Influences of Chinese Cabbage Growth and Soil Salinity to Alternative Irrigation Waters

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Abstract

This experiment was conducted to investigate the available alternative irrigation waters for drought periods in the agricultural land. The treatments were consisted with the discharge water from industrial wastewater treatment plant (DIWT), the discharge water from municipal wastewater treatment plant (DMWT) and ground water as the control. In the chemical compositions of alternative water resources, it appeared that concentrations of the Ni^{2+} and SAR in DIWT and CODcr concentration in DMWT were over the reuse criteria of other countries for agricultural irrigation. SAR value in soil is increased with prolonging the irrigation periods at head forming stage, but not significantly difference except for 30days of irrigation period at harvesting time for DIWT. However, it was not significantly difference along with irrigation periods through the growth stages for DMWT as compared to that of the groundwater. However, EC_e value in upper layer soil (0-15cm) irrigated with DIWT was over twofold less than its DMWT except for 10 days of irrigation period. For the Ni^{2+} concentration in upper layer soil irrigated with DIWT, it was increased with prolonging the irrigation period at head forming stage, but dramatically decreased and almost constant in all the treatments at harvesting time. Therefore, it might be concluded that there was potentially suitable to irrigate the discharge water from municipal wastewater treatment plant for 20days of drought periods with cultivating the Chinese cabbage.

Media summary

There was potentially suitable to irrigate the discharge water from municipal wastewater treatment plant during 20days of drought periods with cultivating the Chinese cabbage.

Keywords

Reuse water, soil salinity, heavy metals and harvest index

Introduction

Rapid growth in the demand for high quality water coupled with natural shortage and continuous restrictions in supply have accelerated the alternative water resources. Wastewater treatment and improvement are required both to minimize the health and environmental risks and to evaluate the utilization of wastewater as a solution to water shortage problems. Furthermore, Shin *et al*. (2003) might be considered that there was limited possibility to irrigate the discharge water from municipal wastewater treatment plant to overcome drought injury of rice transplanting season in the pot experiment. In the status of wastewater reuse in United State, 18 states have adopted some form of regulations regarding the reuse of reclaimed water, 18 states had full fledged guidelines or design standards, and 14 states had nothing (U.S. EPA, 1992). However, the total discharge water from the municipal wastewater treatment plant is about 646,000Mm^3/yr, and only 2.5% of reused water for agricultural irrigation in Korea (Environmental Management Corporation, 2001). Therefore, objectives of this experiment were to investigate the growth effects of Chinese cabbage, soil salinity and heavy metal content to alternative irrigation waters during drought periods.

Methods

The variety used in the greenhouse experiment was Chinese cabbage (Noranja-Baechu), and the soil texture was clay loam. The 20days old seedlings were transplanted with 45?70cm of planting distances on vinyl mulching in the greenhouse at Sept. 5, 2002. Fertilizers are applied with 33-30-16kg/ha (N-P_2O_5-K_2O) in clay loam soil as basal application at 3days before transplanting. The tanks were fulfilled with DIWT and DMWT. Irrigation system with vinyl mulching was drip irrigation, and cabbage is grown with irrigation of ground water until 30days after transplanting. For inducing the initial wilting points, there is stopped to irrigate the ground water until 77kPa of soil moisture content in clay loam soil. The irrigation periods were 10, 20, 30days and continuous irrigation during cabbage cultivation period after transplanting, and then there was irrigated with groundwater after designated periods. Soil samples at each plot are collected at 10, 20, 30 and 60days after irrigation of alternative waters, and dried and passed through 2 mm sieve for soil chemical properties. The chemical characteristics of soil and water were analyzed by standard methods (Korea EPA, 2000). This experiment was conducted with randomized complete design with 5 replications.

Results

For the chemical compositions of alternative water, it appeared that concentrations of Ni^{2+} and SAR in DIWT were over the reuse criteria of other countries for irrigation, but the CODcr concentration in DMWT was higher than the reuse criteria for agricultural irrigation (Table 1). According to classification of water by EC_i value, DIWT and DMWT are ranged from 0.7 to 2.0dS/m, slight salinity (Rhoades *et al*., 1992), but they were not proper for the irrigation water quality owing to the high values of SAR. Average harvest indexes were 0.64 for DIWT and 0.63 for DMWT as compared to 0.61 of the control regardless of irrigation periods. Influences of SAR values were not significantly difference along with irrigation periods through the growth stages for DMWT as compared with the groundwater (Fig. 1). Especially, SAR value of each irrigation period of DIWT at head forming stage was close to 13, a value that separates sodic soils from non-sodic soils (Soil Science society of America, 1997). For electrical conductivity of the irrigated soil, its DIWT was higher at upper layer (0-15cm) depth than that the soil with DMWT except for 20days of irrigation periods at head forming stage (Fig. 2). However, it was observed the reverse pattern in soil with DMWT at harvesting stage. The Ni^{2+} concentration in upper layer soil (0-15cm) irrigated with DIWT was increased with prolonging the irrigation period at head forming stage, but it is dramatically decreased and almost constant in all the treatments at harvesting time (Fig. 3).

Table 1. Chemical characteristics of discharge waters from industrial and municipal wastewater treatment plant, and groundwater, and reused criteria for agricultural irrigation

Parameters	Units	Ground water	DIWT[b]	DMWT[c]	References (Angelakis *et al*., 1999)	
					Criteria	Nations
pH	-	7.0	8.4	8.1	6.5-8.5	Tunisia(1975)
EC_i	dS /m	0.14	2.92	0.84	〈3.0	〃
SS	mg/L	0.03	0.01	0.02	5, 15	U.S.EPA(1992), Israel(1978)
CODcr		49.17	81.39	90.13	90.0	Tunisia(1999)
NH_4^+-N		16.74	25.76	0.82	-	-

NO_3-N	8.27	0.44	17.76	-	-
PO_4-P	N.D.	N.D.	N.D.	-	-
Cl^-	8.18	468.12	13.38	2,000	Tunsia(1999)
SO_4^{2-}	0.89	158.24	386.21	-	-
Al	0.03	0.03	0.06	-	-
Mn^{2+}	0.004	0.222	0.010	0.5	Tunsia(1999)
Ni^+	0.005	0.576	0.037	0.2	〃
Zn^{2+}	0.517	0.012	0.016	5	〃
SAR[a]	4.63	189.5	3.86	〈10	Italy(1977)

[a] $SAR = C_{Na}/\sqrt{(C_{Ca}+C_{Mg})/2}$

[b]Discharge water from industrial wastewater treatment plant; [c]Discharge water from municipal wastewater treatment plant; N.D. was not detected

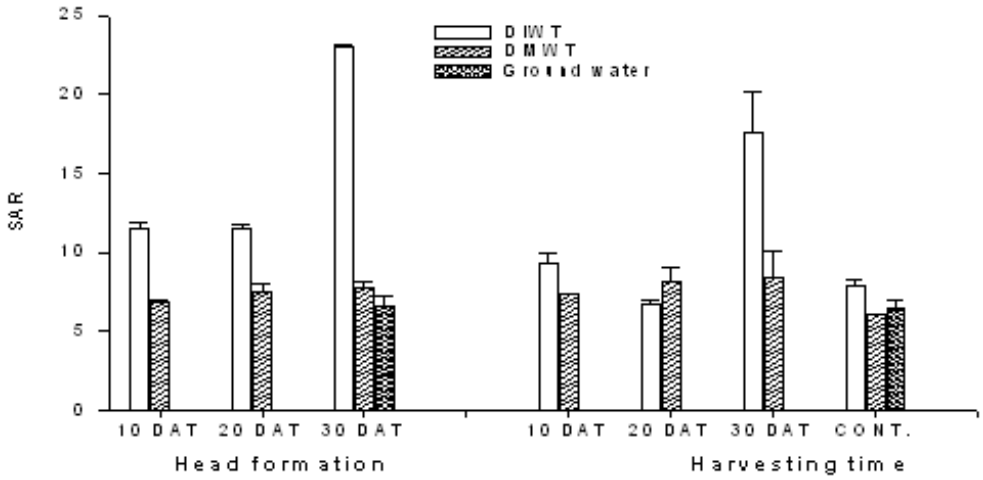

Figure 1. Changes of SAR values in upper layer soil (0-15cm) over 60days after irrigation to alternative irrigation waters with different irrigation periods.

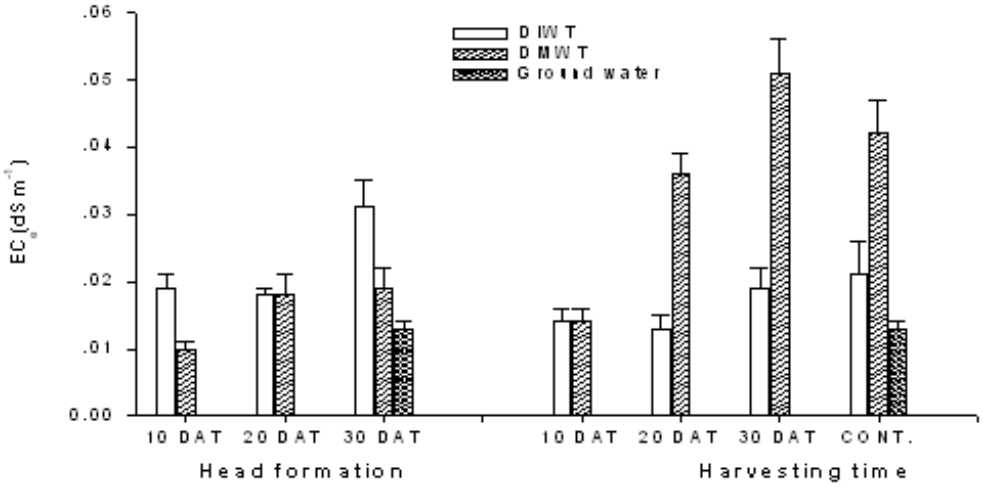

Figure 2. Changes of ECe in upper layer soil (0-15cm) over 60days after irrigation to alternative irrigation waters with different irrigation periods.

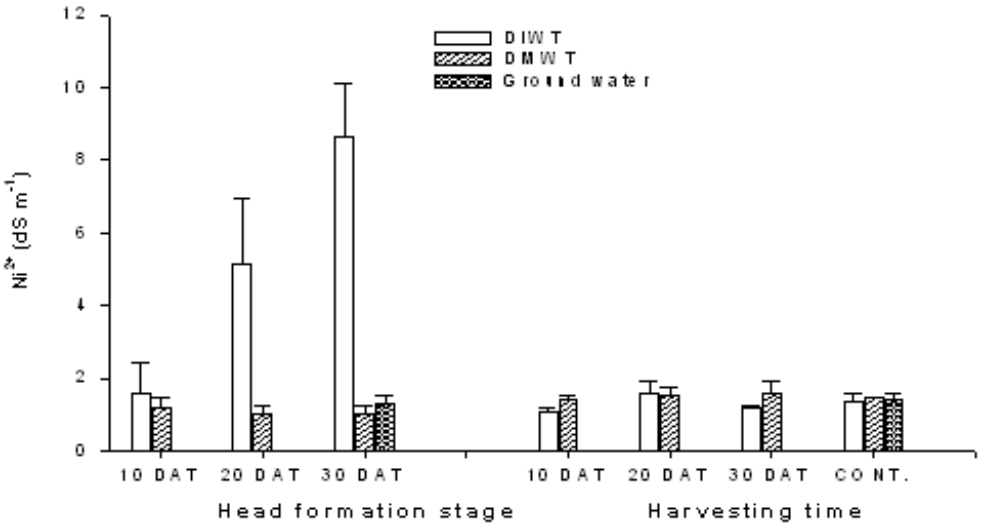

Figure 3. Influences of Ni^{2+} concentration in upper layer soil (0-15cm) over 60days after irrigation to alternative irrigation waters with different irrigation periods.

Conclusion

There was potentially suitable to irrigate the discharge water from municipal wastewater treatment plant for 20days after transplanting to drought periods with cultivating the Chinese cabbage relative to harvest index, SAR value, and Ni^{2+} concentration in soil.

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