

A study on suitable groundwater use for irrigation in Luohui irrigation scheme, China

中国・洛惠渠灌区における地下水の適切な灌漑利用に関する研究

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1. Introduction Eastern part of Luohui irrigation scheme is located in southeastern part of Loess Plateau, China. Luohe River is the main water source of the scheme. There are three irrigation periods such as winter, spring and summer irrigation periods and then, river water is irrigated once during each period. Groundwater is also pumped from wells for supplementary irrigation. However, the quality of groundwater is not suitable for irrigation due to high EC in some areas. In this study, the authors estimate the amount of available groundwater for supplementary irrigation, which does not affect crops growth and yields.

2. Data collection Groundwater EC was measured at about 70 observation wells in the study area. EC of the river water was measured at the head works in Luohe River. Amount of irrigation water is referred from the seasonal report on irrigation schedule. The target crops are cotton, wheat, jujube, apple, pear, corn, apricot, and peach. Salt tolerance of each crop is referred from Ayers R.S. et al. (1985). The amount of river water supply in each irrigation period from 2004 to 2008 was collected from Water Management Bureau. The administrative districts of the study area are shown in **Fig.1**. Average precipitation during each irrigation period is calculated with 5 year data from 2005-2009. The area No.4 was divided into two parts (4-1 and 4-2), because EC of groundwater is greatly different between north and south part.

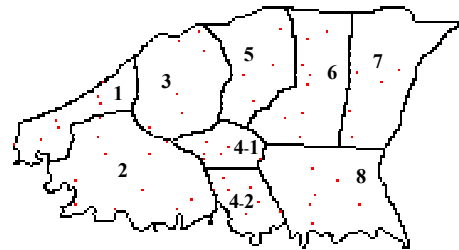


Fig.1 Administrative districts of the study area and locations of the observation wells (red dots)

3. Methodology In the study, we presupposed a crop yield is affected according to the following 2 assumptions; 1) total amount of irrigation water is less than designed irrigation water requirement, 2) EC of irrigation water, which is sum of river water and groundwater exceeds the salt tolerance of crops. Based on the assumptions, **Eqs. 1 and 2** are used for the calculation.

$$Wr + Wg \geq Wi \quad \dots(\text{Eq.1}) \quad \frac{(Wr + R) \times a + Wg \times b}{Wr + Wg + R} \leq T_{crop} \quad \dots(\text{Eq.2})$$

Where, Wi : amount of irrigation water (mm), Wr : amount of river water (mm), Wg : amount of groundwater (mm), R : amount of rainfall (mm), a : EC values of river water and rainfall (dS/m), b : EC value of groundwater (dS/m), T_{crop} : crop tolerance to salt (dS/m)

The straight line of Eq.1 in **Fig.2** is the lower bound of amount of irrigation water, and the straight line of Eq.2 is the upper bound of salt tolerance. Crops will not be affected in terms of both water and salt stresses if groundwater is used for irrigation within the range between these two lines. At first, three EC values are calculated such as EC_{max} , EC_{min} ,

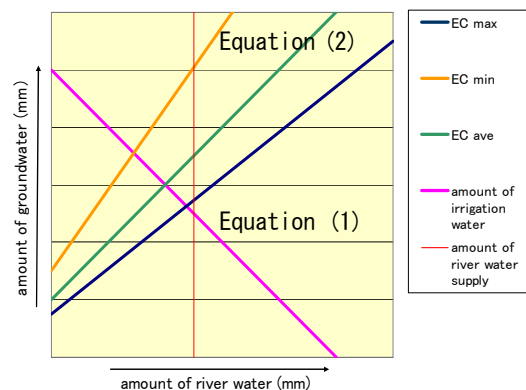


Fig.2 Calculation of quantity of available groundwater

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Keywords irrigation management, electric conductivity, salt tolerance

and EC_{ave} in each district from the EC of each observation well from the investigation that has been conducted since 2002. An inclination of Eq.2 in the figure becomes larger, as the EC is lower. The intersection of the straight line of Eq.1 and the straight line of Eq.2 is indispensable amount of river water, and the vertical line in the figure shows the amount of irrigation water from canals.

4. Results and discussions **Figure 3** shows the result of the area 4-1 as an example. Area 4-1 is located in the center of the eastern part and groundwater EC is high (**Table 1**). The salt tolerance of cotton is as high as 5.1 dS/m, and there is no intersection of the lines of Eqs.1 and 2. It means that it is not necessary for farmers to concern the amount of groundwater use. Similarly other areas brought the same results. Apricot, peach, and corn have salt tolerance as low as 1.1 dS/m. Although the results show that 10 mm of groundwater could be used in almost all area, such a delicate water management seems difficult due to the shape of the field. Therefore, it can be said that groundwater should not be used for irrigation. However, amount of irrigation water to apricot and peach is 90 mm, and in the case of an area 4-1, it seems that there is not big influence because the amount of river water supply meets the requirement. Apple and Pear are very sensitive to salt, and the threshold of salt tolerance is 0.7 dS/m. River water EC is 0.93 dS/m, and it exceeds the threshold, it is desirable to use the groundwater in which EC is lower than river water, or to irrigate only with river water. Finally, the map which indicates the amount of available groundwater is shown in **Fig.4**.

5. Conclusions Irrigation only with groundwater is possible for cotton due to its high tolerance to salt. Wheat and jujube with moderate tolerance can be irrigated only with groundwater in almost all area. However in area 3 and 4-1, it is necessary to use groundwater very carefully. Low tolerant crops e.g. apricot, peach can be irrigated with groundwater in areas 7 and 8 only. Therefore, it is necessary to consider the water distribution based on the groundwater EC in each district. The result of this study becomes useful index to consider that. In this study, In this study the authors presumed the amount of available groundwater for each area and each crop in terms of salt tolerance. For next step, it is necessary to clarify the actual conditions of irrigation and to conduct continuous monitoring on groundwater EC.

References: Ayers R.S. et al. 1985. Water Quality for Agriculture. FAO Irrigation and Drainage Paper 29 Rev. 1. Food and Agriculture Organization

Table 1 EC of the area No. 4-1

area 4-1	EC (dS/m)
EC max	8.84
EC min	4.95
EC ave	6.67

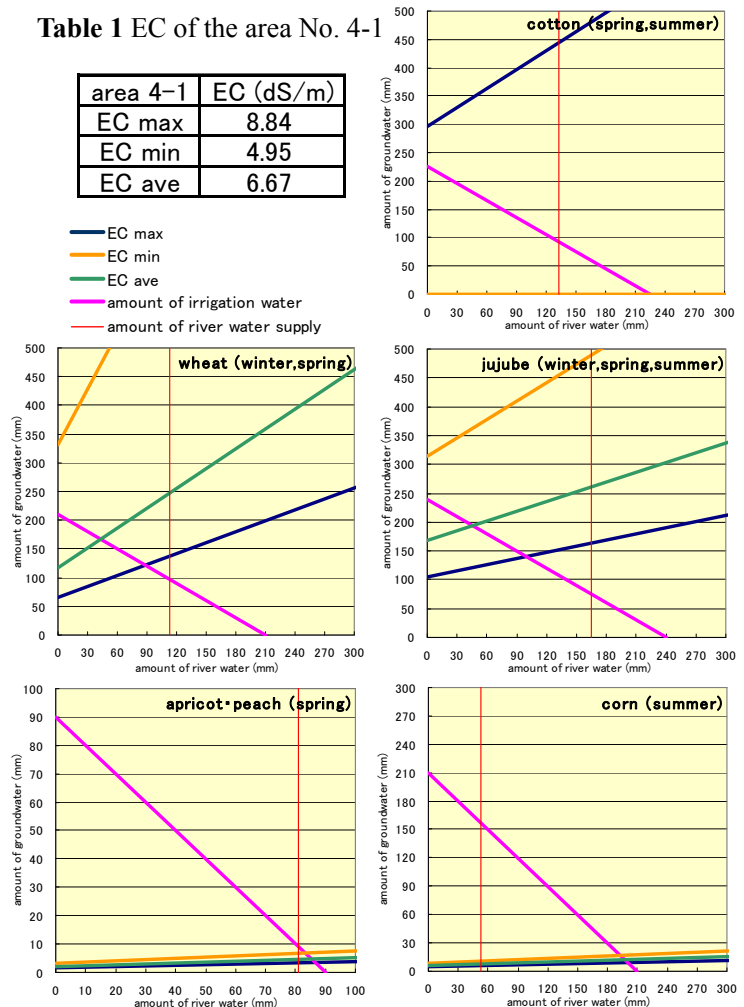


Fig.3 Amount of available groundwater in area No.4-1 based on different crops

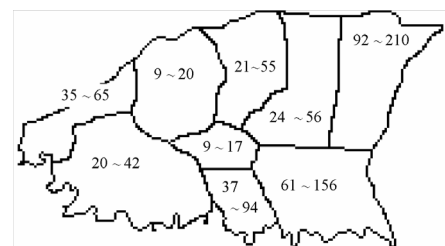


Fig.4 Recommended amount of groundwater use for irrigation