of course its external costs. However, this policy is very difficult to implement, at present, because in many areas the water is allocated free of charge. It is necessary, therefore, for every country, considering socio-economic considerations such as level of subsidies, ability to pay, social and rural welfare, to draft a time schedule over which tariff structures are to reflect the real cost of the water. The present starting price, however, should cover at least the operation and maintenance costs and in any case the price of water should not be adjusted according to the market values, especially when it is used for agricultural purposes (Thabet and Chebil, 2006).

3.4.5 Water conservation measures

Water conservation measures should be communicated to society at large and to the farmers as to the savings possible in water use. These measures should be the subject of public debate, campaigns and information at the farm level via the extension and special advisory services. In general, "water consciousness" should be cultivated in both farmers and the public at large. Currently, conservation of water from the existing water resources represents the main and most popular approach. Conservation of the water, however, in order to be effective should be addressed to the main users. In the entire region most of the water is used for irrigation. It is therefore imperative that water conservation measures should be addressed primarily to the agricultural sector and the farmers. Conservation of water at the farmers' level, together with efforts to reduce losses from the collection and distribution systems, is the most effective, efficient and appropriate way. At the farmers' level, substantial saving of water is feasible. Moreover, being aware that the new technology could potentially achieve high water-use efficiency, if crop water requirement and scheduling or irrigation is also applied, particular attention was attached to these aspects. Through intensive research, estimations of the water requirements of all main crops and sound scheduling of irrigation, high water-use efficiency can be achieved at the farmers' level (Horchani, 2007; Douh et al., 2018; Douh et al., 2021; Khila et al., 2021).

3.4.6 Effective use of water

It should be stressed that although effort and funds have been devoted to efficient water use, the effective water use (water needed per unit of produce) is still suffering and in certain cases is totally ignored. Cropping pattern, based on effective water use, should be a policy in the region. On this aspect, research in progress in Cyprus will provide valuable results applicable to the whole region. Due to the wide acceptance and use of modern irrigation systems, attention was also devoted in the region to fertigation: the application of fertilizers with the irrigation water. In this way, the yield per unit of water applied has been substantially increased. This method, besides, being the most advantageous with the modern irrigation systems, it is also the most environmentally friendly approach. On this aspect substantial multidisciplinary research has been undertaken over the last three decades (Horchani, 2007).

3.4.7 Use of non-conventional water resources

As has already been mentioned, conventional water resources in the region are limited and finite. Water shortage in almost all the countries of the region has been addressed by exploiting all possible resources, and almost all feasible alternatives have been employed. It is therefore imperative that non-conventional water resources should be used. These non-conventional water resources include the use of wastewater and desalination (Bahri, 2001; Mguidiche et al., 2017). In this respect, wastewater reclamation and reuse have emerged as a realistic option of a new reliable source of water to meet shortage, cover water needs and meet wastewater disposal regulations aimed at protecting the environment and public health. However, the use of wastewater could be associated with severe health and environmental impacts. In this respect, research should be undertaken in all countries using wastewater in agriculture, to study agronomic, environmental and health aspects associated with the use of treated wastewater for irrigation.

In this direction, most of the chemical and physicochemical parameters associated with wastewater need to be extensively studied and useful conclusions for a rational, environmentally sound use of these waters obtained. The results of such multidisciplinary research in Cyprus indicated that with, the treatment level required, the irrigation technology available, and the code of practice suggested, the health and environmental risks are well below the acceptable level. Water reuse in Tunisia: Stakes and prospects. In the arid and semi-arid region, countries like Tunisia are facing increasingly serious water shortage problems. In order to control wastewater treatment and reuse, guidelines should be considered as a prerequisite in all countries of the region. Currently, in most of the countries no guidelines exist (Bahri 2001). As a result, desalination has become a viable option for certain strategic uses.

Today, over 20,000 desalination plants in more than 150 countries supply about 300 million people with freshwater every day. Initially a niche product for energy rich and water scarce cities, particularly in the Middle East, the continued decrease in cost and environmental viability of desalination has the potential to significantly expand its use particularly for rapidly growing water scarce coastal cities. The high cost of desalination is still a problem and prohibits agricultural use of such water. Because of this, research efforts to use renewable energy sources (solar and wind) for desalination should be supported. Convincing public opinion to accept this approach is still another major problem. It should be noted that currently, in the process of desalination, conventional fuel energy sources are used. Innovative approaches and use of renewable energy sources may provide desalination processes of lower cost which will also be environmentally friendly. Research in progress is directed towards this target (FAO, 2006; World Bank. 2019).

3.4.8 Strengthening and creation of new institutions for water resources

A water authority responsible for all water-related matters should be established in every country. In parallel, existing relevant institutions and organizations, public or private, should be strengthened. Farmers' user groups and/or irrigation co-operatives should be encouraged to be involved in the processes of water management, especially in annual allocation of the available water resources. In addition, regional and bilateral administrative bodies need to be developed to undertake information exchange on all aspects regarding water development and use. Research in the field is urgently needed and every help, financial or otherwise, must be extended to such kind of institution (Schwaiger et al., 2005).

3.4.9 Establishment of data bases

Each country in the region must establish its own water resources computerized data base for the timely collection, analysis, and dissemination of information for a better management and support of the envisaged research. Concurrently, a regional data base center, linked via a wide area network and by satellite to national centers, is required. Help in the form of financial and technical assistance for the purchase of the required equipment and the training of personnel should be given priority, especially for the poorer countries in the region. Educational programmers aiming at promoting water consciousness should be tailored for the needs at all levels of the society, as well, and will lead to saving and conservation of water (Smets, 2008).

4. Cases Study of Subsurface Irrigation System

The sustainability of agricultural production depends on conservation, appropriate use and management of limited water resources more than ever in arid and semi-arid areas where irrigation is required to produce food and cash crops.

4.1 Subsurface drip irrigation system

The depth of the subsurface drip irrigation system (SDI) influences water's dynamic in soil, soil moisture distribution, water's stock in soil and irrigation water use efficiency. A group researchers conducted a study showing the impact of different depths of the drip irrigation system on the soil dynamics and the maize productivity (Douh et al., 2011). This study was conducted at the experimental field of the Higher Institute of Agronomy of chott Meriem Tunisia. The results indicated that soil moisture content under SDI at 35 cm depth (T3) was more regular compared to 5 cm (T1) and 20 cm (T2). Moreover, irrigation water use efficiency (WUE) was higher in this treatment. Indeed, it increased about

18, 14 and 7% for T3, T2 and T1, respectively when compared with surface drip irrigation. The results of that study showed that SDI allows more uniform soil moisture, reduce the evaporative loss and delivery water directly to the root zone of the crop and consequently increases use efficiency (Douh et al., 2011).

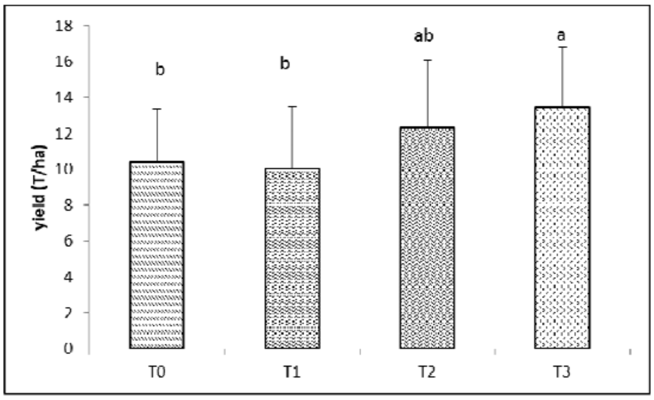

Figure 1: Drip depth effect on maize grain yield (Douh et al., 2011)

Knowledge about the moisture distribution pattern shape and volume of soil wetted by an emitter is the basic need for better SDI function. The dimensions of the pattern are imperative in selecting the right spacing between emitters and the suitable distance between laterals. Water scarcity and the need to obtain the highest water use efficiency have encouraged installation of subsurface drip irrigation systems especially in the limited conditions related to climate and to water and soil resources. As the economics affect system design optimization, the water distribution pattern around drippers should be determined accurately. HYDRRUS-2D software, was used to simulates water, salt, heat transport under both saturated and unsaturated conditions, during and after irrigation to estimate water distribution pattern around drippers installed at different depths in different soil textures (sandy soil, clay, and sandy loam soil). Different flow of the dripper was also included in the treatments. The discharge rates were 2.4; 3.4 and 4.5 liters per hour. The model satisfactorily simulated water redistribution in the soil profile 1, 2, 4, 12 and 24 hours after irrigation termination (R^2=0.93, RMSE=0.0219). Increasing the discharge to 4.5L.h^{-1} resulted in the reduction of the wetted bulb diameter. The relationship between parameters obtained were:

$$W = 3.245\left(\frac{q_w^{0.5} Z^{0.065} t^{0.435}}{K_s^{0.065}}\right)$$

$$D = 3.572\left(\frac{q_w^{0.5} Z^{0.177} t^{0.323}}{K_s^{0.177}}\right)$$

This will involve a reduction in the lateral spacing, consequently an increase in the cost of the irrigation system. Covering the area above the drippers with plastic mulch reduced potential evaporative losses due to preserving a higher relative humidity under the cover (Douh et al., 2018). A group researcher has studied the Using HYDRUS-2D model to assess the optimal drip lateral depth for eggplant crop in a sandy loam soil of central Tunisia (Ghazouani et al., 2015). The main objective of the work is to assess the optimal drip lateral depth for Eggplant crop (*Solanum melongena* L.) irrigated with a drip system in a sandy loam soil by means of field measurements and simulation models. Initially, the performance of Hydrus-2D was assessed based on the comparison between simulated soil water contents (SWC) and the corresponding measured in two plots, in which laterals with co-extruded emitters were laid on the soil surface (drip irrigation, DI-0) and at 20 cm depth (subsurface drip irrigation, SDI-20), respectively.

In order to identify the optimal position of the lateral, the results of different scenarios, obtained by changing the installation depth of the lateral (5 cm, 15 cm and 45 cm) were compared in terms of water use efficiency (WUE), expresses as the ratio between actual transpiration and the total amount of water supplied during the entire growth season. Simulated SWCs resulted close to the corresponding measured at different distances from the lateral and therefore the model was able to predict SWCs in the root zone with values of the Root Mean Square Error generally lower than 4%. According to the examined scenarios, soil evaporation decreases at increasing drip lateral depth, while the associated WUE tends to increase when the depth of the lateral rises from 0 to 20 cm. Depth installation greater than 20 cm involve a higher loss of water to deep percolation with consequent decrease of WUE.

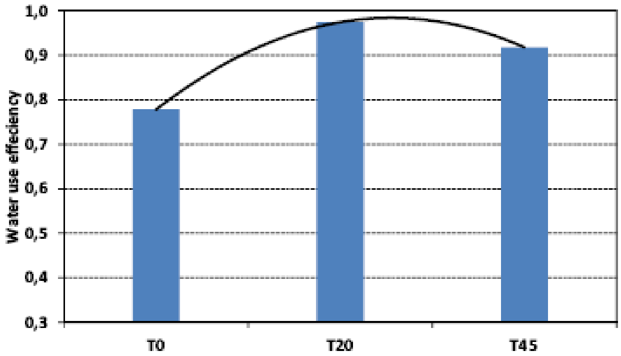

Figure 2: Irrigation water use efficiency for emitter placed at different soil depth 0, 20 and 45 cm (Ghazouani et al., 2015)

A group researcher had conducted and experimental field during the growing season 2012, 2014 and 2015 to investigate the effects of saline water and scheduling on water's dynamic in soil as soil water content moisture distribution, water's stock variation, and salt distribution on the soil then water use efficiency (WUE) to produce potato (*Solanum tuberosum* L.) (Mguidiche et al., 2017). Subsurface drip irrigation was used for two treatments full irrigation (T1) and deficit irrigation (50% of crop Evapotranspiration T2). During the crop season soil water content variation was more important at the end due to root uptake and hard climatic condition, treatment T2 had less water stock and best water use efficiency with 10.83 kg/ha than 5.85 kg/ha for T1.

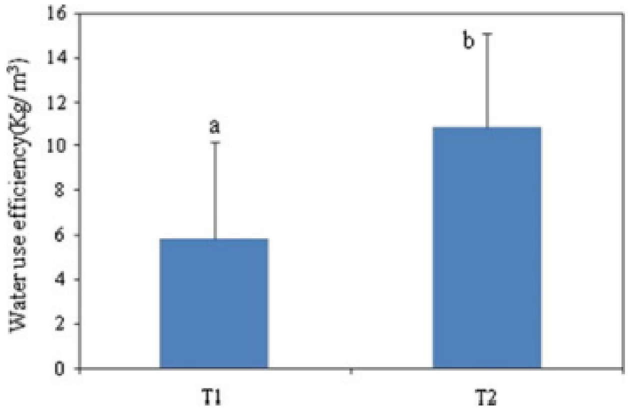

Figure 3: Total Water use efficiency (WUE, kg/m3) for treatments T1 and T2 (Mguidiche et al., 2017)

4.3 Buried diffusers (BD)

The Buried Diffuser is a new technique for underground irrigation which can be used for vegetable in fields, green houses, trees, and plants in containers.

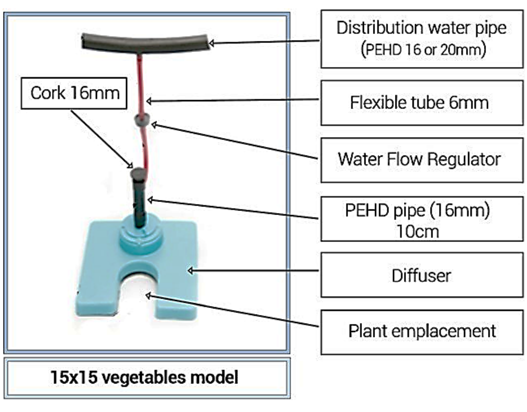

Figure 4: Buried diffuser prototype for vegetables at 15×15 cm (www.chahtech.com)

The aim of this concept is to save and conserve the huge quantities of water received during the wet season, for the next dry season. More than that, we can store the huge quantities of water received during the wet or rainy years to be used during the long dry period. Some researchers conducted an experiment to study the effect of subsurface irrigation by buried diffuser "*Chahtech*" on water dynamics in soil and its influence on agronomic parameters of potato (*Solanum tuberosum* L.) (Douh et al., 2013). This study was done in the experimental field of the Higher Institute of Agronomy of Chott Meriem, Sousse, on a sandy loam soil. Technical characterization of diffuser was determinate based on the calculation of uniformity coefficient of Christiansen and the determination of the flow-pressure relationship.

We followed the variation of the water content in the soil at different depths and calculating stock water and their change in the ground for the treatments that have received 100, 50 and 25% of the ETc respectively TD100, TD50 and TD25 to predict the optimum amount of irrigation. The average values of the soil water content in the soil are 19.6 ± 2.68; 15 ± 3.81 and 14 ± 3.72% respectively for TD100, TD50 and TD25. The stock water for TD25 and TD50 it varied between 28000 and 57000 cm^3/crop, whereas it ranged between 30000 and 60000 cm^3/crop for TD100. The stock of water in the soil resulting from the TD100 treatment was higher compared to other treatments. The TD100 treatment has improved leaf area (0.229 ± 0.084m^2/crop).

Statistical analysis of the effect of using different doses of irrigation performance reveals that there is no significant difference among treatments beyond α=5 %. A group researcher was carried out a study to assess drip irrigation and buried diffuser under greenhouse conditions, on an arid climate (south of Tunisia) (Gasmi et al., 2019). A modeling approach was used to analyze the effect of the two irrigation techniques on repeated measurements of soil at different depths of the sampling sites within the root zone of a pepper crop using two irrigation treatments full irrigation and deficit irrigation with 50% of crop evapotranspiration. As a result, the buried diffuser system significantly improves the soil nutrient levels, with considerable improvement of pepper yield for the two irrigation treatments. Moreover, the buried diffuser keeps the field in better soil salinity conditions than drip irrigation.

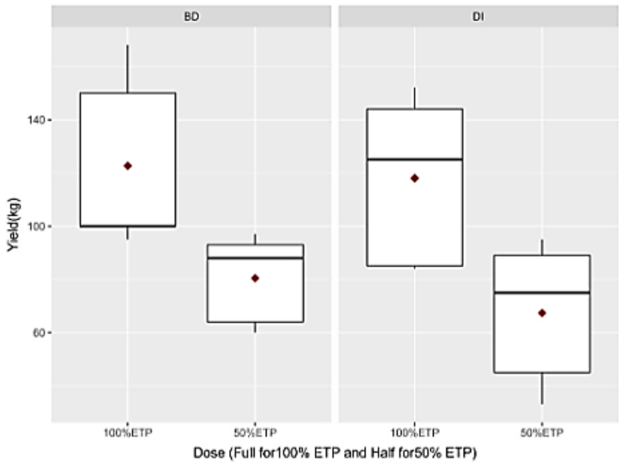

Figure 5: Total yield production in Kg/treatment for pepper for the buried diffuser (BD) and drip irrigation (DI) conducted under full irrigation (100%ETP) and deficit irrigation (50%ETP) (Gasmi et al., 2019)

5. Conclusion

Insufficient water supply and water quality deterioration represent serious contemporary concerns for many municipalities, industries, and agriculture in various parts of the world. Some factors have contributed to these problems; continued population growth in urban areas, contamination of surface water and groundwater, irregular distributions of water resources, and frequent droughts have forced water agencies to search for new dependable water supply. Water in the Mena region as well as the Middle East region is a scarce and valuable commodity. This means that every effort should be devoted to increasing water resources and conserving existing water resources. Conventional water resources in the region are already entirely committed. It is therefore imperative that new non-conventional water resources should be used. In this respect, wastewater reclamation and reuse have emerged as a realistic option for a new reliable source of water to meet the deficiency, cover water requirements and meet wastewater disposal regulations aimed at caring the environment. It is recommended that all treated wastewaters be used. Protection of water from the existing water resources represents the main and most popular approach. Conservation of water, however, in order to be effective, should be addressed to the main users. It is, therefore, imperative that water conservation be addressed primarily to the agricultural sector and farmers. Conservation of water at the farmers' level as one with efforts to reduce losses from the collection and distribution systems, is the most effective, efficient and appropriate way. At the farmers' level, substantial saving of water is feasible. Effort and funds have to be devoted to efficient water use. Effective water use (water needed per unit of produce) is still suffering and in certain cases totally ignored. Cropping pattern based on effective water use should be a policy in Cyprus and in the region. The strategies for planning and use of water resources should promote a sustainable and environmentally friendly development. Countries in the Mena region should protect their environment and work in close co-operation with their neighbors.

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