Egypt. J. Soil Sci. **43** , No. 2, pp.165-173 (2003)

Method of Using Drainage Water in Irrigation. II-Its Effect on Water Intake

M.Y. Tayel, M. Abd El-Hady and E.E. El-Dardiry

Soils and Water Use Department, National Research Centre, Dokki, Cairo, Egypt.

A FIEID experiment was carried out to study the effects of drainage water usage on water intake (IR). The soil (*Typic torrieorthint*) was planted with wheat*(*Triticum sativum* L. cv.) in winter followed by corn (*Zea maize* L.cv.) in summer. In both cases, plants were irrigated with drainage (DW) and ground water (CW), alternatively. Data show that DW and GW have to be used alternatively. Concerning IR, the best GW/DW treatments were: 1/3 and 2/2.

Keywords. Infiltration, Ground water,Drainage water, Water intake.

Rate of water intake (IR) is defined as the head of water (cm) that penetrates the soil in unit time. Several parameters are known to affect the IR . These include: vegetation; soil characteristics (compaction, pore volume, particle size distribution, layering; water content), water quality (EC; adj. SAR), and temperature.

Marshal (1968) found that soluble salt of the irrigation water reduces the IR. Ghazy (1977) and Omar and Aziz (1982) show a significant decrease in IR with increasing the salinity of irrigation water. The highest effect on IR is related to the mean weight diameter of dry stable aggregates. Oster and Schroer (1979) and Shainberg *et al.* (1981) studied the IR of undisturbed loam soil columns . They found that the effect of the chemistry of the applied water were greater than expected. When the exchangeable sodium percentage of the surface soil layer was. 8, the IR decreased from 15 to 1 mm / hr as the concentration of salts in irrigation water decreased from 28 to 8 meq /1.

Agassi *et al.*(1981) mentioned that the IR was more sensitive to the sodicity of the soil and elecrolyte concentration of the applied water than hydraulic conductivity. They concluded that when distilled water is applied to the soil. even low ESP values (< 6.4) are enough to cause a dispersion in the formed crust and a very sharp decrease in the IR. Helalia *et al.* (1988) found the IR of three Californian soils were influenced by the soil layers and the water quality applied.

A high sodium adsorption ratio (SAR) in irrigation water decreases infiltrability and hydraulic conductivity. However, Frankel *et al.* (1978) and Oster and Schroer (1979) showed that this depends on the salt concentration of the percolating solution.

Kandil (1990) showed that the IR, especially in clay loam soil, was greatly decreased by using low water qualities. Postiglione *et al.* (1995) studied the effects of five saline irrigation water (0, 0.125,0.25,0.5; 1% using commercial NaCl in solution) in factorial combination with three irrigation frequencies (every 2, 5 and 10 days) on some physical and chemical characteristics of a clay loam soil. The results show a decrease in the permeability of the soil (infiltration rate <1 mm/hr in the 1% treatment vs. > 10 mm/hr in the 0% treatment) with consequently difficult drainage.

This investigation was carried out to study the effects of agricultral drainage water usage on water intake.

Material and Methods

The field experiment was divided into 50 plots each (108 m^2) leaving one meter apart to avoid irrigation treatment effects. Superphosphate (P_2O_5 15%) at the rate of 200 kg/fed was added before seedbed preparation and ploughed in the top soil layer. Wheat (*Triticum sativum* L.cv, Sakha 69) seeds were planted. Ammonium nitrate was applied at a rate of 150 kg/fed, at three equal doses. Corn (*Zea maize* L.cv huper 310) seeds were planted in the same plots after the wheat crop. The corn plants were thinned when they were 25 cm tall. The plots received ammonium nitrate at the rate of 200 kg/fed in four equal doses every 15 days.

Crop water requirement was calculated after FAO (1977). Irrigation was carried out using ground water (GW) and drainage water (DW) alternatively using the following irrigation treatments (DW/GW: 0/all, 1/3, 2/2, 3/1 and all/0). The experiments were completely a randomized block design. After harvesting each crop, the water intake into the soil was measured using the double wall ring infiltrometer after Bertrand (1965).

Results and Discussion

Table 1 indicates the source and characteristics of water used in irrigation. Data clearly show that the EC (dSm^{-1}) and total soluble ions (meq/l) of drainage water exceed that of the ground one, while the pH and HCO_3^- are the same. Based on data of Table 1 it is expected that irrigating soil using 100 % drainage water would lead to the following changes: + 59.7 % in potential salinity, - 17.3 % in the permeability index. +42.3 % in total salinity, -19.7 in Na %, +36.3 % in EC. and +53.6% in total soluble ions, relative to using 100 % ground water in irrigation. These changes would differently affect the water intake into soil.

TABLE 1. Irrigation water source and characteristics.

Irrigation water	pH	EC (dSm^{-1})	Soluble cations meq/l						Soluble anions meq/l				SAR	Adj. SAR	ESP	Potential salinity	Permeability index
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Total	Na %	CO_3	HCO_3	Cl^{-}	SO4					
Ground	8.22	0.80	1.50	2.00	3.63	0.01	7.14	50.8	-	3.00	3.75	0.40	2.79	5.30	2.78	3.95	75.2
Drainage	8.21	1.09	3.80	1.85	5.25	0.07	10.97	47.9	-	3.00	4.65	3.32	3.13	6.26	3.24	6.31	64.1

Data of the effects of using DW/ GW alternatively in irrigation on water intake rate into soil are given in Table 2 and illustrated graphically in Fig. 1. Since the exponent of time is negative with the intake rate I and positive with the accumulated intake rate (D), the 1st decreased while the 2nd increased with time (Table 2). The decrease in I with time may be attributed to one or more of the following reasons, i) occurrence of a water column above the soil surface may have hindered escaping of the trapped air bubbles, ii) an inevitable decrease in the matric gradient constituting one of the main forces drowning water into the soil which usually occurs as water intake proceeds, iii) large easily accessible pores in the soil may have been filled with water before other pores, iv) fine soil particles from the surface layer may have been washed into the lower soil layers plugging up some of their pores, and v) breakdown soil aggegates due to increasing trapped air pressure in some pores (Tayel *et al.*, 2001).

Data in Table 2 and Fig. 1 elucidate that water intake rate in the all irrigation treatment was less than that in the all/0 treatment for all crops. Other irrigation treatments occupied intermediate positions. This may be attributed to the changes mentioned above that took place as a result of soil solution concentration by the evapotranspiration process.

The resonse of the basic intake rate to irrigation treatments was similar to that of the intake rate *i.e.* it increased by 50% and 70 % in irrigation treatments DW/GW: 1/3 and 2/2, respectively then it decreased by 40% in the irrigation treatments 3/1 and all/0 relative to the 0/all treatment after wheat. On the other hand, the changes in the basic intake rate in the irrigation treatments 1/3, 2/2, 3/1 were +30, +40, -25, -30 % in the irrigation, respectively, relative to the 0/all treatment after corn.

The final water intake rate is important in irrigation system design. Caution should be taken under light frequent irrigation since the irrigation process may be completed before the final intake rate is reached (Tayel *et al.*, 2001). It is interesting to note that all the studied parameters were higher after corn than wheat for all irrigation treatments. This may be due to one or more of the following; i) the higher temperature during summer season decreased water viscosity which led to higher water intake, ii) decomposition of the proceeding wheat fibrous roots improved soil aggregation under corn, iii) corn roots are quite

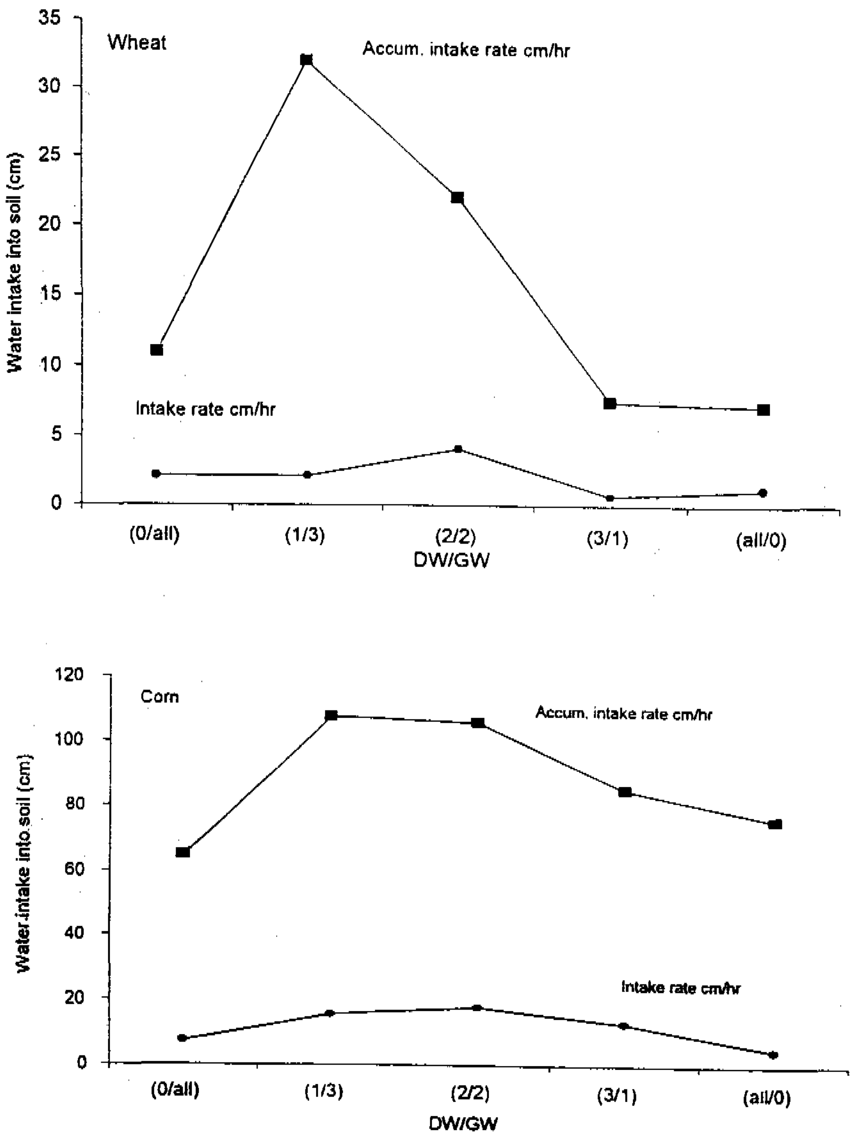

Fig. 1. Effect of using drainage and ground water (DW/GW) alternatively for irrigation on basic water intake into soil after wheat and corn crops.

TABLE. 2. Effect of using drainage and ground water alternatively in irrigation on water intake into soil after wheat and corn crops.

Irrigation treatment GW/DW	Water $^{+}$%	Crop	Equation	R^2	Basic IR^{++} (cm/h)
0/all	16.42	Wheat	$I = 27.212\ t^{-0.4912}$	0.7835**	2.12
			$D = 0.568\ t^{0.5650}$	0.9946**	
1/3	13.73		$I = 99.830\ t^{-0.7439}$	0.8750**	2.10
			$D = 0.263\ t^{0.9256}$	0.9737**	
2/2	20.81		$I = 62.688\ t^{-0.5258}$	0.9210**	4.09
			$D = 0.984\ t^{0.5925}$	0.9904***	
3/1	22.36		$I = 17.686\ t^{-0.6211}$	0.9267**	0.70
			$D = 0.162\ t^{0.7230}$	0.9915***	
All/0	19.74		$I = 9.033\ t^{-0.2839}$	0.8932**	1.17
			$D = 0.119\ t^{0.7688}$	0.9979***	
0/all	14.22	Corn	$I = 322.510\ t^{-0.7257}$	0.9473***	7.45
			$D = 4.219\ t^{0.5283}$	0.9995***	
1/3	13.21		$I = 244.520\ t^{-0.5296}$	0.9504**	15.63
			$D = 2.801\ t^{0.7023}$	0.9978***	
2/2	15.64		$I = 205.370\ t^{-0.4734}$	0.9812***	17.57
			$D = 2.627\ t^{0.7118}$	0.9981***	
3/1	18.38		$I = 227.700\ t^{-0.5546}$	0.7160***	12.78
			$D = 2.969\ t^{0.6469}$	0.9943***	
All/0	19.00		$I = 370.610\ t^{-0.8383}$	0.9333***	4.77
			$D = 3.967\ t^{0.5087}$	0.9746***	

+ at the depth of 30 cm ++ = After 3 hours I = Intake rate (cm/h) D = Accumulated rate (cm /h)

different in their nature than those of wheat, iv) the initial soil water after wheat crop was higher than that after corn at the time of measuring water intake rate into the soil, and v) increasing soil salinity due to the residual effect of using the same treatments in winter. Soil EC varied between 0.61-0.95 and 0.97-1.65 dSm^{-1} at the end of the winter and summer seasons, respectively according to irrigation treatment (El-Dardiry, 2001).

Under similar conditions it could be concluded that using irrigation treatments DW/GW 1/3 and 2/2 would increase water intake into the soil and conserve 33 and 50 % of our ground water resources, respectively.

References

Agassi, M., Shainberg, I. and Morin, J. (1981) Effect of electrolyte concentration and soil sodicity on infiltration rate and crust formation. *Soil Sci. Am. J.*, **45** : 848 .

Bertrand, A.R. (1965). Rate of water intake in field. Methods of soil analysis. (part 1) page 197-209. *Am Soc. of Agronomy* (Inc.) Madison, Wisconson, USA. (Black, C.A. ed.)

El-Drdiry, E.E. (2001) Re-use of agricultural drainage water and its effect on soil and plant. *Ph.D. Thesis,* Fac. Agric., Univ. of Zagazig, Benha Branch,Egypt.

FAO (1977) Crop water requirements. *Irrigation and Drainage,* paper **24,** Rome. 144 pages.

Frankel, H., Goertzen, J.O. and Rhoades, J.D. (1978) Effects of clay type and content of exchangeable sodium percentage, and electrolyte concentration on clay dispersion and soil hydraulic conductivity. *Soil Sci. Soc. Am.J.* **42**, 32

Ghazy, A. (1977) Moisture characteristlcs and physical properties of calcareous soils. *Ph.D. Thesis* , Fac. Agric., Univ. of Ain Shams, Cairo, Egypt.

Helalia, A.M., Letey, J. and Graham, R.C. (1988) Crust formation and clay migration effects on infiltration rate. Soil Sci. *Soc. Am . J.* **52**. 251.

Kandil, N.F. (1990) Effect of using drainage water on soil physical, chemical and hydrological properties in some soils of Egypt. *Ph.D. Thesis,* Fac. Agric., Cairo Univ., Egypt.

Marshall, T.J. (1968) Some effects of drag on structure and hydraulic conductivity of soil. *Trans. 9th Int.Congr. Soil Sci. Adelaide* 1, 213.

Omar, M.S. and Aziz, M.A. (1982) The use of saline irrigation water: Its effect on soil properties and plant growth. II -Water Movement. *Egypt . J . Soil Sci.* **22** (3). 265 .

Oster, J.D., and Schroer, F.W. (1979) Infiltration as influenced by quality of irrigation *water. Soil Sci. Soc. Am. J.* **43**, 444.

Postiglione, L., Barbieri, G and Tedeschi, A. (1995) Long-term effects of irrigation with saline water on some physical and chemical characteristics of a clay loam soil. *Rivista-di- Agronomia*, **29** (1), 24.

Shainberg, I., Rhoads ,J.D. and Prather, R. (1981) Effects of low electrolyte concentration on clay dispersion and hydraulic conductivity of sodic soil. *Soil Sci. Soc. Am. J.* **45** 273 .

Tayel, M.Y.,Abdel Salam, A.A. and Abdel Hameed, M.A. (2001) Evaluation of sprinkler irrigation system under El-Falouga area conditions. 1-Hydrophysical soil characteristics. *Egypt. J. Soil Sci.* **41** (3) , 297.

(Received 7 / 2002)

طرق إستخدام مياه الصرف الزراعى فى الرى
٢- تأثيرها على معدل دخول الماء للتربة

محمد يوسف طايل ، محمد عبد الهادى عبد الحميد و إبتسام إبراهيم الدرديرى
قسم الأراضى وإستغلال المياه ، المركز القومى للبحوث- القاهرة - مصر .

أجريت تجربة فى الحقل لدراسة تأثيرات استعمال مياه الصرف الزراعى على معدل دخول الماء للتربة . وضعت التربة تحت الدراسة فى تقسيم(*Typic torrieorthint*) . زرعت التربة قمحا فى الموسم الشتوى أتبعت بالذرة الشامية فى الموسم الصيفى . استخدم فى رى المحصولين مياه الصرف الزراعى بالتناوب مع المياه الجوفية. وتشير النتائج إلى أنه يجب استعمال مياه الصرف الزراعى بالتناوب مع المياه الجوفية . وبالنظر إلى معدل النفاذية فكانت أفضل المعاملات هى : ٣/١ و ٢/٢ وذلك لأنها تزيد من معدل دخول الماء للتربة وتوفر ٣٣ و ٥٠٪ من مصادر مياهنا الجوفية ، على الترتيب .