Höhere Bundeslehr- und Forschungsanstalt für Landwirtschaft
Raumberg-Gumpenstein

17. Gumpensteiner Lysimetertagung 2017, 189 – 192
ISBN: 978-3-902849-45-8

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

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## Summary

Legume crops have high water demand hence quite a large amount of water is used for irrigation of them. Nevertheless improper irrigation may induce unfavourable processes in the soil and can cause yield depression. This problem 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 during the frequently droughty summers. 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 characteristic in the region and to examine its effect on the soil and the indicator crops. Irrigation with saline and deionised water were used and compared. After the irrigation season of 2015, the yield of the indicator legume crops was determined and soil samples were taken from the soil of the lysimeters down to 40 cm and analysed in order to determine their salt contents. Our results show how legume crops are sensitive to the irrigation with saline water and can contribute the better choice of crop species suitable for the extreme agro-ecological conditions of the Great Hungarian Plain.

*Keywords:* secondary salinization, irrigation, lysimeter, legumes

## Introduction

There are extended agricultural areas in the world that can be utilised only with irrigation for crop production, nevertheless salt affection, erosion, and other physical degradation processes can be induced by the application of irrigation. Therefore the scientific establishment of irrigation in a soil-plant system has been started in several countries with the involvement and support of different international organisations (FAO, UNESCO, World Bank) (Bardaji 1974).

Irrigation with waters of different salt concentrations results in a poorer stability of the soil structure and salt accumulation. Papadopoulos (1985), Ahmedov et al. (1978), Chang and Oosterveld (1980) established that even the irrigation with slightly saline waters causes rapid chemical and physical degradation of the upper, regularly cultivated soil layer, and considerable leaching of the harmful salts can be expected only in soils with high hydraulic conductivity.

The increase of the level of salty groundwater or the application of poor quality (salty) irrigation water can cause secondary salinization. Salt affected soils are low fertility soils with unfavourable water regime. Alkaline salts, mainly sodium, are accumulated in these soils either naturally or this process can be human induced. The latter case is called secondary salinization and mainly related to improper irrigation. Intensively irrigated areas are endangered by secondary salinization worldwide (Letey 1984, Mantell et al. 1985, Rhoades and Loveday 1990). 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. 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 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 importance of legume crops is getting larger and larger nowadays as there is an increasing demand for plant protein sources not only for feeding animals but for human consumption as well. Legume crops have high water demand hence quite a large amount of water is used for irrigation of them. Nevertheless improper irrigation may induce unfavourable processes in the soil and can cause yield depression. This problem 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 during the frequently droughty summers.

## Material and Methods

An experiment was set in 12 simple drainage lysimeters at the lysimeter station of Karcag Research Institute (KRI) of the University of Debrecen, Hungary in 2012 in order to simulate the conditions of irrigation characteristic in the region and to examine its effect on the soil and the indicator crops. The lysimeters were reconstructed in 2009 and filled with a slightly sodic (0.06% salt content) meadow solonetz soil. The lysimeters are 150 cm deep with a drain tube at 120 cm and have a surface area of 0.8 m².

In 2015 and 2016 irrigation with saline and deionised water were used. Two salt concentrations were applied: according to the broad survey of Zsembeli et al. (2011) the salt concentration of 1,800 mg/l is characteristic to the groundwater and the shallow wells of the area, while 600 mg/l salt concentration is characteristic to the deeper drilled wells utilizing the aquifers at 40-70 m depth. The salt concentration of the irrigation water of 600 mg/l was set by dilution: the 1,800 mg/l salt concentration of a groundwater well was mixed with deionised water in a 1:2 ratio. Irrigation was applied

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|---|---|---|---|
| Pea, deionised water replication 1 | Pea, 600 mg/l water replication 1 | Soya, deionised water replication 1 | Soya, 600 mg/l water replication 1 |
| Pea, 1800 mg/l water replication 1 | Pea, deionised water replication 2 | Soya, 1800 mg/l water replication 1 | Soya, deionised water replication 2 |
| Pea, 600 mg/l water replication 2 | Pea, 1800 mg/l water replication 2 | Soya, 600 mg/l water replication 2 | Soya, 1800 mg/l water replication 2 |

rationally and regularly, preferably in smaller amounts by every day when no natural precipitation occurred. The indicator crops were winter fodder pea and soya bean as there is an increasing demand from the farmers to produce these legumes induced by the change of the subsidizing system that remunerates the production of N-fixing legumes in the framework of 'greening'. The irrigation treatments were set in 4 replications combined with the 2 indicator crops giving the arrangement of the 12 lysimeters (see Table above):

After the irrigation season of 2016, the yield of the indicator legume crops was determined and soil samples were taken from the soil of the lysimeters down to 40 cm and analysed in order to determine their salt content balance. The soil samples were analysed in the laboratory of KRI and their salt content was determined according to their electric conductivity. The total actual salt contents (mass of the total soluble salts expressed in grams) of the 0-10, 10-20, 20-30, 30-40 cm deep layers (most important in crop production) were calculated taking the soil mass of each layer into account (m/m%).

## Results and Discussion

*Effect of irrigation on the soil:* The salt contents of the 4 investigated soil layers in the averages of the 4 replications of the 3 irrigation treatments are shown in *Figure 1*. The horizontal line indicates the original salt content of the soil (0.06%) before irrigation was started.

It is obvious that irrigation with deionised water causes leaching of salts out of the upper layers, which is also shown by the salt contents increasing by depth. As no deep percolation (drain) water appeared in any of the lysimeters, the leached salts must have accumulated in the deeper layers and will be leached out when the soil columns of the lysimeters are oversaturated. In the lysimeters where irrigation water

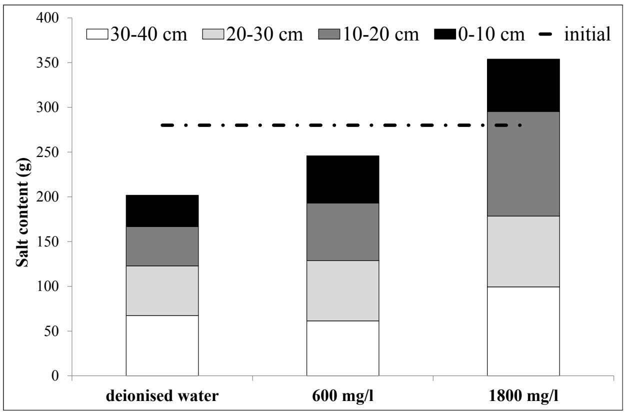


*Figure 1:* **Total soluble salt content in the upper 40 cm soil layers of the lysimeters irrigated with waters of different salt concentrations.**

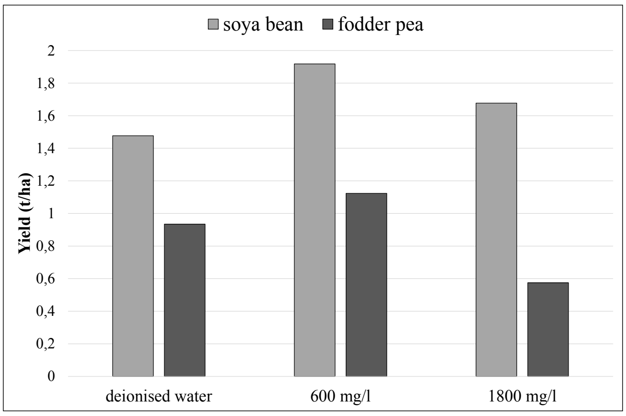


*Figure 2:* **Yields of soya bean and fodder pea irrigated with waters of different salt concentrations.**

with 600 mg/l salt content was applied slightly negative salt balance was characteristic for the upper soil layers. This result is incredibly important as in Hungary for such a soil no irrigation is permitted with waters in which the total soluble salt content is over 500 mg/l. Our results show that the regulation is too strict as no salt accumulation occurred even after a long-term of irrigation with water of 600 mg/l salt content. In the case of irrigation with water of 1,800 mg/l salt content definite salt accumulation took place, especially in the 10-20 cm deep soil layer.

*Effect of irrigation on the indicator crops: Figure 2* and *Figure 3* show the yields of fodder peas and soya beans irrigated with waters of different salt concentrations, respectively. In both cases it can be established that yield depressions of 13-49% were characteristic for the treatments where deionised and 1,800 mg/l irrigation water was applied compared to the lysimeters where water of 600 mg/l salt content was irrigated. These results also prove that under the investigated circumstances no harmful effects can be expected if irrigation with water of 600 mg/l salt content is applied.

## Conclusions

On the base of our results it can be concluded that negative salt balance is characteristic if irrigation with water of 600 mg/l salt content is applied even for 4 years under the given conditions. We suggest the revision of the regulations about the applicability of irrigation waters in Hungary. Our results show how the investigated 2 legume crops are sensitive to the irrigation with saline water and can contribute the better choice of crop species suitable for the extreme agro-ecological conditions of the Great Hungarian Plain.

## Acknowledgements

This study was supported by the National Research, Development and Innovation Office (TéT_12_SK-1-2013-0006).

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