Kufa Journal of Engineering
Vol. 7, No. 2, June 2016, P.P. 104-121
Received 2 march 2016, accepted 11 April 2016

EVALUATION THE OPERATION OF A DRIP IRRIGATION SYSTEM IN DIFFERENT TYPES OF SOIL

Dr. Hassan Ali Omran[1], Dr. Ibtisam Raheem Kareem[2] and Riyam Sahib Hassan[3]

[1] **Building & Construction Eng. Dep., University of Technology, Iraq, Email:** hassn7745@gmail.com

[2] **Building & Construction Eng. Dep., University of Technology, Iraq**

[3] **Building & Construction Eng. Dep., University of Technology, Iraq**

ABSTRACT

Drip Irrigation Method is the best method that has been used in the world among the other irrigation methods because of its good and high uniformity. This method distributes water to the field using a pipe network and transforms it to the plant by emitters. In spite of the advantages of drip irrigation method, the system has many problems, such as the impact of soil type, silt and discharges distribution. To achieve the goals of using a drip irrigation system, it must be designed and operated properly so that rates and location of delivery of water to the root zone is suitable for crop requirements. Generally, the criterion for drip irrigation system operation is based on soil texture. Soil wetting is one of the most important parameters to determine the deep percolation rate and the efficiency of the system. Knowledge of soil wetting pattern and its movement plays a large role in deciding depth and spacing of pipes, design of irrigation scheduling and improving the efficiency of the drip irrigation system.

The objective of this study is to develop an approach to operate the drip irrigation system in sandy and clay soils by a computerized method regarding the type of crops, its consumptive use, type of soil, frequency of irrigation and water distribution in the network .The study adopts two approaches as follows: The field work approach and the theoretical approach. In the field work approach, soil analysis of the physical and chemical properties of the soil which affect the soil quality as well as its suitability for growing plants are determined. For the theoretical approach the well known software CROPWAT is used for the calculation of crop water requirements and irrigation requirements depending on soil, climate and crop data. Measurements of the consumptive use, discharge, velocities, wetted soil width, wetted soil depth, frequency of irrigation for the two types of soil with silt content calculated. The designed discharge was found to be higher in clay soil than sand soil because it saves the water for a long time through a small area as it is little porous. Increasing silt rate for each type of soil, cause to increases the amount of irrigation water requirement. As the wetted soil width depends on emitter discharge and soil type, it will be increase with soils in high silty clay compared with the low silt and bigger as compared to sandy soils.

KEYWORDS:

drip irrigation, soil type, CROPWAT, discharge, wetted depth, wetted width, frequency of irrigation.

تقييم تشغيل منظومات الري بالتنقيط في ترب مختلفه

حسن علي عمران وابتسام رحيم كريم وريام صاحب حسن

قسم البناء والانشاءات، الجامعة التكنولوجية

الخلاصة

تعتبر طريقة الري بالتنقيط من أفضل الطرق التي تم استخدامها في العالم من بين أساليب الري الأخرى نظرا لجودتها وانتظامية توزيع المياه . اذ يتم توزع المياه إلى الحقل باستخدام شبكة أنابيب ترتبط بها منقطات تتولى ايصال مياه الري الى جذور النباتات.

على الرغم من مزايا طريقة الري بالتنقيط ،الا ان النظام له العديد من المشاكل، مثل تأثير نوع التربة و الطمي وتوزيع التصريف . ولتحقيق أهداف عالية باستخدام نظام الري بالتنقيط ، يجب أن يتم تصميمها و تشغيلها بشكل صحيح بحيث تكون معدلات وموقع توصيل المياه إلى منطقة الجذر مناسبة لمتطلبات المحاصيل. ويستند المعيار لتشغيل نظام الري بالتنقيط على قوام التربة .اذ أن معرفة نمط ترطيب التربة و حركتها يلعب دورا كبيرا في تحديد العمق والتباعد بين الأنابيب ، وتصميم جدولة الري وتحسين كفاءة نظام الري بالتنقيط.

أن الهدف من هذه الدراسة هو وضع منهج لتشغيل نظام الري بالتنقيط في التربة الرملية والطينية بطريقة كفوءة حسب نوع المحاصيل ، والاستهلاك المائي ، ونوع التربة ، والفترة بين الريات و توزيع المياه في الشبكة.اذ اعتمدت الدراسة على منهجين هما , العمل الميداني والجانب النظري . ففي العمل الميداني ، تم تحليل الخصائص الفيزيائية والكيميائية للتربة والتي تؤثر على مدى ملاءمتها لنمو النباتات . أما في الجانب النظري فقئد تم استخدام برنامج CROPWAT وهو من البرامج المعروفة لحساب الاحتياجات المائية للمحاصيل ومتطلبات الري طبقا لنوع التربة والمناخ و المحاصيل. ، اضافة الى عرض التربة ، عمق التربة المبللة ، الفترة بين الريات لنوعي التربة .

تم تحديد التصاريف التصيمية والتي وجد بانها تكون أعلى في التربة الطينية من التربة الرملية لقابليتها على حفظ الماء لفترة طويلة كما ان زيادة معدل الغرين لكل نوع من أنواع التربة، يزيد من كمية مياه الري .أما عرض وعمق التربة المبللة فيعتمد على تصريف المنقط و نوع التربة ، حيث انه يكون اكثر في التربة الطينية ذات نسبة الغرين العالية مقارنة مع التربة الرملية.

1. INTRODUCTION:

Drip, or trickle irrigation, is a type of irrigation that slowly applies small amounts of water to part of the plant root zone. Water is applied frequently, often daily, to maintain a favorable soil moisture condition and prevents moisture stress in the plant. When compared with the other irrigation systems, drip irrigation accomplishes this process more efficiently. Furthermore, it requires less water and less labor than other forms of irrigation (Broner, 1998). The system has been used since ancient times. Modern drip irrigation has arguably become the world's most valued innovation in agriculture. Careful study of all the relevant factors like land topography, soil type, crop and agro-climatic conditions are needed to determine the most suitable drip irrigation The energy losses due to emitter's connection in trickle irrigation laterals is very important and have a direct effect on the system (Al-Misned and Ahmed, 2000). This system is suitable for most soils if it is used in the right way. On clay soils water must be applied slowly to avoid surface water pounding and runoff. On sandy soils higher emitter discharge rates will be needed to ensure adequate lateral wetting of the soil. The sensitivity of the flow rate emitters must be examined to ensure the balance operating under large pressure (Hezarjaribi et al, 2009).

There is an exponential relationship between emission rate and operating pressure which is the most important affecting factor (Haijum et al, 2009). The wetting patterns which develop from dripping water onto the soil depend on discharge and soil type. Soil analysis can provide important information about physical conditions and chemical properties that affect a soils quality as well as suitability for growing plants .The soil over pressure would act as a regulation and emitters having large flow rates when placed on the ground surface (Gill et al, 2008). Drip irrigation may also use devices called micro-spray heads, which spray water in a small area, instead of dripping emitters. These are generally used on tree and vine crops with wider root zones. It is becoming popular for row crop irrigation, especially in areas where water supplies are limited or recycled water is used for irrigation.

2. THE AIMS OF THE STUDY

The present study aims to:

1. Use a computer software for operating a drip irrigation system regarding the type of crops, its consumptive use, type of soil and field dimensions.
2. Evaluate the effect of soil type on the performance of a drip irrigation system by monitoring the progress of the wetting front through the soil profile of the two soil types.

3. STUDY AREA

The study area is located in Al-Kut Palms station of Kut Province, (185) Km south of Baghdad. It located between longitude 43°42′ and latitude 31°15′.On the road Kut - Baghdad from the north side as shown in Fig. 1. Its area is about 323760 m^2.

4. EFFECTIVENESS OF SOIL TYPES ON SELECTION OF DRIP IRRIGATION SYSTEM

For drip irrigation systems to deliver improved water, distance between emitters and emitter flow rates must be matched to the soil's wetting characteristics and the amount and timing of water to be supplied to the crop. Broad soil texture ranges (e.g. sand, loam, clay) are usually the only information related to soil wetting used in drip system designs, Peter J.Thorburn, 2003. Wetting pattern for different types of soil can be summarized as:

1. **Clay soil:** It has densely packed particles that have little space for water or air. Water is absorbed very slowly and runoff can occur if water is applied to quickly. At situation,

water tends to move outward away from the drip emitter, clay soil will hold water very well and can stay wet for several days. (http:// plasticulture .cas .psu.edu).

2. **Sandy soil:** It is very loose and has plenty of space for water or air. Water is absorbed very quickly and runoff usually doesn't occur. When wet, water tends to move straight down through the soil. Sandy soil does not hold water very well and can dry out very quickly, (http://plasticulture.cas.psu.ed).
3. **Loam soil:** Drip irrigation system has an ideal state in-between mix of clay and sandy soil. Its absorption rate is greater than that of clay soil but not as fast as sandy soil. At situation of wet water will move outward and down more evenly. Loam soil will hold water well and dry out at a medium rate, (http:// plasticulture. cas.psu.edu).

Fig. 1. Area of study

5. FIELD INVESTIGATIONS

Soil analysis can provide important information regarding the physical and chemical properties affecting a soils quality and suitability for growing plants. Soil samples were collected from ten points at the depths of 0 to 30 cm using auger and core sampler. The augured samples were air dried and ground to pass through a 2 mm-sieve for analysis of the physical and chemical parameters.

Soil of the study area was tested in the engineering Andrea laboratory of Kut Province.

1. Physical soil testing: Physical soil testing is the process of analyzing the gravel, sands, and amendments, used in green construction to determine many factors such as soil texture, moisture content, bulk density, particle density, porosity and hydraulic conductivity. Results of physical characteristics are illustrated in Table 1.
2. Chemical Soil Testing: Chemical analysis is the most common method used to assess the nutrient content (and nutrient needs) of soil. An accurate determination of nutrient need is possible if two conditions are satisfied: first that the soil sample is truly

representative of the field to be analyzed; and, second, that the chemical testing method has been calibrated through enough research to the crops and soils in the area (Manachini et al., 2009). Chemical analyses were performed for 10 samples taken from the study area and the results of the parameter were stated in Table 2.

Table 1. Physical characteristics of the soil samples

Sample	Soil Classification (%)			Type	Moisture content (%)	Bulk density gm/cm^3	Particle density (gm/cm^3)	Porosity (%)	Saturated hydraulic conductivity Ks (cm/min)
	Clay	Loam	Sand						
A1	43	43	13	Silty Clay	7.11	1.60	2.58	36.82	0.0005
A2	44	39	18	Clay	3.17	1.68	2.56	39.37	0.002
A3	46	16	48	Sandy Clay	2.58	1.48	2.55	40.39	0.0002
A4	50	35	24	Clay	5.14	1.64	2.53	35.59	0.002
A5	44	41	25	Clay	3.21	1.54	2.60	40.76	0.0015
A6	52	39	23	Clay	2.26	1.66	2.54	33.07	0.003
A7	45	33	25	Clay	3.31	1.61	2.70	37.77	0.002
A8	50	22	42	Sandy Clay	6.68	1.58	2.57	35.40	0.001
A9	51	39	28	Clay	3.16	1.56	2.64	40.90	0.001
A10	49	18	36	Clay	10.29	1.67	2.54	33.46	0.001

Table 2. Chemical characteristics of the soil samples

Sample	EC Ds/m	C.E.C. mol/kg	Na mmol/l	HCO_3 mmol/l	Ca mmol/l	Mg mmol/l	Cl mmol/l	PH	SAR
A1	5.41	4.28	9.5	2.2	58.4	30.8	27.6	7.42	2.01
A2	4.88	4.28	12	1.4	49.6	24	24.8	7.48	2.80
A2	4.76	2.67	10.6	2	48.8	25.2	22.6	7.40	2.46
A4	5.81	3.74	10.5	2	58.4	36.8	29.9	7.36	2.27
A5	4.78	4.81	9.8	2.4	50.8	25.2	23.1	7.51	2.25
A6	4.60	4.28	11	1.8	49.6	18.4	21.7	7.38	2.91
A7	5.10	5.35	15	2.2	50.4	21.6	23.4	7.47	3.53
A8	4.79	4.81	11.9	1.2	50.4	21.6	23.1	7.75	2.80
A9	5.11	5.35	13.1	2.2	52.4	23.6	23.4	7.18	3.08
A10	4.72	4.28	9.2	2	54	22	19.5	7.26	2.11

6. CONSUMPTIVE USE DETERMINATION

Two types of soil were tested, clay and sand each with different level of silty, the most common parameter which importance to estimate is the percentage permanent wilting point (P.W.P.)which can be found as, (Basak,1999):

$$P.W.P = F.C / f \quad (1)$$

Where: F.C = field capacity.

f = factor varying from 2 to 2.4 depending upon the amount of silt content

While the available moisture content (A.M.C), is equal to:

$$A.M.C = F.C - P.W.P \quad (2)$$

The depth of water stored in root zone (Dw) (cm), then written as:

$$Dw = (Ɣ * d / w)\ (F.C - \text{Optimum moisture}) \quad (3)$$

Where: Ɣ = bulk density (M/L^3).

d = root zone depth (L).

w = Specific weight of water.

Optimum moisture = F.C – R.A.M.C

In which R.A.M.C is the readily available moisture content and it is always assumed to 75% of A.M.C., (Basak, 1999). Field capacity of the study area is found by the soil tests as 7.5% for sand soil and 36% for clay soil. While the bulk densities of the two types of soils (sand and clay) considered in the present study are found as 1.55 gm/cm^3 and 1.45 gm/cm^3, respectively.

Root zone depth varies depending on the type of plant, for the study area 12 croups of plants are proposed with root zone depths range between (50–200) cm as shown in Table 3 (http://www.fao.org/).

The depth of water stored in root zone (Dw) was found to be higher in clay soil than sand soil because it is saving the water for long time by little area as it is little porous. Increasing silt rate for each type of soil, increases the amount of irrigation water to disposal of silt and paid it out of the plant root zone. Fig. 2 shows the relationship between stored water (Dw) and the root zone depth of the proposed croups of crops for both sand and clay soils.

Table 3. Values of root zone depth and crop factor for deferent crops, (http://www.fao.org/)

Item	Crop Name	Root Zone (d)(cm)	Crop factor (k)
1	Cabbage	50	1.05
2	Rice, Potato, Small vegetables	60	1.1
3	Green Beans	70	1.05
4	Groundnut Rabi , Pasture Sweet peppers, Tobacco	80	1.06
5	Artichoke, Dry Beans, Banana	90	1.12
6	Maize, Pulses, Soybean Sugar beet, Sweet Melon, Tomato	100	1.07
7	Barley	110	1.15
8	Alfalfa, Small Grain Millet, Spring Wheat	120	1.04
9	San Flower	130	1.15
10	Citrus, Cotton, Sorghum (Grain)	140	0.92
11	Table Grapes, Wine Grapes, Winter Wheat, Sugarcane (Raton)	150	1.09
12	Mango, Date Plans	200	1.2

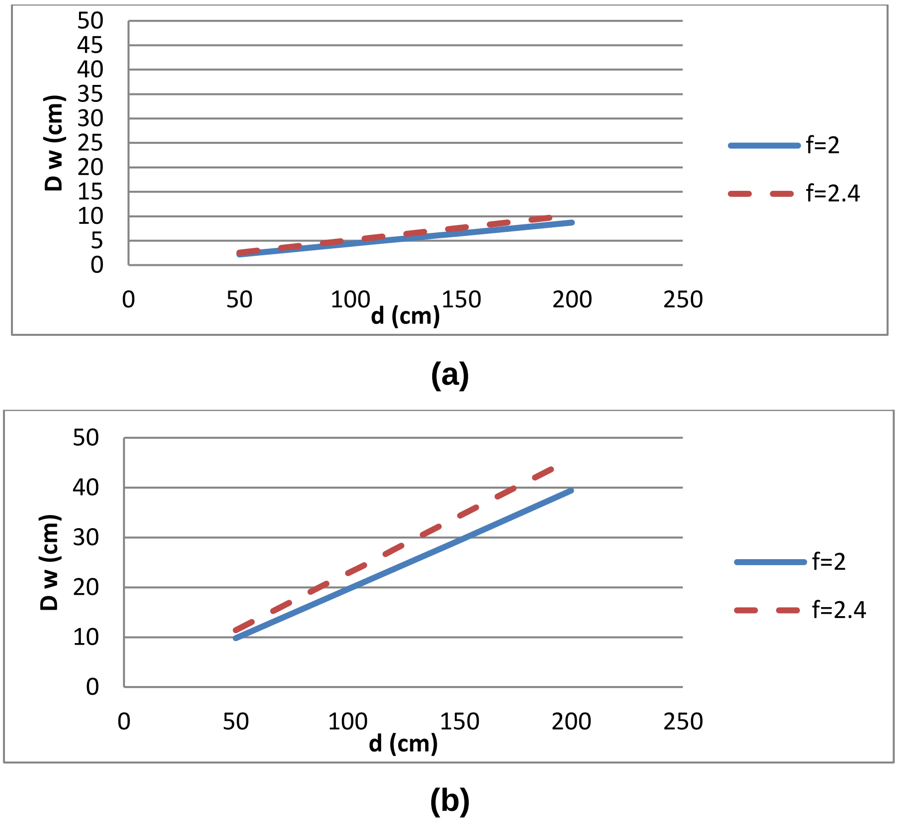


Fig. 2. Relationship between water stored in root zone (D_w) and root zone depth (d); a: sandy soil, b: clay soil

Consumptive irrigation use can be determined using one of several known empirical equations. In the present study Blaney _Griddle formula was used as: Blaney and Criddle (1962).

$$Cu = 0.45\ K * P\ (t + 17.8) \qquad (4)$$

Where: Cu = monthly consumptive use (cm).

K = crop factor of plant, (Table 3).

P = monthly percent of annual daylight hours.

t = highest temperature during the month (°C).

Results of the factor (0.45[p (t + 17.8)]) in equation (4) are obtained according to the annual maximum temperature and sunny hours of Kut Province (Al_Kut Environment Directorate, 2010) as shown in Table 4.

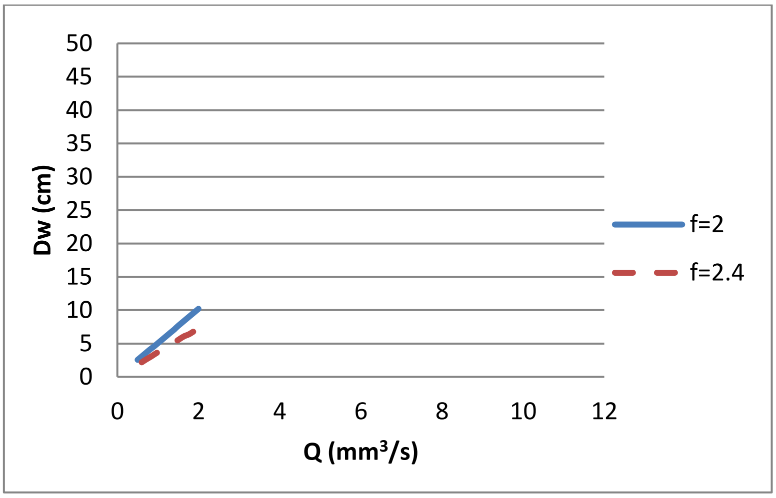
7. DRIP IRRIGATION SYSTEM PARAMETERS USING CROPWAT

7.1. System Discharge (Q)

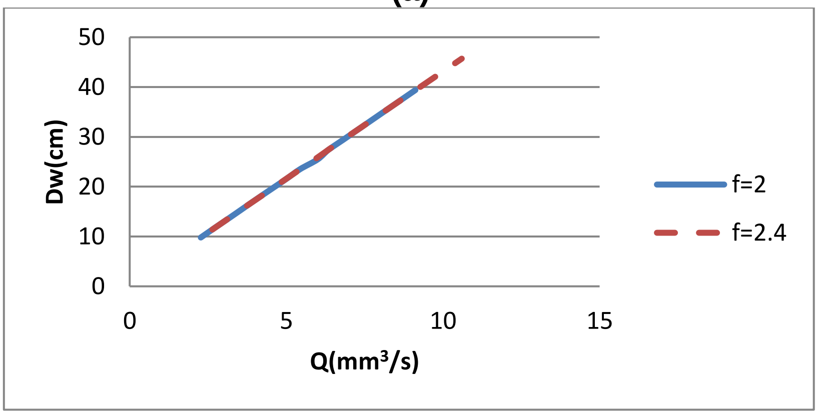
The daily dripper discharge expressed as the volume of water wetting specified area of soil, is for clay soil higher than sand soil because of the ability to save water for a long time as shown in Fig. 3, a and b. The values were found to be in the range of (2.27– 9.12) mm^3/s for clay soil with low silt (f=2) and (2.64–10.6) mm^3/s with high silt (f=2.4), while for the sand soil values of Q ranged between (0.5–2) mm^3/s with low salinity (f=2) and (0.6–2.36) mm^3/s with high salinity (f=2.4). Tables 7 and 8 show the values of dripper discharge for the clay and sandy soils, respectively.

Table 4. Results of the factor (0.45[p (t + 17.8)]) of Kut Province

Month	Max Temp.(°c)	Percent of Sun Shine hours	0.45(P (t + 17.8))
Jan.	16	6	0.9126
Feb.	19	7.4	1.2254
Mar.	24	8	1.5048
Apr.	31	8.7	1.9105
May	38	9.5	2.3854
Jun.	42	12	3.2292
Jul.	44	12	3.3372
Aug.	44	11.2	3.1147
Sep.	40	10.2	2.6530
Oct.	33	8.5	1.9431
Nov.	28	7.1	1.4633
Dec.	18	6	0.9666
	Total		24.6459



(a)



(b)

Fig. 3. Relationship between dripper discharges (Q) and depth of water stored in root zone (Dw); a: sandy soil, b: clay soil

The present drip irrigation system is located in an area of 323760m2. This area is divided into (8) strips each with (40470) m2 (100 * 250) m contains a drip irrigation system consisting of a pump, filter, main pipe of 2.5 inch diameter, lateral pipe of 1 inch diameter and dripper pipe of 16 mm diameter, Fig. 4, (Al_Kut Palms station, 2004). The system is recharged from the Tigris river to a basin with (10 *10 *2.5) m.

Distribution of discharge values in the system can be taken as following:

$$QL = Qd * Nd \tag{5}$$

$$Qm = QL * NL \tag{6}$$

$$Qh = Qm * Nm \tag{7}$$

Where: Q_d= the dripper discharge, (V/T).

Q_L= the lateral pipe discharge, (V/T).

Q_m= the main pipe discharge, (V/T).

Q_h= the head discharge, (V/T).

N_d= number of drippers, (100 drippers).

N_L= number of lateral pipe, (20 pipes).

N_m=number of main pipe, (8 pipes).

From the equation of continuity, the flow velocity of the pipe is:

$$V = \frac{4\, Q_{L,m,h}}{\pi\, d^2} \tag{8}$$

Where: V =the flow velocity of the pipe, (L/T).

d = the diameter of the pipe, (L).

Tables 5 and 6 show the values of flow velocity with discharge of the drip irrigation system for clay and sandy soils, respectively.

Table 5. Estimated flow velocity with discharge of the drip irrigation system in clay soil

Crop No.	Q_L (mm³/s)		V_L(mm/s)		Q_m (mm³/s)		V_m (mm/s)		Q_h (mm³/s)		V_h (mm/s)	
	f=2	f=2.4	f=2	f=2.4	f=2	f=2.4	f=2	f=2.4	f=2	f=2.4	f=2	f=2.4
1	227	264	113.5	132	4540	5280	9.1	10.56	36320	42240	2.54	2.96
2	272	317	136	158.5	5440	6340	11	12.68	43520	50720	3.05	3.55
3	318	370	159	185	6360	7400	12.7	14.8	50880	59200	3.56	4.14
4	363	424	181.5	212	7260	8480	14.5	16.96	58080	67840	4.1	4.75
5	408	477	204	238.5	8160	9540	16.3	19.1	65280	76320	4.6	5.34
6	454	528	227	264	9080	10560	18.2	21.12	72640	84480	5.1	5.91
7	500	580	250	290	10000	11600	20	23.2	80000	92800	5.6	6.5
8	544	634	272	317	10880	12680	22	25.36	87040	101440	6.1	7.1
9	600	687	300	343.5	12000	13740	24	27.48	96000	109920	6.72	7.7
10	635	741	317.5	370.5	12700	14820	25.4	29.64	101600	118560	7.1	8.3
11	681	794	340.5	397	13620	15880	27.2	127040	108960	127080	7.63	9
12	912	1060	456	530	18240	21200	36.5	169600	145920	169600	10.21	12

Table 6. Estimated flow velocity with discharge of the drip irrigation system in sandy soil

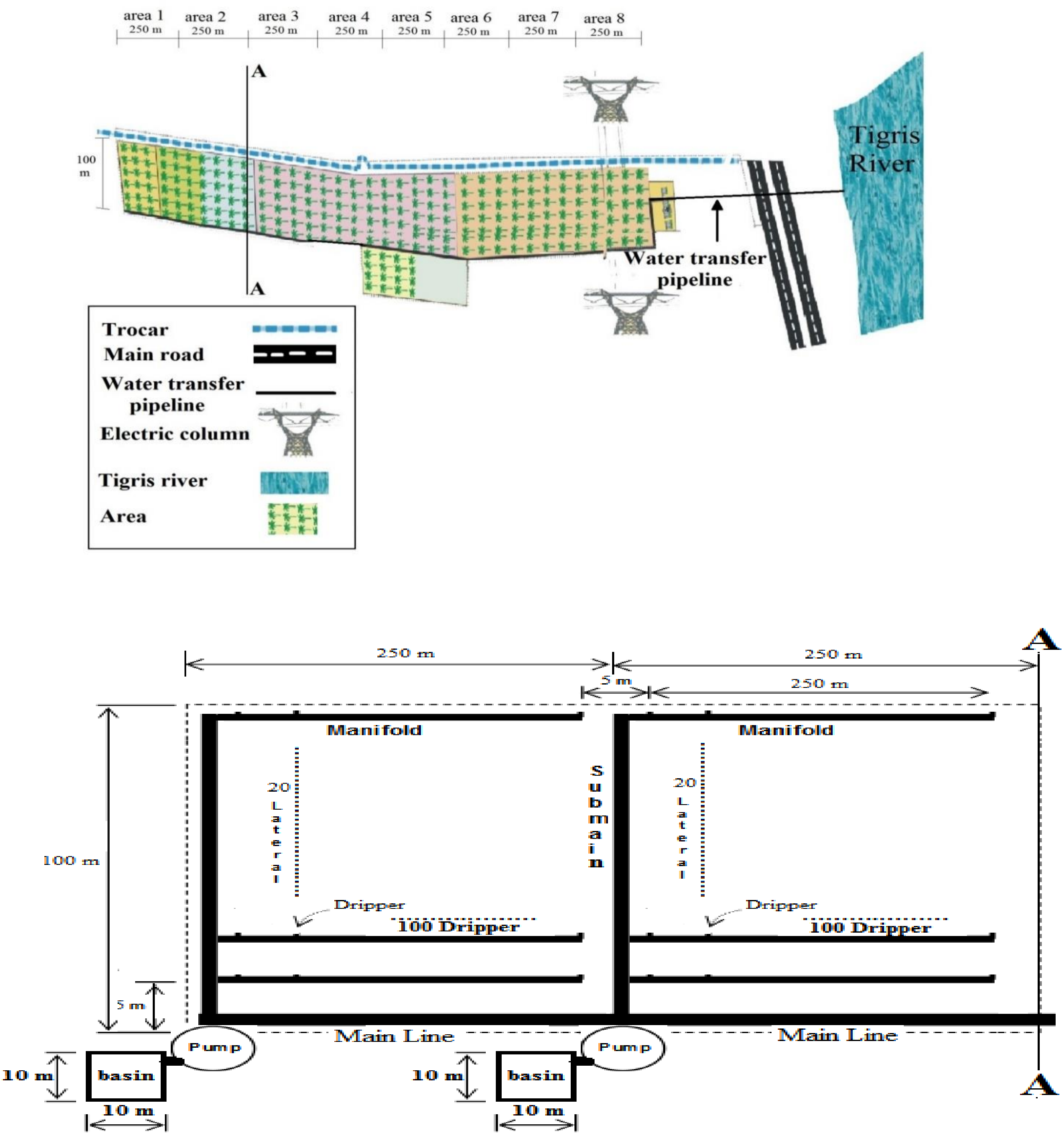
Crop No.	Q_L(mm^3/s)		V_L(mm/s)		Q_m (mm^3/s)		V_m (mm/s)		Q_h (mm^3/s)		V_h (mm/s)	
	f=2	f=2.4	f=2	f=2.4	f=2	f=2.4	f=2	f=2.4	f=2	f=2.4	f=2	f=2.4
1	50	60	25	30	1000	1200	2	2.4	8000	9600	0.56	0.7
2	60	71	30	35.5	1200	1420	2.4	2.84	9600	11360	0.67	0.8
3	70	83	35	41.5	1400	1660	2.8	3.32	11200	13280	0.8	0.93
4	80	49	40	47	1600	1880	3.2	3.76	12800	15040	1	1.1
5	91	106	45.5	53	1820	2120	3.64	4.24	14560	16960	1.02	1.2
6	101	118	50.5	59	2020	2360	4.04	4.72	16160	18880	1.13	1.32
7	111	130	55.5	65	2220	2600	4.44	5.2	17760	20800	1.243	1.46
8	121	142	60.5	71	2420	2840	4.84	5.68	19360	22720	1.355	1.6
9	131	153	65.5	76.5	2620	3060	5.24	6.12	20960	24480	1.47	1.71
10	141	165	70.5	82.5	2820	3300	5.64	6.6	22560	26400	1.6	1.85
11	150	180	75	90	3000	3600	6	7.2	24000	28800	1.7	2
12	200	236	100	118	4000	4720	8	9.44	32000	37760	2.24	2.64

Table 7. Results of discharge, wetted soil width, wetted soil depth, frequency of irrigation for clay soil and consumptive use

Crop No.	Dw (cm)		Q_d (mm^3/s)		W (m)		D (m)		Fw (day)		Cu (cm/month)
	f=2	f=2.4	f=2	f=2.4	f=2	f=2.4	f=2	f=2.4	f=2	f=2.4	
1	9.8	11.4	2.27	2.64	0.056	0.06	0.088	0.095	1.14	1.32	25.878
2	11.76	13.7	2.72	3.17	0.062	0.067	0.1	0.107	1.3	1.52	27.111
3	13.72	16	3.18	3.7	0.068	0.073	0.11	0.12	1.6	1.85	25.878
4	15.68	18.3	3.63	4.24	0.073	0.08	0.121	0.131	1.8	2.1	26.125
5	17.64	20.6	4.08	4.77	0.078	0.084	0.131	0.142	1.92	2.24	27.604
6	19.6	22.8	4.54	5.28	0.083	0.09	0.141	0.152	2.23	2.6	26.371
7	21.56	25	5	5.8	0.087	0.094	0.15	0.162	2.28	2.65	28.343
8	23.52	27.4	5.44	6.34	0.092	0.1	0.16	0.172	2.75	3.21	25.632
9	25.48	29.7	6	6.87	0.097	0.103	0.17	0.181	2.7	3.14	28.343
10	27.44	32	6.35	7.41	0.1	0.108	0.177	0.191	3.63	4.23	22.674
11	29.4	34.3	6.81	7.94	0.104	0.11	0.185	0.2	3.3	3.83	26.864
12	39.4	45.7	9.12	10.6	0.123	0.132	0.226	0.24	4	4.64	29.575

Table 8. Results of discharge, wetted soil width, wetted soil depth and frequency of irrigation for sandy soil

Crop No.	Dw (cm)		Q_d (mm^3/s)		W (m)		D (m)		Fw (day)	
	f=2	f=2.4	f=2	f=2.4	f=2	f=2.4	f=2	f=2.4	f=2	f=2.4
1	2.55	2.175	0.5	0.6	0.026	0.03	0.041	0.045	2.9	2.5
2	3.06	2.61	0.6	0.71	0.03	0.032	0.047	0.051	3.4	3
3	3.57	3.04	0.7	0.83	0.032	0.035	0.052	0.057	4	3.5
4	4.08	3.48	0.8	0.94	0.034	0.037	0.057	0.062	4.8	4
5	4.59	3.92	0.91	1.06	0.037	0.04	0.062	0.067	5	4.3
6	5.1	4.35	1.01	1.18	0.039	0.042	0.066	0.072	5.8	5
7	5.61	4.8	1.11	1.3	0.041	0.045	0.071	0.077	6	5.1
8	6.12	5.22	1.21	1.42	0.043	0.047	0.075	0.081	7.2	6.1
9	6.63	5.65	1.31	1.53	0.045	0.049	0.079	0.086	7	6
10	7.14	6.1	1.41	1.65	0.047	0.051	0.083	0.09	9.4	8
11	7.65	6.5	1.5	1.8	0.05	0.054	0.087	0.095	8.5	7.3
12	10.2	8.7	2	2.36	0.057	0.062	0.106	0.115	10	8.8



Section (A-A)

Fig. 4. Outline of the drip irrigation system in Kut Province (Al_Kut Palms station, 2004)

7.2. Wetted width (W)

The wetted soil width at the root zone of plants can be determined as: (Phull and Babar, 2012):

$$W = 3.245 \left[q_w^{0.5} * d^{0.065} * t^{0.435} / k_s^{0.065} \right] \quad (9)$$

Where: W= wetted soil width, (m).

q_w =water application rate or discharge rate per unit length of pipe, (m2/s).

ks = saturated hydraulic conductivity of the soil, (m/s).

d = Depth of root zone, (m).

t = time of crop irrigation, (s).

Fig. 5 shows wetted soil width of clay and sandy soils in the study area.

7.3. Wetted depth (D)

The wetted soil depth needs to be applied to an irrigated system when soil water is reduced to the specified depletion level. The wetted soil depth at the root zone of plants can be determined as: (Phull and Babar, 2012):

$$D = 3.572[qw^{0.5} * d^{0.177} * t^{0.323} / ks^{0.177}] \quad (10)$$

Where: D = wetted soil depth below porous pipe, (m).

The wetted soil depth (D) values were found to be at range between (0.088–0.226) m for the clay soil with low silty (f=2) and (0.095– 0.24) m with high silty (f=2.4), while in the sand soil it is found to range between (0.041- 0.106) m with (f=2) and (0.045– 0.115) m with (f=2.4), as shown in Fig. 6.

The relationship between wetted soil depth (D) and wetted soil width (W) was drown for both clay and sand soil with (f=2) and (f=2.4) in Fig. 7.

7.4. Frequency of Irrigation (Fw)

It refers to the number of days between two irrigated periods without rainfall. It depends on consumptive use and on the amount of available moisture in the crop root zone. It is function of crop, soil and climate. A moisture use ratio varies with the kind of crop and climate conditions and increases as crop grows larger. Frequency of irrigation (Fw) can be found as: (Basak, 1999):

$$Fw = Dw / Cu \quad (11)$$

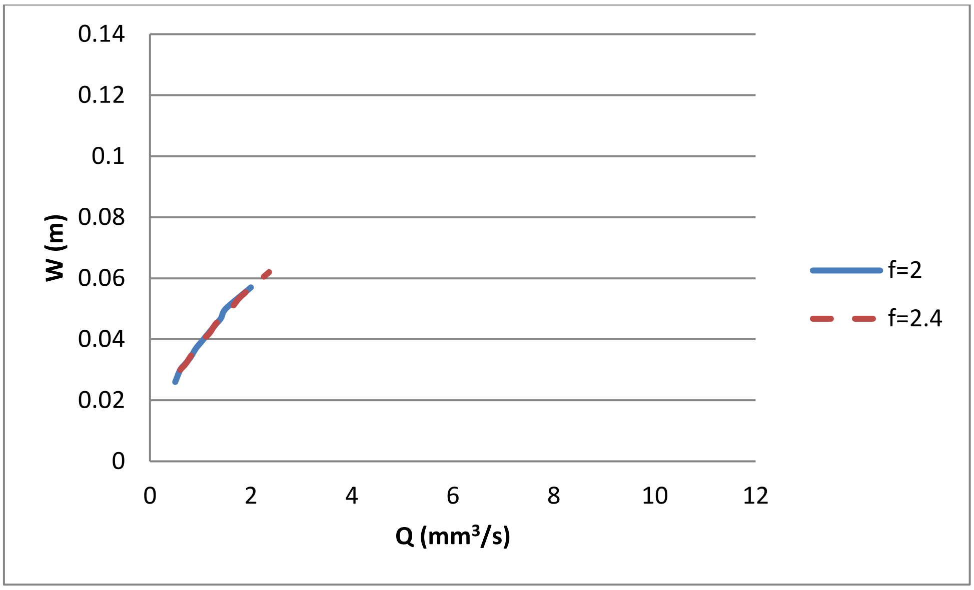
Where: Fw = frequency of irrigation (day).

Dw = the depth of water stored in root zone (cm), column (2) in Tables 7and 8.

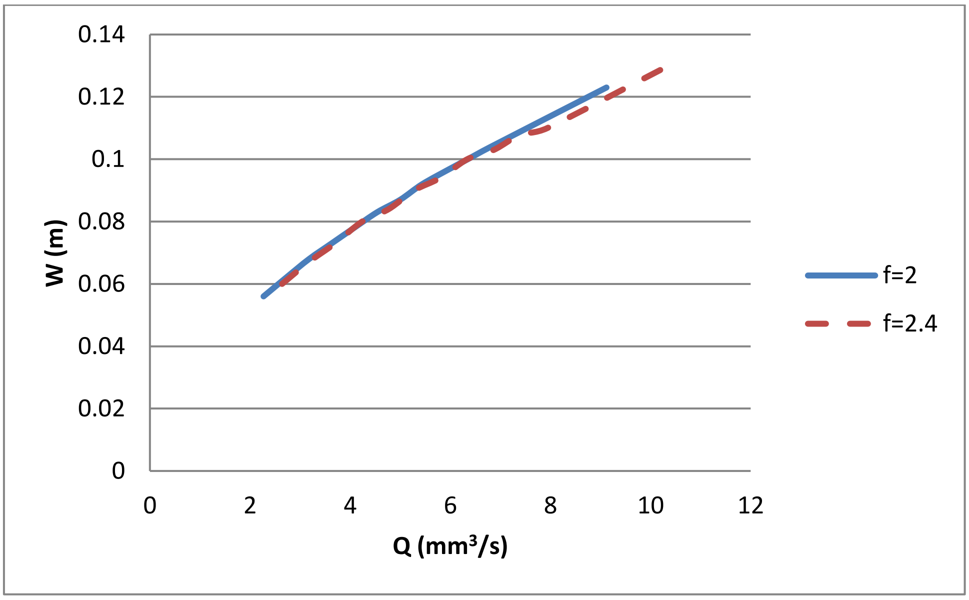
Cu= consumptive use (cm/month), column (12) of Table 7.

The frequency of irrigation is higher in clay and silty soil as in Fig. 8 a and b for sand and clay, respectively. The frequency of irrigation (Fw) values of plants taken for range between (1.14–4) days for clay soil with low silty (f=2) and (1.32 – 4.64) days with high silty (f=2.4), while (0.25 – 0.88) days for sand soil with low silty (f=2) and (0.29 – 1) days with high silty (f=2.4).

Summary of the irrigation system parameters are listed in Tables 7 and 8 for the clay and sandy soils, respectively.

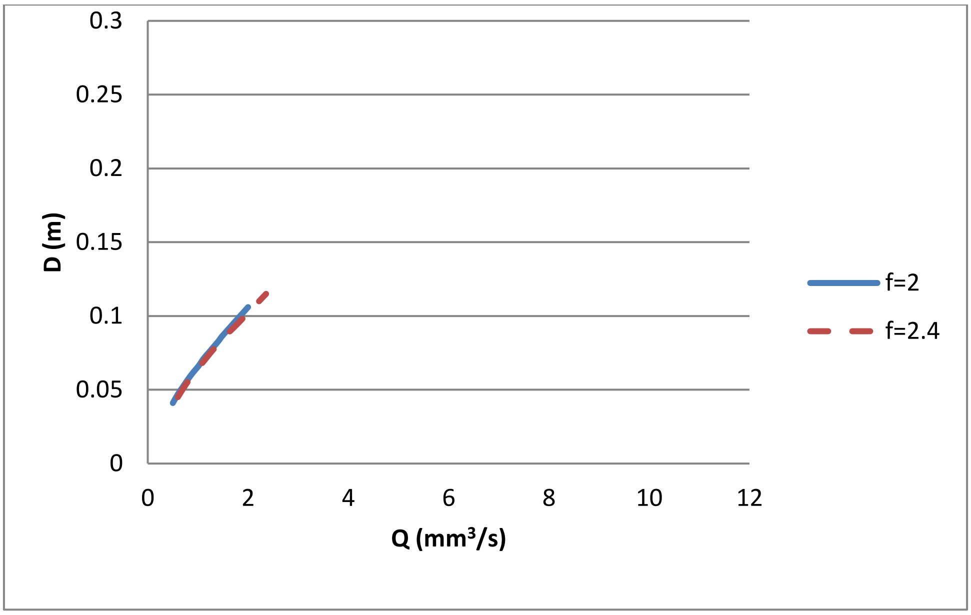


(a)

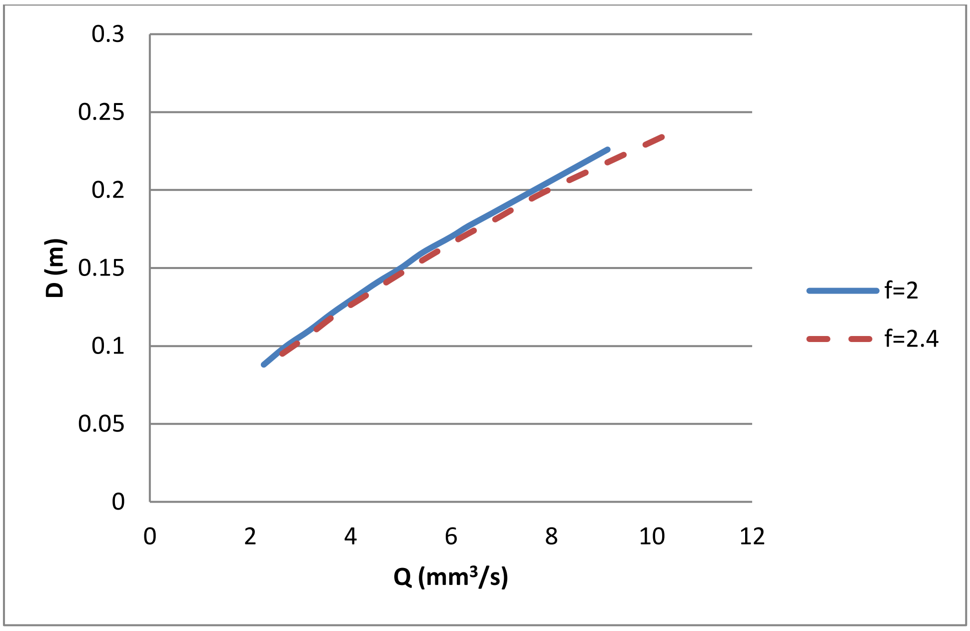


(b)

Fig. 5. Relationship between wetted soil width (W) and dripper discharge (Q); a: sandy soil, b: clay soil

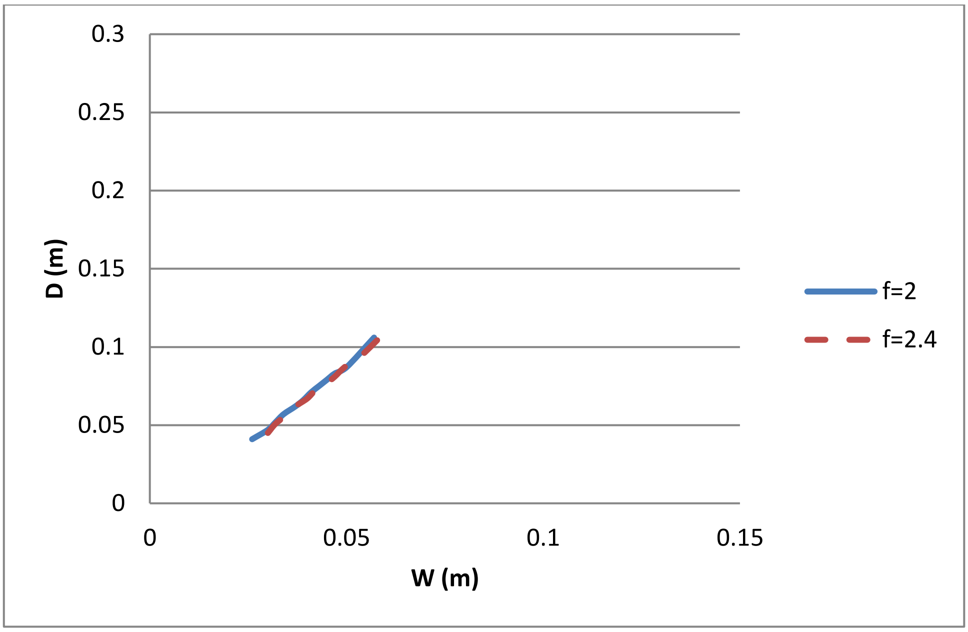


(a)

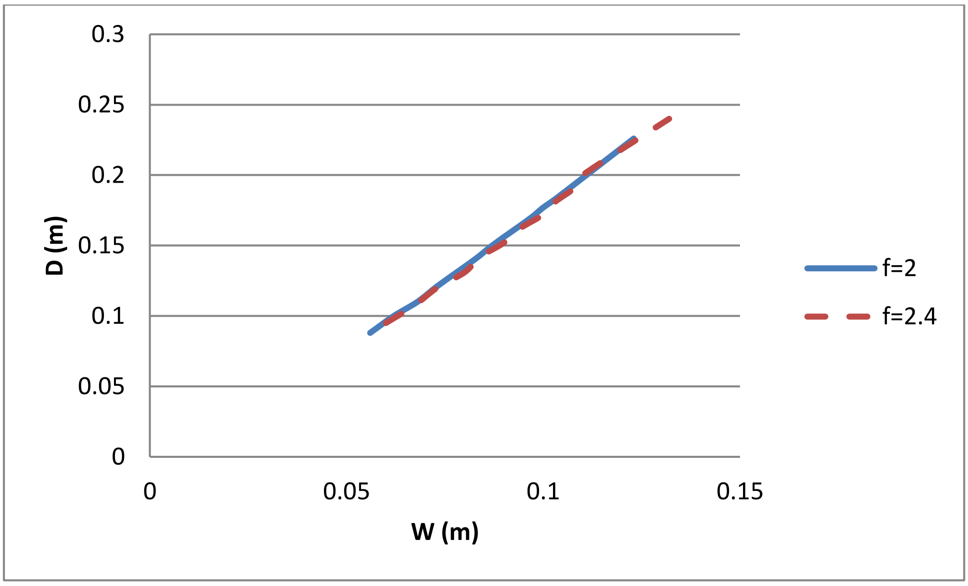


(b)

Fig. 6. Relationship between wetted soil depth (D) and dripper discharge (Q); a: sandy soil, b: clay soil

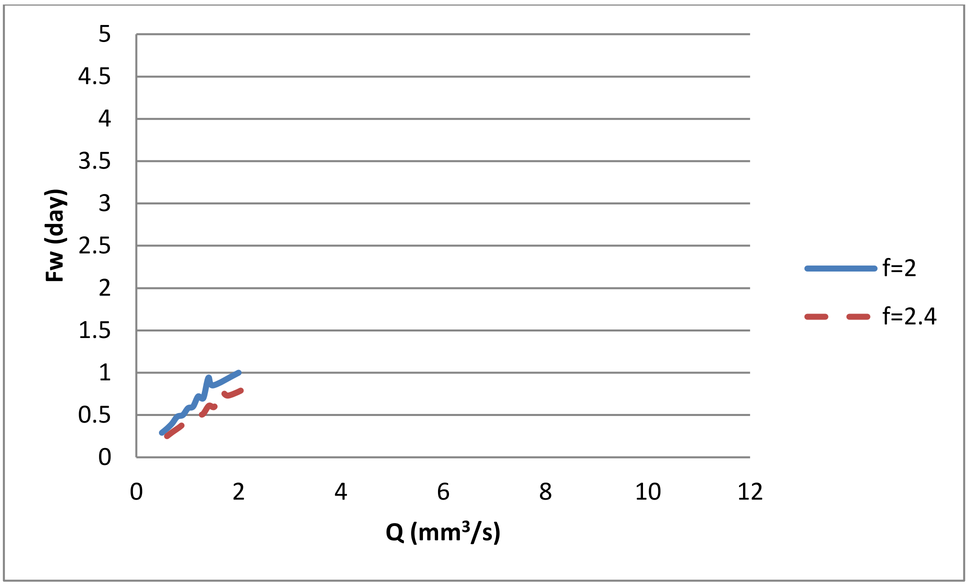


(a)

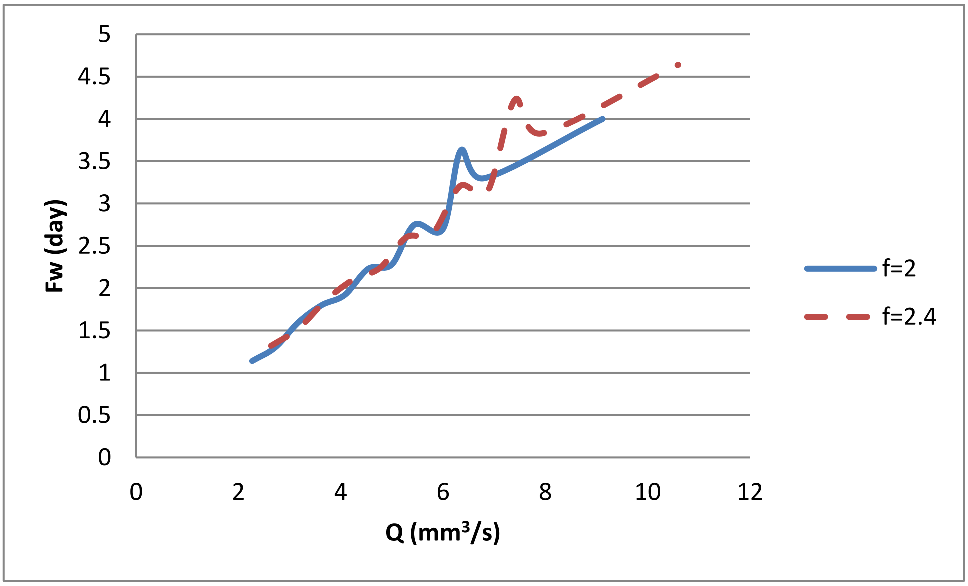


(b)

Fig. 7. Relationship between wetted soil depth (D) and wetted soil width (W); a: sandy soil, b: clay soil



(a)



(b)

Fig. 8. Relationship between frequency of irrigation (fw) and dripper discharge (Q); a: sandy soil, b: clay soil

8. CONCLUSIONS

From the information collected during this study, and from the analysis of results, the following conclusions are drawn:

1. The designed discharge of the drip irrigation was found to be higher in the clay soil than in the sand soil because it is dominated by large pores compared with fine texture clay soil. Increasing silt rate for each type of soil, increases the amount of irrigation water requirement.
2. Flow velocity should be kept low, whenever the pipe diameter of irrigation system increase, this is to avoid water hammer problems in pipelines.

3. The wetted soil width depends on emitter discharge and soil type, it will increase with soils of high silt compared with those of low silt.
4. The wetted soil depth for clay soil is higher than sand soil as it ability to save the water for long time, with high silt.
5. The frequency of irrigation is higher in high silty clay soil than in sandy soil, the latter rapidly drained the water, so it needs more irrigation periods.

9. REFERENCES

Al_Kut Environment Directorate, 2010, a project to measure the annual temperatures for Wasit province, Al_Kut province.

Al_Kut Palms station, 2004, a project to develop palm planting in the Wasit province, Al_Kut province.

Al-Misned, Ahmeds, 2000, "effect of energy loss due to emitters on the design of trickle irrigation laterals" , Soil science , King sand <University Riyadh , Saudi Arabic

Basak, N.N, 1999, "Irrigation Engineering", Tata McGraw-Hill Publishing Co. New Delhi.

Blaney, H.F. and Criddle, W.D., 1962, "Determining consumptive use and irrigation water requirements", United States Department of Agriculture, Agricultural Research Service Tech Bull 1275. 59p.

Broner, I., 1998 "Drip irrigation of home garden", Colorado State University Cooperative Extension publication.

Food and Agriculture Organization of the United Nation: CROPWAT 8.0, http://www.fao.org/.

Gil , M. , Rodriguez-Sinoloas ,L , Juana L , Sandez and Lasada A ,2008 "Emitter discharge variability of sub-surface drip irrigation in uniform soils" Irrigation Science 26, pp 451-458

Huijun , L , Zuoxin , L ,Qiaosheng ,S , and Guarghua, Y ,2009 " Effect of Operating Pressure in the Discharge Characteristics of Porous Pipes as Micro-Irrigation Laterals" Transaction of CSAE , 1002-6819-20001-05

Hezarjaribi A , Dehghari , A ,A. , Mcfath M .,and Kini , A , 2000 " Hydraulic Performance of Various Trickle Irrigation Emitters" , Journal of Agronomy ,7(3), pp265-271

Manachini B., Corsini A. and Bocchi S., 2009, "Soil quality indicator as affected by a long term barley-maize a cropping systems", Italian J. Agron. 1(15):15-22.

Penn State University, 2003, " Drip Irrigation. Discussion of advantages/disadvantages of drip and links to Plasticulture Research

Phull, A. M. and Babar, M. M., 2012, "Simulation of soil wetting pattern of subsurface drip irrigation system", Sixteenth International Water Technology Conference, IWTC 16, Istanbul, Turkey.