IOP Conf. Series: Earth and Environmental Science 208 (2018) 012062 doi:10.1088/1755-1315/208/1/012062

Effect of Brackish Water Irrigation on soil Water-salt Distribution

Xiaoyu Mu, Jinliang Yang, Dengliang Zhao, Yanming Feng, Hanbing Xing, Guibin Pang *

School of Water Conservancy and Environment, University of Jinan, Jinan, China.

*Corresponding author e-mail: stu_panggb@ujn.edu.cn

Abstract. The experiment of winter wheat brackish water irrigation was carried out in Xiawa Town, Zhanhua District, Shandong Province from 2015 to 2016. Four different irrigation schemes were designed by using fresh water and brackish water of salinity of 3.0g/L. The effect of brackish water irrigation on the distribution of water-salt in saline alkali soil was studied. The results showed that the soil water content of three times irrigation could reach 12.5% ~ 19.9%, while that of twice irrigation could only reach 10.8% ~ 13.6% and the salt accumulation of the scheme of fresh water + fresh water + brackish water was 0.0552g/kg, which indicated that this scheme could not only supplement soil water but also accumulate less salt.

1. Introduction

The Yellow River Delta is located in the eastern part of Shandong Province. Because of the restriction of natural environment, the surface water resources of the Yellow River Delta are scarce and the groundwater is mainly saline water and brackish water. The Yellow River is the most important fresh water source in the region, resulting in the great pressure of regional water supply[1]. It is an effective way to alleviate the water shortage by exploiting and developing water-saving technologies and developing substitute water resources (such as brackish water) for farmland irrigation[2]. If the brackish water is exploited and utilized in this area, it can not only provide the water needed for the growth of crops and save fresh water resources, but also reduce the groundwater table and alleviate the problem of soil salinization[3]. According to the local irrigation habits, this paper designs different irrigation combinations to study the effect of brackish water irrigation on soil water-salt distribution and to find a reasonable brackish water irrigation scheme, which is of great significance for the development and utilization of local underground saline water resources and the development of local irrigation agriculture.

2. Materials and Methods

2.1. Research area

The research area is located in Zhangwang Village, Zhanhua District, Shandong Province (117 45 E - 118 21 E , 37 34 N - 38 11 N). The test area is in a warm temperate zone with a semi-humid continental monsoon climate and the annual mean temperature is 12℃. The precipitation shows great inter-annual variations, and the rainy season is from June to August with an annual average precipitation of 575 mm and the average annual evaporation-to-precipitation ratio is 3.22. The rainfall during the 2015-2016 years of wheat growth is shown in Table 1. The depth of groundwater table is 2-3 m in the research area and the shallow groundwater is saline water with the salinity of 5-10 g/L. The average salinity of 0-40 cm soil is 2.11 g/kg, which belongs to moderate saline-alkali land. The physical and chemical properties of soil are as Table 2.

Table 1. Rainfall of winter wheat growing season.

Time	10	11	12	1	2	3	4	5
2015-2016 /mm	7.9	68.4	0.2	2.7	16.7	0.5	10.1	32.6

Table 2. Physical and chemical properties of soil.

Soil layer /(cm)	Bulk density /($g\cdot cm^{-3}$)	pH	Cl^- /($g\cdot kg^{-1}$)	K^+ /($g\cdot kg^{-1}$)	Na^+ /($g\cdot kg^{-1}$)	Total salt content /($g\cdot kg^{-1}$)	Soil properties
0~20	1.39	7.3	0.51	0.1	0.14	1.36	Loam
20~40	1.33	7.13	1.95	0.08	0.24	2.86	Sandy loam
40~60	1.32	7.07	0.76	0.08	0.23	1.56	Sandy loam
60~80	1.36	7.03	0.25	0.07	0.12	0.78	Loamy sand
80~100	1.46	7.03	0.27	0.06	0.14	0.85	Loam

2.2. Research Methods

2.2.1. Experimental design. Four experimental treatments (Table 3) were set up in the test field, each of which had three replicates, totaling 12 experimental plots with an area of 3 m*6 m, and arranged randomly. In order to avoid the interference of seepage, films are used as water barrier between different plots, and a protection area is set around the test field.

Table 3. Experimental schemes of brackish water irrigation for winter wheat.

Treatment	Volume of irrigation /mm	Green stage~Jointing stage /mm	Jointing stage~Heading stage /mm	Heading stage~filling stage /mm
T1	240	80(fresh water)	80(fresh water)	80(fresh water)
T2	160	80(fresh water)	80(fresh water)	0
T3	240	80(fresh water)	80(brackish water of salinity of 3g/L)	80(brackish water of salinity of 3g/L)
T4	160	80(fresh water)	80(brackish water of salinity of 3g/L)	0

Winter wheat was planted on Oct. 8, 2015 and the growth period was 249 days. In seedling stage, because the roots of winter wheat were short and sensitive to salt content[4], fresh water irrigation was used in turning green and jointing stage. Brackish water and fresh water combined irrigation was used in jointing-heading and heading-filling stage. The source of irrigation water came from shallow groundwater in the test area. A set of desalination device was installed in the test area. The desalinated water was directly used as fresh water source and the brackish water used for irrigation, whose salinity is reduced to 3g/L, was the mixture of shallow groundwater and fresh water source[1].

2.2.2. Sample collection and treatment. Before and after irrigation, before planting and after harvest, soil samples were collected at different depth from 0~20cm, 20~40cm, 40~60cm, 60~80cm and 80~100cm respectively to determine the soil salt and water content. The observed items include soil water content, soil salt content and electrical conductivity. Soil water content is measured by drying and weighing. The salt content and electrical conductivity of soil were determined by soil extract with water-soil ratio of 5:1, and the specific operation was referred to *Soil Agrochemical Analysis Method* [5].

3. Results and Analysis

3.1. Soil moisture content change

Vertical analysis of the soil showed that the change of water content in the surface layer (0-30cm) was more obvious (Figure1). After the first irrigation (2016.3.11), the soil moisture content of T2's 0-20cm soil layer increased by 6.24%, 20-40cm increased by 1.89%, 40-60cm increased by 0.04%, 60-80cm increased by 0.67%, 80-100cm increased by 0.61%. This is mainly due to the effects of irrigation, rainfall and evaporation on the upper soil [6].

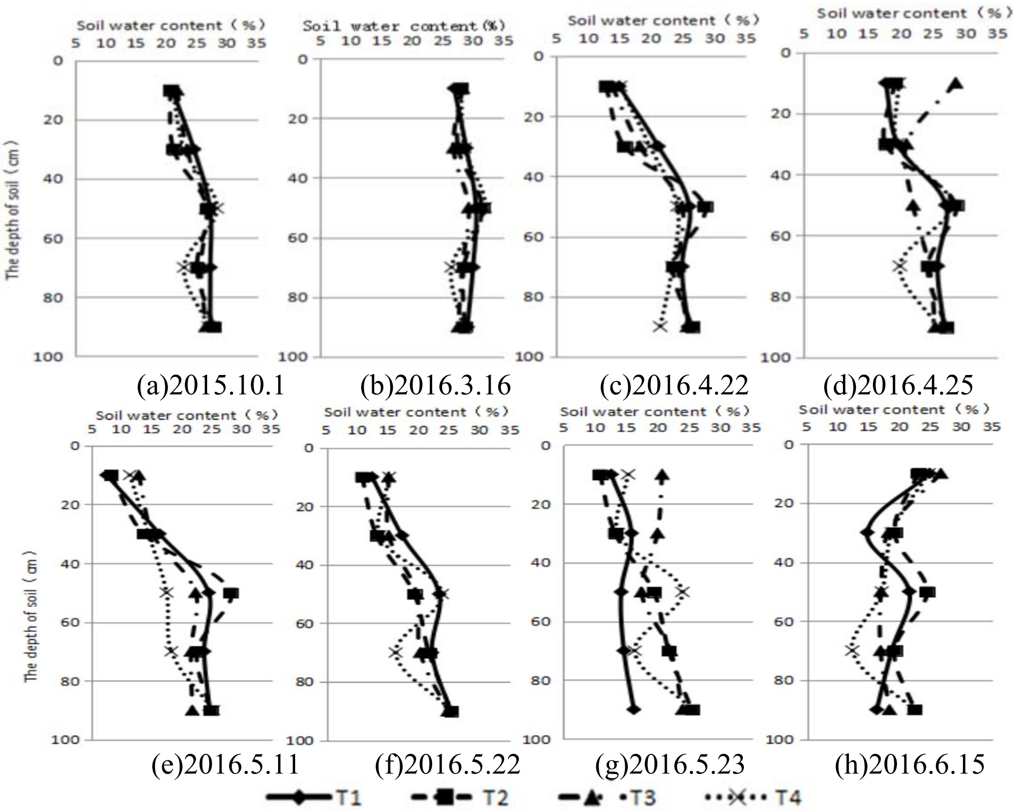

Figure 1. soil water content in 2015~2016

From the first irrigation to the second irrigation (2016.4.21), the surface soil moisture content decreased significantly, which was due to less rainfall in spring and the evaporation of soil moisture. After the second irrigation, although T3 was irrigated with brackish water, the degree of soil water supplement was basically the same as that of fresh water irrigation. After the third irrigation (2016.5.15), the surface soil moisture content of T1 and T3 reached 12.5%-19.9%, while that of T2 and T4 could only reach 10.78%-13.64% because of no irrigation. With the same irrigation volume, T3 can not only ensure suitable soil moisture to maintain crop growth, but also save fresh water resources.

3.2. Soil salt content change

From the results of Figure 2, we can see that the salt content of surface soil is greatly affected by irrigation, rainfall and evaporation, and the change is more obvious than that of deep soil. Before the beginning of the experiment, the salt content of the surface soil was higher than that of the bottom soil. This is because the experimental area has been in a state of drought. No rain and less irrigation result in the groundwater decline, and the strong evaporation makes the soil salinity show a trend of surface accumulation[7].

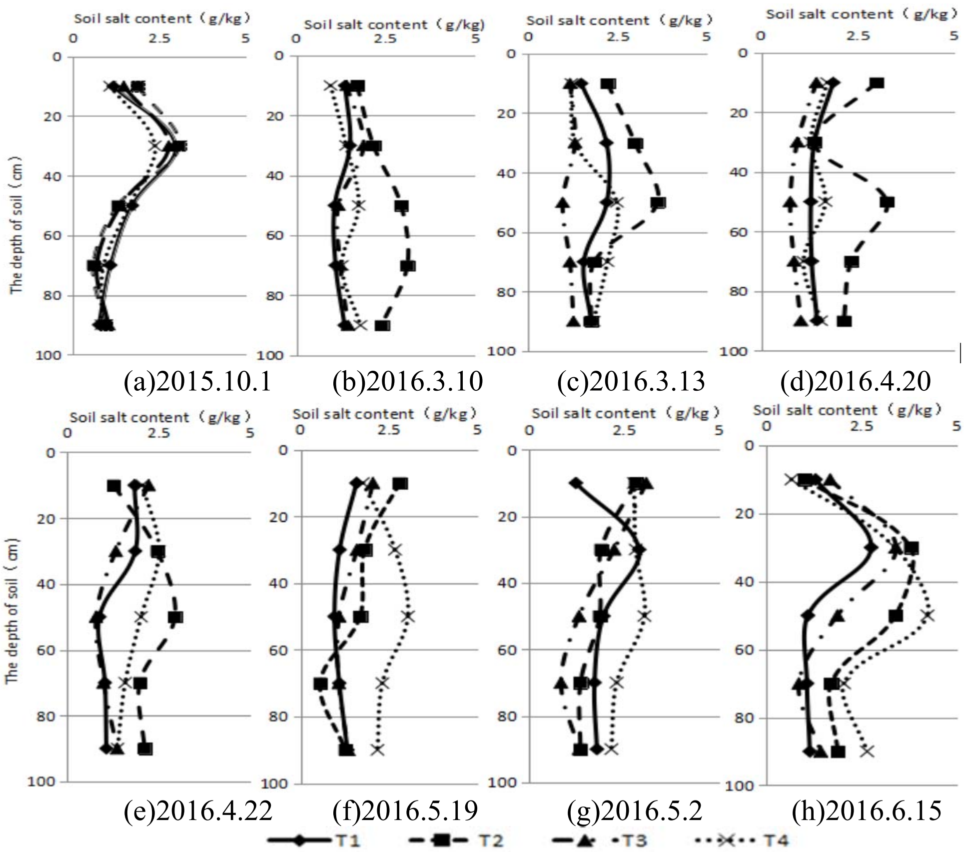

Figure 2. soil salt content in 2015~2016

From the first irrigation to the second irrigation, the soil surface appears obvious salt concentration phenomenon due to little rain in spring and the strong evaporation. After the second irrigation, the salt content of T3 and T4's the soil surface increased because of brackish water irrigation. The soil salt content of T3 and T4's 0-20cm increased by 0.8g/kg and 0.34g/kg respectively, and the soil salt content of T3 and T4's 20-40 cm increased by 0.39g/kg and 1.22g/kg respectively. The soil salt content of T1 and T2 decreased due to fresh water irrigation. In the third irrigation, the soil salt content of T1 decreased significantly, while that of T3 treated with brackish water increased. The soil salt content of T2 and T4's surface showed obvious salt concentration. After the harvest of winter wheat, the area entered the rainy season and the rainfall significantly reduced the soil salt content of the soil surface.

3.3. Analysis of soil salt accumulation and loss

According to table 4, during the growth period from 2015 to 2016, the soil salt content of T1 decreased by 0.053 g/kg due to the use of fresh water. The accumulation of salinity showed different degrees in

T2, T3 and T4 and the accumulation degree was T3 < T2 < T4. In the past years, the salt accumulation of T3 was 0.0552g/kg and it's less than that of T2.

Table 4. Soil salt accumulation and loss in 2015~2016

		TI	T2	T3	T4
2015-2016	Initial salt content(g/kg)	1.53	1.544	1.458	1.346
	Final salt content(g/kg)	1.477	2.362	1.8544	2.599
	Annual variation(g/kg)	-0.053	0.818	0.3964	1.253

4. Discussion
Wu et al. studied at Nanpi Ecological Experimental Station and found that the effects of brackish water infiltration on soil structure was mainly due to the inhibition of crop water uptake. The salt accumulation in different degrees was found when 2-3times brackish water irrigation was carried out and the alternate irrigation should be used in combination irrigation with brackish water twice to avoid aggravating the salt accumulation in soil[8]. In this study, the inhibiting effect of brackish water irrigation on soil moisture content is not obvious, which is different from the previous research results. This may be because the soil particle in this test area is larger than that in the Nanpi test area and the soil of this test area has large pores, good ventilation and permeability, which are conducive to salt leaching. The inhibition effect of brackish water weakened. In this paper, T3 and T4 caused a certain amount of salt accumulation, but rainwater leaching will reduce salt accumulation in rainy season.

5. Conclusion
The water content of soil surface could reach 13.89% ~ 19.9% after irrigation with brackish water in T3 treatment and the final accumulation and loss of soil salinity was T1 < T3 < T2 < T4, which indicated that besides fresh water irrigation, the accumulation of soil salinity in T3 treatment was less. So in order to save freshwater resources, the irrigation scheme of freshwater-brackish water-brackish water with a long series of experimental analysis and good salt drainage measures can be applied to saline-alkaline areas.

Acknowledgments
This work was financially supported by The National Key Research and Development Program of China (NO. 2017YFD0800601) and Natural Science Foundation of China (NO. 51509105)

References
[1] Wang Haixia, Xu Zhenghe, Pang Guibin, et al. Effects of brackish water irrigation on soil water and salt distribution and winter wheat growth[J]. Journal of Soil and Water Conservation, 2017, 3(7):291-297.
[2] Ayars J E, Schoneman R A, Dale F, et al. Managing subsurface drip irrigation in the presence of shallow ground water[J]. Agricultural Water Management, 2001, 47(3):243-264.
[3] Ahmed C B, Magdich S, Rouina B, et al. Saline water irrigation effects on soil salinity distribution and some physiological responses of field grown Chemlali olive[J]. Journal of Environmental Management, 2012, 113(1):538-544.
[4] Chen L J, Feng Q, Li F R, et al. A bidirectional model for simulating soil water flow and salt transport under Mulched Drip Irrigation with saline water[J]. Agricultural Water Management, 2014, 146(12):24-33.
[5] Lu Rukun. Soil agricultural chemistry analysis method[M]. Beijing: China Agricultural Science and Technology Press, 2000.1:87-89.
[6] Wang Shijing, Huang Guanhua, Yang Jianguo, et al. Effects of brackish water irrigation on soil water and salt dynamics and spring wheat yield[J]. Journal of Agricultural Engineering, 2010,

26(5):27-33.
[7] Jiao Yanping, Gaowei, Pan Zenghui, et al. Effects of brackish water irrigation on soil salinity dynamics and wheat and maize yield in Hebei low plain[J]. Agricultural Research in arid regions, 2013, 31(2):134-140.
[8] Wu Zhongdong, Wang Quanjiu. Field experiments on the effects of different brackish water combinations on soil water and salt distribution and winter wheat yield[J]. Journal of Agricultural Engineering, 2007, 23(11):71-76.