Effects of various mulching materials on salt accumulation and water use efficiency of Swiss chard irrigated with diluted sea water

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1. Introduction

Drought and salinization are two limiting factors for agricultural production in many arid and semi-arid regions. Freshwater resources in these areas have been over-exploited, so diluted sea water has some appeal (Ghadiri et al., 2005).

Soil evaporation (Es) is non-beneficial loss of water. Preventing Es can not only control salt accumulation since salts in the liquid phase are left behind as soil water evaporates, but also benefit environment since it can reduce pollution of the leaching water. Mulching can reduce Es because it provides resistance to vapor flow from the soil surface to the atmosphere. However, only a few researches were concerned about effects of preventing salt accumulation using mulching. Furthermore, there is lack of research on application of mulching combined with diluted sea water irrigation and comparing effects of various mulching materials on salt accumulation, especially pine leaf mulching.

The objectives of this study were to irrigate plants with diluted sea water, save water, prevent salt accumulation and improve crop yield and water use efficiency (WUE) with various mulching materials.

2. Materials and methods

From Nov. 2, 2005 to Feb. 8, 2006, a greenhouse pot experiment was conducted at the Arid Land Research Center, Tottori University, Japan. Tohaku clay soil with an average bulk density of 1.1 g/cm^3 was used. There were two seedlings of Swiss chard (*Beta vulgaris L. var. flavescens*) in each pot (36 pots in total).

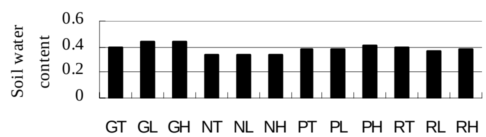

Fig. 1 Effects of mulching and diluted sea water irrigation on soil water content

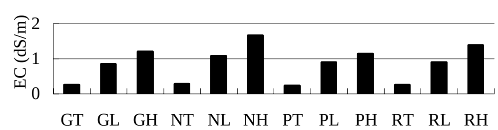

Fig. 2 Effects of mulching on EC1:5 of 0-20 cm soil layer

A completely randomized factorial design was used comprising of three irrigation and four mulching regimes, with three replications of each. The four mulching (3 cm thickness) regimes were: gravel mulching (G), rice straw mulching (R), pine leaf mulching (P) and non-mulching (N). The three irrigation regimes were: tap water alone (T); diluted sea water of low salinity (ECw=4.8 dS/m) (L); and diluted sea water of high salinity (ECw = 7.4 dS/m) (H). The 36 pots were weighed frequently to estimate evapotranspiration (ET) and water-use efficiency (WUE). Soil samples were taken in 4 soil layers before harvesting to measure soil water content (θ) and electric conductivity (1:5 soil extraction solution EC1:5). The EC1:5 was measured with a conductivity meter B-173 (Horiba Co.).

3. Results and discussion

Fig. 1 indicates that gravel mulching can conserve more soil water in the top soil layer than other treatments, while non-mulching treatments tend to consume more soil water. Compared with NH, the θ for GH was improved 33%. Fig. 2 depicts that mulching can prevent salt accumulation in 0-20 cm soil layer. Gravel mulching and pine leaf mulching were more effective than rice straw mulching in reducing salt accumulation. Compared with NH, the EC1:5 for PH was reduced 32%. Fig. 3 shows that gravel mulching can effectively reduce salt accumulation in the 0-5 cm soil layer, compared with non-mulching treatments. Similarly, pine leaf and rice straw mulching had the same effects. Hence, mulching was suitable for crop growth when diluted sea water was used. Fig. 4 shows cumulative ET variation for various mulching treatments followed

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the order: non-mulching > pine leaf mulching > rice straw mulching > gravel mulching, which indicates gravel mulching was the best mulching material for preventing ET. Compared with non-mulching treatments, the ET for mulching treatments was reduced greatly. Compared with NT, the ET for GH was reduced 56%, which indicates GH significantly saved water. The ET reduction for various irrigation treatments followed the order: tap water > low ECw > high ECw. Comparison of dry matter yield for all treatments is shown in Fig. 5. Non-mulching treatments gave the lowest yield, indicating that mulching can improve yield of Swiss Chard. The highest yield occurred on GH treatment. For P and G treatments, diluted sea water with 7.4 dS/m gave the highest yield, while tap water irrigation treatments gave the lowest yield. Hence diluted sea water with 7.4 dS/m can be used to improve yield. Higher-concentration diluted sea water irrigation gave higher yield, which may possibly be explained by the fact that nutrient elements contained in the sea water served as fertilizer. Thus, Swiss chard is suited for moderate diluted sea water irrigation if diluted sea water was used one and a half months after transplanting. The yield variation for the various mulching treatments followed the order: gravel mulching > pine leaf mulching > rice straw mulching > non-mulching. Compared with NL, the dry yield for GH was improved 62%. Fig. 6 shows GH gave the highest WUE in all treatments, while NT and NL gave the lowest WUE. The WUE for GH was improved 266%, compared with NT. The variation in WUE for the various mulching treatments followed the same order as the yield. High-concentration diluted sea water irrigation gave higher WUE, which can be explained by two reasons: high-concentration diluted sea water irrigation gave higher yield and lower ET than other treatments.

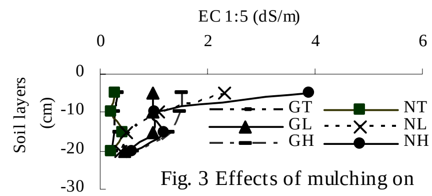

Fig. 3 Effects of mulching on distribution of EC1:5

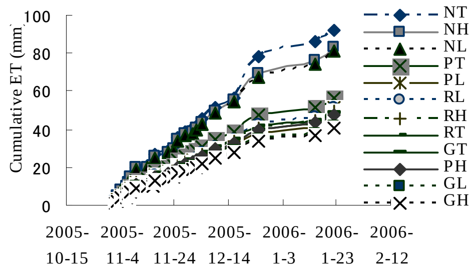

Fig. 4 Effects of mulching and diluted sea water irrigation on cumulative ET

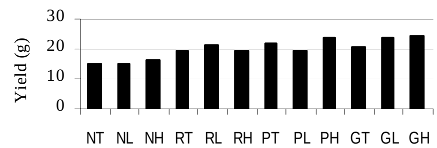

Fig. 5 Effects of mulching and diluted sea water on yield of Swiss chard

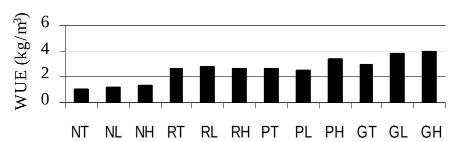

Fig. 6 Effects of mulching and diluted sea water irrigation on WUE

4. Conclusions

Mulching and diluted sea water tended to improve soil water content and reduce ET, so mulching and diluted sea water irrigation improved yield and WUE. Compared with non-mulching treatments, the EC1:5 for mulching treatments was effectively reduced, especially in 0-5 cm soil layer. Gravel mulching and pine leaf mulching were more effective than rice straw mulching in reducing salt accumulation. Diluted sea water irrigation with 7.4 dS/m gave the highest yield and WUE in various irrigation regimes.

Gravel mulching had the best effect on preventing ET and improving soil water content, so the combination of gravel mulching and high-concentration diluted sea water irrigation (GH) gave the highest yield and WUE. The variation in WUE for the various mulching treatments followed the order: gravel mulching > pine leaf mulching > rice straw mulching > non-mulching, which was the same trend observed for yield. GH and PH, the combination of gravel mulching and pine leaf mulching with high-concentration diluted sea water irrigation, are the two best treatments. Thus, gravel and pine leaf mulching may be good materials for sustainable agricultural production, especially under diluted sea water irrigation.

Reference

Ghadiri H., Dordipour I., Bybordi M. and Malakouti M.J., 2005. Potential use of Caspian Sea water for supplementary irrigation in Northern Iran. Agric. Water Manage. (Article in press)