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DYNAMIC EQUILIBRIUM FOR DETERMINING DRAIN SPACING FOR DIFFERENT SOILS

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ABSTRACT

The main purpose of drainage is to provide a root environment that is suitable for the maximum growth of plants. This study is conducted to find the drain spacing using dynamic equilibrium concept for four different soils with different drain depths, and compare the results with those obtained for the peak irrigation period and the steady state equations using arithmetic, geometric and exponential means.

The study included soil texture and hydraulic conductivity tests for four different soils. The drainable porosities of soils were found from especial curves. Two crops were chosen(maize and cotton) and their water requirement and growing season were estimated from previous studies. A computer program was made to obtain the drain spacing using the previously mentioned methods. The drain spacings obtained with the dynamic equilibrium concept were higher than those obtained with the peak irrigation period .The difference in drain spacing becomes more evident with greater depths and higher values of drainable porosity. The drain spacing required for maize is higher than that for cotton. This means that the spacing is affected by both soil type and crop.

أستلم في 2003/8/20 **قبل في 2004/12/14**

[illegible] (1) [illegible] (K) [illegible] (μ)

[8] μ	[illegible] K	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.15	60	[illegible]	890	40	70	A
0.09	20	[illegible]	420	480	100	B
0.042	6	[illegible]	180	630	190	C
0.031	4.5	[illegible]	300	290	410	D

[illegible] (2) [illegible] [9-10] [illegible]

[illegible]	[illegible]	[illegible]	[illegible]
0.7	3	28.3	[illegible]
6.61	3	273.4	[illegible]
9.3	3	384	[illegible]
8.71	4	261.3	[illegible]
4.0	6	82	[illegible]

[illegible] (3) [illegible] [10] [illegible]

[illegible]	[illegible]	[illegible]	[illegible]
0.45	7	8	[illegible]
2.53	5	60.6	[illegible]
5.51	3	227.6	[illegible]
9.34	3	373.6	[illegible]
10.22	3	422.4	[illegible]
6.75	3	279.2	[illegible]
1.20	4	36.0	[illegible]

[illegible] (3-2) [illegible] [8] FAO [illegible] (2.25) [illegible] [12] Abdel-kadir [illegible]

[illegible] (5) [illegible] (3 - 1.5) [illegible]
(1) [illegible]
[illegible]
:[3] [illegible]

$$L^2 = \frac{\pi^2 K d t}{\mu \ln(1.16 h_0 / h_t)} \qquad \ldots\ldots(1)$$

[illegible]
L= [illegible] (م).
K= [illegible] (م/يوم).
t= [illegible] (يوم)
μ = [illegible].
h0= [illegible] (م) [illegible]
[illegible].
ht = [illegible] (م) [illegible]
[illegible].

d= [illegible] (م) [illegible] ($d = \dfrac{D}{1 + \dfrac{8D}{\pi L} \ln \dfrac{D}{U}}$)

:[illegible]
U= [illegible] (م) $2\pi r$
D= [illegible] (م).
r= [illegible] 2 (م).

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible].

[illegible]
[illegible]
:[3] [illegible]

:[illegible]

$$h^{`} = \frac{h_0 + h_t}{2} \qquad \ldots\ldots(2)$$

:[illegible]

$$h^{`} = \sqrt{h_0 \times h_t} \qquad \ldots\ldots(3)$$

:[illegible]

$$h^{`} = \frac{1.16 h_0 - h_t}{\ln\left(1.16 \dfrac{h_0}{h_t}\right)} \qquad \ldots\ldots(4)$$

[illegible]:

$$L^2 = \frac{4Kh^{`}}{q}\left(2d + h^{`}\right) \qquad \text{.........(5)}$$

$$q = \frac{R}{I.I} \qquad \text{.........(6)}$$

[illegible]:

q= [illegible] ([illegible])

h`= [illegible] ([illegible]).

I.I = [illegible] ([illegible]).

R= [illegible] ([illegible])

[illegible]:

$$h^{`} = q\left(\frac{y + h^{`}}{K}\right) + q\frac{L^2}{8KD_1} + q\frac{L}{\pi K}\ln\frac{D}{U} \qquad \text{.........(7)}$$

$$D_1 = D + \frac{h^{`}}{2} \qquad \text{.........(8)}$$

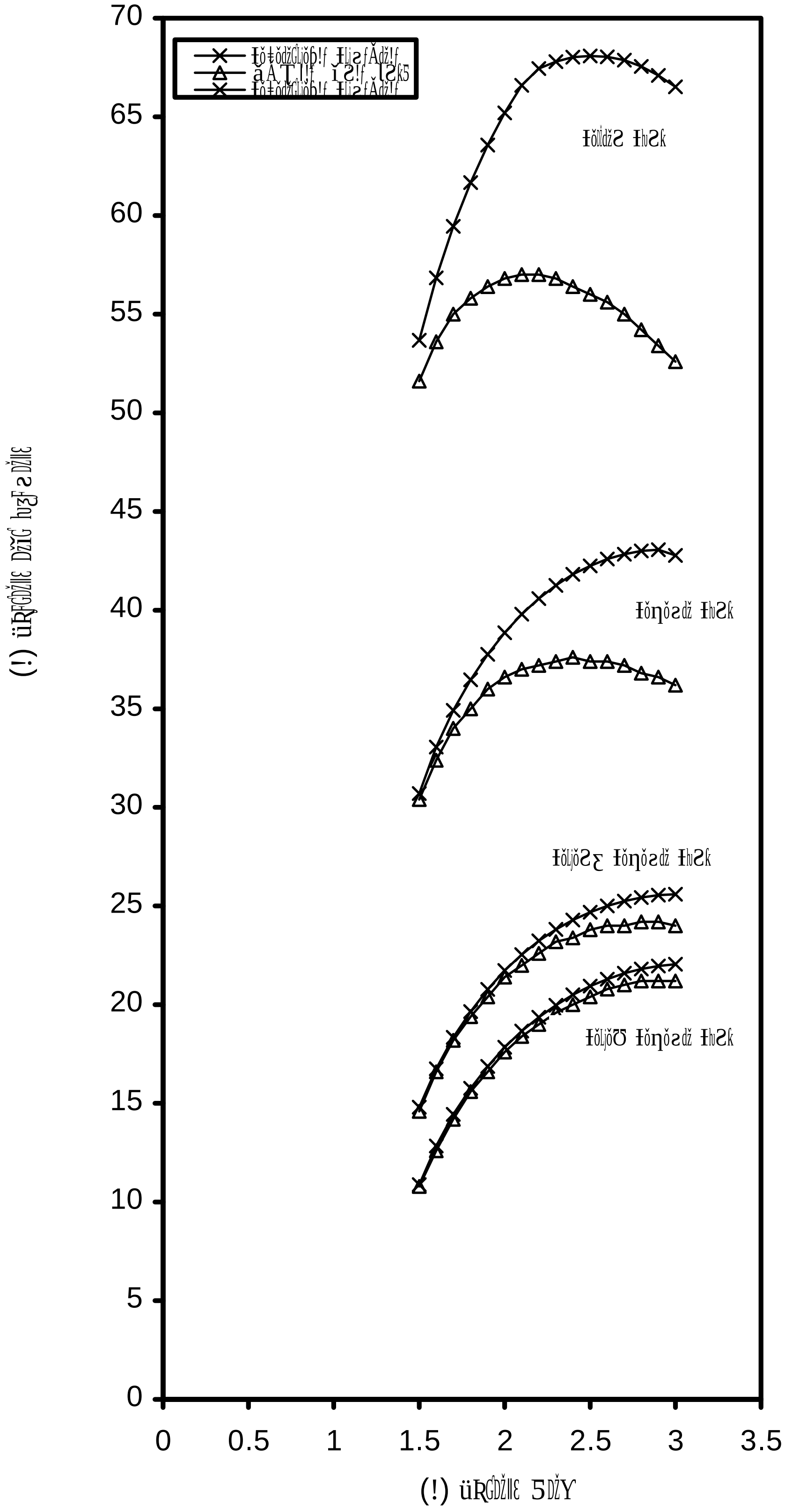
[illegible]:

y= [illegible] ([illegible]).

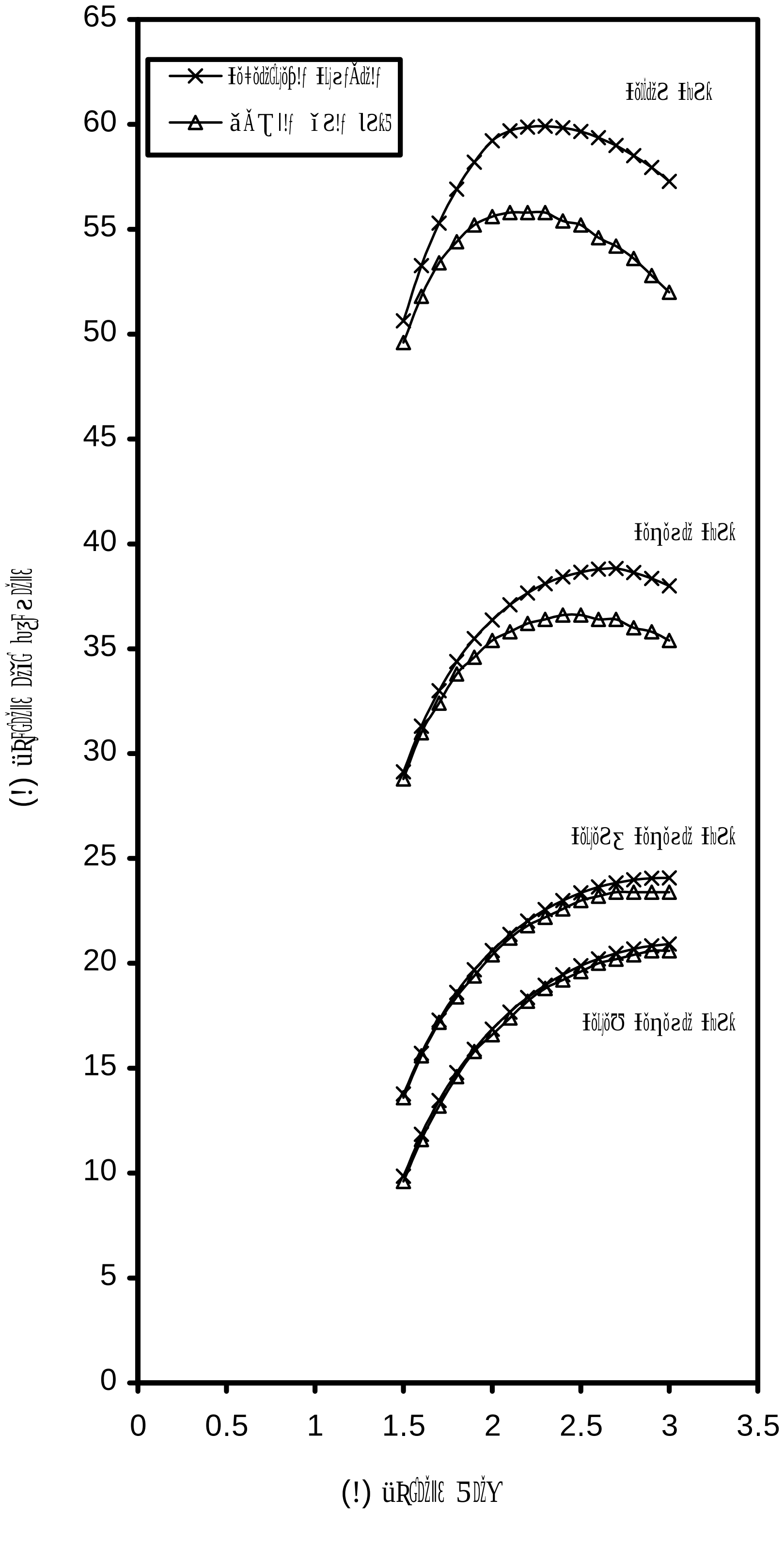
[illegible]

[illegible] (1)[illegible](2) [illegible] (1) [illegible] (2.3)[illegible](2.5) [illegible] (2.7)[illegible](2.9) [illegible] (3) [illegible] (3) [illegible]

[illegible] (1)[illegible](2) [illegible]



(1)



(2)

.hǔǂDžþǁǀ hǔĜþĦǁ (!) üŖƑĜDžǁǀ DžĭĜ hǔƷFƨDžǁǀ(4) üNjǫǁǀ

DžǙšǁǀ üNjTӨDž				ǴþPǁǀ üNjTӨDž				5øøDŽY üŖĜDžǁǀ
hǔǁǫFyDž (l ƨǻþā)	hǔǁǫFyDž (lNjƑƷNjǀj)	ǴþøøøĿƺ ăþøøǁǀ njNjTšǁǀ	hǔøǻŖNjDžǁǀ hǔĭlĭDžƑǻĭǫǁǀ	hǔǁǫFyDž (l ƨǻþā)	hǔǁǫFyDž (lNjƑƷNjǀj)	ǴþøøøĿƺ ăþøøǁǀ njNjTšǁǀ	hǔøǻŖNjDžǁǀ hǔĭlĭDžƑǻĭǫǁǀ	
67.6	68.8	49.6	50.63	71.7	72.8	51.6	53.67	1.5
75.1	76.4	51.8	53.26	79.4	80.8	53.6	56.83	1.6
81.7	83.4	53.4	55.30	86.4	88.0	55.0	59.45	1.7
87.8	89.6	54.4	56.91	92.8	94.6	55.8	61.67	1.8
93.5	95.4	55.2	58.19	98.6	100.6	56.4	63.57	1.9
98.6	100.8	55.6	59.21	104.0	106.2	56.8	65.20	2.0
103.4	105.8	55.8	59.69	109.0	111.4	57.0	66.60	2.1
107.9	110.4	55.8	59.87	113.7	116.2	57.0	67.45	2.2
112.1	114.8	55.8	59.91	118.1	120.6	56.8	67.80	2.3
116.1	118.8	55.4	59.84	122.2	124.8	56.4	68.02	2.4
119.8	122.6	55.2	59.66	126.0	128.8	56.0	68.09	2.5
123.3	126.2	54.6	59.37	129.7	132.6	55.6	68.04	2.6
126.6	129.6	54.2	58.99	133.1	136.0	55.0	67.87	2.7
129.6	132.6	53.6	58.51	136.3	139.4	54.2	67.55	2.8
132.6	135.6	52.8	57.94	139.4	142.0	53.4	67.09	2.9
135.3	138.4	52.0	57.28	142.3	145.4	52.6	66.52	3.0

.hǔǁĭŖDžǁǀ hǔĜþĦǁ (!) üŖƑĜDžǁǀ DžĭĜ hǔƷFƨDžǁǀ(5) üNjǫǁǀ

DžǙšǁǀ üNjTӨDž				ǴþPǁǀ üNjTӨDž				5øøDŽY üŖĜDžǁǀ
hǔǁǫFyDž (l ƨǻþā)	hǔǁǫFyDž (lNjƑƷNjǀj)	ǴþøøøĿƺ ăþøøǁǀ njNjTšǁǀ	hǔøǻŖNjDžǁǀ hǔĭlĭDžƑǻĭǫǁǀ	hǔǁǫFyDž (l ƨǻþā)	hǔǁǫFyDž (lNjƑƷNjǀj)	ǴþøøøĿƺ ăþøøǁǀ njNjTšǁǀ	hǔøǻŖNjDžǁǀ hǔĭlĭDžƑǻĭǫǁǀ	
34.6	35.8	28.8	29.14	36.9	38.0	30.4	30.71	1.5
39.0	40.4	31.0	31.31	41.5	42.8	32.4	33.06	1.6
42.9	44.6	32.4	33.00	45.6	47.2	34.0	34.91	1.7
46.5	48.4	33.8	34.38	49.4	51.2	35.0	36.46	1.8
49.9	51.8	34.6	35.48	52.8	54.8	36.0	37.76	1.9
53.0	55.2	35.4	36.37	56.0	58.2	36.6	38.86	2.0
55.8	58.2	35.8	37.09	59.0	61.4	37.0	39.80	2.1
58.5	61.0	36.2	37.66	61.9	64.2	37.2	40.59	2.2
61.1	63.6	36.4	38.10	64.5	67.0	37.4	41.25	2.3
63.4	66.2	36.6	38.43	67.0	69.6	37.6	41.81	2.4
65.7	68.6	36.6	38.65	69.3	72.2	37.4	42.25	2.5
67.8	70.8	36.4	38.79	71.5	74.4	37.4	42.59	2.6
69.8	72.8	36.4	38.83	73.6	76.6	37.2	42.84	2.7
71.7	74.8	36.0	38.64	75.5	78.6	36.8	43.0	2.8
73.5	76.5	35.8	38.35	77.4	80.4	36.6	43.06	2.9
75.2	78.4	35.4	38.0	79.2	82.2	36.2	42.78	3.0

.hŭǚĭƥǅǁǁ hŭǙŤŘǅǁǁ hǓƥǂǁ (!) üŘǴǅǁǁ ǅǚǴ hǯƑ ƨǅǁǁ(6) üǸǭǁǁǁ

ǅǕ$ǁǁ üǸȚǾǅ				ɣƥǷǁǁ üǸȚǾǅ				5øøǅɣ üŘǴǅǁǁ
hǁǭƑyǅ (l ƨǚƥǟ)	hǁǭƑyǅ (lǸƑ3Ǹǰǰ)	ɣƥøøøŁǯ ǎƥøøøǁǁ ǹǸȚ$ǁǁ	høǚŘǁǸǅǁǁ hŭlǚǅƑǚǭǁǁ	hǁǭƑyǅ (l ƨǚƥǟ)	hǁǭƑyǅ (lǸƑ3Ǹǰǰ)	ɣƥøøøŁǯ ǎƥøøøǁǁ ǹǸȚ$ǁǁ	høǚŘǁǸǅǁǁ hŭlǚǅƑǚǭǁǁ	
14.0	15.0	13.6	13.77	15.3	16.4	14.6	14.8	1.5
16.5	17.8	15.6	15.72	17.9	19.2	16.6	16.75	1.6
18.7	20.2	17.2	17.30	20.2	21.8	18.2	18.35	1.7
20.8	22.6	18.4	18.61	22.4	24.0	19.4	19.66	1.8
22.7	24.6	19.4	19.70	24.3	26.2	20.4	20.78	1.9
24.5	26.6	20.4	20.61	26.2	28.4	21.4	21.73	2.0
26.2	28.4	21.2	21.38	27.9	30.2	22.0	22.54	2.1
27.7	30.2	21.8	22.02	29.6	32.0	22.6	23.24	2.2
29.2	31.8	22.2	22.56	31.1	33.6	23.2	23.82	2.3
30.6	33.4	22.6	23.00	32.6	35.2	23.4	24.29	2.4
31.9	34.8	23.0	23.36	34.0	36.8	23.8	24.69	2.5
33.2	36.2	23.2	23.64	35.2	38.2	24.0	25.00	2.6
34.4	37.4	23.4	23.84	36.5	39.6	24.0	25.25	2.7
35.5	38.6	23.4	23.98	37.7	40.8	24.2	25.43	2.8
36.6	39.8	23.4	24.06	38.8	42.0	24.2	25.55	2.9
37.6	40.8	23.4	24.07	39.9	43.0	24.0	25.60	3.0

.hŭǚǗǁǁ hŭǙŤŘǅǁǁ hǓƥǂǁ (!) üŘǴǅǁǁ ǅǚǴ hǯƑ ƨǅǁǁ(7) üǸǭǁǁǁ

ǅǕ$ǁǁ üǸȚǾǅ				ɣƥǷǁǁ üǸȚǾǅ				5øøǅɣ üŘǴǅǁǁ
hǁǭƑyǅ (l ƨǚƥǟ)	hǁǭƑyǅ (lǸƑ3Ǹǰǰ)	ɣƥøøøŁǯ ǎƥøøøǁǁ ǹǸȚ$ǁǁ	høǚŘǁǸǅǁǁ hŭlǚǅƑǚǭǁǁ	hǁǭƑyǅ (l ƨǚƥǟ)	hǁǭƑyǅ (lǸƑ3Ǹǰǰ)	ɣƥøøøŁǯ ǎƥøøøǁǁ ǹǸȚ$ǁǁ	høǚŘǁǸǅǁǁ hŭlǚǅƑǚǭǁǁ	
9.7	10.6	9.6	9.85	10.8	11.8	10.8	10.89	1.5
11.8	13.0	11.6	11.85	12.98	14.2	12.6	12.85	1.6
13.7	15.2	13.2	13.46	14.96	16.4	14.2	14.44	1.7
15.4	17.2	14.6	14.79	16.78	18.4	15.6	15.76	1.8
17.0	19.0	15.8	15.91	18.47	20.4	16.6	16.88	1.9
18.6	20.6	16.6	16.87	20.04	22.2	17.6	17.84	2.0
20.0	22.2	17.4	17.68	21.51	23.8	18.4	18.66	2.1
21.3	23.8	18.2	18.37	22.90	25.4	19.0	19.37	2.2
22.6	25.2	18.8	18.96	24.21	26.8	19.6	19.98	2.3
23.8	26.6	19.2	19.46	25.46	28.2	20.0	20.50	2.4
25.0	27.8	19.6	19.88	26.64	29.4	20.4	20.94	2.5
26.0	29.0	20.0	20.21	27.76	30.8	20.8	21.30	2.6
27.0	30.0	20.2	20.48	28.83	31.8	21.0	21.60	2.7
28.0	31.2	20.4	20.69	29.85	33.0	21.2	21.81	2.8
29.0	32.2	20.6	20.83	30.80	34.0	21.2	21.96	2.9
29.9	33.0	20.6	20.92	31.76	35.0	21.2	22.06	3.0

ϸǫƑ Ƭ ǅǁǫ

1. Moustafa, M.M. and Yomota, A. Spatial Modeling of Soil Properties for Subsurface Drainage Projects .Journal of Irrigation and Drainage Engineering. Vol.124(2).1998.pp218-228.

2. Kacimor, A.R. Calculation of Inflow and Outflow in Phreatic Aquifers. Journal of Irrigation and Drainage Engineering, ASAE ,127(1). 2001.pp16-19.

Ɨùƶǆǝƞ ÜƧƬùǉ!ƒĂ ƗùƵǅǆƱǁ! Ɣùƙƚ!ƒ Ƨƒƥ.ýƨǂ!ƒ.Ơ!ǵƮ Ƈǖ Ƶ ÜǑǂǅǉƞ!ƒĂ ÜƔƧǴơǆ ǈƪơǆÜǑǆǖ!ƒ **.3**
.ƗơƸƮ 334. 1992**.** ýƬĂǆ!ƒ

4. Dumm, L.D., and Winger R.J. Subsurface Drainage System Designed for Irrigated Areas Using Transient Flow Concept .ASAE Paper No. 63- 213. 1963.

5. Kessler, J . Field Drainage Criteria. In: Drainage Principles and Applications, Publication 16, Vol. 2 International institute for Land Reclamation and Improvement .Wageningen, The Netherlands, 1979.

6. Gee,G.W. and J.W. Bauder. Particle-size Analysis. In: Methods of Soil Analysis. Part 1:Physical and Mineralogical Methods.2nd ed., Edited by A.Klute.1986.p383-409.

7. Klute.A. and C.Dirksen. Hydraulic Conductivity and Diffusivity: Laboratory Methods. In: Methods of Soil Analysis. Part 1:Physical and Mineralogical Methods.2nd ed., Edited by A.Klute.1986.p687-732.

8.FAO/UNESCO. Drainage Design Factors. FAO Irrigation and Drainage Paper No.(38), FAO, Rome,1980.

9.NEDECO. North Jazera Irrigation Project, Design Criteria, p52,1989.

10. NEDECO. North Jazera Irrigation Project, Operation and Maintenance Manual-Final Version, p.68,1984.

ÜǉƒƧĂƙƚϸ ƗơĂƧƱǇ ÜǑ!ǴƬ!ƒ ƖƧǒƨƞ!ƒ ƳĂƧƬǆ! ýǆǆǕƒ ǑƒƒĂƧǕƒ ǕǕĂǆǉ!ƒ .ƨǒƨ!ƒ ϸǂƵ ƧǴǆǉǇ ÜƔ!ǴƱ!ƒ**.11**
. 1999Üý ƬĂǆ!ƒ Ɨƶǆǝƞ.ƗƪϸǉǊ!ƒ Ɨǖǁƚ

12. Abel-Kadir,N. Basic Principles in The Design of Drainage Systems. Seminar on Science and Technological Uses of Water, March 15-20,1980.Ministry of Higher Education and Scientific Research, Iraq,1980.

13. Bouarfa,S. and Zimmer, D. Water-table Shapes and Drain Flow Rates in Shallow Drainage Systems. Journal of Hydrology, 235(3-4). 2000.pp264-275.