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The Latest Techniques for Sustainable Management of Irrigation Water under the Egyptian Environmental Arid Conditions: A Review

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Abstract

Egypt is currently facing many major challenges, foremost of which is the limited and scarcity of water resources, as the total of these resources reaches 72 billion cubic meters/year (the main part constitutes 55.5 billion cubic meters of the country's annual revenue). The Nile River according to the 1959 agreement between Egypt and Sudan, while groundwater, agricultural drainage water, rainwater ... etc. the other part). At a time when the stability of this limited amount of water is considered a serious problem with the continuous increase in the population, the construction of the Ethiopian dam on the course of the Blue Nile threatens the stability of this amount with a decrease, which will lead to a sharp decrease in the per capita share of water. Among the most important and best sustainable technologies that have shown positive effects in improving water productivity and that are compatible with the environment when applied are: (1) Pulse irrigation technology to improve water use efficiency and reduce water stress within the root zone, (2) Micro-drying technology to save 50% of water Irrigation, (3) Minimum tillage technology to improve soil environment and crop productivity with minimal environmental impact, (4) Automatic irrigation scheduling to reduce water stress within the root zone and save irrigation water (5) Innovating new irrigation network designs to improve irrigation efficiency (6) Laser leveling Land to improve water distribution efficiency, (7) Use of simulation models in irrigation and climate management, (8) Towards the application of organic mulching as a sustainable alternative to plastic mulch, (9) Addition of biochar as a soil amendment, (10) Addition of organic fertilizers to it. As a natural material to improve water use efficiency and as a source of nutrients.

Keywords: PRD, Pulse irrigation, Minimum tillage, Automated Irrigation, New designs, Laser land leveling, Simulation models, Organic mulch, Biochar, Organic fertilizers

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1. Introduction

Egypt is currently facing a lot of major challenges, foremost of which is the limited and scarcity of water resources. The total of these resources reaches 72 billion m3 per year (The main part constitutes 55.5 billion m3 of the country's annual revenue from the River Nile). The Nile River according to the 1959 agreement between Egypt and Sudan, and the other parties from groundwater, agricultural drainage water, rainwater...etc.). At a time when the stability of this limited amount of water is considered a serious problem with the continuous increase in the population. The construction of the Ethiopian dam on the course of the Blue Nile threatens the stability of this amount with a decrease, which will lead to a sharp decrease in the per capita share of water for Egypt.

The limited and scarcity of water resources is one of the most important and most dangerous challenges facing the agricultural production sector of agricultural crops in Egypt. So, improvement of new methods, methods, and techniques that help to benefit from these precious inputs in a way and in a significantly positive way in mitigating the face of this challenge, which is reducing and rationalizing water consumption in irrigation [1], [2],[3]. The large gap between food production and the increasing consumption of the population can be reduced through the development and modernization of agricultural practices in arid regions such as the precision irrigation systems methodology [4]. In Egypt, the criterion of water productivity for

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agricultural crops (WP) is very important because of the limited water resources in dry areas and the scarcity of fresh water, which is the main reason for the decline in crop yields all over the world. Therefore, irrigation water use must be appropriate so that it does not cause a significant reduction in yield in line with the principles of under-irrigation with a small level of yield reduction [5], [6]. Deficient

irrigation strategies have been widely evaluated as beneficial and sustainable production techniques in arid and semi-arid regions. The practice aims to increase the water productivity of agricultural crops. The results of previous research and experiments confirm that the levels of irrigation deficiency are positive and successful in improving and increasing the productivity and water productivity of many crops without causing a sharp and unnoticeable decrease in crop yield [7], [8], [9].

Because of the high percentage of water used for agricultural purposes, where the volume of cut resources from the total water resources of Egypt enters with a share of 70 to 80%. There is a continuous and urgent need to focus on the effective, efficient and sustainable use of these limited water resources, with the aim of increasing the crop yield per unit of water. Maximizing the irrigation water use efficiency or water productivity is a common concept used by irrigation project managers and the term crop water productivity is the primary criterion used to evaluate the effectiveness of irrigation systems and the sustainable management of water resources.

After our previous review of all the water scarcity challenges facing Egypt, it is imperative to adopt and focus on all sustainable technologies for conventional water sources. Therefore, the main objective of this review article is to focus on the many sustainable and important technologies that have proven positive effects on improving water productivity through many local and international studies to be a guiding reference for farmers and researchers in Egypt to save conventional water sources in agriculture.

BODY (REVIEW)

Among the most important and best sustainable technologies that have proven positive effects in improving water productivity and which are compatible with the environment when applied are: (1) Pulse irrigation technique, (2) Partial roots drying technique, (3) Minimum tillage technique, (4) Automated Irrigation Scheduling, (5) Innovating New Designs for Irrigation Networks (6) Laser land leveling, (7) Using simulation models in the irrigation and climate management, (8) Towards applying organic mulching, (9) Adding biochar as a soil amendment, (10) Adding organic fertilizers to the soil.

1- Pulse Irrigation Technique

Pulse irrigation technique is an irrigation technique mainly used in drip irrigation. Maintaining a high level of soil moisture for seed germination is one of the reasons for using this technique. Pulse drip irrigation has the following advantages: (1) Reducing runoff in heavy soils, (2) Reducing leaching or water loss in sandy soils, (3) water management can be used more efficiently in shallow soils and in mountainous areas, and also, in intermittent operation of sprinklers and mists can provide temperature-controlled evaporative cooling.
(https://en.wikipedia.org/wiki/Pulse_drip_irrigation).

[10] also indicated that, the use of pulse technique with irrigation systems with the addition of cobalt element led to an increase in the yield of tomato crop values with compared to the control treatment under the subsurface irrigation system.

[11] reported that, most researchers used the pulse technique to apply variable rate irrigation to match the water needs of crops within a normal application rate that does not result in runoff. This paper presents variable pulse irrigation based on the ON-OFF pulse technology to conserve irrigation water by (1) reducing the runoff losses by considering surface storage capacity, reducing the soil infiltration rate, and sprinklers wetting diameter; (2) High efficiency in water distribution. Among the wide range of pulsations and widths tested when applying a given water depth to sandy clay soils, the best solution was selected which gives the lowest run-off and the highest uniformity efficiency while providing an acceptable water depth.

[12] evaluated the effect of rapid flow and alternative irrigation on irrigation performance indicators, and the results confirmed that the highest values of water application efficiency and distribution efficiency were obtained through alternative irrigation and sudden flow compared to continuous flow irrigation. The runoff losses in continuous flow irrigation were higher than those that occurred in alternate flow irrigation with the same flow rate. They recommended that irrigation methods (alternative and alternative) can enhance and improve wastewater management practices in a water-stressed world. [13] compared to flash and continuous irrigation under different flow rates and plowing depths to assess their ability to improve irrigation system performance and wheat production. Water savings of 8 to 34% was achieved by applying sudden irrigation under different flow rates and plowing depths. Various parameters were emphasized such as water volume, distribution efficiency, water use efficiency, deep filtration loss and wheat yield, the boom irrigation technology is convincingly better when compared to continuous irrigation even under the border irrigation as shown in Figure (1). [13] concluded that, there are many benefits of the surge irrigation technique (1) surge irrigation treatments

require less time to complete the advanced stage than continuous irrigation treatments. Therefore, less water was consumed and lost to achieve an advanced distance. The three cycles with the rotary plow had a fast rate of progress. (2) The surge technique caused lower steady-state infiltration rates for the three plows studied, despite the shorter treatment times with the surge technique. (3) The water use efficiency of the sudden flow coefficients gave the highest values, which indicates the good management of the method compared to the continuous flow.

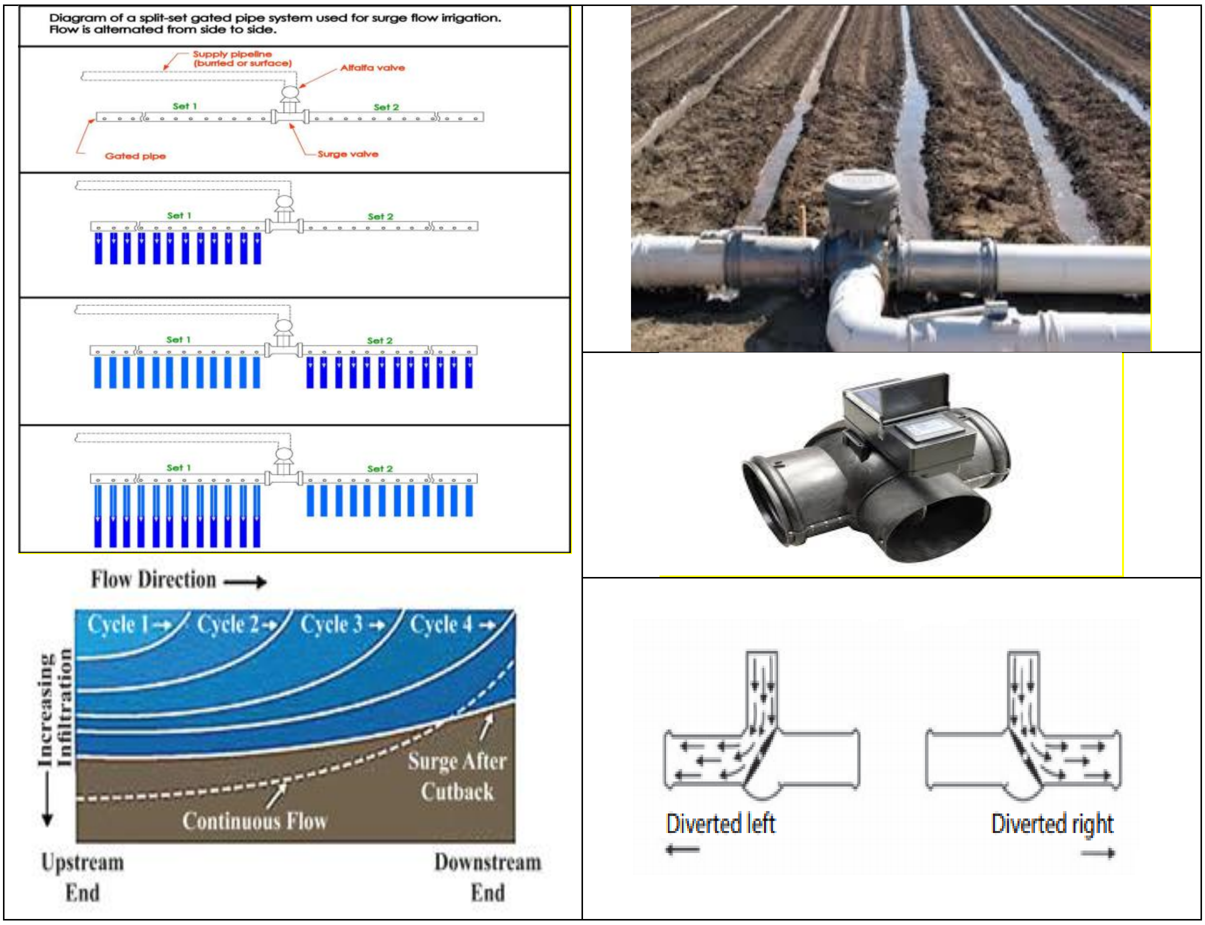

Figure (1): Pulse irrigation or surge irrigation of furrow irrigation and automatic surge valve (The source: https://extensionpublications.unl.edu/assets/html/g1870/build/g1870.htm)

2- Partial Roots Drying Technique

[14] mentioned that, the partial drying technique of roots is the second most common method of regulated deficit irrigation (RDI). The mechanism of this technique is as follows, half of the volume of the roots is completely irrigated, while remaining half of the roots undergoes soil drying (Fig. 2). RDI is an essential technology because it helps in improving water productivity. It has been found that RDI is widely and substantially implemented by three methods: (1) growth stage-based on deficit irrigation (DI), (2) partial root zone, and (3) subsurface drip irrigation. Among these areas, a partial root zone is the most common and effective method because many field crops and some woody crops can save irrigation water up to 20-30% with little effect on crop yield, for the following reasons: (1) An improved guard cell signal transmission network reduces transpiration water loss, (2) improved stomata control improves photosynthesis to transpiration ratio, and (3) reduced evaporation from surface areas. The mechanisms involved in plant response to moisture stress include most

morphological traits, for example, improved nutrient uptake and recovery; some physiological traits, for example, reduced leaf respiration, mouth obstruction, preservation of photosynthesis and some biochemical qualities, for example, increase the signaling of molecules and enhance and improve the activity of the antioxidant enzyme.

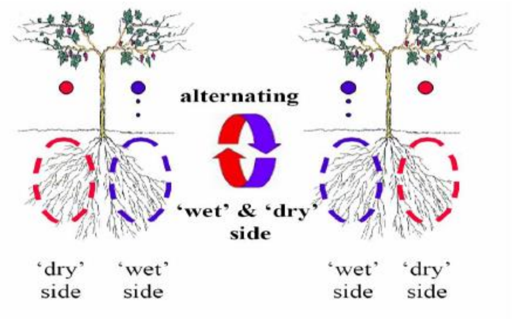

Figure (2): The schematic of irrigation pattern in partial root-zone drying

[15] reported that, one of the possible methods for maximizing crop yields with limited irrigation water is partial drying of the root zone. The results of various studies showed that partial irrigation in the root zone maintains soil moisture and irrigation water absorption by replacing the absorbed water from the dry part of the root zone with the wet part and the dry part is either irrigated or pre-moistened. Using partial irrigation to dry out the root zone, the ABA-mediated aquaporin activity increases, which in turn increases upward movement of water to the stem and leaves. This occurs in both wet to dry areas. Partial irrigation of the root zone with an area of 518 m^3 hectares of irrigation water annually saves from lack of moisture and increases the efficiency of irrigation water use by 70% compared to full irrigation. Chlorophyll fluorescence may aid in early detection of plant water stress and eventually irrigation scheduling for partial root-zone irrigation.

Given the climate change conditions, water-saving application strategies is of particular importance. The objective of the field study was to evaluate the effect of under-irrigation and partial root drying (PRD) techniques on the water stress index and water productivity (WP), as well as the quality parameters of open-field tomatoes in the Mediterranean climate. The IR70% PRD and IR70%DI both saved 24% less water than the IR100% DI, but the yield drop with respect to the optimized system was 16.2% under the IR70%DI, but it was only 7.6% under the IR70%PRD. The increase in water yield of IR70%PRD with respect to IR100% was 27% for the first growing season and 17% for the second growing season, indicating that the positive effect of PRD on water production of tomatoes is more pronounced in more stressed areas of the year [16]. [17] reported that, the practical application of PRD technology offers the possibility of increasing the yield of water as well as nutrients, improving the nutritional properties of various species and agricultural crops, and in some cases maintaining or even increasing crop yields. Although some recent findings indicate that frequent irrigation of the dry root zone using PRD technology leads to obvious changes in soil and nitrogen and phosphorous uptake by cultivated plants, more research is needed to understand the relationship between partial drying of roots and soil microorganisms,. and increase the absorption of these nutrients under different environmental conditions. The challenge here also lies in ways to understand hormonal signaling in the presence of various changes in food and water resources, in particular the role played by cytokinins. Due to limited data availability, further research and experiments are necessary to understand the different pathways of highly complex biosynthesis and synthesis of nutrient metabolites and antioxidants within PRD-treated plants. Actual application and dissemination of this knowledge and information to the general public to farmers in dry areas with scarce water resources by adapting this PRD not only as an important method and strategy for providing irrigation water, improving diversified use of nutrients, as well as increasing and maintaining yields, but also for obtaining high quality crops and enhanced nutritional and health properties.

Alternative irrigation is another concept of the PRD system under surface irrigation (AFI) as shown in Figure (3). AFI is a method of irrigating one side of the plant, that is, half of the root zone in the case of watering is irrigated at the first watering, while the other side of the breeding zone receives water in the next watering. The obtained results showed that the average water use efficiency of alternative irrigation was 67%, which is a high percentage compared to other irrigation systems and a high productivity of 32667.8 kg/ha was achieved. Alternative irrigation also increased productivity by 100% compared to the traditional irrigation method. The results also showed that the alternative irrigation method saved 50% of the irrigation water compared to the traditional irrigation methods. Therefore, it is recommended for water-poor countries to use and adopt an alternative irrigation method with an appropriate irrigation period, which is the appropriate irrigation method for dry clay soil as water is a limiting factor for potato production [19].

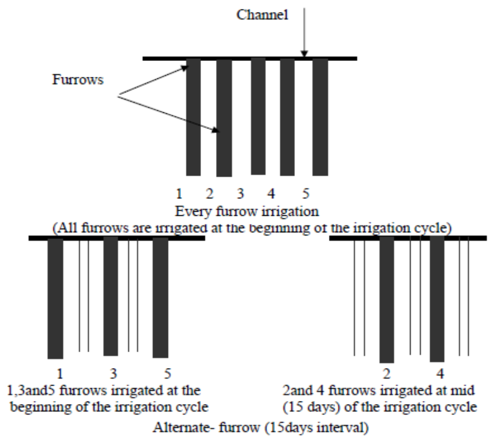

Figure (3): The layout of alternate-furrow irrigation technique

[18] reported that, the results of our field study on the alternative irrigation (AFI) for okra cultivation and production showed that this technique can achieve the following benefits (1) save more than 50% of irrigation water compared to conventional irrigation (CFI). (2) Improving water productivity and (3) this technique can be used as a tool to manage the irrigation water supply so that it can be used to irrigate other areas. Despite the importance of its application, the negative economic effects of simple farmers may lead to reluctance and reluctance to make changes and adopt this technology. One reason women farmers are less likely to adopt this water-saving technology is that current water charges are based on crops and land area rather than the volume of water used for irrigation. Therefore, we strongly recommend further studies and research on the possibility of using AFI to determine what can be achieved in achieving similarly large volumes of irrigation water and the diversity of benefits resulting from the application of this technology, across a wide range of different cropping systems in arid and semi-arid regions and environments.

3- Minimum Tillage Technique

Tillage is defined as the mechanical manipulation of soil with the aim of fertilizing the soil for agriculture and crop production. Tillage greatly affects soil properties such as soil water conservation and soil temperature, as well as infiltration and evaporation. This indicates that the farming process leads to and affects the soil in order to produce crops and also affects the environment. There are multiple types of conservation tillage as shown in Figure 4: Conservative tillage practices range from zero (no-till), low (low) tillage, mulch tillage, and ridge tillage to ocean tillage. Conservation tillage, the most important aspect of conservation agriculture, is

believed to be concerned with soil health, plant growth, and the environment. Several research and research reports have identified many important benefits of conservation tillage (CT) in terms of physical, biological and chemical properties of soil as well as crop yield. Through several studies, it was found that at least 25% of the greenhouse gases flow into the atmosphere due to agriculture. It was found that among the mitigation and adaptation processes to climate change, the zero-till (ZT) process is the most and the best environmentally friendly among the different tillage techniques. Therefore, conservative tillage, including ZT, in addition to the application of minimal tillage, has the potential to break the surface compact areas of the soil, thereby creating a better soil environment and reducing the impact of crop productivity on the environment. Therefore, conservative tillage practices to achieve sustainable food production with minimal impact on soil and atmosphere are more important than ever [20].

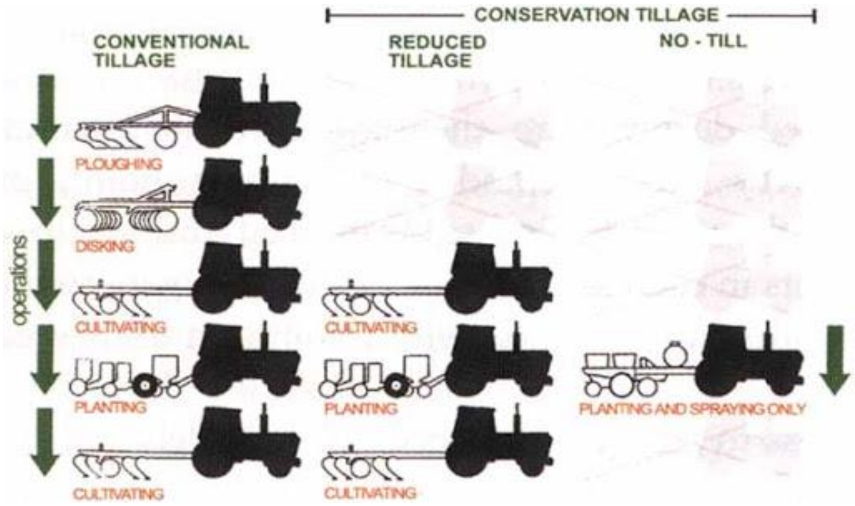

Figure (4): Types of conservation tillage

It is clear and widely recognized that, sustainable agriculture is a viable and viable concept of sustainable agriculture due to its many and comprehensive advantages in economic, environmental and social sustainability. Therefore, the aim of this research was to identify and evaluate the effects of non-scheduled irrigation systems and reduced tillage on barley yield in dry conditions of sandy soils. After reviewing and discussing the above results, the study concluded that, there were no significant differences between the highest values of barley yield when irrigated at 100% or 75% of the irrigation needs when plowing at the lowest depth of 10 cm. Therefore, the most appropriate and recommended treatment and solution for implementation and application when growing barley under dry sandy soil conditions was to schedule irrigation by adding 75% of the barley irrigation requirement and plowing depth of 10 cm. As a result of adopting this recommendation, 25% of the water needs for irrigating barley has been saved, and energy will be saved for two reasons, the first is due to the reduced fuel consumption of the tractor as a result of reducing fuel consumption. The second reason is the result of saving energy used to pump 25% of the irrigation water on schedule irrigating by 75% of the irrigation needs instead of irrigating with 100% of the water needs for irrigating barley, as shown in Figure (5) [21].

Figure (5): Adjustment the depths of minimum tillage under the sprinkler irrigation system

4- Automated irrigation scheduling

Irrigation system automation is the method of operating an irrigation system without manual or minimal intervention. Currently, the various irrigation systems have become automated, where the large area to be irrigated is divided into parts and small pieces called blocks and irrigation areas, where the parts are irrigated sequentially and in a certain sequence in proportion to the available withdrawal rate from the water source. Recently, manual irrigation, which is based on the determination and measurement of soil moisture, has been replaced by automatic irrigation scheduling techniques. It is noteworthy that, the process of estimating the evaporation of plants, depends on different weather factors such as air humidity, wind speed and solar radiation, in addition to various factors specific to crops such as growth stage, plant density and soil properties as well. It is taken into account during the application and implementation of the automatic irrigation schedule.

The application and implementation of automated irrigation systems are encouraged in order to ensure a more rational allocation of water in the fields according to crop conditions and water consumption is reduced by (1) measuring irrigation consumption, (2) improving network irrigation efficiency, and (3) developing new water management framework and tools of irrigation [22], [23], [24]. Smart irrigation technology has been developed to increase yield production without involving a large number of workforces by detecting water level, soil temperature, nutrient content and weather forecasting. [25] mentioned that, an automated model for detecting moisture content and temperature using different and many sensors as shown in Figure (6). [26] also recommended that, the implementation of an Arduino automatic watering system to reduce labor use and save time in the watering process. [27] also, developed the idea and method of automated irrigation systems by modernizing and developing remote sensors using the application of Arduino technology, which can lead to an increase in production up to 40%. Another automated irrigation system has also been developed by [28]. In this regard, different instruments and sensors are designed for different purposes, such as a soil moisture sensor to measure and determine the moisture content of the soil, another sensor to measure temperature to determine the soil temperature, and another sensor as a pressure regulator to maintain pressure, all with the aim of improving crop growth and saving water. Digital cameras are also installed and the output of all these devices is converted into a digital signal and sent to the multiplexer via a wireless network such as Zigbee and hotspot. In addition, applications of smart irrigation technologies are not limited to agricultural purposes only, but also extend to landscape, garden and lawn management in order to better manage irrigation water use [29]. [30] argue that, due to the physical limitations of natural resources such as land and water, the necessity for optimal use of land and water resources and food security is inevitable. Therefore, all new technologies are very necessary and required to address the problems of water management and use as well as to raise the performance of agricultural production processes. These techniques aim to reduce the volume of excess irrigation water through accurate estimation of soil moisture content as well as atmospheric moisture, or in different words estimation of air humidity around plants in order to ensure optimum use of water resources. One of the most common types of sensors for irrigation water management is capacitive-type soil water sensors [31]. Among the weaknesses of localized irrigation systems is the uneven distribution of soil water, in contrast to sprinkler and flood irrigation systems, where irrigation water infiltrates and permeates most parts of the soil surface, while local irrigation seepage occurs directly in the area around the emitter [32]. Hence, one way to deal with variation and variance between sensors is to physically calibrate the implant area for each individual sensor for a post-installation procedure [33]. [34] emphasized that, automated software tools are highly required to perform the repetitive functions and tasks of irrigation scheduling. One big issue with this issue is how sensors are integrated into the automatic watering scheduling approach. This study showed that the water balance method based on capacitive soil moisture sensors provides and gives a sound basis for scheduling automated irrigation in different orchards

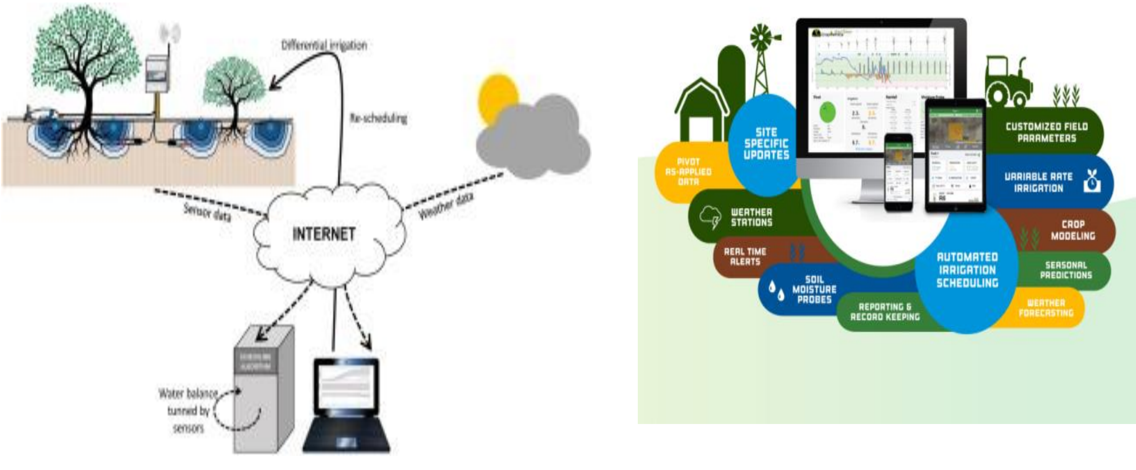

Figure (6): Many kinds of automation of irrigation scheduling tools

5- Innovating New Designs for Irrigation Networks

Although the drip irrigation system is one of the most efficient irrigation systems in rationalizing and conserving irrigation water, the instability of emitters for the disposal of irrigation water requires great attention because the disposal of these drops varies along the drip line, which constitutes an unfair error. Distribution of the quantities of irrigation water are distributed to plants within the same field, may lead to water stress in some places of the cultivated soil. Two experiments were conducted during the 2015/2016 and 2016/2017 seasons in sandy lands in northern Egypt to evaluate the performance of the newly developed design of the drip irrigation system compared to the two conventional designs of the irrigation system. The aim of this research is to provide water and fertilizers in sandy soil when growing potatoes as a water stress sensitive crop. The different designs of tested drip irrigation are: the first design: the traditional drip irrigation system (controller), the second design is: the same directional drip irrigation system for the manifold and lateral lines, the third design is: the innovative design: the drip irrigation system in the opposite direction of the manifold and lateral lines. The study concluded that, the maximum values of potato yield were obtained under the new innovative design as shown in Figure (7). This is due to the great uniformity in the distribution of irrigation water and fertilizers along drip lines [35].

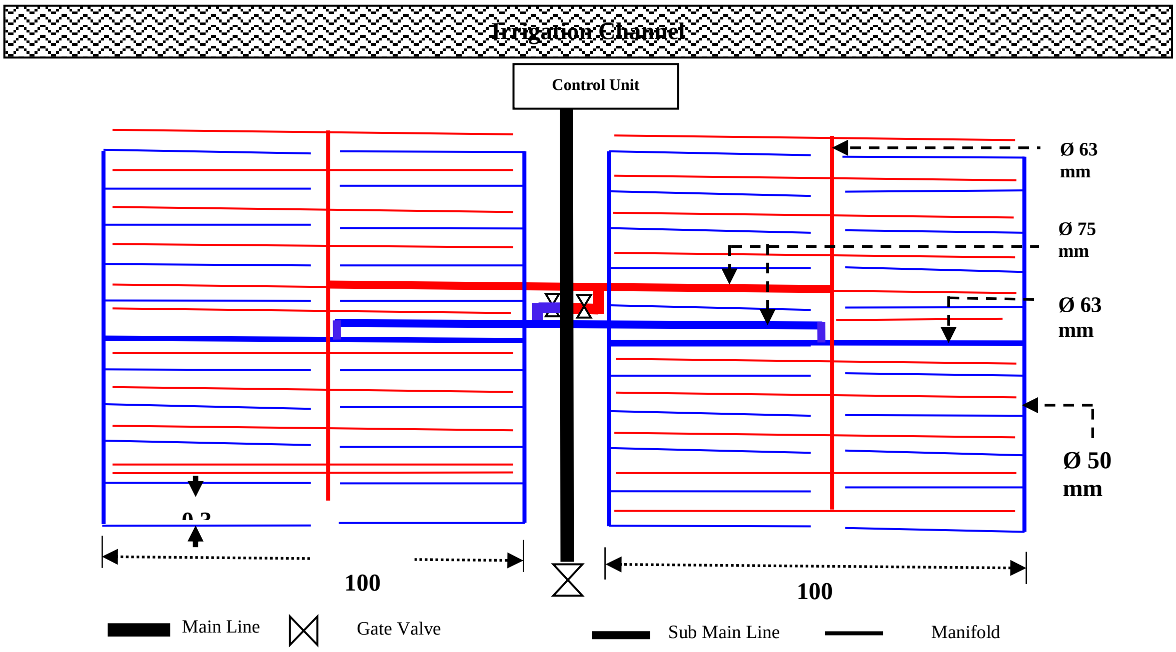

Figure (7): Layout of Innovative design with opposite direction for manifolds and laterals

Saving 50% of irrigation water and energy, reducing salt build-up in the soil and reducing weed growth using a drip irrigation system is the main and main objective of all researchers and water professionals to pursue management under conditions of water scarcity and dry land. Despite the high efficiency of the drip irrigation system, which is considered the most efficient irrigation system in conserving water, it has some disadvantages when used, including the accumulation of salts in the soil, in addition to the growth of weeds...etc. especially in dry areas. To avoid the obvious drawbacks of a more efficient irrigation system, two experiments were conducted to study the effect of the CSPPP (cultivation in small pieces of plastic tubes) method as shown in Figure (8), and compare it with the conventional method. Drip irrigation method, under conditions of insufficient irrigation (full irrigation “FI”, 75% FI (50% FI) because the new method affected soil salt accumulation and concentration (SSA), weed growth, yield of sweet pepper crop (Ysp), water productivity (WP sweet pepper) and its effect on some quality characteristics of sweet pepper fruits, and the results showed that there are positive effects of applying CSPPP as a new method of drip irrigation compared to the traditional method, where the most important values under study, which are sweet pepper yield and water productivity, in addition to improving the quality characteristics of pepper fruits which means that, the CSPPP method was adding a small volume of irrigation water to the soil around the roots of the transplanted plant, which resulted in a clear reduction in water stress even when 50% FI of the irrigation water needs for growing sweet pepper plants were added. The use of the CSPPP method reduced weed growth around the plants; however, there is a decrease in the wet surface area of the sandy soil surface compared to the sandy soil surface using the traditional method, which together expands the wet area of the moist soil around the cultivated plants [36].

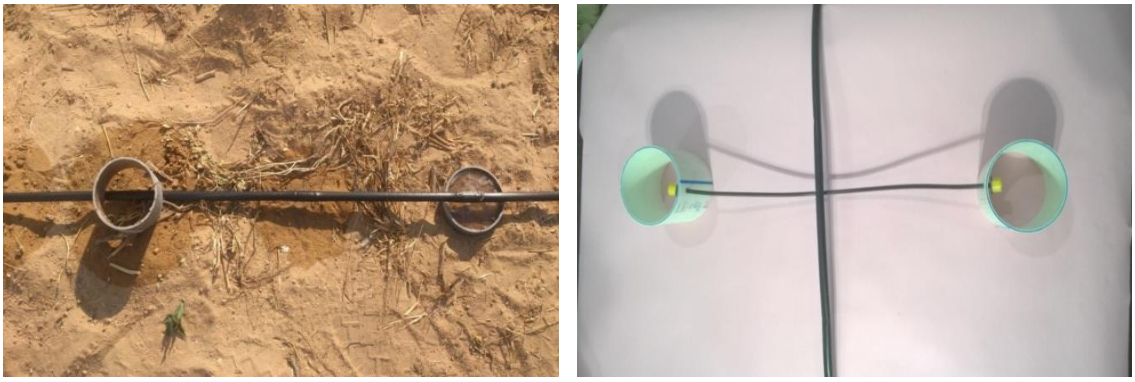

Figure (8) The CSPPP method (cultivation in small pieces of PVC pipes) with drip irrigation

[38] note that, by improving proper farm planning and laser leveling techniques, it is possible to significantly conserve irrigation water and available agricultural resources. It can be used very efficiently and effectively. Moreover, these practices can also increase crop yields per unit of water and land. In addition, it can expand the arable area and reduce labor requirements for irrigation while reducing weed growth problems. Therefore, it is highly recommended to shift towards modifying the current poor farm scheme to alleviate water problems in a particular area as the application of laser leveling is the best and most suitable option to solve water management problems related to agriculture in Central Asia. He assures us that the application of these methods achieves higher crop productivity, while improving water productivity, expanding the arable area, and thus the total return of the farm, which contributes to increasing the rural economy of these areas.

[39] that, new surface irrigation techniques as well as modern irrigation systems require careful leveling of agricultural land in order to reach the best performance standards. In this context, the development of a high-quality settlement of the land is the main and important condition for the modernization of irrigation methods. Laser leveling technology provides high quality and accuracy for land leveling, which leads to significant benefits in water savings, as well as salinity control, as well as increased crop yields.

7- Using Simulation Models in the Irrigation and Climate Management

Simulation models can be very effective and useful tools in managing various agricultural resources as well as predicting the impact of future climate changes on food production and environmental changes. It has been largely proven that simulation models are very useful tools for water and crop management as well as fertilizers. It can also be used to run "what if" scenarios as a valid alternative to conducting various field experiments with these models. For example, to name a few, the process of soil salinization is a slow process and many experiments have a long life. We cannot prove the long-term impact of poor management on soil salinization, and in such cases also we can use reliable and reliable simulation models to predict the long-term impact as it can be resolved. Replacing many expensive field trials, several simulations have been developed for water, crop and fertilizer management. Examples include HYDRUS-1D, HYDRUS-2D, CropSyst, SWAP, ENVIRO-GRO, SRFR, SIRMOD, ISAREG, WAVE, EURO-ACCESS, CERES, and WOFOST. Some of the current simulations are designed for a specific irrigation system, or specific processes such as movement of water and salts, percolation, percolation, water uptake by plant roots or a combination thereof. Therefore, the SALTMED simulation model was developed as a general model in which a variety of irrigation systems, soil types, soil layers, crops, and different irrigation water addition strategies (incomplete irrigation, partial root drying, PRD, and subsurface irrigation) can be used. During this simulation, nitrogen is applied from various sources (chemical fertilization, organic fertilization, or even crop residues present in the soil). It is also possible, through the model, to accurately simulate different water quality (freshwater, wastewater, saline, saline, and agricultural wastewater). The SALTMED simulation model contains a utility to save input files and parameters as text files for multiple operations. The current version of this model also allows up to 20 fields or treatments to be operated simultaneously ([40], [41].

The actual results of several studies showed that the SALTMED model gave a high simulation of crop production, dry matter, and soil moisture [42], [43], [44]. The use of simulation models is that it is the cheapest and fastest way to access and predict important information that can be obtained from the model simulation results as a cheap and fast alternative to conducting various field experiments [45], [46], [47], [48]. About the suitability and benefits of using wastewater for fish farms (DWFF), instead of fresh water inside the canal, for irrigation and noted that the SALTMED model (Fig. 10) simulates soil moisture well. To be precise, the nitrogen content in all sandy soil layers as well as the dry matter, yield, and water yield of wheat for all R^2 coefficients were 0.99, 0.97 and 0.96, respectively.

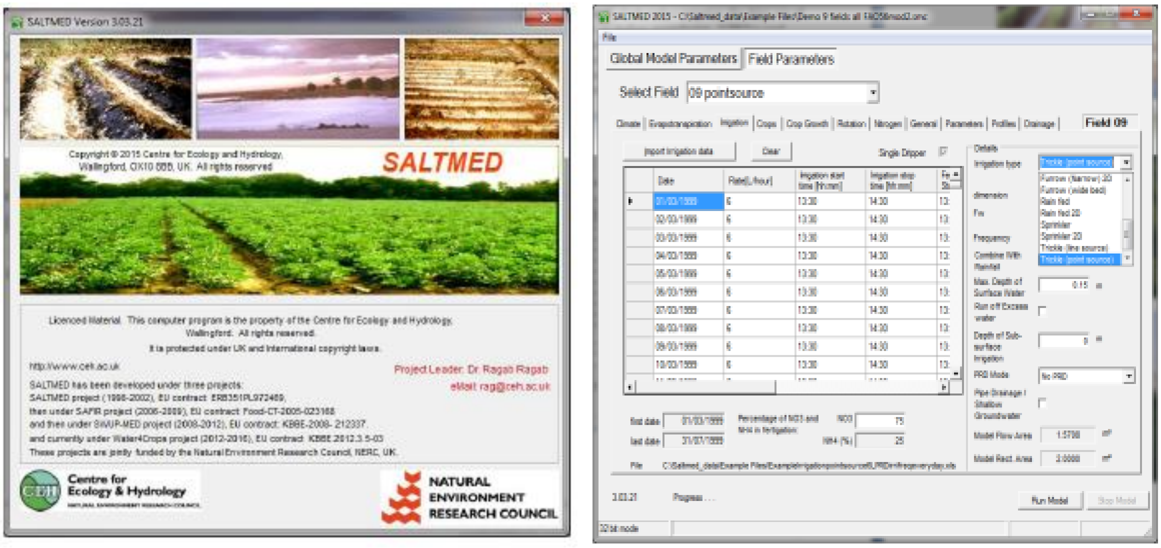

Figure (10): SALTMED model

8- Towards Applying Organic Mulching

The amount of agricultural waste in Egypt ranges 30-35 million tons annually. Only 7 million tons are made as animal feed and 4 million tons are organic manure. Agricultural residues become a problem after the summer crops are harvested. This is because at this time of the season the farmer is in a hurry to re-cultivate his land again, so the problem of getting rid of agricultural residues is his top priority, and this is usually done by burning. The method of burning agricultural residues is not only an economic loss, but also has harmful effects on the environment. These harmful effects are the emission of toxic gases into the air and the reduction of microbial activities in the soil. Additionally, storing these residues in the field after harvest may make them a suitable environment for the breeding and growth of pests and pathogens that will attack new crops. Therefore, the use of agricultural residues in any other environmentally friendly way is very important. One sustainable way to reduce the severity of water stress on cultivated crops and plants is to exploit agricultural residues found in many developing countries, including Egypt, as a sustainable material and its main function, in addition to other benefits, is the ability of these materials to retain water for as long as possible, and thus Reduce stress. Watering cultivated plants and increasing crop yield under severe drought conditions. Therefore, there is a need to adopt appropriate approaches to reduce and reuse agricultural wastes to produce organic cover to provide irrigation water. The organic covering of rice straw is a by-product of the rice crop, which is found in large quantities after harvest. There are many beneficial uses for straw, which is used as organic mulch in order to reduce water erosion from the soil surface and concern about water stress on plants under dry conditions.

Mulching is the technique of covering the surface of the cultivated soil around plants with an organic or artificial cover to create suitable and favorable conditions for plant growth and highly efficient crop production [49]. Any material spread on the surface of the soil to protect it from direct exposure to solar radiation or evaporation is called mulch as shown in Figure (11).

Covering the soil surface can be the addition of synthetic inorganic materials (such as gravel and polyethylene sheets) or organic materials (such as There are two types of mulch: organic mulch, which is biodegradable mulch made of organic materials, and inorganic mulch, which are mulch made of plastic materials [49]. Both have become popular in recent years [52]. Maintaining soil moisture by using mulching may be an effective option to save water as well as increase production in dryland farming. The relationship between the interaction of CA practices and coverage technology with global climate straw, crop residue, farm manure, and weeds) to the soil surface to provide more than one service to the ecosystem such as soil protection, soil fertilization, and preventing their formation and the emergence of pests, which ultimately leads to improved and increased crop yields [50]. The application and practice of mulching in general is a beneficial practice for crop production, and properly used organic mulching can have many benefits [51]. environments is becoming very clear [53]. One of the most serious problems is the burning of rice straw, as shown in Figure (12, a). Rice straw can also be used as a useful organic mulch as shown in Fig. 12, b) as rice straw is a very inexpensive source of sustainable mulching material and can be used very economically and reduces the rate of evaporation of irrigation water from the soil surface [54].

Figure (11): Examples of types of organic mulching

A). Mismanagement of rice straw B). Using rice straw as an organic mulch

Figure (12): Using rice straw as an organic mulch instead of burning it

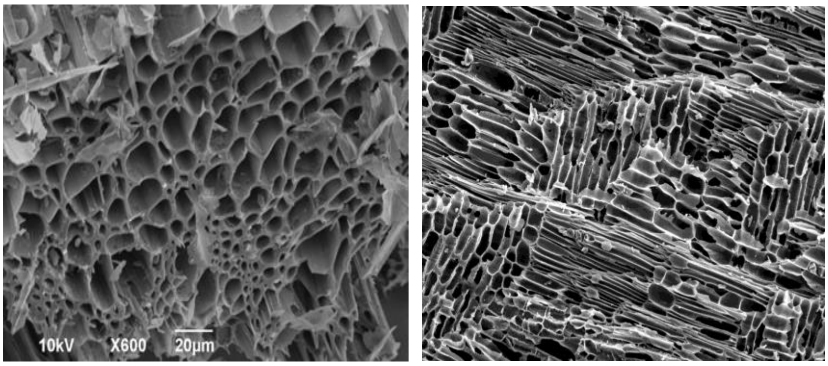

Figure (13): The porous structure of biochar

9- Adding Biochar as a Soil Amendment

As defined by the International Biochar Initiative (IBI), biochar is defined as a fine-grained carbon product with high organic carbon content and low solubility, which can be obtained through pyrolysis of biomass and degradable waste (IBI Standards). Biochar has high carbon content, rich porous structure, large specific surface area, various organic functional groups present (or adsorbed) on the surface, high adsorption capacity, ion exchange and stable chemical-physical properties and characteristics [55]. The most important properties of biochar include chemical composition, stability, specific surface, and high porosity as shown in Figure (13).

Importantly, the chemical composition of biochar depends mainly on the chemical composition of the different organic materials used in biochar production [56].

Biochar is used as a soil amendment. Biochar is a stable, carbon-rich solid made from biomass via pyrolysis. Biochar is hygroscopic. It is thus a desirable soil material in many locations due to its ability to attract and retain water. This is possible due to its porous structure and high surface area. As a result, nutrients, phosphorous and agrochemicals are retained for the benefit of the plant. Thus, plants are healthier, and less fertilizer seeps into surface or groundwater. Compost is organic matter that has been decomposed and recycled as a fertilizer and soil amendment. Composting recycles organic matter and is a waste-free process. Provides a rich growing medium or absorbent porous material that retains moisture and soluble minerals, and provides support and nutrients to plants and crops grown. Three examples will be presented to focus on the benefits of organic mulching, biochar and compost to increase water use efficiency under dry conditions in an environmentally friendly manner.

Biochar produced from woody biomass and agricultural field residues has several properties that make it a compelling evidence and argument for its widespread use in agriculture, improving irrigation water addition efficiency and significantly reducing electricity consumption and water retention especially for dry sandy soils with little organic matter [57].

[57] found an improvement in water holding capacity of 15%, still a significant improvement. The oxidized biochars were better able to retain most of the irrigation water within the root dispersal zone, which implies and assures that the water-retaining capacity of the soil by biochar addition will increase with age in the soil. Meaning that as a result of this improvement, it will inject less irrigation water needed to meet the needs of irrigation crops and maintain sustainable production during hot weather. Another advantage of biochar is that it improves fertilizer use efficiency while sequestering soil carbon for hundreds and thousands of years, in a form that will continue to provide improvements in soil water use. Biochar and its application to soil is also used to overcome some of the limitations encountered while growing in sandy soils, allowing an additional option of soil management as well as adding other organic and sustainable materials such as compost and manure. Biochar has been added to sandy soils to improve an important set of soil hydraulic and physical properties including soil bulk density [58], soil hydraulic conductivity [59] as well as water infiltration rate and soil water retention [60] available soil water [61] as well as crop characteristics including crop yields [62] water use [63] and resistance Crop drought [64].

There are many environmental sustainability benefits of biochar when compared to the use of compost. The effective impact of biochar strongly indicates the importance and necessity of managing organic resources such as biochar that sterilizes the soil and builds up organic carbon, which may help improve sandy soil quality as well as increase the soil's water-holding capacity for irrigation, ultimately increasing the productivity and water productivity of crops producer. This has been achieved. Increase irrigation with an irrigation water deficit of 75% FI with the addition of biochar at the rate of 6 tons/acre. This treatment was the most effective as it provided 25% of the irrigation water needs needed for the growth of Anna apple trees [65].

10- Adding Organic Fertilizers to the Soil

[66] noted that intensive cultivation, misuse and excessive use of chemical fertilizers may lead to loss of organic matter in the soil, have adverse effects on the environment, and may threaten human and animal health as well as food safety and quality. Fertilizers are necessary to increase yields, especially in nutrient-poor soils. With the increase in fertilizer prices and limited resource reserves, organic amendments like compost and manure as a source of nutrients and organic matter are an economical and environmentally friendly alternative as shown in Figure (14). Slow decomposition is more effective in increasing soil organic matter content, which plays an important role in soil fertility through nutrient retention, soil structure preservation, and water retention. Care must also be taken when generalizing the effects of fertilizers on soil health, fertility and crop nutrition due to the changing nature of fertilizers and their interaction with climatic, compositional and crop characteristics. The general effects of compost use on soils have been well documented such as increased soil structural stability, improved water holding capacity, plant water availability, reduced nutrient leaching, and reduced erosion and evaporation. However, it is likely that the effect of compost on the soil is strongly dependent on the composition of the compost, which depends on the starting materials, fertilization conditions and duration. Compost such as compost depletes nutrients very slowly in plants and plants do not absorb these nutrients directly. Therefore, plants do not have access to the required number of nutrients in the period of critical yield formation. Hence, an integrated approach that combines the use of organic manure and the use of inorganic fertilizers is a good strategy to increase crop productivity. This will reduce the cost of inorganic fertilizers and improve soil fertility.

Figure (14): Production of compost

In addition to the above sustainable techniques, some additional engineering techniques will be introduced in the following sections which are only applicable to sandy soils to increase crop yield and water productivity. [67] indicated that the statistical analysis of the effect of percentages of non-uniform volume distribution of fertilizers along the sides under the low emission criterion indicates that maximum values of yield and irrigation water use efficiency for fertilizers were obtained for groundnut. Uneven distribution of fertilizers under drip irrigation system is very necessary with emission uniformity less than 80% and there is no need to perform uneven volume distribution under drip irrigation system if emission uniformity is 90% or more as shown in Figure (15).

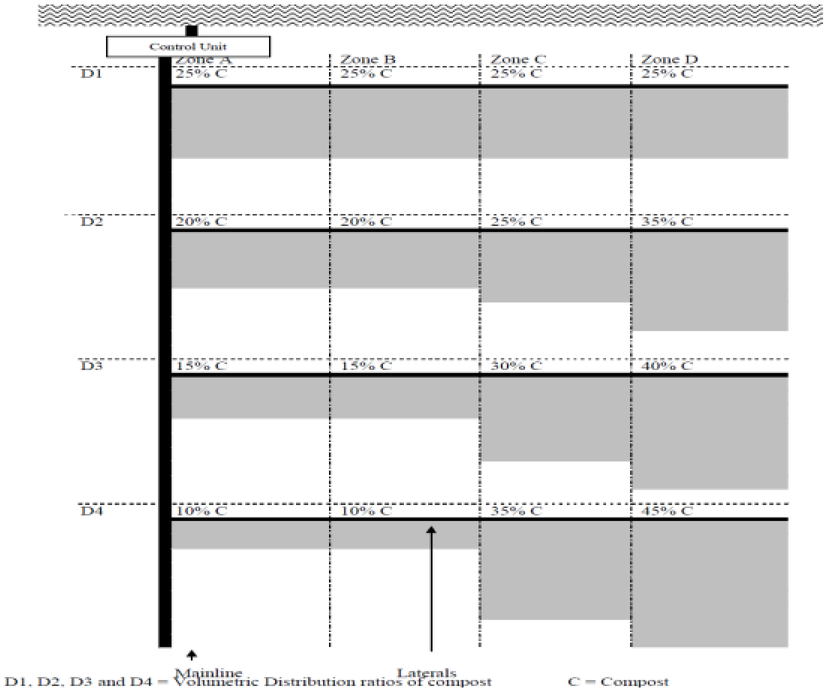

Figure (15): Irregular volumetric distribution ratios of compost on four zones along laterals.

CONCLUSION AND RECOMMENDATIONS

Therefore, it is imperative for all workers and specialists in the field of sustainable water management to focus on, adopt and publish how to apply most water-saving technologies suitable for the conditions of the simple Egyptian farmer. Maximizing irrigation water use efficiency is a popular concept used by irrigation project managers; The term crop water productivity is the primary criterion used to evaluate the effectiveness of irrigation systems and the sustainable management of conventional and water resources. Among the most important and best sustainable technologies that have proven positive effects in improving water productivity and which are compatible with the environment when applied are: (1) Pulse irrigation technique for improving water application efficiency and reducing water stress inside root zone, (2) Partial roots drying technique for saving 50% from irrigation water, (3) Minimum tillage technique for improving the soil environment and crop yield with minimal impact on the environment, (4) Automated Irrigation Scheduling for reducing water stress inside root zone and saving irrigation water (5) Innovating new designs for irrigation networks for improving irrigation efficiency (6) Laser land leveling for improving water distribution efficiency , (7) Using simulation models in the irrigation and climate management, (8) Towards applying organic mulching as a sustainable alternative to plastic mulching, (9) Adding biochar as a soil amendment, (10) Adding organic fertilizers to the soil as natural materials for improving water application efficiency and as a source for elements nutrients.

All the mentioned above mentioned technologies, as a researcher, have actually applied them and made sure of their feasibility and effectiveness in providing traditional water sources in addition to maximizing the use of non-conventional water resources, but at the present time and in the near future I will have new contributions to save irrigation water using: (1) Remote sensing technology and (2) Maximizing the productivity of rainfed agriculture in the coastal areas in Egyptian in addition to (3) designing a new innovation for agriculture with seawater.

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