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Infiltration Rate and its Relation to Irrigation Schedule for Cropping Patterns in North Sinai Area

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Abstract: The current work was carried out on the soils at four locations in North Sinai (Baluzza, Romana, Beir El-Abd and Al-Tina plain (south port said), which are considered among the most promising potential areas for agricultural expansion in Egypt. Each location is represented by four soil profiles, studied for infiltration rates and other soil physical properties in relation to irrigation frequencies. The studied soils are characterized by sand to clay texture and electric conductivity of about $\pm$ 2000 ppm. On the basis of infiltration rate classes, most values of such parameter range between 0.33 to 49.74 cm/hr corresponding to moderate and very rapid. Results show that the irrigation frequencies vary according to the texture of soil, crop and growth season. For coarse and medium sand, the lowest frequency was varied from one day to 3 days according to summer and winter seasons, also the use of sprinkler or drip irrigation systems is recommended. In the case of fine sand the irrigation frequencies are larger than 9 days, while in the clay – textured soils the irrigation frequencies ranged between 5 and 30 days in the summer and winter seasons.

Key words: infiltration rate, physical properties and irrigation frequencies

INTRODUCTION

Man/land ratio in Egypt has become one of the highest values in the world. So, the agriculture expansion in the desert should be continuous by one of the main fetal objects of the national plan to meet the food requirements for the tremendous increase in population.

Undoubtedly the horizontal and vertical agricultural expansion in Egypt depend mainly on the rational use of the available water resources, and the main objective of water management is usually to capture and save the natural precipitation within the soil for crop production, and to reduce the evaporation rate.

As already known, infiltration rate is the first step that expresses the movement of water into and through the soil,[1]. The importance of the infiltration rate value was discussed by Kramer[2] and Hillel[3] who pointed out that this process determines the amount of surface runoff, and water economy at the rooting zone. Skaggs *et al.*[4] found that infiltration rates tended to increase with coarser deep soil profile. However, in as much as soil profiles of most natural soil are seldom uniform, the effect of stratification on infiltration rate is often spectacular. In this accord, Agrawal *et al.*[5] found a highly significant positive relationship between sand content and final infiltration rate. Similar results were obtained by El-Samanoudy[6], Marshall and Holmes[7], Jensen *et al.*[8] and Humphrey and Fisher[9].

Salinity of irrigation water is a significant factor in many of the irrigated lands and must be considered in developing optimum irrigation strategies. The time and amount of irrigation water application of various salinities along with crop selection based on salinity tolerance are some of the management variables whose, effects on crop yield and amount and salinity of the water percolation below the root zone are necessary in establishing optimal management practices, Bauder[10] and Bauder and Borck[11].

This paper aimed at studying the infiltration rate and other soil physical properties in the newly reclaimed areas of North Sinai to choose the best irrigation system beside determination of irrigation frequencies for different crops that might be considered to be potentially grown in this areas.

MATERIALS AND METHODS

The current study was conducted on soils of four regions, namely, Baluzza, Romana, Beir El-Abd and Al-Tina plain, North Sinai Governorate. Each of these regions is represented by four soil profile; the first region, Baluzza (profiles 1, 2, 3 and 4), the second region, Romana (profiles 5, 6, 7 and 8), the third region, Ber El-Abd (profiles 9, 10, 11 and 12) and, the fourth region, Al- Tena plain (profiles 13, 14, 15 and 16). All soil profiles are chosen as representation of soil units in such areas.

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Also, 16 tests of infiltration rates were conducted beside each soil profile and determined under constant head using double ring infiltrometer, as described by Klute[12]. The cumulative depth of infiltrated water "D" in cm as a function of time, was evaluated according to kostiakove[13] and Philips[14,15] two terms equation.

Kostiakove equation: $D= kt^n$ $i=knt^{n-1}$
Philips equation $D = st^{0.5} + At$ $i = 0.5.t^{-0.5} + A$

where i, is the infiltration rate, i.e. the steady state infiltration rate, S and A, k and n are constants.

The study also includes the determination of irrigation frequencies for various crops that might be considered potentially-grown in this area. These determinations were based on the infiltration tests and available soil moisture by using meteorological data collected from Egyptian meteorological Authority, Cairo, Egypt, (Table 1and 2) to compute ETo rates using Penman-Montieth method as recommended by FAO Expert Consultation held in May (1990) in Rome, Italy, by using CROPWAT, software version 5.7 Smith,[16].

Montieth Approach: (Smith,[17] and Allen *et al.,*[18])

$$ETo = \frac{0.408\ \Delta\ (Rn - G) + \gamma\ (900/T+273)\ u2\ (es - e_a)}{\Delta + \gamma\ (1 + 0.34\ u_2)}$$

Where:

- ETo = reference evapotranspiration (mm day^{-1}),
- Rn = net radiation at the crop surface (MJm^{-2} day^{-1}),
- G = soil heat flux density (MJ m^{-2} day^{-1}),
- T = mean daily air temperature at 2 m height (ºC),
- U_2 = wind speed at 2 m height (m s^{-1}),
- e_s = saturation vapor pressure (Kp_a),
- e_a = actual vapor pressure (Kp_a),
- e_s- e_a = saturation vapor pressure deficit (Kp_a),
- Δ = slope vapor pressure curve (Kp_a $ºC^{-1}$),
- γ = psychometric constant (Kpa $ºC^{-1}$).

Also, crop coefficient (Kc) can be used to relate reference crop evapotranspiration (ETo) to maximum crop evapotranspiration (ETc) when water supply fully meets water requirements of the crop ETc = ETo * Kc (Doorenbos and Kassam,)[19].

All soil samples were analyzed for their content of clay, silt and sand by the method of Gee and Bouder[20], water content at 0.1 and 15 bar, according to Klute[12]. Undisturbed soil samples were taken to determine soil bulk density[21]. Moreover, ECw = electrical conductivity of irrigation water in the studied area of Baluzza, Romana ,Beir El-Abd and Al Tena plain is found to be approximately 2000 ppm.

RESULTS AND DISCUSSION

Climate: The meteorological data of the studied area were collected from Egyptian Meteorological Authority, Cairo, Egypt, and presented in Table (1) which reveal that the mean monthly maximum temperature varies from 17.5 to 32.5 ºC, the mean monthly minimum temperature varies from 7.5 to 22.5 ºC, the sunshine hours varies from 6.6 to 12.3 hr., the relative humidity ranges between 60 and 70%, the mean monthly evapotranspiration ranges from 2.9 to 6.94 mm., the mean monthly surface wind speed varies from 8.21 to 20.88 Km/hour, the mean monthly precipitation is about 1.0 to 15.0 mm. and the total rainfall is about 74 mm/year. The reference evapotranspiration, (ETo) varies from 6.94 mm/day in summer to 2.90 mm/day in winter. The mean annual of evapotranpiration is moderate (1752 mm/year). In general, the study area is dominated by the Mediterranean climate that characterized by hot dry summer and relatively cold winter,

In case of AL- Tena plain, Table (2) shows that the mean monthly maximum temperature varies from 17.5 to 32.5 ºC, the mean monthly minimum temperature varies from 8.3 to 22.5 ºC, the sunshine hours varies from 6.5 to 12.1 hr, the relative humidity reaches between 57 and 68 %, the mean monthly precipitation is about 1.0 to 13.3 mm and the total rainfall is about 63 mm/year. The reference evapotranspiration, (ETo) varies widely form 7.1 mm / day in summer to 2.7 mm / day in winter. The mean annual evapotranspiration is moderate (1772 mm / year).

Physical Properties: Data in Tables (3 and 4) clearly reveal that the soil texture in the first locality (Baluzza) is almost nearly homogenous loamy sand in the four soil profiles representing such locality except the two bottom layers of the soil profile No. 3, which are sandy loam. The weighted mean of soil fractions; total sand, silt and clay along the representative soil profiles (1, 2, 3 and 4) are, 90.43, 88.87, 65.91 and 83.45%, for total sand, 6.84, 8.16, 20.33 and 10.46% for silt and 3.08, 2.97, 13.76 and 6.09% for clay, respectively. Data also indicate that bulk density ranges from 1.35 and 1.56 g /cm3 and the soil moisture contents fluctuate between 10.55 – 21.29%, 4.98 – 9.58% and 3.98 – 11.7% for FC, PW and AW, respectively. It is clearly noticed that these moisture contents are very low due to the coarse texture nature of soil in this area.

Table 1: Average meteorological data of (Baluzza, Romana and Beir El-Abd) North Sinai regions average of 30 years (1973 – 2003).

Average 30 Year	Max Temp. ^oC	Min. Temp. ^oC	Avg. Temp. ^oC	Relative Humidity %	Sun-shine Hours hr	Wind Speed Km/h	Total Rain mm.	Effective Rain mm.	Solar Radiation (MJ/m2/day)	Evapotra-nspiration (mm/day)
Months										
Jan.	17.50	7.50	12.50	70.00	7.20	18.67	15.00	12.00	12.30	2.90
Feb.	17.50	10.00	13.75	65.00	8.20	15.08	10.00	8.00	15.70	3.15
March	22.50	12.50	17.50	60.00	8.70	20.88	10.00	8.00	19.40	4.99
April	25.00	15.00	20.00	60.00	9.40	18.38	7.00	5.60	22.70	5.75
May	27.50	17.00	22.50	60.00	10.80	17.29	1.00	0.80	25.90	6.56
June	27.50	20.00	23.75	60.00	12.30	17.33	0.00	0.00	28.40	6.94
July	30.00	22.50	26.25	70.00	12.00	8.33	0.00	0.00	27.80	5.96
Aug.	32.50	22.50	27.50	70.00	11.70	8.50	0.00	0.00	26.30	6.04
Sep.	30.00	22.50	26.25	70.00	10.60	9.00	1.00	0.80	22.60	5.14
Oct.	27.50	20.00	23.75	65.00	9.40	8.21	5.00	4.00	18.10	4.07
Nov.	22.50	15.00	18.75	70.00	7.90	11.92	10.00	8.00	13.60	3.11
Dec.	20.00	12.50	16.25	65.00	6.60	14.75	15.00	12.00	11.10	2.99
Avg.	25.00	16.46	20.73	65.42	9.57	14.03	6.17	4.93	20.33	4.80
Annual							74.00	59.20		1752.00

Climatic Atlas of Egypt (2003)

Table 2: Average meteorological data (30 years 1973-2003) of Al -Tena plain South port saied.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
Max.Temp. (°C)	17.5	18.3	22.5	25.8	28.3	29.3	31.3	32.5	30.2	28.3	23.3	19.3	25.6
Min.Temp (°C)	8.3	10.0	11.7	14.2	17.5	20.8	22.5	22.5	21.7	19.2	15.0	11.2	16.2
Rel.Humidity (%)	66.7	63.3	58.3	57.7	58.3	58.0	65.0	65.0	65.0	64.7	67.7	65.7	62.9
Wind speed (km/hr)	13.90	13.19	18.54	16.02	14.65	14.95	8.05	8.11	7.82	8.75	11.94	15.0	12.58
Sunshine (hours)	7.0	7.8	8.4	9.2	10.4	11.9	12.1	11.9	10.8	9.3	7.5	6.5	9.4
Rain (mm)	11.7	9.7	8.3	5.3	1.0	0.0	0.0	0.0	0.7	4.7	8.3	13.3	63.0
ETo (mm/day)	2.69	3.16	4.91	5.81	6.48	7.11	6.31	6.21	5.20	4.20	3.26	2.93	4.85

Climatic Atlas of Egypt (2003)

Table 3: Some properties for different locations .

Location	Profile No.	Depth (Cm)	Particle size distribution (%)				Texture	P_b g/cm^3	$CaCO_3$ %	Moisture content at		Avail. moisture %
			C.s	F.s	Silt	Clay				0.1 atom	15 atom	
Baluzza	1	0--10	49.9	37.4	11.2	1.48	LS	1.51	7.33	12.2	6.34	5.88
		10--30	34.83	41.3	13.9	9.95	LS	1.53	5.66	14.7	7.32	7.34
		30--90	66.22	29.5	3.22	1.05	S	1.45	4.33	10.6	5.24	5.31
	2	0--30	59.22	23.8	14.26	2.77	LS	1.5	7.21	11.7	5.48	6.2
		30--60	56.99	30.1	7.73	5.17	LS	1.56	5.33	16.4	7.99	8.36
		60--120	71..11	21.6	5.33	1.97	LS	1.49	4.88	11.3	6.48	4.86
	3	0--30	60.25	19.6	11.99	8.18	LS	1.38	6.53	17.2	8.22	9
		30--50	29.24	30.8	19.82	20.2	SL	1.35	7.22	21.3	9.58	11.7
		50--90	51.66	21.4	12.31	14.6	SL	1.50	2.99	17.6	8.22	9.33
		90--120	11.22	35.1	39.71	14	SL	1.43	4.88	16.9	8.97	7.91

Table 3: Continued

	4	0--20	44.99	50.3	3.49	1.18	S	1.42	5.66	8.99	5.01	3.98
		20--50	39.49	41.2	10.85	8.44	LS	1.43	7.55	16.2	6.59	9.63
		50--70	28.1	43.1	20.39	8.4	LS	1.44	5.33	16.6	7.89	8.69
		70--100	39.22	47.2	8.11	5.47	LS	1.38	5.34	11.4	4.98	6.37
Rommana	5	0--30	55.22	31.9	12.55	0.32	S	1.51	9.11	8.79	4.87	3.92
		30--90	51.91	34.2	12.67	1.2	LS	1.50	9.6	10.7	4.99	5.67
		90--120	32.81	59.1	7.00	1.08	LS	148	6.33	9.99	4.88	5.11
	6	0--30	50.92	36.4	11.33	1.34	LS	1.52	8.13	13.6	6.54	7.01
		30--90	47.81	39.5	10.21	2.46	LS	1.45	6.99	12.4	6.23	6.12
		90--120	34.75	49.8	11.91	3.58	LS	1.39	7.66	12.5	7.01	5.53
	7	0--20	37.97	43.2	14.2	4.61	LS	1.38	5.39	15.3	7.59	7.74
		20--70	49.11	41.6	8.11	1.17	LS	1.45	5.66	9.84	4.23	5.61
		70--120	31.7	50.1	14.96	3.23	LS	1.43	8.99	13.3	5.99	7.26
	8	0--30	50.69	39.1	7.39	2.81	LS	1.39	10.2	11	5.99	5.02
		30--90	42.97	43	8.48	5.6	LS	1.46	5.78	14.3	7.02	7.24
		90--120	23.22	66.3	7.89	2.6	LS	1.48	5.57	10.6	5.05	5.54
Beir Abd	9	0--25	37.99	44.3	14.91	2.81	LS	1.49	9.39	13.5	6.08	7.46
		25--65	45.22	29.1	22.11	3.56	LS	1.4	8.31	13.5	7.86	5.68
		65--90	22.82	43.7	29.99	3.48	LS	1.37	5.62	16.1	8.66	7.39
		90--120	25.65	52.6	19	2.8	LS	1.49	5.7	14	6.88	7.13
	10	0--30	36.41	51.2	9.99	2.38	LS	1.48	5.87	11.9	5.46	6.42
		30--90	34.76	54.9	8.11	2.22	LS	1.53	8.22	9.87	4.23	5.64
		90--120	23.9	66.2	7.87	2.01	LS	1.39	9.37	9.56	4.57	4.99
	11	0--15	41.33	39.7	17	1.96	LS	1.41	12.74	11.6	4.99	6.58
		15--45	36.11	41.3	18.21	4.37	LS	1.46	8.33	15.3	7.68	7.66
		45--100	33.77	52.1	12.32	1.8	LS	1.43	5.34	12.3	5.67	6.67
	12	0--30	51.39	43.3	3.99	1.33	S	1.44	8.22	8.77	4.01	4.76
		30--60	37.61	54.7	4.82	2.91	LS	1.49	5.69	9.81	4.02	5.79
		60--120	29	63.1	5.38	2.61	LS	1.39	7.04	10.1	4.89	5.22
Al-Term plain	13	0--25	3.54	10.5	33.97	49.99	SC	1.18	0.78	32.66	14.0	18.66
		25--50	4.00	10.11	39.58	46.31	C	1.19	0.00	32.55	13.64	18.91
		50--90	0.59	13.19	44.72	41.5	SC	1.12	0.00	31.0	13.11	17.89
	14	0--25	4.34	9.88	39.64	46.14	C	1.2	0.00	35.00	15.11	19.89
		25--50	1.00	6.33	40.22	52.45	SC	1.19	0.90	36.9	17.79	19.11
		50--90	4.02	8.00	40.87	47.11	SC	1.21	0.00	36.06	16.71	19.35
	15	0--25	2.56	17.11	35.01	45.22	C	1.24	0.46	29.32	12.77	16.55
		25--50	3.45	12.22	39.22	45.11	C	1.20	0.00	31.98	12.93	19.05
		50--90	1.65	15.13	32.92	50.22	C	1.17	0.32	34.11	14.49	19.62
	16	0--25	9.78	11.01	40.32	40.01	SC	1.21	0.00	31.01	12.17	18.84
		25--50	4.90	9.77	41.24	43.09	SC	1.23	0.22	35.11	15.22	19.89
		50--90	3.84	13.41	33.31	49.44	C	1.19	0.00	36.17	16.00	20.17

C.S. = Coarse Sand F.S. = Fine Sand LS = Loamy Sand SC = Sandy Clay C = Clay

From the above mentioned results, it is remarkable that the soil profile No. 3 has a relatively heavy texture (15 over SL) compared with the soil profiles in the same locality (Baluzza soils). As regard to soil infiltration rate data in Table (4) reveal that the basic infiltration rate of the studied soil profiles (1, 2, 3 and 4) range widely between 2.67 and 20.52 cm/hr (moderate and rapid).

According to Taylor, if the basic infiltration rate exceeds 12 cm/hr or the value on "n" exceeds 0.70, the soil is considered unsuitable for surface irrigation except under special conditions. Meanwhile, the sprinkler or dripping systems are applicable for sandy soils.

Data in Table (4) also showed that the infiltration rate is high and rapid in soil profiles No. 1, 2 and 4 while being moderate in soil profile No. 3. This finding is attributed to the fact that coarse textured soil have higher macropores than the fine textured ones. Thus, the drip irrigation could be the most suitable

Table 4: Infiltration parameters of the studied areas.

Profile NO.	Equations	Initial intake rate	I.R cm\hr	Class of intake rate
1	$D = 0.91^{0.5} + 0.29*t$ $I = 27.30*t^{-0.5} + 17.40$	44.70	19.16	R.
2	$D = 0.99*t^{0.5} + 0.31*t$ $I = 29.7*t^{-0.5} + 18.6$	48.30	20.52	R.
3	$D = 0.45*t^{0.5} + 0.03*t$ $I = 13.5*t^{-0.5} + 1.8$	15.30	2.67	M.
4	$D = 0.61*t^{0.5} + 0.20*t$ $I = 18.30*t^{-0.5} + 12.0$	30.30	13.18	R.
5	$D = 1.83*t^{0.5} + 0.77*t$ $I = 54.9*t^{-0.5} + 46.2$	101.10	49.74	VR.
6	$D = 2.66*t^{0.5} + 0.51*t$ $I = 79.8*t^{-0.5} + 30.6$	110.40	35.75	VR.
7	$D = 1.95*t^{0.5} + 0.69*t$ $I = 58.50*t^{-0.5} + 41.40$	99.90	45.18	VR.
8	$D = 2.11*t^{0.5} + 0.47*t$ $I = 63.30*t^{-0.5} + 28.20$	91.50	32.29	VR.
9	$D = 1.991*t^{0.5} + 0.44*t$ $I = 59.70*t^{-0.5} + 26.40$	86.10	30.25	VR.
10	$D = 2.01*t^{0.5} + 0.51*t$ $I = 60.30*t^{-0.5} + 30.60$	90.90	34.49	VR.
11	$D = 2.51*t^{0.5} + 0.290*t$ $I = 75.30*t^{-0.5} + 17.40$	92.70	22.26	R.
12	$D = 2.89*t^{0.5} + 0.31*t$ $I = 86.70*t^{-0.5} + 18.60$	105.30	24.20	R.
13	$D = 2.01*t^{0..19}$ $I = 22.69*t^{-0.81}$	22.69	0..33	S.
14	$D = 5.94*t^{0.14}$ $I = 48.92*t^{-0.86}$	48.92	0..55	M.S
15	$D = 1.26*t^{0.44}$ $I = 32.96*t^{-0.56}$	32.96	1.77	M.S
16	$D = 6.57*t^{0.18}$ $I = 69.17*t^{-0.82}$	69.17	0..96	M.S

I.R.: Infiltration rate R. : rapid M: moderate V.R. : very rapid S: Slow M.S :Moderately slow

Table 5: Irrigation intervals (days) of some crops and fruit trees proposed to be grown in the North Sinai (Balozza, Romana, Beir El-Abd).

Crops	Month	Period (days)	ETo mm/day	Kc (FAO)	ETc (mm/day)	Etc (mm/month)	Root depth (m)	Effective rain (mm)	Irrigation intervals (days)		
									Coarse sand	Medium sand	Fine sand
Barley	Nov.	15	3.11	0.30	0.93	13.98	0.30	3.0	2	3	4
	Dec.	31	2.99	0.70	2.09	64.82	0.50	4.5	2	2	2
	Jan.	31	2.90	1.15	3.33	103.37	0.70	4.5	1	2	2
	Feb.	28	3.15	0.90	2.84	79.39	0.85	3.0	2	2	3
	March	15	4.99	0.40	2.00	29.95	1.00	3.0	3	4	5
	Total	120				291.51					

Table 5: Continued

Wheat	Nov.	14	3.11	0.30	0.93	13.04	0.30	3.0	3	3	4
	Dec.	31	2.99	0.50	1.49	46.30	0.50	4.5	2	3	3
	Jan.	31	2.90	0.75	2.17	67.41	0.70	4.5	2	3	3
	Feb.	28	3.15	1.10	3.47	97.03	0.85	3.0	2	2	2
	March	31	4.99	0.60	2.99	92.84	1.00	3.0	2	3	3
	April	5	5.75	0.40	2.30	11.50	1.00	2.1	3	4	5
	Total	140				328.14					
Tomato	Dec.	15	2.99	0.30	0.90	13.44	0.30	4.5	3	4	5
	Jan.	31	2.90	0.60	1.74	53.93	0.40	4.5	2	2	2
	Feb.	28	3.15	0.80	2.52	70.57	0.50	3.0	1	2	2
	March	31	4.99	1.15	5.74	177.94	0.60	3.0	1	1	1
	April	5	5.75	0.90	5.18	25.88	0.70	2.1	1	1	1
	Total	110				341.77					
Maize	Ma.	15.0	6.56	0.30	1.97	29.51	0.30	0.1	1	1	1
	Jun.	30.0	6.94	0.70	4.86	145.65	0.50	0.2	1	1	1
	Jul.	31.0	5.96	1.05	6.26	193.96	0.70	0.2	1	1	1
	Aug.	31.0	6.04	0.70	4.23	131.15	0.90	0.3	1	2	2
	Sep.	18.0	5.14	0.30	1.54	27.76	1.00	0.3	4	5	6
	Total	125.0				528.03					
Olive	March	31	4.99	0.65	3.24	100.58	1.20	3.0	2	3	3
	April	30	5.75	0.65	3.74	112.16	1.30	2.1	2	3	3
	May	31	6.56	0.65	4.26	132.15	1.40	0.3	2	2	3
	June	30	6.94	0.70	4.86	145.65	1.50	0.0	2	2	3
	July	31	5.96	0.70	4.17	129.30	1.60	0.0	2	3	3
	Aug.	31	6.04	0.70	4.23	131.15	1.70	0.0	2	3	4
	Sept.	26	5.14	0.70	3.60	93.57	1.70	0.3	3	4	4
	Total	210				844.55					
Peaches	April	30	5.75	0.50	2.88	86.27	1.20	2.1	3	3	4
	May	31	6.56	0.65	4.26	132.15	1.30	0.3	2	2	3
	June	30	6.94	0.65	4.51	135.25	1.40	0.0	2	2	3
	July	31	5.96	0.65	3.87	120.07	1.50	0.0	2	3	3
	Aug.	31	6.04	0.70	4.23	131.15	1.60	0.0	2	3	3
	Sept.	30	5.14	0.70	3.60	107.96	1.70	0.3	3	4	4
	Oct.	27	4.07	0.70	2.85	76.88	1.70	1.5	4	5	5
	Total	210				789.73					

Table 5: Continued

Citrus	Feb.	10	3.15	0.45	1.42	14.18	1.20	3.0	6	8	10
	Mar.	31	4.99	0.60	2.99	92.84	1.30	3.0	3	3	4
	Apr.	30	5.75	0.70	4.03	120.78	1.40	2.1	2	3	3
	Ma.	31	6.56	0.75	4.92	152.48	1.50	0.3	2	2	3
	Jun.	30	6.94	0.80	5.55	166.46	1.60	0.0	2	2	3
	Jul.	31	5.96	0.70	4.17	129.30	1.70	0.0	2	3	4
	Aug.	31	6.04	0.65	3.93	121.78	1.70	0.0	3	3	4
	Sep.	30	5.14	0.60	3.08	92.54	1.70	0.3	3	4	5
	Oct.	16	4.07	0.45	1.83	29.29	1.70	1.5	6	7	9
	Total	240				919.65					

system for irrigating this area to avoid deep percolation, seepage of irrigation water and lost of nutrition.

Regarding the second locality (Romana), data in Table (3) indicate that the soil profiles No. 5, 6, 7 and 8 have similar texture (loamy sand) throughout their soil layers. Also, the weighted means of soil fractions are 87.83, 86.63, 85.42 and 87.79% for total sand, 11.22, 10.92, 11.98 and 8.06% for silt and 0.95, 2.46, 2.6 and 4.15% for clay, respectively.

Table (3), also revealed that the soil bulk density ranges between 1.38 to 1.52 g/cm^3, available water ranges from 3.92 and 7.74%, field capacity ranges from 8.79 and 15.33%, wilting point ranges from 4.23 to 7.59, accordingly available water varies.

In other words, data in Table (4) reveal that the basic infiltration rate from 3.92 lies in the same class (very rapid) and the values of infiltration rate ranges from 32.29 to 49.74 cm/hr. The higher infiltration rate of these soil profiles might be attributed to the high sand content (over 85.0% total sand) and very low clay content. Since the major of irrigation management or water applied is to achieve high application efficiency and uniform water, water distribution by reducing deep percolation and reduces environmental problems caused by unrational use of irrigation water, thus the obtained results dictate that drip irrigation is the most suitable system to Romana soils.

Regarding, Beir El-Abd soils, data in Table (3) pointed out that the area under study is characterized by light texture (loamy sand) where their content of coarse sand varies from 23.9 to 51.39%, fine sand percentages from 29.11 to 66.22%, silt from 3.99 to 29.99% and clay from 1.33 to 4.37%. On the other hand, the estimated weighted mean distinguished that the percentages of soil fractions along soil profiles No. 9, 10, 11 and 12, are, 75.33, 89.27, 82.62 and 92.79 for total sand, 21.47, 8.52, 14.78 and 4.89 for silt and 3.20, 2.21, 2.60 and 2.37 for clay, in the same sequences. Also, data in Table (3) reveal that the bulk density varied from 1.37 to 1.53 g/cm^3, FC varied from 8.77 to 16.05%, WP varied from 4.23 to 8.66% and AW ranges from 4.76 to 7.66%.

Data in Table (4) declared that the values of basic infiltration rate are considerably high and ranges between 22.26 to 30.25 cm/hr, and therefore classified between rapid for soil profiles No. 11 and 12 and very rapid for soil profiles No. 9 and 10. Undoubtedly, this behavior is due to the presence of high percentages of total sand and very low percentages of clay. Therefore the correlation between basic infiltration rate and total sand is positive and highly significant. In case of Al-Tena plain , data in table (3) showed that the area under study is characterized by heavy texture (silty clay to clay in all soil profiles). Clay content varied from 41.11 to 52.45 %, silt from 23.97 to 44.72%, coarse sand varied from 1 to 9.78 % and bulk density ranged between 1.17 to 1.24 gm/cm3. Accordingly, soil moisture retention data reveal that the ability of pores to retained are considerably high in the all soil layers compared to the other areas under study.

Concerning soil intake rate, table (4) declared that the values of such parameter ranged between 0.33 to 1.77 cm/hr, indicating moderately slow to slow rates. This is mainly rendered to the presence of high clay content.

Since infiltration data are fundamental prerequisite for designing, evaluating and managing irrigation systems, and very important key process in the management of water resources for crop production in both irrigated and dry land agriculture, so irrigation design should be implemented and monitored more carefully increase water application efficiency and consequently decrease any loss of nutrients moving beyond the roots zone..

Table 6: Calculated irrigation intervals (days) for various crops, fruit trees and vegetables considered to be grown in the Al-Tena plain (South port Said).

Crops	Irrigation systems & Deficit	Month	Period (days)	ETo (mm /day)	Kc (FAO)	ETc (mm /day)	ETc (mm /month)	Root depth (m)	Effective rain (mm)	Irrigation intervals (days)		
										Silty clay loam *	Silty clay **	Clay ***
Barley	Surface	Nov.	15	3.26	0.30	0.98	14.67	0.30	2.50	15	17	18
		Dec.	31	2.93	0.70	2.05	63.50	0.50	4.00	10	12	13
	P	Jan.	31	2.69	1.15	3.09	95.89	0.70	3.50	9	11	12
	0.25	Feb.	28	3.16	0.90	2.84	79.63	0.85	2.90	12	14	16
	Deficit	March	15	4.91	0.40	1.96	29.44	1.00	2.50	22	25	28
		Total	120				283.13					
Wheat	Surface	Nov.	14	3.26	0.30	0.98	13.69	0.30	2.50	15	17	19
		Dec.	31	2.93	0.50	1.46	45.35	0.50	4.00	15	17	19
	P	Jan.	31	2.69	0.75	2.02	62.54	0.70	3.50	15	17	18
	0.25	Feb.	28	3.16	1.10	3.48	97.33	0.85	2.90	10	11	13
	Deficit	March	31	4.91	0.60	2.94	91.27	1.00	2.50	14	16	17
		April	5	5.81	0.40	2.32	11.61	1.00	1.60	20	22	25
		Total	140				321.80					
Tomato	Drip	Dec.	15	2.93	0.30	0.88	13.17	0.30	4.00	16	18	20
		Jan.	31	2.69	0.60	1.61	50.03	0.40	3.50	9	10	11
	P	Feb.	28	3.16	0.80	2.53	70.78	0.50	2.90	7	7	8
	0.20	March	31	4.91	1.10	5.40	167.33	0.60	2.50	4	4	5
	Deficit	April	5	5.81	0.60	3.48	17.42	0.70	1.60	7	8	9
		Total	110				318.73					
Sugar beet	Spry	Aug.	15	6.21	0.30	1.86	27.94	0.3	0.00	6	7	8
		Sep.	30	5.20	0.50	2.60	78.00	0.5	0.20	8	9	10
	P	Oct.	31	4.20	0.70	2.94	91.07	0.6	1.40	8	9	10
	0.25	Nov.	30	3.26	0.95	3.10	92.90	0.6	2.50	8	9	10
	Deficit	Dec.	31	2.93	1.12	3.28	101.59	0.6	4.00	8	9	10
		Jan.	31	2.69	0.75	2.02	62.54	0.6	3.50	13	14	16
		Feb.	12	3.16	0.40	1.26	15.17	0.6	2.90	23	26	28
		Total	180				454.05					
Maize	Surface	Ma.	15.0	6.48	0.30	1.94	29.16	0.30	0.30	6	7	8
		Jun.	30.0	7.11	0.70	4.97	149.24	0.50	0.00	4	5	5
		Jul.	31.0	6.31	1.05	6.62	205.28	0.70	0.00	4	5	5
	P	Aug.	31.0	6.21	0.70	4.35	134.74	0.90	0.00	8	9	10
	0.25	Sep.	18.0	5.20	0.30	1.56	28.08	1.00	0.20	26	29	30
	Deficit	Total	125.0				546.51					
Olive	Drip	March	31	4.91	0.65	3.19	98.88	1.20	2.50	6	7	8
		April	30	5.81	0.65	3.77	113.20	1.30	1.60	6	6	7
		May	31	6.48	0.65	4.21	130.55	1.40	0.30	5	6	7

Table 6: Continued

	P	June	30	7.11	0.70	4.97	149.24	1.50	0.00	5	5	6
	0.10	July	31	6.31	0.70	4.41	136.86	1.60	0.00	6	7	7
	Deficit	Aug.	31	6.21	0.70	4.35	134.74	1.70	0.00	6	7	8
		Sept.	26	5.20	0.70	3.64	94.64	1.70	0.20	7	8	9
		Total	210				858.12					
Date Palm	Drip	Jan.	30	2.69	0.55	1.48	44.38	3.0	3.50	18	20	22
		Feb.	31	3.16	0.55	1.74	53.88	3.0	2.90	15	16	18
		Mar.	31	4.91	0.55	2.70	83.67	3.0	2.50	9	10	11
	P	Apr.	28	5.81	0.55	3.19	89.40	3.0	1.60	8	9	10
	0.05	Ma.	31	6.48	0.55	3.56	110.47	3.0	0.30	7	8	8
	Deficit	Jun.	30	7.11	0.55	3.91	117.26	3.0	0.00	6	7	8
		Jul.	31	6.31	0.55	3.47	107.53	3.0	0.00	7	8	9
		Aug.	30	6.21	0.55	3.42	102.45	3.0	0.00	7	8	9
		Sep.	31	5.20	0.55	2.86	88.66	3.0	0.20	8	9	11
		Oct.	31	4.20	0.55	2.31	71.55	3.0	1.40	11	12	13
		Nov.	30	3.26	0.55	1.79	53.79	3.0	2.50	14	16	18
		Dec.	31	2.93	0.55	1.61	49.89	3.0	4.00	16	18	20
		Total	365				972.93					

Irrigation Intervals: Irrigation scheduling is the process of determining when to irrigate and how much water to apply per irrigation. Proper scheduling is essential for the efficient use of water, energy, and other production inputs, such as fertilizers. It allows irrigation to be coordinated with other farming activities including cultivation and chemical application. Among the benefits of proper irrigation scheduling are improved crop yield and / or quality, water, and energy conservation and low production costs. Irrigation schedules are designed to either fully or partially provide the irrigation requirement.

The provision of irrigation water and its economic use is of prime importance in the production of crops under semi-arid and arid climates where the sources of irrigation water are limited. In addition, plants vary in the timing of their high need for water, this need by different plant species depends on how much moisture stress they are able to tolerate at any particular stage of growth. If water supply is acutely inadequate, care should be taken at least to provide water at the critical stages of growth. Thus the knowledge of sensitive stages of water deficit by plants is very important for judicious water management.

Wherever irrigation water is not sufficient and is restricted, irrigation to attain optimum production should be based on avoiding water deficits during the periods of peak water use from flowering (2) to early yield formation period (3), made without causing additional heavy yield losses by reducing water supply during the vegetative (1), late yield formation (late 3) and ripening period (4).

So, the irrigation for the most predominant field crops and trees that are considered to be potentially grown in the study area is calculated. The calculations are based on two parameters; a) The depth of available water in the root zone and, b) The monthly consumptive use for each crop during its growth season which is obtained from Penman – Montieth Equation by climatic record, Allen *et al.*[21].

The following equation is applied, according to Doorenbos and Pruit[22]:

$$I = \frac{(P.Sa)^{*}\ D}{(ETc) - Pe}$$

Where:

- I = irrigation interval, day.
- P = Fraction of total available soil water.
- Sa = Total available soil water, mm/m soil depth.
- D = Rooting depth, m.
- Etc = crop evapotranspiration, mm/day.
- Pe = Effective rainfall, mm.

Tables (5 and 6) show that calculated irrigation frequencies vary according to soil texture, crop and growth season. For coarse, medium and fine textured soil barley, wheat, tomato and maize can be grown satisfactory using sprinkler irrigation system while in case of citrus, peaches and olives using drip irrigation systems is necessary. The irrigation frequencies ranged between 1-10 days for sandy textured soil, while in the clay textured soils they range between 5 to 30 days in the summer and winter seasons. Needless to mention that surface irrigation under special conditions can be applied for all crops, in spite of the high intake rates. These findings are concomitant with those reported by Giriappa,[23].

Conclusion: In conclusion, the use of infiltration parameters as an indication to the suitability of an irrigation system must be coupled with the data of irrigation intervals for plants which might be grown in the area under study.

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