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CSBE | SCGAB

Paper No. 06-204

DATE PALM RESPONSE TO SUBSURFACE DRIP IRRIGATION

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Written for presentation at the
CSBE/SCGAB 2006 Annual Conference
Edmonton Alberta
July 16 - 19, 2006

Abstract

A study was made on date palm trees to investigate the effect of three subsurface drip irrigation systems on the yield and water requirements of date palms. Experiments were conducted in Alwatania Agricultural Project – Gassim (350 Km north west of Riyadh), on 50 mature palm trees (17 years old) of Helwa type with 10 meters spacings between rows and between trees, all treatments were fixed during experiment except the subsurface drip line type (T-Tape, Techline, Queen-Gill). Irrigation scheduling was made through a soil moisture sensing device to ensure enough soil water level in the soil.

Results have indicated that there is a significant increase in the yield in addition there were a considerable saving in water compared to the conventional drip irrigation method. As for the type of subsurface system, the results have shown that the T-Tape followed by Techline subsurface systems are durable and highly efficient compared to other subsurface drip pipes.

Keywords: *Drip irrigation, Subsurface drip irrigation, Date palm trees, Date palm water use, Date* palm yield.

INTRODUCTION

Agriculture is considered the biggest consumer of water resources in the world. The consumption of water by agriculture could account for up to 90% of total annual water consumption in some countries of the arid region like Saudi Arabia. In addition, agriculture could be the reason for water degradation because of the absence of proper water management, therefore, there is an urgent need for optimum use of water for agriculture and an extra emphasis should be directed towards water management to prevent water pollution or deterioration of water quality. In that respect, drip irrigation is considered as one of the most important practical and effective means for irrigation water application compared to other irrigation methods.

Drip irrigation system have proven its superiority over other irrigation systems in increasing yield and reducing the cost of labor and energy, in addition, it improves efficiency and reduces water losses due to evaporation and deep percolation. However, the traditional surface drip irrigation system has some disadvantages including; possibility of damage, exposure of pipe network to sun and the accumulation of salts. A recent better alternative is the subsurface drip irrigation system. It represents the recent improvement in irrigation application, as it prevents or in most cases reduces considerably the evaporation from soil surface and the evapotranspiration is satisfied in a better way due to upward movement of water in the root zone, also the water use efficiency become higher as the water is actually added to the active roots, in addition, it prevents the growth of weeds around the crop (Ayers et al, 1995).

After three decades of research and development, the subsurface drip irrigation system becomes one of the systems that is characterized by high efficiency and productivity. Through extensive research, most of the subsurface drip irrigation system problems were solved including; clogging of emitters by small roots, lateral installation and fertigation. The results of many experiments have indicated a significant increase in efficiency of water and nitrogen use that lead to a high increase in production and an improve in quality. The system have also contributed in limiting of ground water pollution with nitrate and salts in the long run. As the system work under the soil surface, it was noticed that it has an advantage over the traditional surface drip system in saving water and nutrients in addition to the control of salinity, deep percolation and durability of the system, this may be due to the spherical soil water wetting as compared to the half spherical in the case of surface drip system (Phene, 1995).

Comparing the subsurface drip irrigation system with traditional surface drip system and sprinkler irrigation system, results have shown that the overall water use is reduced by 50% compared to sprinkler system and 30% compared to traditional surface drip irrigation system. It was also noted that production was increased by a percentage ranging between 30% to 70% compared to surface irrigation system (Barth, 1995). An experiment on tomato using an automatic scheduling system for subsurface drip irrigation have clearly shown a high saving in water and an increase in yield compared to non automatic system (Mohammad and Al-Amoud, 1994).

Under the arid and semiarid climates where rainfall is minimal and the air temperature is high, this will result in high increase in evaporation rate from soil surface that result in salt accumulation in the top layer of the soil where active roots concentrates which in turn lead to yield reduction. To minimize salt accumulation caused by evaporation it is possible to apply subsurface drip system to wash away salts beyond root zone. This method was applied successfully, on mature Pear trees, where subsurface laterals was laid at depths of 30 cm and 60 cm under soil surface (Oron et al, 1995). Other experiments on porous subsurface systems have shown that operation pressure have a clear influence on the performance of these pipes, where the best performance was noticed at an operation pressure not less than 80 kiloPascal (kPa) and not more than 150 kPa (Mohammed, 1998).

Date Palm tree is considered one of the most important fruit trees in the Kingdom of Saudi Arabia. The number of trees are more than 19 million and it is increasing every year. The production have increased to reach 0.71 million ton in the year 1999, they are grown in an area exceeding 141 thousand hectare (MOA, 2002). Date palm tree is a drought resistant that can withstand salinity up to 4 Dsm/m without any reduction in yield (Ayers and Wescot, 1985). Although the root zone depth is ranging between 1.5m to 2.5 m (Doorenbos and Pruitt, 1977), the tree could uptake 65% to 80% of water within a root zone depth not exceeding 1.2 meter (yaacob, 1996). Date palm tree usually irrigated by basin irrigation system that uses an abundant amount of water, the quantity is usually decided based on farmer's experience. The crop water requirement for mature date palms ranges between 115 and 306 cubic meters, that is equal to 1.15 to 3.06 meter per hectare (Albaker, 1972). If the expansion in date palm agriculture continues at the same present rate in the Kingdom it is expected that a huge quantity of water will be required to irrigate the date palms. However, due to the limited water resources in the Kingdom, it is vital to use some water saving methods such as recent irrigation systems (drip irrigation). Therefore, the study aiming to evaluate the date palm water requirement is essential and will lead to the accurate application of irrigation water with no excessive use.

It is possible to estimate the crop water requirement for date palms based on available information of similar areas such as the studies conducted in Al-Hassa region in Saudi Arabia (Hussain, 1986; Helal et al, 1986), south California (Furr, 1975), Egypt (Hussain and Hussain, 1982), and Iran (Furr, 1975). Studies have indicated that low

frequency irrigation with high quantities for date palms is better compared to high frequency irrigation (Helal et al,1986). The result of a study on date palm (Sakoti type) in Egypt on irrigation frequency have shown that the best period between irrigations is four weeks with a quantity equal to 71 mm for each irrigation (Hussein and Hussein, 1982). A study was conducted on the effect of drip irrigation on the growth and yield as compared to sprinkler irrigation (Reuveni, 1971 & 1974), it was concluded that drip irrigation is more superior than the sprinkler system, it was due to the smaller volume of wetted soil under drip irrigation, results have indicated also that date palms irrigated with drip irrigation show a clear increase in leaves, flowers and fruits compared to those irrigated by sprinkler system. It was also noted that the yield of drip irrigated palms is higher than those irrigated by sprinkler systems. In a comparison study between traditional drip and bubbler irrigation systems on date palms, it was noted that, an accumulation of salts on the surface layer were higher for drip compared to bubbler system (Naimah, 1985).

Results on experiments of date palm water consumption in Riyadh area, have indicated that the average amounts that have been delivered to date palms per year were; 108 m^3/tree (1.08 m/ha), 216 m^3/tree (2.16 m/ha) and 324 m^3/tree (3.24 m/ha) for corresponding water treatments of 50%, 100% and 150% of evaporation rate, respectively (Al-Amoud et al 2000), economical analysis of yield for the various irrigation systems (drip, basin and bubbler) in the above experiment, have shown that, the highest yield was for drip irrigated palms then the basin systems, differences within water treatments, were minimal, in other word, the use of an amount of 108 m^3/year/tree is enough to obtain the highest efficiency of water use for date palms. Comparison between water use efficiencies for various irrigation methods (drip, basin and bubbler) on date palms have shown that the drip system the highest water use efficiency followed by the basin system then the bubbler irrigation system (Al-Amoud et al, 2000). The optimum date palm response to drip irrigation is due to the nature of the system where water is delivered in a slow process for relatively long period of time through emitters, this process provides better control and distribution for water through soil profile to an extent that, losses due to evaporation and deep percolation reduced to the minimum, therefore, date palm tree could make use of almost all water delivered.

Economical analysis studies have shown the superiority of the subsurface drip irrigation over center pivot sprinkler irrigation system. It was found that the total cost for the subsurface drip irrigation system per hectare (including; investment management, operation , etc..) is less by 30% compared to the center pivot system (Dhuyvetter et al, 1995).

The aim of this research work is to investigate the efficiency and practicality of subsurface drip system use for irrigating date palm trees and to compare it with the traditional surface drip irrigation system and to study the effect of the subsurface irrigation system on yield and water conservation.

MATERIALS AND METHODS

Experiments on date palm trees were conducted in Alwatania Agricultural Project in Gassim, Saudi Arabia (elevation 649 m, Lat. 26 18N, Longt. 043 46E). Soil texture is characterized as sandy clay loam soil, with physical and chemical characteristics as outlined in Table 1. The experimental site was selected in the middle of the project, the plot consists of 170 trees of mature trees with distances of 10 meters between trees and between lines of trees, 50 of those trees are selected for study, they are of a popular type name; 'Helwa' . For irrigating the date palm trees, an irrigation pipe network was designed (Keller and Karmeli, 1975; Vermeiren and Gobling, 1980; Howel et al., 1992; Nakayama and Bucks, 1986; Al-Amoud, 1999). The irrigation network consists of three types of subsurface drip systems locally available; the first was the T-Tape system of the type: TSX715, with 22mm diameter, 0.375 mm thickness and 3.4 liter per hour discharge per 1 meter length, The second type is the : Queen Gil Tape, with 15.9 mm diameter, 0.38 mm thickness and 3.5 liter/hour/m discharge, the third type is the : Techline of Netafim that have pre installed emitters, with 16 mm diameter , 1.125 mm and 3.5 liter per meter length in one hour, the hydraulic characteristics are shown in Table 2. All subsurface drip pipes are installed in a circular way around the tree trunk with 3 meter diameter at a depth of about 0.4 meter so that they can feed the active root of the tree. The pipe network have included all the necessary units and parts such as ; valves , filters, water meters and control board as indicated in the network design sketch in Figure 1. Irrigation scheduling was conducted by using soil moisture sensing devices that can measure moisture at a depth of 0.8 meter or lower , Figure 2, show the calibration of the soil moisture sensing device. The experimental plot is supplied with water from a well in the site with suitable water quality as indicated in Table 3. The area is characterized by high temperature in the summer with low rain fall as shown in the climatic data (Table 4). The System was installed and operated in April 2001 through the 2002 season. Harvesting of crop starts at the beginning of August and end at middle of September.

Table 1. Soil Analysis Results.

Soil Characteristics	Value

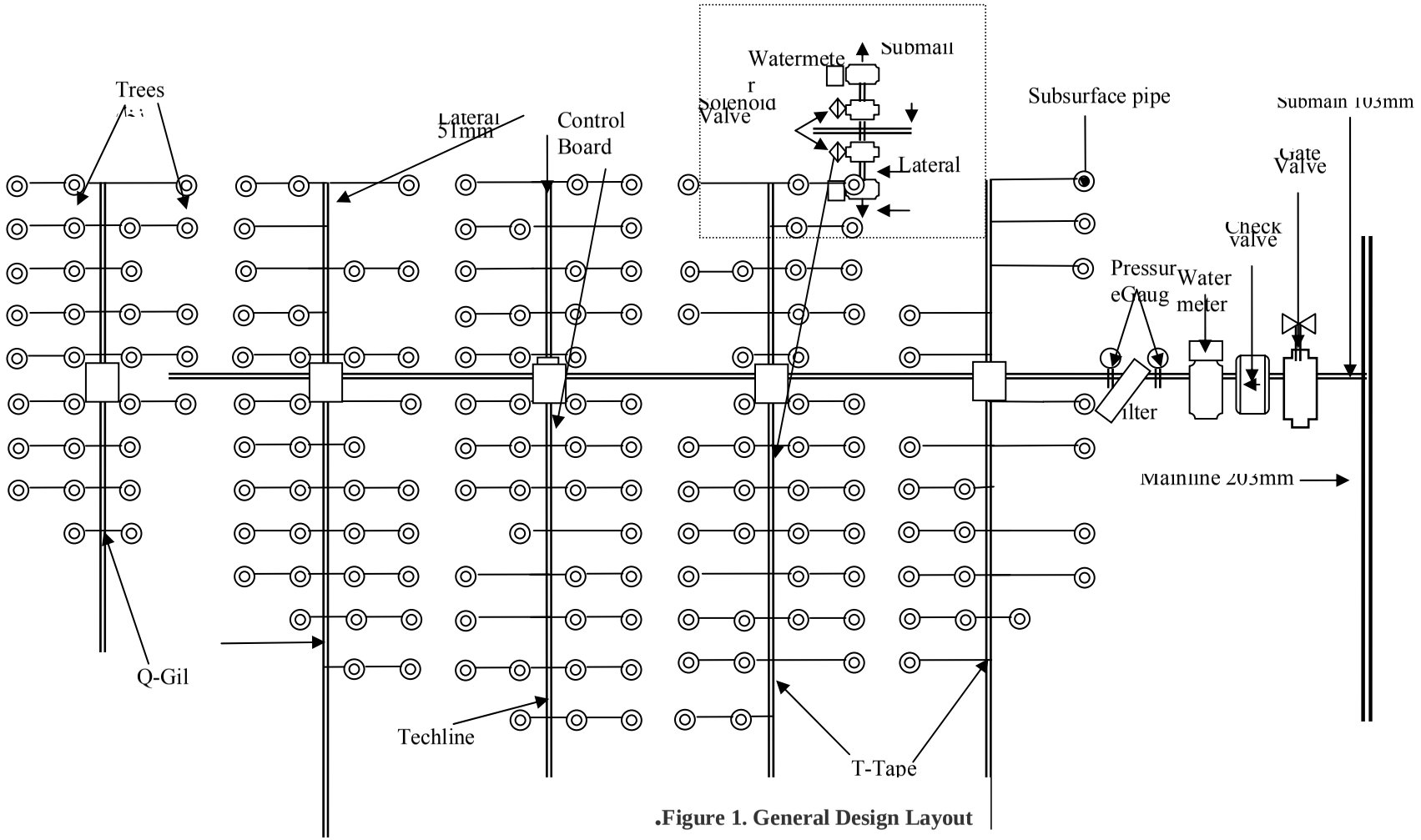
Physical Characteristics	
Sand (%)	65
Loam (%)	15
Caly	20
Texture	Sandy clay loam
Field Capacity	11.2
Wilting Point	5.7
Available Moisture	5.5
Apparent Density	1.62
Chemical Characteristics	
Soil pH	7.8
Electrical conductivity EC, dS/m	2.57
Positive ions (Cations), meq/L	
Ca	21.3
Mg	9.3
Na	8.4
Negative ions (Anions), meq/L	
CO_3	0.22
HCO_3	2.3
Cl	11
Organic Matter	0.084
Available elements	
P	6.56
K	152

Table 2. Physical and Hydraulic Characteristics of Pipes.

Factor	**Pipe Type**		
Type	T-Tape	Techline	Queen-Gill
Code	TSX715	TL16912	Q-G16
Diameter, mm	22	16	15.9
Discharge, l/hr/m	3.40	3.50	3.5
Emitter distance, m	0.60	0.30	0.20
Pressure Range, kPa	28-104	70-386	50-450
Wall Thickness, mil	15	45	16

Table 3. Water Analysis.

Water Characteristic	**Value**
Water pH	7.36
Total Dissolve Salts TDS	950
Alkalinity	140
Conductivity	1893
Chlorides	319
Hardness	136
Ca	44
Mg	6.27
Fe	0.026
S	354
NO_3	34



.Figure 1. General Design Layout

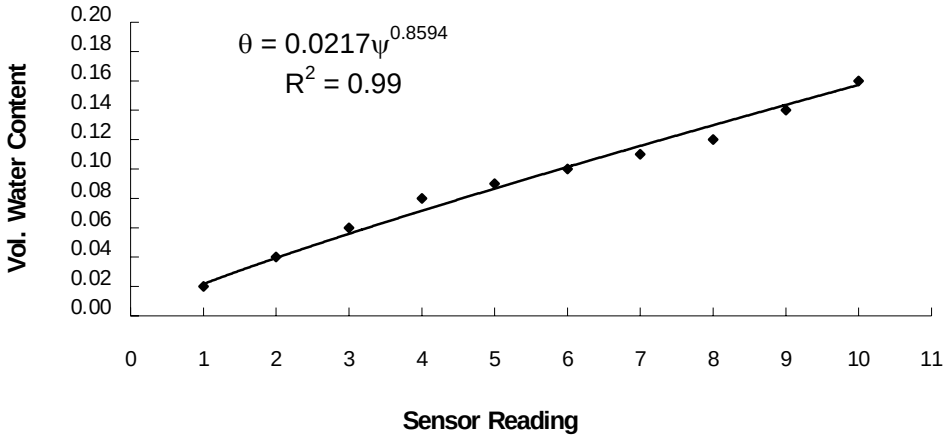


Figure 2. Chart of Sensor Calibration

RESULTS AND DISCUSSIONS

A preliminary laboratory trials were made on seven subsurface drip irrigation pipes available locally in the Kingdom, to study their hydraulic characteristics, the aim was to select the most proper pipes to be used for the date palm irrigation experiment. Based on the experiment, three pipes were selected that gave the best performance, especially the uniformity of water distribution.

The results of water consumption and yield (Table 5) show that, the T-Tape system is the best compared to others, followed by the pressure compensating type (Techline), where the average yield recorded was 180 kg/tree, 176 kg/tree and 135 kg/tree respectively, with an average reduction of the second and third compared to the first 2.2% and 25%. Although the average yield of trees irrigated by 'T-Tape' and 'Techline' are close, it was noticed that the water consumption is different, as the results have shown that the water used by the 'Techline' is higher compared to the 'T-Tape' by 27%. As for the 'T-Tape' and the 'Queen-Gill' , it seems that the water consumption is very close.

The analysis and computations of water use efficiency, indicates that, the 'T-Tape' is the highest in efficiency that amount to 1.94 kg/m^3, as for the other two their efficiency are: Techline = 1.49 kg/m^3, Queen-Gill = 1.41 kg/m^3, therefore, there is a reduction in efficiency for the 'Techline' by 23% compared to the 'T-Tape', and by 27% for the third type: 'Queen-Gill'.

The differences in water consumption using the three types of subsurface pipes could be due to few factors, including; difference in soil texture and structure, organic matter, partial or complete clogging of some emitters, also the difference of water use could be due to the pressure differences in the network and the errors in installing pipes that may reduce diameter size. Theoretically, the difference in water consumption, may reflect the differences in yield, but the difference in yield have its factors, such as; plant disease, insects, soil salinity and others.

Comparing the results of yield and water consumption for date palms (Helwa Type), for the year 2002 with previous years, it is obvious that there is an increase in yield with decrease in water consumptions. As indicated by Table 6, the average yield have increased from 75.5 kg/tree in the year 2000 to 120.25 kg/tree for the year 2001 to reach 163.1 kg/tree in the year 2002. It was noted that, the trees were irrigated by the traditional drip system the beginning of the year 2001 till April when the subsurface system was operated.

Although the experiment was conducted for two seasons, and the results shown are very promising, the results shown are considered preliminary, and a further investigation is needed to done for more seasons and more trees.

Table 4. Climatic Data.

Month	Temperature, ^{0}C	Rel. Humidity, %	Av. Rainfall, mm	W. speed, km/hr

January	12	41	50	14
February	15	70	80	12
March	19	60	90	12
April	24	55	60	14
May	30	51	20	14
June	32	33	0	14
July	33	20	0	14
August	33	17	0	14
September	31	17	0	9
October	26	19	10	9
November	19	31	50	12
December	15	52	70	12

Table 5. Yield and Water Consumption of Helwa Date Palms for 2002.

Plot	Drip Pipe Type	Water Consumed, m^3/tree/year	Number of Trees	Av. Yield, kg/tree	Water use eff. Kg/m^3
A	T-Tape	93	10	180	1.94
B	Techline	118	23	176	1.49
C	Queen-Gill	95.6	17	135	1.41

Table 6. Comparison of Yield, water consumption and water use efficiency.

Season	2000	2001	2002
Total Yield, kg	7873	12537	17003
Average Yield, kg	75.5	120.25	163.1
Average Water Consumption, m^3/tree/year	86.4	86.0	102.5
Water Use Efficiency Kg/m^3	0.87	1.43	1.59

SUMMERY AND CONCLUSION

An experiment was conducted on 50 date palm trees of 'Helwa' type in Watania Agricultural Project in Gassim, Saudi Arabia. The aim was to study the effect of using three types of subsurface drip irrigation lines on yield and water consumption, the types were; T-Tape, Techline and Queen-Gill brands. Results have indicated that the yield and water consumption of the T-Tape were the best compared to the other two, followed by the pressure compensating type named 'Techline'. Results have shown also that, the water use of the second type (Techline) was the highest with a percent increase of 27% compared to the first type. The analysis of water use efficiency have shown that the first type (T-Tape) was the best followed by the second (Techline) then the third (Queen-Gill). Comparing the results of yield and water consumption for date palms, for the year 2002 with previous years, it is clear that there is an increase in yield accompanied by decrease in water consumptions, the average yield have increased from 75.5 kg/tree in the year 2000 to 120.25 kg/tree for the year 2001 to reach 163.1 kg/tree in the year 2002.

Based on the results of this experiment, although for only two seasons, it is possible to conclude that subsurface drip irrigation for date palms is an effective and practical method for irrigating date palms where, a noticeable amount of water could be saved due to the elimination of evaporation water compared to other irrigation systems including the traditional surface drip system. I was noted that the subsurface system could eliminate the weed growth around the tree and prevent salt accumulation on the soil surface.

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