IMPACT OF DIFFERENT WATER QUALITIES ON SOME SOIL PHYSICAL PROPERTIES

IMPACT DES DIFFERENTES QUALITES D'EAU SUR CERTAINES PROPRIETES PHYSIQUES DU SOL

Mohammad Reza Emdad[1]

ABSTRACT

The quality of irrigation water (Salinity & Sodicity) can significantly affect the soil structural properties. While the effect of electrolyte concentration (EC) and sodium adsorption ratio (SAR) have been studied under laboratory conditions, reports of field investigations are few. In this paper, water with three different levels of sodium (SAR = 0.9, 10, 30) was applied as alternative treatments to a clay loam soil in furrow irrigation. Soil physical properties as surface and subsurface bulk density and Mean Weight Diameter (MWD) and the basic infiltration rate of the soil were measured. Increase in the SAR of the applied water was found to reduce aggregate stability, increase the bulk density of both the surface crust and underlying soil. MWD in the moderate and high saline-sodic treatments decreased, respectively, by about 17% and 53% during the irrigation season compared to control. Also, bulk density in surface layer increased by about 4% and 7%, respectively, with using moderate and high sodic treatments. Both of these results indicate the impact of high SAR_{iw} *on the collapse of soil structure and soil dispersion. At the end of the season, the soil basic infiltration rate in Control treatment decreased by about 34% as compared to the beginning. For the moderate and high sodic treatments, the decrease was, respectively, about 45% and 61% during the season.*

Key words: *Water quality, soil physical property, alternate wetting and drying, surface sealing, Iran.*

RESUME ET CONCLUSIONS

Afin de déterminer les effets de différentes qualités d'eau (salinité et de sodicité) sur le taux d'infiltration du sol de base et certaines propriétés physiques du sol dans l'irrigation par rigoles ce travail a été fait dans l'état du terrain. Le sol sur le site du procès avait une texture loam argileux avec du sable 27%, limon 46% et 27% d'argile. qualités d'eau d'irrigation ont

1 Scientific member of Soil and Water Research Institute of Iran. Karaj. Email: emdadmr591@yahoo.com

été appliqués à trois niveaux différents en tant que traitement CE-SAR faible (de commande avec CE = 0,6 dS / m et SAR = 0,9), traitement modéré CE-SAR (CE = 2,0 dS / m et SAR = 10) et de haute CE traitement SAR (CE = 6,0 et SAR = 30). Le travail de première instance se composait de 27 irriguées sillons avec 0,75 m espacement. Les lits ont été plantés avec du maïs. À cet égard, propriétés physiques du sol que la densité apparente de surface, la densité apparente du sous-sol, le poids moyen diamètre qui est un indice de stabilité des agrégats et le taux d'infiltration dans le sol de base ont été mesurées. En outre, les propriétés chimiques du sol, y compris, la conductivité électrique de saturation du sol extrait, pH, des cations (Ca^{++}, Mg^{++}, Na^{+}) et anions (Cl^{-}, SO4 =, $HCO3^{-}$), ainsi que d'adsorption du sodium Ratio ont été mesurée. taux d'infiltration du sol de base a été mesuré avec la méthode d'entrées-sorties. Les résultats ont montré que le taux d'infiltration de base ont diminué au cours de la saison. À la fin de la saison, le taux d'infiltration du sol de base dans le traitement de contrôle a diminué d'environ 34% par rapport au début. Pour les traitements modéré et élevé sodique, la baisse a été, respectivement, environ 45% et 61% au cours de la saison. taux d'infiltration de base a montré une tendance à réduire de façon significative avec les événements d'irrigation durant toute la saison. diamètre moyen pondéré de tous les traitements ont montré une réduction significative avec le temps long de la saison. MWD dans les traitements modéré et élevé salins-sodiques ont diminué, respectivement, environ 17% et 53% au cours de la saison d'irrigation par rapport au témoin. En outre, la densité apparente dans la couche de surface a augmenté d'environ 4% et 7%, respectivement, avec l'aide de moyen et élevé des traitements de début sodique. Ces deux résultats indiquent l'impact de la hausse SARiw sur l'effondrement de la structure du sol et la dispersion du sol. En tant que tel, l'augmentation de la CE de notre support n'a pas été suffisamment important pour empêcher les effets néfastes des SARiw sur la propriété d'infiltration du sol. Nous avons conclu que la théorie généralement acceptée que la hausse de la salinité de l'eau d'irrigation peut réduire les impacts négatifs de SARiw haute sur le processus d'infiltration n'est pas toujours valable. En d'autres termes, il ya probablement un certain équilibre entre ces deux paramètres de qualité de l'eau par rapport à leurs impacts positifs et négatifs sur le processus d'infiltration. Dans cette expérience, les concentrations de sodium supérieures ont dépassé les effets positifs de la concentration en sel plus élevée total de l'eau d'irrigation.

Mots clés: *Qualité d'eau, propriété physique du sol, méthode alternée d'humidification et de séchage, scellement superficiel du sol, Iran.*

(Traduction française telle que fournie par les auteurs)

1. INTRODUCTION

In much of the arid and semi arid regions, the salts present in irrigation water are mainly the chlorides, sulfates, carbonates, and bicarbonates of calcium, magnesium, sodium and potassium. While salinity can improve soil structure, it can also negatively affect plant growth and crop yields. Irrigation with water containing excess amounts of sodium can adversely impact soil structure making it difficult for plant growth. Highly saline and sodic water qualities can cause problems for irrigation, depending on the type and amount of salts present, the soit type, the specific plant species and growth stage, and the amount of water that is able to pass through the root zone.

Under field conditions, irrigated soils are exposed to sequential periods of rapid wetting followed by drying. Soils which are subjected to these wetting and drying cycles have been found to exhibit low aggregate stability resulting in the release of colloidal material and the collapse of soil pores (Levy and Miller1997, Caron et al 1992; Rasiah et al 1992). However, the quality of the irrigation water applied will also affect the soil chemical properties which influence soil dispersion and aggregate breakdown, surface sealing and crust formation (Shainberg and Letey, 1984). Few workers have been able to distinguish the physico-chemical impacts associated with the quality of the water applied (e.g. dispersion) from the physical impacts associated with wetting and consolidation.

Under furrow irrigation, water quality affected soil cohesivity by altering clay dispersion and aggregate stability characteristics (Smith et al 1992, Malik et al 1992, Shainberg et al 1992).

Hence the objective of the work reported in this paper is to evaluate the effect of irrigation water quality (Salinity and Sodicity) on the soil structure properties under field conditions.

2. MATERIAL AND METHODS

The soil at the trial site has a uniform clay loam texture. The trial work consisted of setting up 27 furrows (three water quality treatments with three replication) with a spacing of 0.75m, length of 30m and a slope of 0.01%. The beds were planted with maize and divided into nine plots.The soil properties is shown in Table 1.

Table 1. Soil physical and chemical properties in trial site(propriétés physiques du sol et chimiques dans le procès de site)

Sand	Silt	Clay	K	p	CEC Meq (100g)	pH	EC $(dS.m^{-1})$	Depth (cm)
%			$mgkg^{-1}$					
29.2	45.4	25.4	204	8.2	13.0	7.9	0.56	0-30
25.2	47.4	27.4	128	3.6	13.0	7.9	0.95	30-60
SAR		Anions $(meq.l^{-1})$			Cations $(meq.l^{-1})$			Depth (cm)
		Cl^-	HCO_3^-	$SO_4^=$	Ca^{++}	Mg^{++}	Na^+	
0.92		5.0	2.8	0.7	3.6	3.2	1.7	0-30
1.16		4.0	2.4	8.0	6.4	5.2	2.8	30-60

Irrigation water was applied to all plots at the same time on 12 occasions during the season. No rainfall was received during the trial. Irrigation water of three qualities were applied: low EC-SAR (LS: EC=0.6 dSm^{-1} and SAR=0.9, LS), moderate EC-SAR (MS: EC=2.0 dSm^{-1} and SAR=10) and high EC-SAR (HS: EC=6 dSm^{-1} and SAR=30).

The development of a surface seal was identified by measuring the density of the soil formed by irrigation and the change in bulk density within the profile. To meaure the surface seal density, two samples of the seal layer(0-5cm) were removed as clods from each treatment and oven dried at 100 °C for 2 days.The clods were then coated in paraffin and volume displacement method was used to determine their densities (Blake and Hartge 1986).

Bulk density was measured using a core (diameter = 5cm) sampler. The bulk density at the end of season was measured on the soil below the apedal surface layer (5-20cm). Changes in the aggregate stability at the surface soil was assessed using the wet sieve method (Kemper and Rosenau 1986). Surface soil samples were collected both before the first irrigation and after the last irrigation and crushed to pass through a 4.6 mm sieve. A 50g soil sample was put on the top mesh of sieve nest and immersed in distilled water.The sieves were then oscillated through a vertical distance at a rate of 30 rpm for a period of 10 min. The results are presented as the mean weight diameter (Youker and McGuinnesss 1956).

Analysis of variance (ANOVA) was done prior to the calculation for the soil physical data.

3. RESULTS AND DISCUSSION

The values of mean weight diameter(MWD), which is an index of wet aggregate stability were analysed in the end of the season.

The values of mean weight diameter using different water qualities are grouped in different classes (level of significancy<0.01). This results shows that with increasing SAR values in irrigation water, mean weight diameter decreased rapidly.

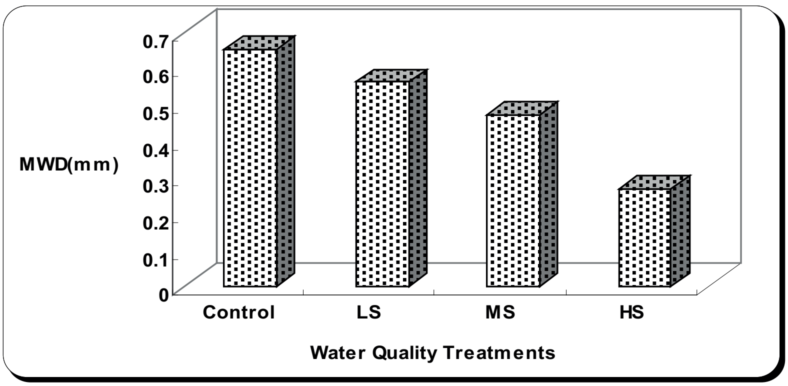

Fig. 1. Effect of water qualities on mean weight diameter(Effet de qualités d'eau sur le diamètre poids moyen)

Mean weight diameter in all treatments showed a significant reduction with time through the season (**Fig. 1**). MWD in the moderate and high saline-sodic treatments decreased respectively, by about 17% and 53% during the irrigation season compared to control (MWD in the beginning). The aggregate stability of the surface soil decreased during the season with the application of the low EC-SAR water. However, the application of the high EC-SAR water was associated with a decrease in MWD (0.267mm) to less than half of that measured for the soil irrigated with the low EC-SAR water (0.563 mm).

Exchangeable sodium percentage (ESP) and electrolyte concentration (EC) of the soil solution play a significant role in determining soil physical properties and the response of soil clays to dispersion and swelling using waters with high SAR.

Also bulk density analysis in surface (0-5cm) and subsurface (5-20cm) showed that high SAR waters caused increasing bulk densities in both surface and subsurface layer (**Table 2**).

Table 2. Variation of surface and subsurface bulk densities (Variation de la surface et la densité apparente du sous-sol)

	Surface layer ($g.cm^{-3}$)	Subsurface layer ($g.cm^{-3}$)
Control *	1.38 a	1.33 a
LS	1.41 a	1.33 a
MS	1.44 ab	1.35 ab
HS	1.48 b	1.39 b

* : Measurement in the beginning

Bulk densities in surface layer increased by about 4% and 7%, respectively, with using moderate and high sodic treatments than beginning. Increasing bulk densities(Surface and subsurface) and decreasing mean weight diameter indicate the impact of higher SAR_{iw} on the collapse of soil structure and soil dispersion. The density of the soil (5-20 cm) underlying the apedeal surface layer was related to the EC-SAR of the irrigation water with the high EC-SAR treatment showing a statistically significant higher density of 1.39 $g.cm^{-3}$ compared to 1.33 $g.cm^{-3}$ for the low EC-SAR treatment. Hence, the processes of structural breakdown in the layer are influenced by the chemical changes within the profile.

Sodium has the opposite effect on soils than what salinity does. The primary physical process associated with high sodium concentrations in soil is dispersion. Soil dispersion results from the breakdown of soil aggregates in water, leaving clay particles to disperse and settle into soil pore spaces between soil (aggregate breakdown and increase bulk density).

The relation between ESP and subsurface bulk density of soil is shown in **Fig. 2.** Bulk density increased linearly with increase in exchangeable sodium percentage.

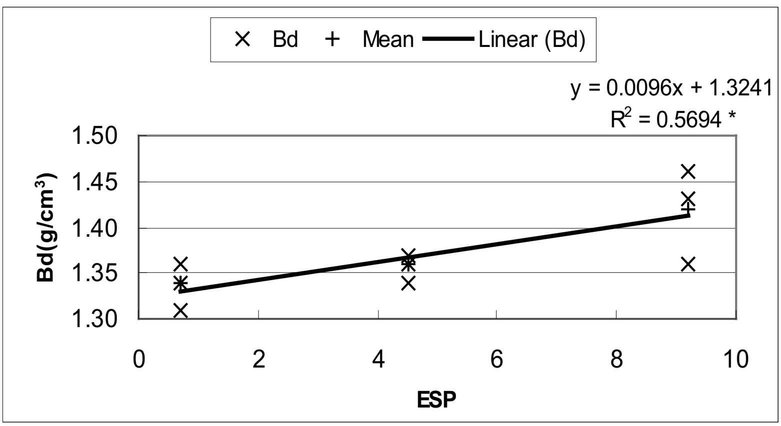

Fig 2. Relation between ESP and subsurface bulk density(Relation entre ESP et la densité apparente du sous-sol)

At the end of season, the soil basic infiltration rate in Control treatment decreased about 34% as compared to the beginning. For the moderate and high sodic treatments, the decrease was, respectively, about 45% and 61% during the season.

4. CONCLUSIONS

Irrigation water quality has been found to significantly affect soil physical properties. These changes occurred in the presense of high solute concentrations normally associated with maintaining soil aggregate stability and continued throughout the irrigation season. Soil dispersion causes clay particles to plug the soil pores, decrease the mean weight diameter and increase bulk densities. Salinity and sodicity affect soil structure, which must be stable for adequate permeability and water infiltration. High sodium levels combined with low soil-water electrical conductivity can lower a soil's permeability through the swelling and dispersion of clays and the slaking of the aggregates.

REFERENCES

Blake ,G. and K. Hartge.1986. Bulk density. In: Klute A (ed) Methods of soil analysis. Part 1: physical and minerological methods. (Monograph no. 9, 2nd edn) ASA, Madison, Wis:363-375.

Caron, J., B. Kay and J. Stone. 1992. Improvement of structural stability of a clay loam with drying. Soil Science Society of America Journal 56: 1583-1590.

Kemper, W. and RC. Rosenau. 1986. Aggregate stability and size distribution. In: Klute A (ed) Methods of soil analysis. Part 1: physical and minerological methods. (Monograph no. 9, 2nd edn) ASA, Madison, Wis.

Levy, G. and W. Miller. 1997. Aggregate stability of some southern US soils. Soil Science Society of America Journal 61: 1176-1182.

Malik, M., M.A. Mustafa, and J. Letey. 1992. Effect of mixed Na/Ca solutions on swelling, dispersion and transient water flow in unsaturated montmorillonitic soils. Geoderma. 52:17-28.

Rasiah, V., B. Kay and T. Martin. 1992. Variation of structural stability with water content: Influence of selected soil properties. Soil Science Society of America Journal 56: 1604-1609.

Shainberg, I. and J. Letey. 1984. Response of soils to sodic and saline conditions. Hilgardia 52(2): 1-57.

Shainberg, I., D. Warrington, and J.M. Laflen. 1992. Soil dispersibility, rain properties, and slope interaction in rill formation and erosion. Soil Sci. Soc. Am. J. 56:278-283.

Smith, G., J.L. Foley, and R.J. Loch. 1992. Effects of electrical conductivity of water used in wetting and in wet sieving on measured aggregate water stability. Soil Technol. 5:177-184.

Youker, RE. and J. McGuiness. 1956. A short method of obtaining mean weight diameter values of aggregate analyses of soils. Soil Sci 83:291-294.