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Effect of Irrigation with Saline Water on the Soil in Simple Drainage Lysimeters

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Summary

An experiment was set in 12 simple drainage lysimeters at the lysimeter station of Karcag Research Institute in 2012 in order to simulate the conditions of irrigation in the hobby gardens characteristic around Karcag, and to examine its effect on the soil. Sprinkler and drip irrigation and saline and deionised water were used and compared. We expected lower salt accumulation in the case of drip irrigation as the salt load of the soil is lower due to the lower amount of water when drip irrigation is applied. One of our goals was to quantify this difference in salt affection. We also applied a compost material called TERRASOL (sheep manure based) aiming to mitigate the harmful effect of irrigation with saline water. After the irrigation period soil samples were taken from the soil of the lysimeters down to 50 cm and analysed in order to determine their salt content and these data were compared to the original salt content of the soil. Our results show that both the application of drip irrigation and TERRASOL compost can mitigate the extent of secondary salinization even though it definitely occurs.

Keywords: secondary salinization, irrigation, lysimeter

Introduction

Negative climatic water balance is characteristic to the majority of the areas in Hungary as the annual potential evaporation exceeds the amount of annual precipitation. Furthermore the spatial and time distribution of precipitation is uneven and not favourable from the point of view of plant production VÁRALLYAY (1985). Therefore irrigation is essential to cover the demands of plants when they suffer from the shortage of water to an extent that is beneficial (RUZSÁNYI 1996). Nevertheless improper irrigation may induce unfavourable processes in the soil like soil compaction and secondary salinization. According to a survey by FAO and UNESCO half of the irrigated lands (approximately 250 million ha) of the world is seriously endangered by human induced salinization and overload of water (SZABOLCS 1985). RADAELLI et al. (1981) irrigated the soil with waters with different salt content and found lower stability of the soil structure. PAPADOPOULOS (1985), AHMEDOV et al. (1978), and CHANG and OOSTERVELO (1980) also established that chemical and physical degradation of the regularly cultivated soil layer occurs due to irrigation even with slightly saline waters and leaching of the salts can be expected only in soils with high hydraulic conductivity.

In the Great Hungarian Plain approximately 400,000 ha is the area where secondary salinization has occurred, mainly due to the rise of the level of salty groundwater. This was studied and proved by several scientists (SZABOLCS 1961, VÁRALLYAY 1989, BACSÓ and FEKETE 1969, FEKETE 1969, KUTI et al. 1999). BLASKÓ (2005) monitored the salt- and water balance of irrigated areas and found the increase of salt content of the soil in several cases. During the 1980ies and 1990ies on 30% of the studied area (Jász-Nagykun-Szolnok County) increasing soil salt content could be detected, especially on the susceptible areas where the soil can be only potentially irrigated due to the high salt content in their deeper layers.

The problem of improper irrigation is serious in Karcag area in the centre of the Great Hungarian Plain as extended irrigation with saline water originating from drilled wells is characteristic in the hobby gardens during the frequently droughty summers. Mainly vegetables and fruits with high water demand are grown in these gardens, hence quite a large amount of subsurface waters are used for irrigation. The quality of these waters is not checked by the owners of the gardens, the chemical composition, hence the suitability of the water for irrigation is not known. Our hypothesis was that these waters are salty and irrigation with them involves the risk of secondary salinization. In a preliminary research started in 2009 water samples were taken from 46 drilled wells located in the hobby gardens around the town of Karcag. On the base of the results we gained it can be concluded that none of the waters used for irrigation in the hobby gardens around Karcag are suitable for irrigation as all the indexes indicating the salinization effect of irrigation waters were above the thresholds. The main goal of our recent study is reveal the possibility of the mitigation of the harmful effect of irrigation with saline water taking the facts for granted that irrigation is essential and only saline water is at the disposal for the hobby gardeners at Karcag.

Material and Methods

An experiment was set in 12 simple drainage lysimeters at the lysimeter station of Karcag Research Institute of University of Debrecen CAS (KRI) in 2012. Sprinkler and drip irrigation and highly saline (1978 mg/l salt content) and deionised water were used and compared. Saline water was

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applied in order to simulate the conditions of irrigation in the hobby gardens and to examine its effect on the soil, while deionised water was used as a control. Sprinkler irrigation is very common in the hobby gardens, but drip irrigation is getting more and more popular recently. The idea of the use of drip irrigation in the experiment came from the fact that micro-irrigation methods have much lower water demand compared to conventional irrigation techniques hence less salt gets into the soil by the irrigation water. Therefore we consider drip irrigation a good possibility to mitigate the salt load of soils by irrigation. The other approach we used is soil reclamation with compost: even we cannot avoid salinization, we can mitigate its effect on the soil and indirectly on the plants. We used green pepper as an indicator plant which is a very commonly grown plant in the hobby gardens around Karcag. Irrigation was carried out with waters with different salt contents in 3 replications with both irrigation methods. The treatments of the experiments are shown in *table 1*.

The dose of irrigation water was determined according to the high water demand of green pepper as well as the low infiltration rate of the investigated soil: 4 litres of water was irrigated with sprinkler, while two third of that with drip irrigation method at the same time for each lysimeter. The compost material we used was a sheep manure based compost called TERRASOL that can be used in organic farming as well.

Figure 1: **The irrigation experiment in the lysimeters in 2012.**

Table 1: **The treatments of irrigation experiment set in the lysimeters.**

Lysimeter	Replication	Irrigation method	Irrigation water	Application of compost
1.	1	sprinkler	deionised	-
2.	2	sprinkler	deionised	-
3.	3	sprinkler	deionised	-
4.	1	sprinkler	saline	-
5.	2	sprinkler	saline	-
6.	3	sprinkler	saline	-
7.	1	drip	saline	-
8.	2	drip	saline	-
9.	3	drip	saline	-
10.	1	sprinkler	saline	+
11.	2	sprinkler	saline	+
12.	3	sprinkler	saline	+

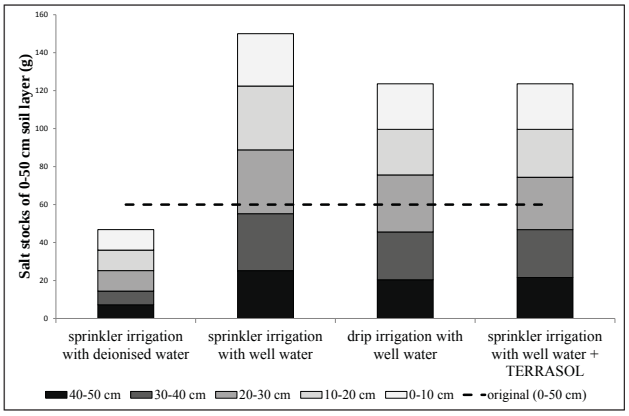

Figure 2: **Average salt stocks of the soils in lysimeters before and after irrigation.**

After the end of the irrigation season, on 10th September, the soil of each lysimeter was sampled at every 10 cm down to 50 cm. The pH-values, total soluble salt content, humus content and P_2O_5, K_2O, Ca, Mg, Na, NO_3-N contents of the soil samples were determined in the accredited laboratory of KRI.

Results and Discussion

After the irrigation period, the effect of irrigation was determined by the salt content of the investigated soil layers compared to the original salt stocks of the top 50 cm deep soil layer (*Figure 2*). This latter value was 60 g (0,1% (m/m) in 60 kg soil of 0-50 cm layer).

Due to irrigation with deionised water, leaching was characteristic as the original salt content of the upper 50 cm soil layer decreased from 60% to 46,8% (m/m). The stratification was not even, as higher leaching occurred in the soil layers of 30-40 and 40-50 cm, but the difference was not significant. In the soils of the lysimeters irrigated with saline well water with sprinkler irrigation the measured salt stocks of the upper 50 cm soil layer highly exceeded the original value (more than double). When drip irrigation was used, due to the less water hence lower salt load of the soil, salt accumulation occurred, but in a lower extend compared to overhead irrigation. Similar results were gained when the soil of the lysimeters were reclaimed with TERRASOL compost.

Conclusions

In Karcag area, in the centre of the Great Hungarian Plain irrigation is essential in the droughty summer months especially if vegetables with high water demand are grown. Good quality irrigation water is not available for the hobby farmers having small gardens in the outskirt of the town therefore they use saline water originating from drilled wells. Our results call the attention that the use of saline water for irrigation cause secondary salinization, especially on soils susceptible to that. Nevertheless the application of drip irrigation and TERRASOL compost can mitigate the extent of secondary salinization, even though it definitely occurs.

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