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Irrigation Water Saving of Date Palm Tree Plantations Using Soil Amendments in UAE

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ABSTRACT

Date palm (Phoenix dactylifera) tolerates relatively harsh climatic and soil condition in Arab countries. The annual total irrigation water requirements in the Arab regions is ranging from 73.0 to 95 (m^3/tree). Approximately 70-80 per cent of global freshwater consumption is used in the agricultural sector, yet water use efficiency in many countries is below 50 per cent. Water saving amendments, are a natural soil mixes and has been developed and used to reduce the amount of water needed in irrigation for date palm farms, to maintain vigorous plants growth. When mixed in the soil, the material can retain great amounts of water per kg of product. When the soil dries, the product will release its water to the plant. Water saving amendments acts as a water reservoir, especially during periods of drought and the stored water is released to the plants. Using water saving amendments not only save water but also, improve the soil physical properties e.g. water holding capacity (WHC) and cation exchange capacity (CEC) of the treated soil. In this experiment we used three natural different water conservative materials to study its effects on saving irrigation water under date palm plantations. Three different levels of water saving materials e,g., compost ©, Bio Char (BC) and water saving (WS) product from Emirates Biofertilizers Factory products were used at four different levels e.g. 5, 10 ,15 and 20 kg per date palm tree against control of 7 years old trees grown in Al Salamat research station, Al Ain UAE. The plants tested were, Date palm trees. After two years of testing, we found that water saving amendments can save more than 40% of irrigation water. Our results recommended that, addition of 15 kg/date palm tree can reduce the water needed for irrigation by 40%. In this research paper, we focused mainly on introducing a natural means of managing irrigation water through soil conditioning, using water saving amendments to be incorporated in soil around the trees to prevent water losses by run off, evaporation and infiltration and to improve the soil physical, chemical and biological properties. Economic Values of water saved are studied

KEY WORDS: Compost, Biochar, Water Saver, Irrigation, and Date palm trees.

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INTRODUCTION

Today, some 2.8 billion people live in water-scarce areas, but by 2030, it is expected that about half of the world's population will live in water stressed areas. World agriculture faces an enormous challenge over the next 40 years: to produce almost 50% more food up to 2030 and double production by 2050. This will probably have to be achieved with less water, mainly because of pressure from growing urbanization, industrialization and the negative impact of climate change, (FAO, 2012 and Ahmed et al. 2012.]

An increase in C content of the soil increases aggregation, decreases bulk density, increases water holding capacity, (Vengadaramana & Jashothan, 2012) .Date palm trees (DPT) in the UAE generate around 600000 tons of date fronds which is an abundantly available agricultural waste and small percentage is economically used and recycled , and same problems exists in many date producing countries. DPT, are cultivated in arid and semi-arid regions and can thrive in long and hot summers, low rainfall and very low relative humidity (WHO, 2010). About 105 million trees are available around the Arab world covering over a million hectares. The UAE has the largest number of date palm trees in the Arab world, there are about 42 million date palm trees. Each tree generates about 15 kilograms (kg) of waste biomass annually, totaling 600 million kg of green waste. Converting date palm waste into soil amendments can reduce carbon dioxide (CO_2) and methane (CH_4) emissions generated by the natural decomposition or through burning of the waste. UAE is one of the largest producers of date fruits with more than 42 million date palm trees and an annual production rate of 770,000 tons of date fruits (MOEW, 2015 & Zainab et al. 2015 and Qasim, et al.2015 & Badawi, 2020).

The United Arab Emirates (UAE) h as sandy soil with very low water and nutrient holding capacities. In these conditions, date palm is considered one of the most resilient crops in the region. Over the years, with rising temperatures and scarce precipitation, there have been calls for new ways to conserve water, improve soil properties and prevent nutrient loss to achieve future food and nutrition security.

Two major natural resource concerns of this century are climate change and water (quality and quantity). Soil texture and organic matter content are the key components that determine soil water holding capacity (WHC). Water holding capacity of soils is controlled primarily by: (i) the number of pores and pore-size distribution of soils; and (ii) the specific surface area soils. Because of increased aggregation, total pore space is increased (FAO, 2012 and Ahmed et al. 2012and Sohi,

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et al. 2010, Wallace, 2000 and Claoston et al. 2014). Furthermore, as a result of decreased bulk density, the pore-size distribution is altered and the relative number of small pores increases, especially for coarse textured soils (Sohi et al. 2010). Sandy soils have much less surface area than clayey soils and, thus, retain much less water at higher tensions. However, with the addition of organic matter, specific surface area increases resulting in increased WHC at higher tensions [Sohi et al. 2010 and Barrow, 2012). Soil "holds" water available for crop use, retaining it against the pull of gravity. And this is one of the most important physical facts for agriculture. If the soil did not hold water. Soil texture and organic matter are the key components that determine soil water holding capacity. In one study, after 32 years, AWC increased by 23% in NT vs. CT where residue was retained under both systems. This increase was correlated to soil organic matter (SOM) increases (Mobius-Clune et al., 2008). Soil organic matter (SOM) increased 102% under NT in the surface 20 centimeters (cm). In another study, "because of the changing nature of the soil matrix (mineral-dominated to organic carbon dominated surfaces), the change in AWC ranges from about 2.5 to 5% per 1.0% change in organic carbon in soils containing less than 2.5% organic carbon and less than 40% clay" (Olness and Archer, 2005). The increase in amount of SOM in any soil is highly correlated to the increase in AWC. In all textural classes studied (sand, silt loam, silty clay loam), increasing SOM from 1 to3 percent for the sand, and 2 to 4 percent for the silt loam and silty clay loam classes, increased AWC by 73, 45, and 47 percent respectively.

This paper demonstrates that in a business-as-usual scenario, water consumption in agriculture would almost double. current water use trends are not sustainable in the face of population growth and climate change [Donnelly and Cooley, 2015]. Both economic development and security are placed at risk by poor water management. Groundwater has provided great benefits to agriculture irrigation in semi-arid countries, but its intensive use beyond recharge in certain regions has depleted resources and generated significant negative environmental externalities.

During seasons of drought and water scarcity, the other inefficiencies of irrigation and soil management make already difficult times for farmers even worse, (MOEW , 2015 and Badawi, 2019 AB). Since water is essential to grow food, a drought situation can pose major problems for agriculture. Hence, farmers often face extreme poverty in drought-prone areas. Efficient water use techniques are very important in the face of climate change, (Sohi et al. 2010, Clawston et al. 2014, Barrow 2012 and Khanmohamadi et al. 2015)

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In The Kingdom of Saudi Arabia ,KSA, (Abdulrasoul et al. 2017). studied the irrigation water requirements for date palm trees in several areas. The annual total irrigation water requirements (m^3 /tree) in these regions are 95, 73.4, 73, 89, 86, 85.7, 80, 85 m3 , respectively as the radius of shaded area per tree is 3.5 m. Each soil type has a different capability to hold moisture based on soil depth, soil texture (ratios of various soil particle sizes), soil structure (soil porosity) and soil water tension. A combination of these elements determines the amount of water available to the plant. Soil type may vary within the root zone, so it is important to know crop root depth and the soil type throughout the root zone. [Hansen, et al. 1979, Russel, 1980, Wan et al. 2007 and Zhang et al. 2017).

Soil acts as a water reservoir between irrigations or rains. Soil is also a nutrient reservoir, and it mechanically supports and stabilizes plants. Each soil type has a different capability to hold moisture based on soil depth, soil texture (ratios of various soil particle sizes), soil structure (soil porosity) and soil water tension. A combination of these elements determines the amount of water available to the plant.

Biochar is a solid product produced from thermal conversion of unstable carbon-enriched materials into stable carbon-enriched charred materials that can be incorporated into the soils as a mean for agronomic or environmental management. Biochar can be produced out of a long list of feedstock. The composition of biochar (content in carbon, nitrogen, potassium, calcium, etc) is directly related on the feedstock used and the duration and temperature of pyrolysis.

Biochar has been produced with a range of pH values between 4 and 12, dependent upon the feedstock and pyrolysis temperature [8]. Generally, low pyrolysis temperatures (< 400° C) yield acidic biochar, while increasing pyrolysis temperatures produce alkaline biochar. Once incorporated to the soil, surface oxidation occurs due to reactions of water, O_2 and various soil agents (Lehmaan, 2007 and Cheng et al. 2006). The cation exchange capacity (CEC) of fresh biochar is typically very low, but increases with time as the biochar ages in the presence of O2 and water (Lehmman 2007, Cheng et al. 2008 and Liang et al. 2006)

Previous analysis have shown that it is feasible to prepare biochar with relatively high BET surface areas from date palm fronds, which is favorable for microbial communities to grow and therefore enhancing fertility of the soils,. Biochar enhances soils. By converting agricultural waste into a powerful soil enhancer that holds carbon and makes soils more fertile, we can boost food security, discourage deforestation and preserve cropland diversity (Yu et al. 2013, Muhamad et al. 2018, Badawi 2019 , a) and Pokharel et al. 2020).

Biomass produced from date palm trees can't be composted easily in normal composting process due to its high content of lignocellulose compound, while the biochar production can be the option to generate both energy and soil conditioner for the improvement of sandy soil under the gulf countries severe climate. Compost, biochar and water saver are stable biologically produced carbon sources that can be added to soil. It processes agricultural waste into a soil enhancer that improves soil fertility, saves water, helps to mitigate greenhouse gas (GHG) emissions and fight global warming.

MATERIALS AND METHODS

A. Soils, sandy soil used in this study, located in Al Ain, Abu Dhabi – UAE.
B. Irrigation water used was underground water wells. Analysis of soil and irrigation water, are presented in table (1).
C. Water Saving amendments were produced at Emirate Bio Fertilizer Factory from natural materials e.g. Composted animal manure and biochar from the pyrolysis of dry date palm trees frond treated at 350^{o}C. While water saver product is produced at EBFF from clay minerals, organic matter, Gypsum and Amorphous Silica. Analysis of water saver used are in Table (2).

Table (1) Soil and irrigation water analysis used in experiment

Samples				Cations				Anions			
	pH	EC	$CaCO_3$	Ca	Mg	Na	K	Cl	CO_3	HCO_3	SO4
Soil	7.30	21.2	26.95	27.6	58.3	124	3.8	146	0.0	2.5	42.9
Water	7.50	13.6	---	490	462	1393	46	3053	0.0	91.5	2640

Preparation of compost ©:

Mixed cow manure and chicken manures collected from dairy and chicken farms in Al Ain, AD emirates are composted in windrow systems, with a proper conditions of aeration, moisture and adjusting for one month till maturation, and heat treated properly, and the analysis of end product are depicted in table (2).

Preparation of biochar (BC) Date palm tree waste leaves, was collected from al Ain City, UAE. The waste was dried in air under sunshine and then chopped to small pieces. Pyrolysis of the

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processed date palm waste was carried out in a closed stainless-steel container 200 l capacity, at 350 0C were maintained for 4 h under a limited supply of air. Feedstock samples were pyrolyzed to the desired temperature at the rate of 5◦C min−1. The biochar produced (25% W/W) were left to cool inside the furnace overnight, analysis of biochar are in Table (3).

Preparation of water saver (WS): Water saver product (WS) is a special mix of clay minerals, organic substances, gypsum and amorphous silica. Analysis of WS are in Table (3).

Table (2) Analysis of water saving amendment products used in experiment.

Parameter	Values			
	Sandy soil	Compost	Biochar	Water saver
Moisture (%)	15.0	12.0	12.2	12.1
Organic matter (%)	0.22	42.0	75.0	40.0
pH value	7.73	7.2	6.8	7.0
EC mmoh/cm	0.51	9.2	6.4	4.5
Total nitrogen (%)	0.12	1.6	1.12	1.0
Total phosphorus (%)	0.09	1.2	0.9	0.5
Total potassium (%)	0.9	1.2	1.4	0.5
Total sulfur (%)	0.3	0.8	0.6	5.0
Water holding capacity L/Kg	0.160	0.8	1.5	25.0
Specific gravity, (kg / l)	2.65	0.6	0.3	0.4
Cation Exchange capacity (meq/100 gm)	7.6	36.0	48.2	120

METHODS:

10 identical date palm trees of 7 years old are used in each treatment for this experiment of the month of October 2016/2017 and 2017/2018 at Al Salamat research station. Treatments were Control, 5 kg/tree, 10 kg/tree, 15 kg/tree and 20 kg/tree of materials, and it was mixed in the tree bits around the tree.

Irrigation was scheduled every 6 days in summer months and every 16 days in winter months and every 8 days in moderate months.

1- Irrigation water was monitored and water consumption was recorded, using water meter.

2- Soil samples were taking for analysis of water content, and samples dried at 105°C for 24 hours.

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3- Chemical analysis of soil, water, compost, biochar and water saver, followed the standard methods protocol as per, AOAC 1975 & Black et al. 1982)

4- Water holding capability for retention of water was measured in a separate experiment in 100 grams of materials and soil mix samples were saturated with water and incubated for 24 hours, then weight of water drained and water retained are recorded. Then calculated WHC of the tested materials as in table (3).

Table (3) values of water holding capacity and cation exchange capacity of material used in the experiment.

Material	Water Holding capacity l/kg of materials	Cation Exchange Capacity Meq/100g
Sand	0.16	3.5
Compost	3.0	85.0
Biochar	5.0	120
Water saver	25.0	180.0

CEC, an abbreviation for Cation Exchange Capacity, refers to the amount of negative charges available on the surface of soil particles. It gives an indication of the potential of the soil to hold plant nutrients, by estimating the capacity of the soil to retain cations, which are positively-charged substances. Th CEC was measured following the (Black et al. 1982).

Periodical samples were taken after one week, 30 days, 60 days, 90 days and at the end of experiment at 180 days. Soil samples were prepared and tested according to protocol followed by Total bacterial counts CFU, was measured using nutrient agar media, according to (Difco, 1985), while potato dextrose media was used to measure the total fungi in respective order.

Each mixture used in this study was saturated with water by following the procedure found in (Chapman and Pratt, 1961) to establish sample's water holding capacity. Water was slowly applied to each mixture container, while gently agitating, until excess water was observed. The mixtures were then allowed to sit for 24 h to assure homogeneity of water content throughout the sample. After that, the mixtures were drained by gravity for another 24 h through a coffee filter. Three 90-mL stainless steel containers were then tared, filled to two third full, and massed using a 0.01-g digital balance to determine wet mass. The samples were then dried at 110° C for 24 h using a

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convection oven and remassed to determine the dry mass. The results yielded the amount of water being held by each mixture.

RESULTS & DISCUSSIONS

The results obtained in this study showed that incremental increase in percent water holding capacity normalized to percent biochar amendment.

addition of water saving amendments, e.g. Compost ©, Biochar BC and water saver product (WS) improved water holding capacity and reduced irrigation water requirements for date palm trees in all treatments against control. It gives an indication of the potential of the soil to hold plant nutrients, by estimating the capacity of the soil to retain cations, which are positively-charged substances. Evaluation of water holding capacity, WHC and water saving amendment in sandy soil over time as affected by addition of water saving amendments are depicted in table (7-8-9). Increasing the ratio of water saving amendments reduced the water losses and increased the water retention to be used by date palm trees.

Table (7) showed the effect of adding compost to date palm trees grown in sandy soils. It is clear that irrigation water requirements decreased with increasing amount per tree from 5 kg/tree to 20 kg/tree. The irrigation water decreased from 70.5 m^3 to 63.4 m^3/tree per year.

Table (4) Average irrigation water per date palm tree of 7 years old, during different seasons and water saved percent when using compost soil amendment in Al Ain for two years.

Treatment	Compost				
	Summer months (L)	Winter months (L)	Moderate Months (L)	Average Per year (L)	Annual Requirement (L)
Control	288.0	105.0	213.0	200.0	70511.0
5 kg/Tree	279.36	101.85	206.61	194.0	68395.67
10 kg/Tree	270.72	97.65	200.22	188.0	66280.34
15 kg/Tree	264.384	96.6	194.895	184.0	64165.01
20 kg/Tree	259.2	94.5	191.7	180.0	63459.9

While in Table (8) biochar addition to date palm trees grown in sandy soil improved soil properties and reducing irrigation water per tree from 70.49 m^3 /tree per year to 56.39 m^3/tree per year. All

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treatments showed that increasing biochar percentage improved soil water retention above control. Increasing the amounts of biochar increased the amounts of water saved and reduced the irrigation water requirements.

Table (5) Average irrigation water per date palm tree of 7 years old, during different seasons and water saved percent when using Biochar soil amendment in Al Ain for two years.

Treatment	Biochar				
	Summer months (L)	Winter months (L)	Moderate Months (L)	Average Per year (L)	Annual Requirement (L)
Control	281.0	103.0	214.0	197.0	70490.0
5 kg/Tree	264.14	96.82	201.16	185.18	66260.6
10 kg/Tree	257.958	94.039	196.88	180.846	64850.8
15 kg/Tree	236.883	86.52	179.974	165.874	59141.11
20 kg/Tree	229.015	82.4	171.2	156.615	56392

Table (5). Depicts the effect of water saving products on reducing irrigation water for date palm tree grown in sandy soils. All treatments showed better results against control. Irrigation water required per tree has been reduced from 70.44 m^3/tree per year to 36.6 m^3/tree per year.

The results prove that water saver performed much better than biochar and biochar was better than compost, WS > BC > C as in Tables (4-5-6).

Table (6) Average irrigation water per date palm tree of 7 years old, during different seasons and water saved percent in Al Ain for two years.

Treatment	Water saver				
	Summer months (L)	Winter months (L)	Moderate Months (L)	Average Per year (L)	Annual Requirement (L)
Control	279	99	202	193	70440
5 kg/Tree	200.88	71.28	145.44	138.96	50716.8
10 kg/Tree	178.56	63.36	129.28	123.52	45081.6
15 kg/Tree	151	51	115	105.6	38540
20 kg/Tree	142.29	52.47	105.04	102.29	36628.8

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It is very clear that cultivating sandy soil consume huge amounts of irrigation water, due to its physical properties e.g. open structure and less organic matter content. (Russel1980 & Wanjura, et al. 2002). Irrigation water requirements (m3/ha) after taking into account the proportion of cultivated area of date palm for each year were found to be 7044 m3 considering 100 trees per ha which mean, date palm tree consumed 70.44 m^3/tree under control while the percent water saved is 10%, 20.% and 48.0 % when adding 20 kg/tree of compost, biochar and water saver respectively. The annual total irrigation water requirements (m^3/tree) in different regions in KSA were, 95m3/tree, - 85 m^3 /tree. Gafar (2010) in UAE stated that mature trees require 69.7 m^3 pr year. Similar results obtained by (MOEW, 2015, Al Khalaf et al. 1998, Bruce & Stanly , FAO, 2009, GAFAR, 2010 and Abdulrasoul, 2017).

The results recommend that for better management of irrigation water, farmers have to add soil amendments to reduce water losses and to improve the soil water retention and plant growth, (Wanjura, et al. 2002). The reason for soil amendment is to provide a better environment for roots and plant growth, this includes the improvement of the soil structure and water holding capacity, the availability of nutrients, and the living conditions for soil organisms, which are important for the plants to grow, (Xu et al. 2003, Wang et al. 2008 and Yazar et al. 2002) .

Biochar is used as a soil amendment to improve soil nutrient status, C storage and/or filtration of percolating soil water (Lehmaan & Josef,, 2009). Biochar from pyrolysis and charcoal produced through natural burning share key characteristics including long residence time in soils and a soil conditioning effect (Glasser et al. 2002). Research has claimed that application of biochar can increase soil organic carbon (SOC), improve the supply of nutrients to plants and therefor enhance plant growth and soil's physical, chemical, and biological properties (Glaser et al. 2002) and Rondon et al. 2007).

Water saving amendments can alter soil physical properties such as structure, pore size distribution and density, with implications for soil aeration, water holding capacity, plant growth, and soil workability. Consequently this may improve soil water and nutrient retention (Dowine, et al. 2009). Biochar may increase the overall net soil surface area (Chan et al. 2007) reduce soil bulk density which is generally desirable for most plant growth (Brady and Weil 2004). Water saving

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amendments has a higher surface area and greater porosity relative to other types of soil organic matter, and can therefore improve soil texture and aggregation, which improves water retention in soil. Improved water holding capacity with biochar additions is most commonly observed in coarse-textured or sandy soils (Gaskin et al. 2009) and Glaser et al. 2002). Biochar has a higher sorption affinity for a range of organic and inorganic compounds, and higher nutrient retention ability compared to other forms of soil organic matter (Bucheli, et al.2000 and Bucheli and Gustafason 2003). and (Allen, et al., 2002, Kleineidam et al. 2002 and Nguyen et al. 2008).

Table (10) showed the periodical changes of WHC of sandy soil amended with compost. Results revealed that addition of compost increased WHC in all treatments over control, in the same time increasing the amounts of compost from 5kg/tree till 20 kg/tree increased WHC for all treatments from 0.17 to 1.33. that means WHC increased more than 7 times over control. While in table (11) showed addition of biochar to sandy soil increased WHC in all treatments above control. WHC of sandy soil amended with biochar increased from 0.17 to 3.37, which means increased by 19 times. But for water saving product which is considered the highest water holding capacity material in this study, WHC increased from 0.17 to 8.73 which means increased by 51 times above control. Addition of compost organic fertilizer and biochar and water saver around the trees separately increased the WHC of the sandy soil (Table 2). But the addition of biochar increased the WHC of the soil doubly than addition of compost organic fertilizer, while addition of 20 kg/tree of water saver increased WHC more than 50 times of control and 2.6 times than compost and more than 6.56 times the compost treatments. The reported results are in line with several studies, (Badawi, 2019 b, Pokharel, 2020).

Table (7) Periodical changes of Water holding capacity (%) in sandy soil amended with biochar through 180 days.

Treatment	Compost			
	7 Days	60 Days	120 Days	180 days
Control	0.17	0.16	0.16	0.16
5 kg/Tree	0.81	0.84	0.79	0.81
10 kg/Tree	0.90	0.94	0.91	0.89
15 kg/Tree	1.11	1.27	1.26	1.23
20 kg/Tree	1.33	1.30	1.31	1.17

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Table (8) Periodical changes of Water holding capacity (WHC%) in sandy soil amended with biochar through 180 days.

Treatment	Biochar			
	7 Days	60 Days	120 Days	180 days
Control	0.17	0.16	0.16	0.16
5 kg/Tree	2.12	2.10	2.07	2.05
10 kg/Tree	2.65	2.67	2.60	2.53
15 kg/Tree	2.81	2.78	2.69	2.68
20 kg/Tree	3.37	3.30	3.19	3.17

Table (8) depicted the water holding capacity of soil treated with biochar in comparison to control. All treatments received biochar showed water holding capacity improvement compared to control and increasing biochar content increased water holding content values (Katy et al. 2015 & Glazonova et al. 2018).

Table (9) Periodical changes of Water holding capacity (WHC%) in sandy soil amended with biochar through 180 days.

Treatment	Water saver			
	7 Days	60 Days	120 Days	180 days
Control	0.17	0.16	0.16	0.16
5 kg/Tree	5.12	5.10	5.07	5.05
10 kg/Tree	6.65	6.67	6.60	6.53
15 kg/Tree	7.81	7.78	7.69	7.68
20 kg/Tree	8.73	8.33	8.39	8.30

At higher tensions close to wilting range, nearly all pores are filled with air and the moisture content is determined largely by the specific surface area and the thickness of water films on these surfaces. Sandy soils have much less surface area than clayey soils and, thus, retain much

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less water at higher tensions. However, with the addition of organic matter, and water saving products specific surface area increases resulting in increased WHC at higher tensions [Sohi et al. 2010 and Barrow 2012).

The application of biochar to soil offers multiple benefits in a wide range of agricultural systems. Biochar have been evaluated in various field crops and pastures around the world. Studies have found that biochar can improve plant yields, enhance soil water holding capacity and reduce fertilizer requirements, and results vary widely between different biochar, soil types, climates and target crops.

Compost, or decomposed organic matter, biochar and water saver has been found to enhance water-holding capacity improve soil structure. It further enhances the soil's water-holding capacity. It can help to retain more water in the soil during dry season. Farmers may also use and water saving amendments as soil to reduce evaporation, and infiltration of water (Cheng et al. 2006 & Badawi, 2019a, b and Badawi, 2020)

The potential benefits of biochar soil amendment are well identified in the literature. These include carbon sequestration, improved crop yields, and enhanced water retention. The conversion of biomass carbon to biochar leads to sequestration of about 50% of the initial carbon compared to 3% sequestration from burning and less than 20% from biological decomposition (Chan et al. 2007) Biochar is resistant to decomposition and remains in the soil for centuries or millennia.

While many articles report on carbon sequestration potential and nutrient trapping, there have been only a few studies on the effect of biochar on water holding capacity. (Beat & Suphler 2018) reported an increase in the water holding capacity of a loamy sand soil with 2% mixtures of biochar made from various switchgrass feedstocks. They were interested in understanding the different effects of temperature and feedstock on the water holding capacity of biochar but all values were calculated at a 2% mixture rate only. Another finding was an 11% increase in water holding capacity reported as an additional observation and was not validated through the use of control techniques (Dowine et al. 2009). The ability of biochar to increase water holding capacity could have profound effects on areas prone to drought. (Dowine et al. 2009), Sohi et al.2010) summarized the current state of biochar knowledge and concluded that soil water holding capacity was an area of significance that was lacking in research.

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Table (10) Periodical changes of Total Plate Counts, TPC content in sandy soil amended with compost through 180 days, CFU/10^6.

Treatment	Compost			
	7 Days	60 Days	120 Days	180 days
Control	31.9	34.1	36.2	32.3
5 kg/Tree	69.3	71.2	88.1	74.3
10 kg/Tree	84.0	91.0	92.3	89.0
15 kg/Tree	88.0	98.5	99.1	99.4
20 kg/Tree	93.7	103.0	107.0	107.8

Table (11) Periodical changes of Total Plate Counts, TPC content in sandy soil amended with biochar through 180 days, CFU/10^6.

Treatment	Biochar			
	7 Days	60 Days	120 Days	180 days
Control	31.0	32.0	33.0	32.0
5 kg/Tree	68.0	67.2	88.1	74.3
10 kg/Tree	84.0	88.0	92.3	89.0
15 kg/Tree	87.0	96.5	98.1	99.4
20 kg/Tree	91.7	101.0	102.0	100.8

Table (12) Periodical changes of Total Plate Counts, TPC content in sandy soil amended with water saver through 180 days, CFU/106.

Treatment	Water saver			
	7 Days	60 Days	120 Days	180 days
Control	32.9	33.0	33.4	32.6
5 kg/Tree	69.0	71.2	78.1	74.3
10 kg/Tree	86.0	98.0	94.3	89.0
15 kg/Tree	89.0	96.5	98.8	101.4

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20 kg/Tree	91.7	101.0	105.0	103.8

Table (13) Periodical changes of Total fungi colonies content in sandy soil amended with compost through 180 days, CFU/10^4.

Treatment	Compost			
	7 Days	60 Days	120 Days	180 days
Control	7.90	7.99	7.31	7.28
5 kg/Tree	13.10	13.90	14.20	13.10
10 kg/Tree	14.60	16.20	17.20	17.00
15 kg/Tree	16.00	17.40	19.90	19.00
20 kg/Tree	18.80	19.20	19.90	21.00

Table (14) Periodical changes of Total fungi colonies content in sandy soil amended with biochar through 180 days, CFU/10^4.

Treatment	Biochar			
	7 Days	60 Days	120 Days	180 days
Control	7.20	7.29	7.31	7.28
5 kg/Tree	12.10	12.90	13.20	13.90
10 kg/Tree	14.30	16.10	17.20	17.00
15 kg/Tree	16.00	17.40	18.60	19.00
20 kg/Tree	18.30	19.20	19.40	20.00

Table (15) Periodical changes of Total fungi colonies content in sandy soil amended with water saver through 180 days, CFU/10^4

Treatment	Water saver			
	7 Days	60 Days	120 Days	180 days
Control	7.16	7.29	7.30	7.28
5 kg/Tree	14.10	14.90	14.20	13.90
10 kg/Tree	16.30	16.80	17.20	17.10
15 kg/Tree	17.00	17.40	18.90	19.00

20 kg/Tree	18.30	19.90	19.40	21.40

Table (10-11-12) describe the total bacterial population measured by plate count technique in the soil amended with different rates of water saving products Compost, biochar and water saver from 5 kg/tree till 20 kg/tree. Numbers of CFU increased with increasing dose of compost, biochar and water saver applied in all treatments. All treatments showed high microbial counts over control. Bacterial population was in the range of 31-32 millions bacteria in the control treatment while increased sharply in all treatments reaching 10^7 millions of CFU/gram for compost treated sandy soil while in case of biochar the numbers were in the range of 100 millions of CFU, while in water saver treatments bacterial numbers reached 10^3 millions microbes after 180 days.

Microbial biomass and total plate counts in most cases increases in the presence of biochar. Notable exceptions are mycorrhizae in situations of abundant nutrient supply. No direct negative effects of biochars on roots have been detected. Critical to further advances is the recognition and reporting of the diversity of biochars. (Lehmaan, et al. 2011, and Pokharel et al. 2020).

Fungi population are depicted in Tables (13-14-15) the total fungi colonies showed less numbers, e.g. control treatments showed $7X10^4$, while for treatments received compost, biochar, and water saver the fungi numbers grown in the range of 20-21 $X10^4$ CFU/gram of soil received compost, biochar and water saver respectively. . The significant differences in bacteria, and fungi population were observed between biochar and control (Lehmaan et al. 2011 Rolf and Bakken (1987) and Adel et al. 2015).

The microscopic structure of,compost biochar and water saver is one of the primary determinants in its soil conditioning properties; the surface area of the pre-charred source material can be increased several thousand fold (Wang 2008).

The water retained in sandy soil by the water saver product was higher than Biochar and compost organic fertilizer. Therefore addition of soil amendments in date palm tree sandy lands increases the WHC of the soil. This addition enhance plant growth and improve water use efficiency. Surface area and organic matter percentage influences in the water-holding capacity. As the percentage increases, the water-holding capacity increases because of the affinity of organic matter has for

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water (Vengadaramana, A. & Jashothan, 2012 and Yuan et al. 2001 and Christopher and Michael 2018).

Much of this interest is focused on water saving amendments. The claims for them are many: larger crop yields, decreased fertilizer requirements, greater microbial activity, reductions in greenhouse gas emissions from fields, greater soil water holding capacity, drought mitigation, and increased soil organic carbon content (SOC), which can improve the physical properties of soil. Further, carbon sequestration benefits of biochar soil amendment have been heavily studied (Lehmaan, 2007 and Liang et al. 2006 and Badawi, 2019 a), while (Sohi et al 2010) . showed that soils with a high water holding capacity produce increased crop yields and a decreased need for irrigation. (Singh et al. 2010) & (Glaser, 2002) suggested that the increased porosity of biochar increases water retention in soils, and the enhancement depends on biochar feedstock, soil type, and mixture rates. Nutrients dissolved in the water may also be retained in the soil so plants may be better able to access the nutrients (Yuan et al. 2001).

Economics of using irrigation water saving amendments:

Table (16) Evaluation of water saving amendments on economics of water consumption on date palm plantation, using 15kg per tree under UAE water tariff of 0.85$/m^3.

Product	Material unit cost, ($/kg)	Material cost ($/15kg)	Water saved (M^3/tree/year)	Total money Saved in ($) / tree / year
Compost	0.110	1.65	6.35	5.40
Biochar	0.380	5.70	11.35	9.65
Water saver	1.600	24.00	31.90	27.13

Water saving amendments was calculated at 15 kg/tree and water price a per UAE Agriculture tariff, (subsidized price).

When we add 15 kg/tree of different water saving amendments, we found that compost can save 6.35 m^3 / tree of water per year , while adding 15 kg of biochar it can save 11.35 m^3 /tree of water per year, while using the water saver product, we can save 31.90 m^3 of water/tree per year, if we calculate how much money we can save when we use water saving amendments materials it can be as follow, compost can save 5.40 $, followed by biochar can save 9.65 $ per tree per year while water saver product can save 27.13 $ per tree per year. To reflect these water saving we can save huge amounts of water on the global basis or at least for Arab countries which have 105 millions

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of date palm trees. Along with these irrigation water saving, soil physical, chemical and biological properties are improved.

To promote the practice of agricultural soil water saving amendments, the full life cycle costs and benefits to soil amendment must be estimated. The effect of water holding capacity on crop growth due to water holding capacity, nutrient retention, and microbial growth must be understood, in addition to the benefits of the likely reduced need for irrigation and fertilizer and pesticide usage. Inclusion of traditionally externalized costs associated with carbon and environmental degradation, a side effect of current farming and irrigation techniques, will further improve the cost/benefit analysis of agricultural water saving amendments usage.

CONCLUSION

Proper water management in sandy soil should use available organic matter in their farms to be serving as soil conditioner and to act for saving water for better plant growth and soil microbial activities in the soils.

Addition of water saving amendments improved water retention and contribute to:• improved crop yields, produces uniform moisture at the root zone, reduces irrigation requirement by up to 50%, saving both water and money, reduces evapotranspiration, holding water and nutrients at the roots to produce strong, healthy plants. Sandy soils to retain water and nutrients. We can save more than 40% of irrigation water requested for date palm plantation. This water saving can be used for other eventual needs of water e.g. industry and other purposes.

To promote the use of compost, biochar and water saver as soil amendment, it is important to understand the mechanism of the amended water retention, to characterize the effects of feedstock, biochar production, soil types, and mixtures, and to quantify these effects on plant growth.

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توفير مياه الرى فى مزارع النخيل بإستعمال المواد الطبيعية الحافظة والموفرة للمياه

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الملخص العربى

يتحمل نخيل التمر ظروف مناخية وتربة قاسية نسبيًا في الدول العربية. وتتراوح الإحتياجات السنوية لمياه الري للنخلة في المنطقة العربية بين 73.0 إلى 95 (م 3 / شجرة). ويستخدم ما يقرب من 70 في المائة من الموارد المائية للمياه العذبة في القطاع الزراعي ، وعلى الرغم أن كفاءة إستخدام المياه في العديد من البلدان العربية تقل عن 50 في المائة. وتحتاج التحول لطرق رى حديثة ومستدامة و فى هذه التجربة إستعملنا مواد طبيعية لتوفير مياه الرى ، وهي خلطات طبيعية من مواد متاحة فى المزرعة من التربة ومخلفات تقليم النخيل يتم تطويرها ومعالجتها وإستخدامها لتقليل كمية المياه اللازمة للري لمزارع نخيل التمر ، وللحفاظ على نمو النباتات والأشجار بحالة جيدة. وعند مزج هذه المواد حول المجموع الجذرى في التربة ، يمكن أن تحتفظ المادة بكميات كبيرة من الماء لكل كجم على سبيل المثال 3 و 5 و 25 لتر/كجم من المنتج - كمبوست – بيوتشار – ووتر سيفر على الترتيب. وعندما تجف التربة سيطلق المنتج مياهه إلى النبات. وتعمل المواد الوفرة لمياه الرى والحافظة للمياه على توفير المياه وتخزينها ومنعها من الفقد، حتى أثناء فترات الجفاف فإنه يتم إطلاق المياه المخزنة إلى النباتات. ولا يقتصر إستخدام مواد الحافظة للمياه على توفير المياه فحسب ، بل يؤدي أيضًا إلى تحسين الخصائص الفيزيائية للتربة مثل تحسين قدرة الإحتفاظ بالماء (WHC) وقدرة التبادل الكاتيوني (CEC) للتربة المعالجة. في هذه التجربة إستخدمنا ثلاث مواد طبيعية مختلفة للمحافظة على المياه لدراسة تأثيرها على توفير مياه الري تحت مزارع نخيل التمر فى دولة الإمارات. تم استخدام ثلاث مواد مختلفة لتوفير المياه ، مثل ال Compost ©، Bio Char (BC) ومنتج ووتر سيفر لتوفير المياه (WS) من منتجات مصنع الإمارات للأسمدة البيولوجية على أربعة مستويات مختلفة على سبيل المثال الكنترول و 5 كج و كج10 و 15 كج و 20 كجم لكل شجرة نخيل عمرها 7 سنوات مزروعة في محطة أبحاث السلامات ، العين الإمارات العربية المتحدة. والتى تضاف لمرة واحدة وتبقى فعالة فى التربة لسنوات عديدة. وتم إستخدام منتجات توفير المياه لدراسة أثرها فى توفير المياه في التربة الرملية لمزارع النخيل في دولة الإمارات العربية المتحدة. وإستمرت الدراسة لمدة عامين متتاليين 2016/2017 وكذلك 2018/2017 وتم تقييم النتائج بعد عامين من الإختبار ، وجدنا أن إضافة مواد توفير المياه يمكن أن توفر أكثر من 45٪ من مياه الري لأشجار النخيل. أوصت النتائج بأن إضافة 15 كجم / شجرة النخيل يمكن أن يقلل من المياه اللازمة للري بنسبة 45 ٪. وفي هذه الدراسة ، ركزنا بشكل أساسي على إدخال وسيلة طبيعية لإدارة مياه الري من خلال تحسيين وإصلاح التربة ، بإستخدام مواد توفير المياه لخلطها في التربة حول الأشجار لمنع فقدان المياه عن طريق التبخر والتسرب وتحسين خصائص التربة الفيزيائية والكيميائية والبيولوجية. تمت دراسة المردود والعائد الإقتصادي لقيمة لمياه الموفرة ووجدنا أنه يمكن توفير ماقيمته 27 دولار فى العام عند إضافة 15 كج للنخلة من مادة الووتر سيفر بينما يمكن توفير 5 دولارات لكل نخلة عند إستعمال 15 كج كمبوست أما فى حالة البيوتشار يمكن توفير 9.6 دولار مياه رى لكل شجرة عند إستعمال 15 كج من البيوتشار.

الكلمات الرئيسية: الكمبوست – البيوتشار – الووتر سيفر – رى أشجار النخيل – المواد الحافظة لمياه الرى.