EIP-AGRI Focus Group
Soil salinisation

Case studies on innovativetrategies and market opportunities

funded by European Commission

Index:

Innovative strategy

Salt tolerant crops and cultivation strategies

Contact persons: Arjen de Vos, Saline Farming

Website 1 | Website 2

Country and region:

The Netherlands, island of Texel
Southern Europe and outside Europe

Climate conditions:

Temperate
Arid

Type of soil:

Sand
Loam and clay

Main crops:

Potato, carrot, beets, cauliflower, cabbage, green manure crops, halophytes

Irrigated/rainfed:

irrigated

Background of the salinisation problem:

In the Netherlands the salinity problem is mostly in the form of salty groundwater. This seepage is really strong due to the fact that the land is below sealevel. These low lying areas are mostly reclaimed lands and used to be the ocean (floor). So the salty water remains as groundwater and due to the drainage system and pumping (to keep the reclaimed land dry) the salty water is coming up even quicker.

Innovative strategies to tackle the salinisation problem:

The main approach is to flush all the surafce water systems with fresh water from the rivers and lakes. In this way the salty water, that collects in the surface water from the drainage system, is diluted or replaced by fresh water in order to ensure that most farmers have access to fresh water for irrigation. Another approach that is explored now is to collect and store fresh water in times of surplus and use it in times of shortage. However, the approach of Saline Farming is adaptation. We continuously show that many crops are more salt tolerant than is commonly believed. By selecting and cultivating salt tolerant crops there is no need to keep the whole water system as fresh as tap water

What makes this strategy a success?

We identify salt tolerant crops and varieties and develop specific cultivation strategies that also involve soil wand water (irrigation) aspects. By combining these different aspects we are able to grow crops under moderate and high salinity levels, both conventional crops as well as halophytes. Besides the current approach that only focusses on “keeping it fresh”, we need an adaptation solution as well.

What are the potential fail factors?

Every location is unique, so we need to develop tailor-made adaptive farming systems. These require time and research which makes it difficult to offer it to a single farmer in an affordable way. Also, new locations may be so unique that a new solution has to be developed rather than a proven approach can be selected. This may result in poorer results than expected.

Knowledge gaps which may be solved by further research or practical testing:

Saline agriculture is a complex mix of salt tolerant crops, various soil aspects and smart water management. Ideally, one could use a standard approach and produce tailor made solution based on various inputs (climatic conditions, soil type, quality irirgation water) in order to predict which crop (variety) and which soil and water approach works best under the specific conditions. To predict this, more data is needed on the different effects and benefits under different circumstances and possibly a model can be composed that helps as a tool to standarize tailor made solutions.

REFERENCES:

www.saline-farming.com

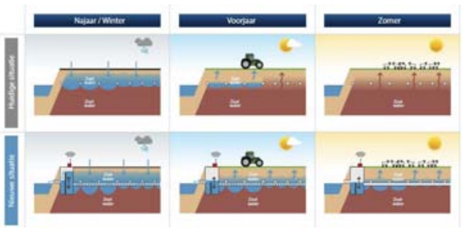
funded by European Commission

This poster was presented at the 1st meeting of the EIP-AGRI Focus Group ‘soil salinisation’ – May 2019
More information: whttps://ec.europa.eu/eip/agriculture/en/focus-groups/soil-salinisation

Adaptative subsurface drainage– Innovative strategy

Peter Prins

www.spaarwater.com | Website 2



Country and region:
Netherlands, northern (coastal) region

Climate conditions:
Moderate maritime climate

Type of soil:
Clay and sand

Main crops:
Seed potatoes, bulbs, grassland

Irrigated/rainfed:
rainfed

Background of the salinisation problem:
In the coastal zone of Northern Netherlands most agricultural fields are drained by subsurface hoses. However, research made clear that the regular design increases salinity in the rootzone of cash crops such as seed potatoes. Until recently, farmers were not aware of the impact of salinity. Symptoms of disrupted growth were supposed to be the effect of prolonged drought events. Intense monitoring, in close collaboration with the farmers' organisation LTO Noord opened the eyes of farmers.

Innovative strategies to tackle the salinisation problem:
Adaptive subsurface drainage might reduce the impact of saline groundwater. Wider distance between drains, deeper drains and controlled drainage systems could foster a thicker lens of fresh (rain) water in the upper zone of the soils above the drains, including the rootzone.

What makes this strategy a success?
Monitoring of current salinity of agricultural soils contributed to awareness raising among the farmers. Farmers' organisation LTO Noord played a crucial role to bridge researchers to the farmers. Results were shared with study groups of farmers. Alternative drainage systems were designed and applied on pilot scale. Controlled drainage levels makes the farmer more resilient in terms of water management.

What are the potential fail factors?
Only frontrunners will take knowledge. Location specific details are necessary for optimal design, which implies thorough preparatory research (extra costs). Drainage companies continue to do their business as usual, due to lack of knowledge operators.

Knowledge gaps which may be solved by further research or practical testing:
Specific design requirements different soil types. Mapping tools geohydrological situation.

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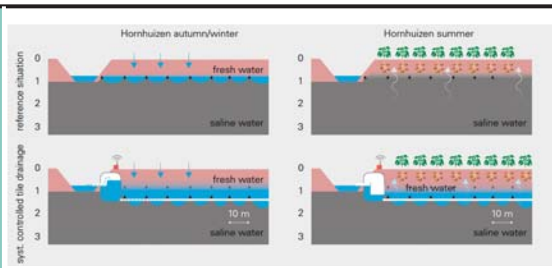

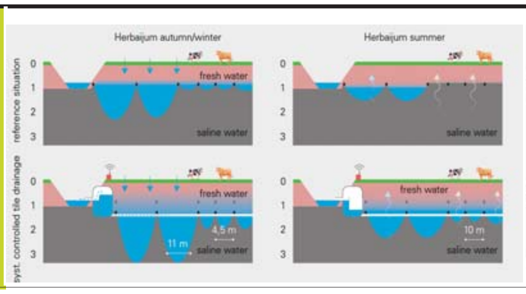

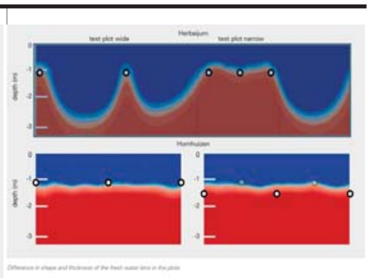

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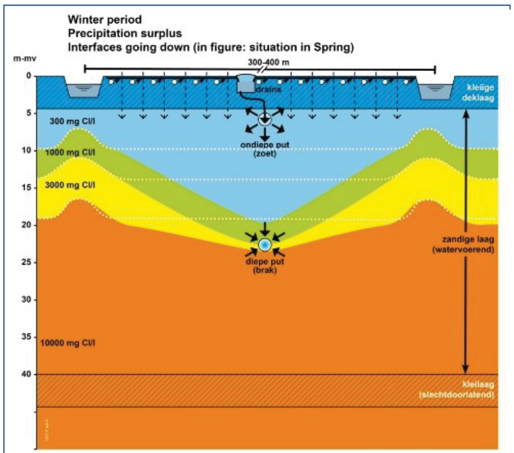
Freshmaker– Innovative strategy

Peter Prins

[Freshmaker] [Website 2]



Country and region:

Netherlands, province of Zeeland

Climate conditions:

moderate (maritime) climate

Type of soil:

clay

Main crops:

pear

Irrigated/rainfed:

Rainfed with additional drip irrigation

Background of the salinisation problem:

In the province of Zeeland (SW Netherlands) fresh water resources are scarce. Salinity affects the rootzone and also limits the use of water when needed for protection against late frost events (in particular when fruit trees are already blooming). Overhead irrigation by sprinklers reduces the risk of damage by frost.

Innovative strategies to tackle the salinisation problem

The Freshmaker offers a technology whereby, in the winter, the (thin) fresh water aquifer situated below agricultural areas is enlarged, so that more fresh water can be extracted. Using a (deep) horizontal well (drainage tube), saline or brackish water is abstracted at a depth of 10 to 15 meters, thus freeing up space for the (artificial) infiltration of the precipitation surplus which is thus not discharged through the waterways. In the summer this fresh water aquifer is used to meet the water needs of the agricultural sector

What makes this strategy a success?

The farmer could combat night-frosts when the trees were sensitive and large amounts of water were needed while the current pipeline couldn't meet the peak demand. The underground water storage created the opportunity to irrigate in summer. Pears had a bigger size. The price of investment was around € 0,60 per m3 water, comparable to the price of water as offered by the pipeline.

What are the potential fail factors?

Costs of investment and clogging were considered barriers for largescale implementation.
However, clogging is tackled by introduction of a (simple) sand filtration, that could be located in an existing ditch.

Knowledge gaps which may be solved by further research or practical testing:

Appropriate arrangements for scaling up (finance) and insight (mapping) suitable creek ridges.

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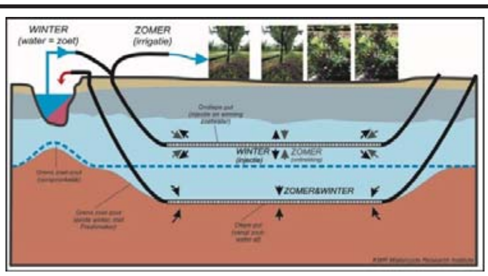

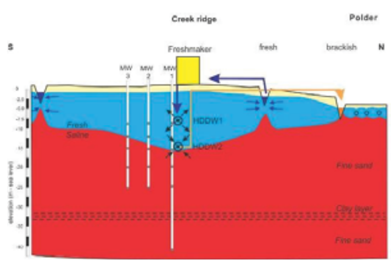

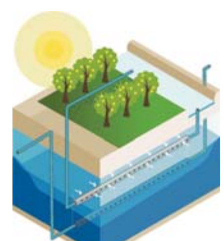

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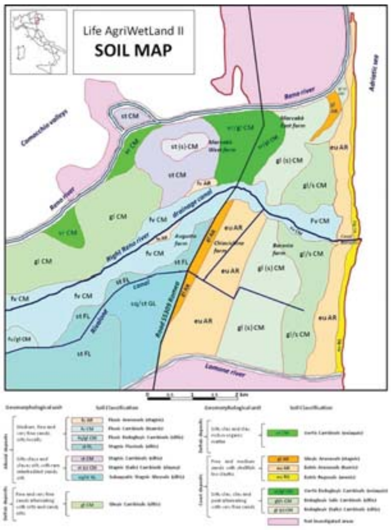
This poster was presented at the 1st meeting of the EIP-AGRI Focus Group 'soil salinisation' – May 2019
More information: whttps://ec.europa.eu/eip/agriculture/en/focus-groups/soil-salinisation

Reclaimed agricultural lands – Innovative strategy

L. Vittori Antisari, M. Speranza, C. Ferronato, G. Vianello, G. Falsone

http://www.distal.unibo.it/en | http://www.lifeagrowetlands2.eu/en/



Country and region:
Italy, Emilia Romagna Region, coastal plain

Climate conditions:
Mediterranean with generally warm and dry summers and wet and mild winters

Type of soil:
Mainly Cambisols, Arenosols, Fluvisols

Main crops:
Maize, alfalfa, barley

Irrigated/rainfed:
Irrigated (from March/April to September/October)

Background of the salinisation problem:
In agricultural lands of Northern Italian coastal plain, low crops yield is a problem affecting in particular the coastal plain near Ravenna. This area has been reclaimed in the last century for agricultural purposes and at present agriculture is one of the main land uses. The area is strictly regulated by an artificial network of canals and furrows that serves for both irrigation and drainage purposes, but due to the proximity to the coast, saline intrusion affects the quality of both superficial and groundwater, increasing the risk of soil salinisation. At present, seawater intrusion along the rivers and canals courses and groundwater aquifer is exacerbated by subsidence, and this phenomenon is carrying the progressive freshwater deterioration and represents one of the principal threats of the area.

Innovative strategies to tackle the salinisation problem:
A monitoring survey of soil properties and EC variation in both soil and canal water network was performed over two years, with the aim to evaluate the soil degradation taking into account soil classification, soil physicochemical properties, and irrigation water quality.

What makes this strategy a success?
Wide soil quality investigation coupled to water quality monitoring allow to identify the efficiency of soil irrigation with high water quality in reducing the risk of soil salinisation. Furthermore, the use of simple and common parameters of soil quality (e.g. organic carbon content, bulk density values) can help farmers or landscape planners to identify hotspots which are particularly susceptible to soil salinisation.

What are the potential fail factors?
We have some doubts on the long-term efficacy of the use of water resource in reducing the risk of soil salinisation. In the studied areas, only superficial layer of certain type of soil (Arenosols) appeared to guarantee it, while the other soils did not efficaciously reduce their EC values. Additionally, we cannot exclude the leaching of the most labile organic C fraction soluble in water due to high input of water for irrigation, especially in the summer period.

Knowledge gaps which may be solved by further research or practical testing:
In these areas, the soil vulnerability to salinisation is site-specific, related to soil type and water system. The water management should thus be accurately revised taking into account the soil properties to maintain the soil quality, thus avoiding a rapid degradation of the soil resource. Furthermore, in these areas, as well as in pedoclimatic similar area, the agriculture systems should be based on low water demanding crops.

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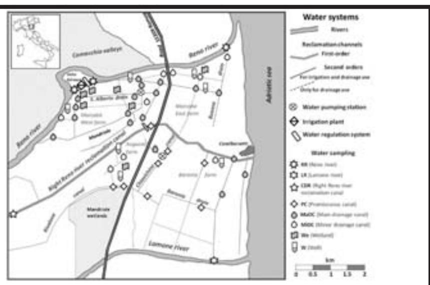

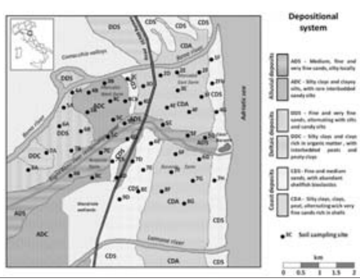

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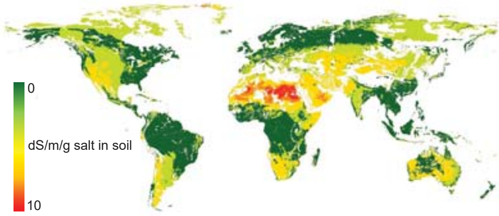
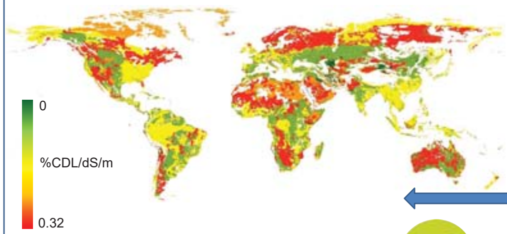
Considering the whole environment to truly reduce environmental impacts of irrigation-induced salinisation

Montse Núñez

$\Delta EC_e/\Delta$mass salt in soil



Δcrop diversity loss/ΔEC_e



Country and region:

All countries with agricultural lands

Climate conditions:

Particularly drylands, but important everywhere

Type of soil:

All can be affected

Main crops:

All irrigated crops, both herbaceous and woody

Irrigated/rainfed:

Irrigated

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- Payen et al 2016. Salinisation impacts in LCA: a review of challenges and adoptions towards their consistent integration. Int J LCA 21: 577-594.
- Núñez 2019. A worldwide and regionalized model to assess soil salinisation impacts in life cycle assessment. SETAC 2019, 26-30 May, Helsinki (Finland).

Background of the salinisation problem:

- **Problem**: soil salinisation is an important concern in many irrigated agricultural areas worldwide because it affects soil quality and food production on the long term.
- **Drivers**: the use of poor quality irrigation water and improper agricultural practices leads to soil salinisation.
- **Consequence**: on-site costs in agricultural soils (reduction of the soils' natural capital and its capacity to deliver ecosystem services) + off-site costs in other croplands and environmental media (salinisation downstream leads to loss of ecosystem services and a biodiversity turnover to halophytic species).
- Agricultural **practices** that are **worsening** the **environmental implications**: unknown. We need measures and models to leverage the limitation of lack of information about the salinisation-related environmental impacts of different agricultural practices.

Innovative strategies to tackle the salinisation problem:

- **On-site environmental impacts**: a global, yet locally-resolved model (5' resolution) that quantifies the potential effects on the loss of soil quality (ΔEC_e/ Δmass salt emitted with irrigation water) and on the diversity of crop varieties that can be grown at increasing salinity levels is now available.
- **Off-site environmental impacts**: model not available yet.

What makes this strategy a success?

- It counts environmental impacts of different farming practices.
  - *If you cannot measure it, you cannot improve it* (Lord Kelvin)
- It considers a holistic, life-cycle perspective: reducing soil salinisation impacts at the cost of impacts elsewhere is not optimal for the environment.
- Contributes to choosing the most sustainable agricultural practice if a multicriteria approach is used (e.g. counting also the impacts of using water to leach out salts from soils).

What are the potential fail factors?

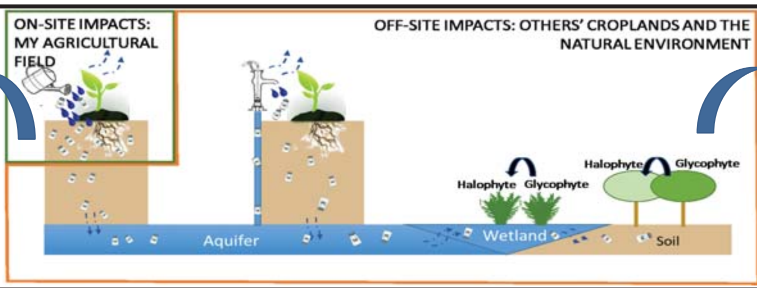
- The model may have an important role in assessing the environmental performance of farms, if applied. Main failure is a lack of application of the model.

Knowledge gaps which may be solved by further research or practical testing:

The model can be improved by:

- Gathering georeferenced information on drainage systems and any other soil salinisation control system that can be geolocalised.
- Adapting soil water and salt balance models from high data demanding plot scale assessments to global scale assessments, for which cropping practices and paedoclimatic conditions are usually unknown.
- Updating salt tolerance guidelines of crops and natural plant species to improve modelling of effects on the diversity of species.
- Measure and model the transport of salts from soils to aquifers and water bodies downstream and its environmental impacts.

Agricultural field in the Badopal village of Fatehabad (India).
Source: *The Tribune India* (http://www.tribuneindia.com/news/haryana/soil-salinityleaves-fatehabad-f...) *photo: Sanjeev Sharma. Retrieved from https://wad.jrc.ec.europa.eu/soilsalinization*



Doradne Creek (2003), a naturally-formed creek in the Dumbleyung Catchment of South-Western Australia. Crusted salt is seen on the banks and flows are from deep drains upstream intersecting saline groundwater. Photography by DoW. Retrieved from: www.water.wa.gov.au

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Biostimulants to overcome salinisation problems

Albino MAGGIO

Website 1 | Website 2

Background of the salinisation problem:

In some coastal areas of Campania Region (Castel Volturno – Villa Literno) salinized ground water is contaminated by sea water. Saline stress occurs during the summer crop (tomato). Farmers use saline water without applying leaching fractions. So far, winter rains have been sufficient to leach down salts accumulated during the summer. No major stress for the winter crops (e.g. cauliflower).

Innovative strategies to tackle the salinisation problem:

Use of biostimulants from different sources (algal, microbial, protein based and or combinations) to overcome seasonal/temporary salinity problems.

Country and region:

Italy, Campania

Climate conditions:

Mediterranean

Type of soil:

Clay-loam

Main crops:

Vegetables, tomato, leafy vegetables

Irrigated/rainfed:

Irrigated

What makes this strategy a success?

Biostimulants from different sources, microbial and algal (Ref. 1 and 2) are easy to apply and may help in overcoming seasonal stress damages as activators of stress protective mechanisms.

What are the potential fail factors?

Long term effects of salinization on soil physical, chemical and biological characteristics.

Knowledge gaps which may be solved by further research or practical testing:

Systematic monitoring of both seasonal and over-years salinization progression would be useful to descibe salinization trends vs agricultural practices in order to anticipate problems and identify possible solutions.

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funded by European Commission

Desalinisation of greenhouse soils by halophytes

Stephan Jung and Ute Perkons

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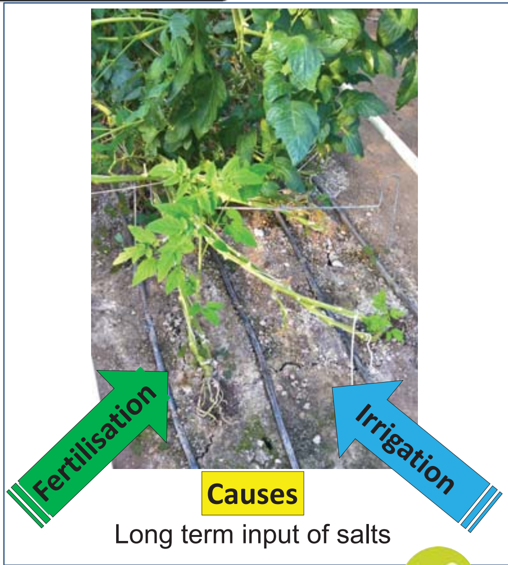

Country and region:
Germany - North Rhine-Westphalia

Climate conditions:
Semiarid (Greenhouse)

Type of soil:
Depends on location of greenhouse

Main crops:
Tomato, cucumber, paprika, salads

Irrigated/ rainfed:
Irrigated

Background of the salinisation problem:

In organic farming, greenhouse vegetable cultivation takes place on "natural" soils. Over the timeframe of several years, salts of irrigation water and organic fertilizers (with high sodium chloride concentrations) accumulate in the soil. Often these salts cannot be washed out with (salt-free) irrigation water, since loamy soils do not drain sufficiently enough. More so, during winter these soil do not dry up quick enough in between vegetable cultivations.

Innovative strategies to tackle the salinisation problem:

We investigate whether halophytes can accumulate sufficient amounts of salts to desalinate the soil and to be a marketable product at the same time. Some chard (silverbeet) cultivars have proven to take up high amounts of sodium chloride. Customers already know this vegetable well. Buck´s-horn plantain (minutina or erba stella, *Plantago coronopus*) or New Zealand spinach (*Tetragonia tetragonoides*) have also proven to be able to reduce salt contents of greenhouse soils. In the first season, customers liked both vegetables as a part of mixed green salads.

One important project goal is to establish a calculation model for all greenhouse salt intakes and outtakes to have an advisory tool for the farmers.

What makes this strategy a success?

Farmers can diversify their product portfolio and have a stand alone position by offering "new" vegetables to costumers.

What are the potential fail factors?

Costumers have to get used to the "new" vegetables and have to buy higher quantities of them. Only then farmers can cultivate these salt extracting halophytes in higher numbers to have a desalinisation success on their greenhouse soils.

Knowledge gaps which may be solved by further research and practical testing:

For some halophytes (which could be used as alternative vegetables), there is still little know about their salt-resistance strategies: exclusion of salts at the root surface and restricted uptake, or translocation and detoxification of salts by vacuolar sequestration in leaves.

It is known for maize and other main crops that there are huge differences in s a l t accumulation depending on their variety. Halophytes which have a good market potential already, could be improved with regard to their desalinisation abbilites by selecting for salt accumulation traits during the plant breeding process.

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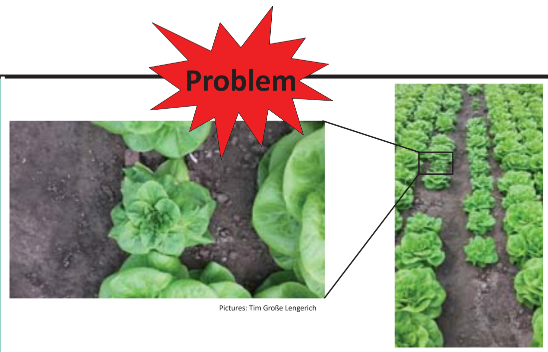

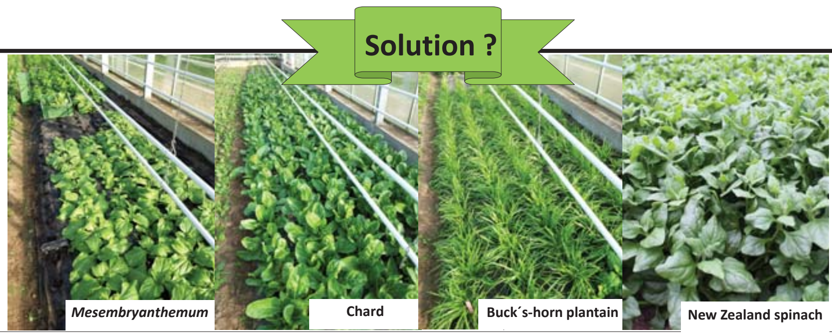

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More information: https://ec.europa.eu/eip/agriculture/en/focus-groups/soil-salinisation

Strategies to counter salinisation in rice fields

Jorge Zambujo

Website 1 | Website 2

Background of the salinisation problem:

This is a production area of rice in the margins and in the basin of Rio Sado. Due to the infiltration of salty water becuase of the sea tides that reach the area where the rice paddy area is located, most of the soils have high leveles of salinty. During year of drought the intensity of the salinisation effects are heavier.

Innovative strategies to tackle the salinisation problem:

The only crop that can grow in such conditions is rice. This is a crop with moderate to high tolerance to salinity. That means growing crops with high resistance to saline stress it´s a way to tackle the problem, but, avoiding pumping water from the river (during high tide) and making some trenches inside the paddy to irrigate with greater homogeneity are some of the strategies to limit this problem. During crop development we use only fresh and good quality water (from a damn) to avoid the increase of salinity levels. In this type of soils there´s no other crop that can grow and produce like rice.

Country and region:

Portugal, Alcácer do Sal

Climate conditions:

Mediterranean Climate

Type of soil:

Heavy clay

Main crops:

Rice

Irrigated/rainfed:

Irrigated

What makes this strategy a success?

This strategy has been sucssefull so far becuase of the tolerance that some rice varieties present to saline soil and saline stress.

What are the potential fail factors?

At this point rice is affected by the problem of monocropping. Because there i s no crop rotation, agronomic questions arise like the usage of the same herbicides causing weed resistance and cross resistance making the weed control less efective and decreasing yield year by year.

Knowledge gaps which may be solved by further research or practical testing:

Future research is needed on management strategies such as breeding for salt-tolerant cultivars, application of molecular markers to select salt-tolerant germplasm, potential of genetic transformation for salinity resistance, application of arbuscular mycorrhizal fungi, and plant growth regulating rhizobacteria, nutrient management, and seed priming techniques for sustainable rice production in saline areas.

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funded by European Commission

Salinisation risks in irrigated alluvial and marine origin soils

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www.iniav.pt | www.arimnet2.net/index.php/researchprojects/projects-2nd-call/saltfree

Country and region:

Portugal, Lezíria Grande de Vila Franca de Xira (Corte Lobo and Ermida)

Climate conditions:

Mediterranean climate: hot and dry summers and mild winters with irregular rainfall. Aridity index of 0.5.

Type of soil:

Fluvisol (clay loam texture)

Main crops:

Zea mays L. and *Lolium multiflorum* Lam in crop rotation

Irrigated/rainfed:

Sprinkler irrigation in spring/summer (maize) rainfed in autumn/winter (annual ryegrass)

Background of the salinisation problem:

Primary salinisation: due to the alluvial and marine origin of the soil, the tidal nature of the estuary and existence of a saline water table (12-30 dS m^{-1} at 1-2 m depth). Secondary salinisation: due to the degradation of the irrigation water quality in drought years (uptake of water in an estuarine zone under tidal influence and saline intrusion), that restricts the application of the leaching water fraction. Drainage systems are installed, yet in the south (Ermida) the ditches are shared for irrigation and drainage. In Corte Lobo the subsoil layers are sodic (>0.7 m depth) and therefore facing degradation of their structure.

Innovative strategies to tackle the salinisation problem:

(a) Use of calibrated electromagnetic induction methods (EMI) to map soil salinity and sodicity; (b) Use of transient models (HYDRUS) to describe the salinisation and sodification processes in the soil profile, to simulate risks and to predict the impact of irrigation and farming practices; (c) Use of crops inoculated with plant growth promoting microorganisms (PGPM), namely PGP bacteria; and (d) Crop rotation with beneficial salt tolerant cover crops (legumes or N scavenger plants).

What makes this strategy a success?

Non-invasive surveys using EMI methods allows to map soil salinity and sodicity with good accuracy. Model HYDRUS allows the consideration of site-specific soil, water, and crop parameters, and accounts for time-varying field conditions. This interactive and detailed approach constitutes a tool to predict the impact of management and farming practices in ameliorating and/or preventing salinisation. Inoculated crops can perform better in saline conditions due to the presence of beneficial bacteria that participates in nutrients acquisition, phytostimulation and in increasing root growth and architecture. When associated to the use of cover crops it helps to increase the pool of nutrients in the soil and to reduce the amount of chemical fertilizers applied and ultimately to increase soil health in general.

What are the potential fail factors?

Modelling requires good comprehension of the several model concepts and soil dynamics. The quantity and quality of the input data needed (initial and boundary conditions, time-series parameters) to run and validate the model. Plant-host specificity of the PGP bacteria used as biofertilizer and its capacity to function in different field conditions.

Knowledge gaps which may be solved by further research or practical testing:

Need of soil data with quality and spatial variability to use in modelling. Better understanding of the crop response to the spatial and temporal distributions of soil water and soil salinity. Better understanding on the mechanisms by which PGP bacteria alleviates salt stress in crops and if the bacterial inoculant strains must be isolated from plants naturally growing in saline conditions. Better evaluate (quantify) the contribution of the use of PGP bacteria and the cover crops in increasing the pool of nutrients in the soil.

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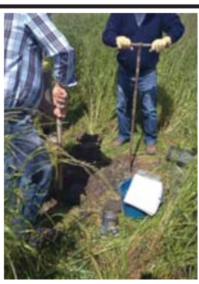
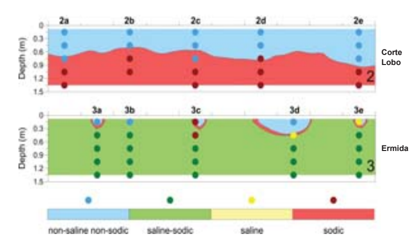
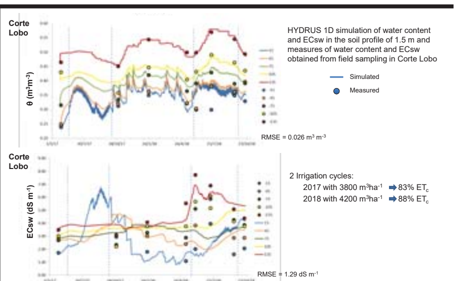




2-D maps of the soil salinity and sodicity classification predicted from σ (obtained with EM38 surveys). The circles represent the actual classification obtained from EC_e, SAR and ESP measured at the samples.



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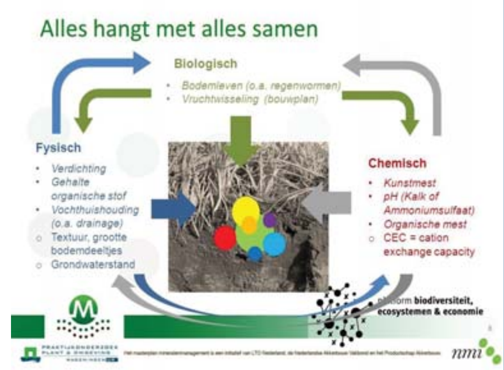
Strategies to counter salinisation problems in Waddenregion

Tineke de Vries

Website 1 | Website 2



Country and region:

The Netherlands, northern region (Wadden region)

Climate conditions:

Sea climate

Type of soil:

Clay

Main crops:

Potatoes, sugarbeets, onions, wheat, barley, flowerbulbs, grass, maize

Irrigated/rainfed:

Irrigation of surface water on potatoes is not allowed

Background of the salinisation problem:

In the Waddenregion, we can grow crops because of the fresh water lens. Because of the rising sealevel and soil subsidence the fresh water lens becomes thinner and even disappears in dry summers. On clay soils the structure becomes very bad then, so that is the limiting factor.

Innovative strategies to tackle the salinisation problem:

- Replace average drainage by anti –salinisation drainage
- Underground storage of fresh water
- Use drip irrigation instead of sprayers
- Use different kinds of soil tillage
- Try to find green crops or manure to improve the soil structure under salt conditions
- Try to catch the Natrium ions before they can replace Calcium on the clay-humus complex
- Make new varieties adapted to salt on clay by breeding programs

What makes this strategy a success?

If we can make these strategies economic profitable for the farmers

What are the potential fail factors?

- Business, governement, research and education must see the salinisation problem and the need to do something about it.
- We don't get the opportunity to try this strategies on a larger scale
- We don't succeed in develop soil knowledge by scientific research

Knowledge gaps which may be solved by further research or practical testing:

- We need to know the background of salt tolerance in crops, otherwise we can't make breeding programs.
- Therefore we need to research the realation between soil and crop (roots), including soil life

REFERENCES:

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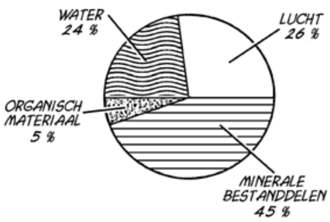

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More information: whttps://ec.europa.eu/eip/agriculture/en/focus-groups/soil-salinisation

Salinisation problems in the Axios river wetlands

Stelios Tamvakidis

Website 1 | Website 2

Image of the Rivers Part and the Alyki Kitros part

Country and region:

GREECE, Region of Central Macedonia

Climate conditions:

Mediterranean towards the coastal zone.

Type of soil:

Clay soils. Ninety (90%) percent of the cultivated rice area is characterized by pathogenic soils with high salinity

Main crops:

Rice, Cotton, Maize, Alfalfa and Cereals

Irrigated/rainfed:

Surface irrigation, Basin or Furrow Irrigation

REFERENCES:

MONITORING OF SALINAZATION OF IRRIGATED FIELDS IN AXIOS DELTA (in Greek)

Background of the salinisation problem:

The Axios River basin is located in the central Balkan Peninsula covers an area from FYROM, parts of Bulgaria and Greece, approximately 25.000 km^2. Greece occupies the delta area. The wetlands of the Thessaloniki plain, where the Axios Delta is located, provide a characteristic example of wetland destruction in Greece. While in 1917, 36% of the plain were wetlands, today this area amounts only to 5.5%.

The main environmental pressures, which affected negatively the delta's area ecological character, leading to the destruction of 70% of the original wetlands during the 20th century, are numerous, such as Water Discharge Decrease, Drainage works, Urbanization and Pollution. Moreover the general decrease in rainfall, combined with excess of water for irrigation, has resulted in severe salinization of the delta area, with a direct impact on the flora and fauna of the Wetlands. Nowadays some of these activities have been stopped and their impacts have already been mitigated. The high underground water level and high salinity cause a problem due to capillary rise in root zone

Innovative strategies to tackle the salinisation problem:

In the Axios Delta Area after the Land Reclamation Work and infrastucture for irrigation and drainage were made in 1930, were about of 100.000 Hectares turn from a swamp to high productivity fields. The soils of the low plain of Axios Delta, were saline due to the intrusion of seawater in addition with the dry-warm climate and the low annual rainfall. Much of these lands improved after the drainage network and the seafront dyke which prevent the sea from entering.Near the coastal zone where the fields level are below sea level and the ground table water is only 50 cm in the root zone, there are salinity problems due to capillary rize. Most of the crops failed or the output was low yield. The Land Reclamation Institute sugest the farmers to mitigate to paddy rice, with land levelling of fields and creation of basins which are flooded. The excess irrigation water retains the salinity of the underground water to low level not affecting the yield in rice fields.

In some cases inovative Precision Agrigulture methods are used to confront spot remedy of soil salinity in the fields

What makes this strategy a success?

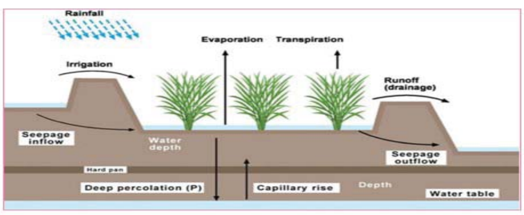
The Axios Delta area suffer due to high salinity of high water table which due to capillary rise in root zone causes problem to most of crops. Farmers mitigate from maze, cooton and vegetable to paddy rice and keep salinity to low level with the excess use of irrigatation water by flooding the rice fields.Rice is more tolerant to salinity and with these cultivation methods result to high yield per ha.

What are the potential fail factors?

- Water scarcity due to limitied rainlfall because of climate change
- New water pricing due to compliance with the Directive 2000/60 EU
- The rise of price for the amount of energy needed to pump the excees drainage water to the sea because farms level are below sea level

Knowledge gaps which may be solved by further research or practical testing:

- Training of the farmers for the best application of irrigation water to the rice fields
- Better leveling techniques for perfect plain with new Precision Agrigulture Machinery
- Use of Electromagnetic induction instruments to characterize soil salinity spatial variability across large areas and application of spot remedy of soil salinity



Schematic representation of the water balance

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Salinity management in Almeria greenhouses – Blending and other solutions

Rodney Thompson

Group web page | SCOPUS

Country and region:
Spain, Almeria

Climate conditions:
Mediterranean

Type of soil:
Varied

Main crops:
Pepper, tomato, cucumber, melon, watermelon, zucchini, eggplant

Irrigated/rainfed:
Irrigated

Background of the salinisation problem:

- Aquifers provide 90% of water used in greenhouse vegetable production
- Aquifer water used for irrigation is increasing saline
- 90% crops in soil
- Fertigated crops that receive complete nutrient solutions in all irrigations
- Causes are: poorly installed wells, over-pumping, excessive irrigation
- Poorly-installed wells a problem in main greenhouse area where water taken from deep aquifers and drainage enters a shallow aquifer

Innovative strategies to tackle the salinisation problem:

- Blending aquifer water with desalinated water
- Use of ceramic cup suction samplers and hand-held EC meters to monitor soil salinity
- Application of salt leaching irrigations in response to monitoring of soil solution EC
- On-farm desalination

What makes this strategy a success?

- Blending with de-salinated water enables salinity sensitive crops to be grown without adpating crop management
- Monitoring soil solution EC etc. enables crop and site salinity management

What are the potential fail factors?

- Blending: growers may become complacent and not adopt optimal irrigation practices
- Blending: may reduce incentives to ensure that all wells are legal & correctly installed
- On-farm desalination: saline waste water (approx. 40% of volumen desalinated)

Knowledge gaps which may be solved by further research or practical testing:

- What are threshold values of EC in soil solution for these species?
- What are optimal practices for integrated irrigation and salinity management of these fertigated vegetable species?
- The "salinity/nitrate leaching paradox"

REFERENCES:
None currently available

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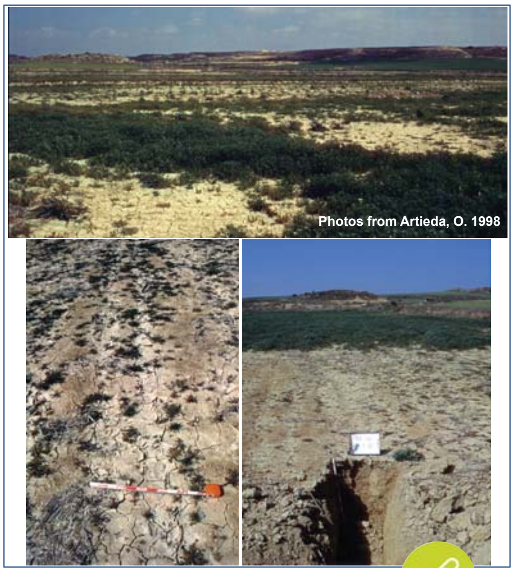
Sodic soil reclamation – Chemical amendments

Amezketa, E.



Photos from Artieda, O. 1998

Country and region:

Spain (Sádaba municipality, Aragón, Bardenas I irrigation district, middle Ebro River Basin)

Climate conditions:

Arid-zone area (Mediterranean climate)

Type of soil:

Typic Xerorthent, calcareous (44% $CaCO_3$), clay-loam texture, high in hydrated micas, no swelling clays, low in organic carbon (1.6%)

Main crops:

Veza (*Vicia sativa*)

Irrigated/rainfed:

Irrigated (flood irrigation)

Background of the salinisation problem:

Sodic soil (ESP = 25) with poor physical conditions, prone to clay dispersion. Irrigation with low-salinity water induced impermeable surface sealing and reduced permeability (infiltration rates, hydraulic conductivity), negatively affecting crops emergence and productivity and producing waterlogging and soil erosion.

This sodic soil when exposed to rainfall (very low-salinity water) also leads to the same degradation indicated above.

Clay dispersion is the principal process inducing sealing and decreasing soil permeability due to the high soil sodicity (Na, SAR/ESP) levels and the low-salinity (EC) waters.

Innovative strategies to tackle the salinisation problem:

Incorporation of gypsum amendments into the soil or addition of sulfuric acid on the surface of calcareous soils, and then irrigating the soils, are effective practices to reduce soil sodicity levels (Na levels, SAR/ESP levels) and their negative consequences.

Besides sulfuric acid, mined-gypsum and gypsum-like industrial by-products can be used as chemical amendments, e.g. coal-gypsum obtained in coal-burning power plants and lacto-gypsum in the manufacture of lactic acid and lactates.

PGR (Pure Gypsum Requirement) = 1.25 x ($mmol_c$ Na^+ removed to reduce ESP to 1) = $mmol_c$ SO_4^{2-} of amendment added

What makes this strategy a success?

Gyspum dissolution or calcite dissolution by sulfuric acid release, during the irrigating/leaching process, soil water electrolyte and Ca concentrations necessary for the Na–Ca soil exchange process. Then, Na has to be leached out of the root zone. The efficiency of the exchange process is a function of (i) the rate of Ca release, (ii) the rate of diffusion of the dissolved Ca and the exchanged Na through aggregate micropores, (iii) the mass flow processes, and (iv) the number of actively conducting macropores.

Reduction of sodic soil levels improves soil permeability and reduces soil degradation.

What are the potential fail factors?

Soil crusting and too low soil permeability are some limiting factors in the reclamation process.

Other limiting factors are too coarse gypsum particles, to low rate of dissolution of the amendment, too low doses of amendment, use gypsum products of very low purity, overestimate the efficiency of the Na–Ca exchange process, too low water irrigation doses to dissolve the amendments, etc.

Knowledge gaps which may be solved by further research or practical testing:

Practical testing should be performed in the field. Testing if part of gypsum should be left on the soil surface instead incorporating all into the soil. Posibility of reclaiming in sequential steps. Sulfuric acid poses management risks.

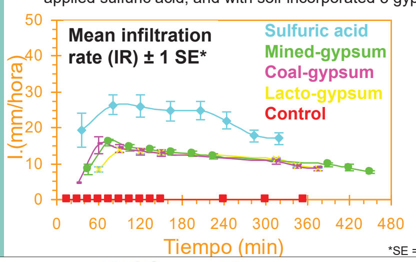
REFERENCES:

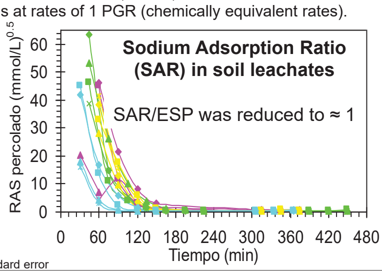
Amezketa, E., R. Aragüés, & R. Gazol. 2004. Infiltration of water in disturbed soil columns as affected by clay dispersion and aggregate slaking. Span. J. Agric. Res. 2(3): 459-471.

Amezketa, E., R. Aragüés, & R. Gazol. 2005. Efficiency of sulfuric acid, mined gypsum and two gypsum by-products in soil crusting prevention and sodic soil reclamation. Agronomy Journal, 97: 983-989.

Efficiency of chemical amendments in sodic soil reclamation (↓ESP 25 to ESP 1): Laboratory disturbed soil columns

Leaching process with irrigation water (EC = 0.38dS m^{-1}) of non-amended soil (control), and amended with surface-applied sulfuric acid, and with soil-incorporated 3 gypsums at rates of 1 PGR (chemically equivalent rates).





*SE = standard error

Surface-applied sulfuric acid and soil-incorporated gypsums reduced SAR/ESP and increased FIR of the control soil

AMENDMENTS	Final IR (mm h^{-1})
Control	0.0 ± 0.0 a
Sulfuric acid	17.1 ± 1.7 c
Coal-gypsum	8.7 ± 0.6 b
Lacto-gypsum	8.9 ± 0.3 b
Mined-gypsum	7.8 ± 0.4 b

FIR (± 1SE) with different letters significantly different at P<0.01

Amendments efficiency:

Sulfuric acid > 3 gypsums

3 gypsums equally effective

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This poster was presented at the 1st meeting of the EIP-AGRI Focus Group 'soil salinisation' – May 2019

More information: whttps://ec.europa.eu/eip/agriculture/en/focus-groups/soil-salinisation

Soil crusting prevention – Chemical amendments

Amezketa, E.

Photos from Artieda, O. 1998

Background of the salinisation problem:

Saline (ECe = 16.1 dS/m) and sodic (RAS = 23.6) soil with severe problems of soil crusting, reduced water infiltration rates, reduced seedling emergence and crop productivity, and increased surface runoff and soil erosion.

Clay dispersion was the principal process inducing sealing and decreasing the infiltration rates when the soil was subjected to low-salinity waters, such as the used irrigation water and rainwater. The dispersed clay clogged the pores and led to soil crusting.

Leaving the soil naked increased the soil crusting susceptibility.

Innovative strategies to tackle the salinisation problem:

The application of chemical amendments on the surface of sodic (and even non-sodic) soils at equivalent rates of 5 Mg pure-gypsum ha^{-1} is an effective practice to prevent or minimize soil crusting and maintain or improve water infiltration rates.

Possible chemical amendments include, among others, sulfuric acid in calcareous soils, and gypsum products such as mined-gypsum and gypsum-like industrial by-products, *e.g.*, coal-gypsum obtained in coal-burning power plants and lacto-gypsum in the manufacture of lactic acid and lactates.

Country and region:

Spain (Sádaba municipality, Aragón, Bardenas I irrigation district, middle Ebro River Basin)

Climate conditions:

Arid-zone area (Mediterranean climate)

Type of soil:

Typic Xerorthent, calcareous (44% CaCO3), clay-loam texture, high in hydrated micas, no swelling clays, low in organic carbon (1.6%)

Main crops:

Veza (*Vicia sativa*)

Irrigated/rainfed:

Irrigated (flood irrigation)

What makes this strategy a success?

Gyspum dissolution or calcite dissolution by sulfuric acid release/increase, during the irrigating/leaching process, the Ca and the total electrolyte concentrations of the soil solution at the soil surface, minimizing clay dispersion, the clogging of pores, and thus, soil crusting. Preventing/minimizing soil crusting maintains or improves water infiltration rates.

What are the potential fail factors?

Limiting factors: Too coarse gypsum particles, low dissolution rates of gypsum, high sulphate concentrations in the soil that will limit the dissolution of gypsum due to the commom ion effect, too low doses of amendment, use gypsum products of very low purity, too low water irrigation volume to dissolve the amendments, the limited movement of the disolved ions (Ca^{2+}, SO_4^{2-}), etc.

Knowledge gaps which may be solved by further research or practical testing:

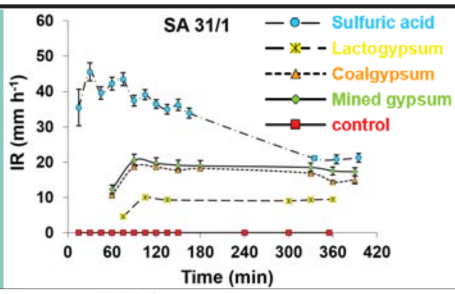
Practical testing should be performed in the field. Sulfuric acid poses management risks.

REFERENCES:

Amezketa, E., R. Aragüés, & R. Gazol. 2004. Infiltration of water in disturbed soil columns as affected by clay dispersion and aggregate slaking. Span. J. Agric. Res. 2(3): 459-471.

Amezketa, E., R. Aragüés, & R. Gazol. 2005. Efficiency of sulfuric acid, mined gypsum and two gypsum by-products in soil crusting prevention and sodic soil reclamation. Agronomy Journal, 97: 983-989.

Efficiency of chemical amendments in soil crusting prevention: Laboratory disturbed soil columns



Mean infiltration rate (IR) ± 1SE* along the leaching process with irrigation water (EC = 0.38 dS m^{-1}) of non-amended soil (control) and surface-amended at equivalent rates of 5 Mg pure-gypsum ha^{-1} of sulfuric acid, mined-gypsum, coal-gypsum, and lacto-gypsum.

*SE = standard error

Surface-applied amendments minimized crust formation. FIRs of amended soils were significantly higher than that of the control soil

AMENDMENTS	Final IR (mm h^{-1})
Control	0.0 ± 0.0 a
Sulfuric acid	21.2 ± 1.2 d
Coal-gypsum	15.0 ± 1.1 c
Lacto-gypsum	9.4 ± 0.3 b
Mined-gypsum	17.3 ± 1.1 c

FIR (± 1SE) with different letters significantly different at P<0.01

Amendments efficiency:

Sulfuric acid > Mined-gypsum ≈ Coal-gypsum > Lacto-gypsum

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More information: whttps://ec.europa.eu/eip/agriculture/en/focus-groups/soil-salinisation

Strategies to counter salinisation in pastures of the Tagus river margins

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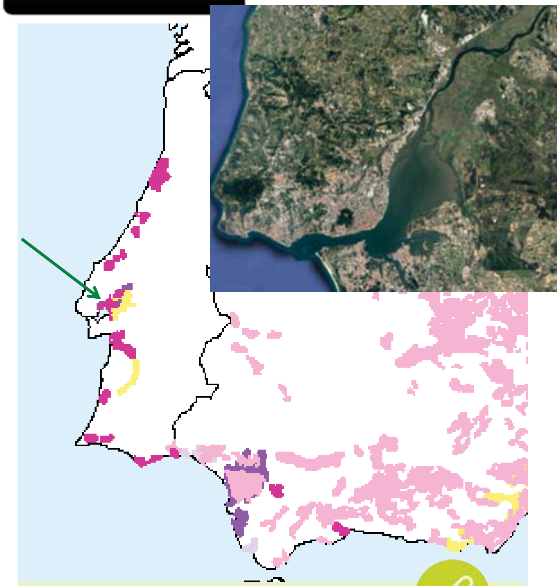


Background of the salinisation problem:

In the west margin of the River Tejo, close to Lisbon, there is a fertile alluvial area used for intensive agriulture (Lezíria). This area has been benefited with drainage and irrigation infrastructure. The southern part lays by the estuary, where the water has EC ~50 dS/m due to the influence of the ocean. As a result, saline groundwater table raises periodically causing salinization of the subsoil. The surface (0-30 cm) is non-saline (< 4 dS/m) and layers below are mainly **saline-sodic** (SAR> 13). Due to high salt content below 30 cm, the land in this area is used as pasture. Grasses (*Poaceae*) dominate the pasture, but near the drainage ditches the presence of halophites is evident (*Salicornia* spp; *Sarcocornia* spp; *Beta maritima*).

Innovative strategies to tackle the salinisation problem:

- The use of the land, which is non-saline at the surface, as a **pasture** with spontaneous, well-adapted species, is an interesting strategy for its productive use.
- Removal of the excess Na would be needed before the soluble salts are removed to avoid degradation of the soil structure (e.g. **phytoremediation** with species that facilitate Ca release for Na replacement, such as *Medicago sativa*).
- A well-planed **irrigation** scheme with good quality water to wash the soluble salts. This can be designed by **modeling** the water and salts behavior in the soil under different irrigation schemes, climate and water table conditions.
- Knowledge of the water table movements and EC and SAR/ESP monitoring is needed – **Electromagnetic Induction** methods can be applied!

What makes this strategy a success?

Phytorremediation has shown to be successful with results comparable to chemical amendments in several studies. Its represents less costs than a chemical remediation

Modeling enables simulation of different assumptions such as EC and level of the water table and climate change scenarios (lower precipitation and higher evapotranstipration).

Electromagnetic induction can be used to predict ECe, SAR and ESP and can efficiently monitor salinity in-depth and over large areas.

What are the potential fail factors?

The success of **phytorremediation** is highly dependent of site-specific factors, such as the availability of a Ca source. It is essential to define the correct rotation for the site and physical amendment could be needed in some cases - tests are needed in the present case!

Modeling can give trustable results depending on the quality of the data used to characterize the soil. This demands initial sampling efforts and for correct calibration and validation of the model.

Knowledge gaps which may be solved by further research or practical testing:

Further studies for testing the efficiency of Na removal by phytorremediation in the site-specific conditions.

Country and region:

Portugal (River Tejo estuarine area)

Climate conditions:

Mediterranean hot summer (Csa)
Average yearly precipitation (1971-2000): 700 mm

Type of soil:

Solonchak (HWD) (silty-clay texture)

Main crops:

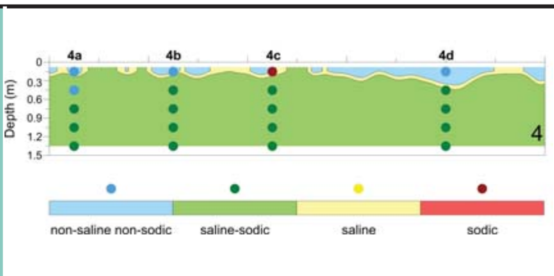
Spontaneous pasture

Irrigated/rainfed:

Rainfed

REFERENCES:

Farzamian, M. et al (2019) Mapping soil salinity using electromagnetic conductivity imaging – a comparison of regional and location-specific calibrations. Land Degradation & Development. https://doi.org/10.1002/ldr.3317



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Salinization risk in soils irrigated with saline waters

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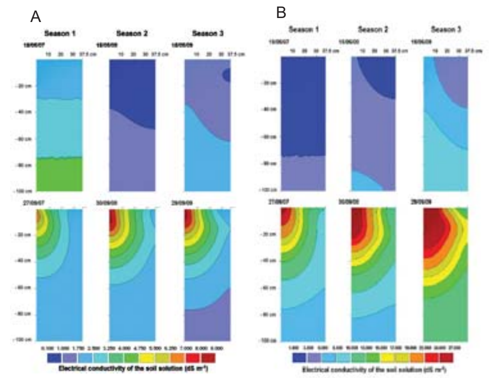


Simulated distributions of the electrical conductivity of the soil solution in plot irrigated with fresh (A) and saline (B) waters during sowing (top) and harvest (bottom) of the 2007-2009 crop seasons. The drip emitter was located in the top left corner of each contour plot.

Country and region:

Portugal, Alentejo region

Climate conditions:

Dry sub-humid, with hot dry summers and mild winters with irregular rainfall

Type of soil:

Fluvisol

Main crops:

Sweet sorghum

Irrigated/rainfed:

Irrigated

Background of the salinisation problem:

In Portugal soil salinization is limited to marshes in western and southern coastal regions, and some irrigated areas, in Alentejo region, due to the use of poor quality water, soils with poor drainage, and climatic conditions with dry hot summers and irregular rainfall. However, the increase of the irrigated area and the prospects of climate change, including rising temperatures, can enhance salt concentration in the soil profile and lead to an increase of the degraded area in Portugal.

Innovative strategies to tackle the salinisation problem:

Numerical models are very useful tools to predict the long and short-term effects of irrigation water quality on soil properties, crop yield, groundwater, and the environment. They also allow to calculate the leaching requirement needed to control salts within the tolerance of the crop and the nitrogen losses.

Hydrus-2D was used to model soil salinization, and the fate of nitrogen in a plot planted with sweet sorghum grown under Mediterranean conditions, while considering drip irrigation scenarios with different levels of nitrogen and salty waters, during three crop seasons (may 2007 to april 2010).

What makes this strategy a success?

Salinization control processes have to be based on the knowledge of water and solutes dynamics in the soil, the relationships between the concentrations of soluble and adsorbed salts on the soil in an integrated approach. Modeling is a processes integration tool, that avoid favoring one problem over the other.

What are the potential fail factors?

The quality of the information needed to run the model (e. g. input data, initial, boundary conditions, and long-term monitoring time series to validate the results).

Knowledge gaps which may be solved by further research or practical testing:

Lack of soil information (input data for modeling) and long term monitoring campaigns (modeling validation data);

Need of soil properties databases;

Spatial variability and upscaling of soil properties, namely soil hydraulic properties, from plot scale (where they usually are measured) to larger areas.

REFERENCES:

Ramos, T. B., Šimůnek, J., Gonçalves, M. C., Martins, J. C., Prazeres, A., Pereira, L. S., 2012. Two-dimensional modeling of water and nitrogen fate from sweet sorghum irrigated with fresh and blended saline waters. Agricultural Water Management 111: 87-104, http://dx.doi.org/10.1016/j.agwat.2012.05.007

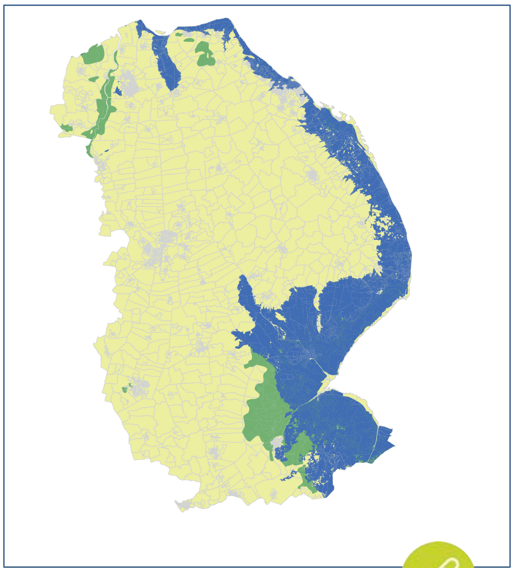
Ramos, T. B., Castanheira, N. L., Gonçalves, M. C., Fernandes, M. L., Januário, M. I., Lourenço, M. E., Pires, F. P., Martins, J. C., 2012. Effect of Combined Use of Brackish Water and Nitrogen Fertilizer on Biomass and Sugar Yield of Sweet Sorghum. Pedosphere 22 (6): 785-794. http://dx.doi.org/10.1016/S1002-0160(12)60064-2.

funded by European Commission

Water Scarcity and Brackish/Saline Water in Eastern England

Dr Iain Gould

https://staff.lincoln.ac.uk/b070586c-1a2e-4778-b35b-cc207ba07bc1



Background of the salinisation problem:

In the East of England, there is growing concern for water availabilty for agirulcture. The driest counties of the UK are also produce much of the higher value agriculture – for many of these irrigation and sustainable water resource is essential.

These areas are often found in coastal zones, and much of the groundwater resource for irrigation is becoming increasingly saline. Drier summers, like 2018, are exacerbating the problem. Further to this, the risk of one-off salinity events such as coastal flooding, has decimated farmland in 2013, 1978 and 1953. Under furture climate preictions, this is only set to rise

Innovative strategies to tackle the salinisation problem:

Due to the increased risk of groundwater salinity, farmers have adopted novel ways to ensure crop growth. These include modifiying the water extraction process by digging 'seepage pits' to rapidly abstract freshwater lenses. Farmers are also trialling brackish water irrigation, by including some slaine water in with teh freshwater abstracted

What makes this strategy a success?

It was initiated by farmers to meet an dindsustry demand. It also pushes less pressure on water uses for other means (e.g. domestic, othe industry)

What are the potential fail factors?

We do not fully understand the long term impacts of brackish water irrigation to soil function in these climates, and how it may impact on later crops in the rotation.

We also do not know how sustainable this water abstraction method is. There is a chance that we could exploit all the freshwater reserves leaving none for farming

Knowledge gaps which may be solved by further research or practical testing:

It appears there is potential to exploit some brackish water reserves to irrigate certain crops with no yield penalties. However, just beacuse one crop may grow, it doenst necessarily mean that subsequent, potentially more sensitive, crops may not be challenged by longer term impacts of salinity to soil function.

Furthermore, the vast majority of data on crop responses to salinity comes from arid and semi-arid environments. In Northern Europe, we predict increases in salinity but do not know how crops would respond to such threats in this climate. More research, much like that carried out in Salt Farm Texel, Netherlands, needs to be undertaken to explore responses of varieties to salinity in Northern climates.

Country and region:

UK

Climate conditions:

Dry for UK ~600-700mm rain pa

Type of soil:

Silt loams, loamy sands, sandy loams

Main crops:

Potatoes, carrots, onions, wheat

Irrigated/rainfed:

Mostly irrigated

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This poster was presented at the 1st meeting of the EIP-AGRI Focus Group 'soil salinisation' – May 2019

More information: whttps://ec.europa.eu/eip/agriculture/en/focus-groups/soil-salinisation

Assessing soil salinization in very high-density olive orchards through modeling

Tiago Ramos (tiagobramos@tecnico.ulisboa.pt)

http://soil4ever.pt/

Country and region:

Portugal, Alentejo

Climate conditions:

Dry, sub-humid

Type of soil:

Several

Main crops:

Olive

Irrigated/rainfed:

Deficit irrigation

Background of the salinisation problem:

The area with high and very high-density orchards has been rapidly expanding in the Alentejo region of southern Portugal, covering now more than 55,000 ha as new irrigation land becomes available with the Alqueva project. In this water scarce region, deficit irrigation practices are now adopted for maximizing water use, yields and the quality of olive oils, but can also potentially promote soil salinization and sodification problems in a region where rainfall may not always be sufficient to remove the salts accumulated in the soil profile during irrigation.

Innovative strategies to tackle the salinisation problem:

Well defined monitoring programs aimed at assessing the impact of the land use radical change from rainfed agriculture to irrigation on local soil and water resources have practically been absent. As such, modeling has been used for quantifying soil salinization and sodification risks from deficit irrigation practices carried out in high and very high-density orchards. Model implementation relied on the use of regional soil datasets and auxiliary tools (pedotransfer functions) for characterizing landscape variability, while results from past modeling applications were taken into account for evaluating the quality of the results.

What makes this strategy a success?

Modeling is currently the only feasible way to assess soil salinization and sodification risks at the regional scale, making the best use of state-of-the-art knowledge to assess the long-term sustainability of olive orchards production systems without great cost.

What are the potential fail factors?

Results were associated with a large uncertainty as the modeling approach was not calibrated/validated *in situ* for all studied cases. Nonetheless, model predictions should not be taken lightly as they show that the risk of soil salinization/sodification is real, evidencing the need to closely monitor the problem at the local scale to prevent further degradation of soil and water resources in the region.

Knowledge gaps which may be solved by further research or practical testing:

There is need of a monitoring program aimed at assessing soil quality levels at the regional scale on a regular basis. Also, there is need of better soil information, particularly on soil hydraulic properties; field datasets describing soil water dynamics and salt transport in olive orchards that can used for calibrating/validating models and more reliable model predictions; better description of olive orchards management practices, particularly in terms of fertilization; models capable of assessing the impact of soil salinity on soil hydraulic properties; and exploring the potential of Sentinel-2 (or other remote sensing platforms) for assessing soil salinity risks at the regional scale.

REFERENCES:

Ramos, T.B., Darouich, H., Šimůnek, J., Gonçalves, M.C., Martins, J.C., 2019. Soil salinization in very high-density olive orchards grown in southern Portugal: Current risks and possible trends. Agricultural Water Management 217, 265-281; https://doi.org/10.1016/j.agwat.2019.02.047

Landscape prior to the expansion of irrigation

Nowadays

High-density olive orchard

funded by European Commission

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More information: https://ec.europa.eu/eip/agriculture/en/focus-groups/soil-salinisation

Water management and crop selection to counter salinsation in Bulgaria

Contact persons: Biser Hristov

Website 1 | Website 2

Background of the salinisation problem:

Most of the salinity in Bulgaria is associated with irrigation. Rather it is due to the redistribution of existing salts in the area with irrigation water in the past. Irrigation channels, wells, excess irrigation, raising the water table are increasing salinity of soils.

Innovative strategies to tackle the salinisation problem:

Water management is the most important issue for controlling salinity. The degree to which water movement can be managed determines the feasibility of controlling the salinity problem. Crop selection is the main practice that a farmers can use to prevent a soil salinity problem in the affected area also.

What makes this strategy a success?

Soil salinization needs a long-term management strategy because it is a problem of both water and soil. Good agricultural practices such as applying gypsum, manure, mulch, continuous cropping or growing perennial forages, could reduce soil salinity. Although few soils may me completely restored to a normal state.

Country and region:

Bulgaria, Sofia field

Climate conditions:

Continental / Mesic - Udic

Type of soil:

Haplic Phaeozem (Ednoclacaric, Sodic, Clayic)

Main crops:

Pasture

Irrigated/rainfed:

Rainfed

What are the potential fail factors?

There are many factors of failure that should be considered such as lack of information about soils and water in the region, bad management of the soil, using improper chemical amendments and fretilizers, irrigation without contorl and etc.

Knowledge gaps which may be solved by further research or practical testing:

Research on plants, crops and cover crops also for saline soils and flooded areas. New environmental friendly amendments for saline areas such as zeolites, gypsum, manure, plant residues and etc. Research on water managment and quality.

REFERENCES:

Andreeva N., B. Hristov, 2015, Characteristic and Classification of Slightly Saline Soils Form Sofia Field, Conference: 15 International Multidicplinary Scientific Geoconference SGEM 2015At: AlbenaVolume: 2 DOI: 10.13140/RG.2.1.3095.4006

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This poster was presented at the 1st meeting of the EIP-AGRI Focus Group 'soil salinisation' – May 2019
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Case description – Crop observation on saline soils

Marcello Mastrorilli

Website 1 | Website 2

Background of the salinisation problem:

The general term «saline soil» mainly refers to two conditions:

1) the huge increase in irrigated areas over the last century. In hot-arid climate regions, where this growth is associated with overestimation of crop water requirements and the absence of a drainage system, it leads to soluble salt accumulation in the soil layers explored by roots
2) the use of saline water in agriculture on soils previously contaminated, at varying degree, by salinity

Innovative strategies to tackle the salinisation problem:

How **to observe** a crop growing on saline soils

The effects of soil salinity on plant functioning are similar to those caused by soil drought. As soil salinity increases, soil water available to the plants decreases as a result of the reduction in osmotic potential. Accordingly, this may cause short-term disturbance in plant water status and gas exchanges and long-term disturbance in growth and productivity.

How **to model** the crop functioning under saline conditions

In natural environment, drought and salinity conditions are quite often associated, as it is particularly the case in the Mediterranean region.

Observations that consider the combined effects of drought and salinity are thus more appropriate to represent the actual situation of this region.

Country and region:
Mediterranean region

Climate conditions:
Mediterranean climate

Type of soil:
any

Main crops:
annual, perennial

Irrigated/rainfed:
both

What makes this strategy a success?

This strategy gathers a multidisciplinary community of observers

What are the potential fail factors?

Effective transfert of wnowledge from research laboratorries to farms.... and *vice versa*

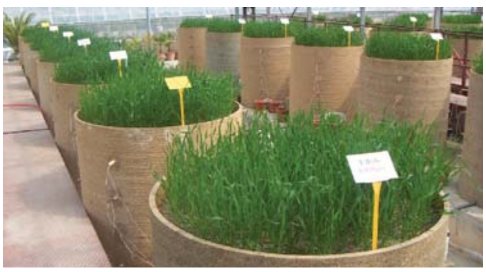
Knowledge gaps which may be solved by further research or practical testing:

Integrating different research areas:

- eco-physiology,
- agronomy,
- genetics,
- soil science

REFERENCES:

Mediterranean crop production on saline soils (Katerji, Hamdy, Mastrorilli, eds).
CIHEAM edition ISBN: 2-85352-424-8, 397 pp



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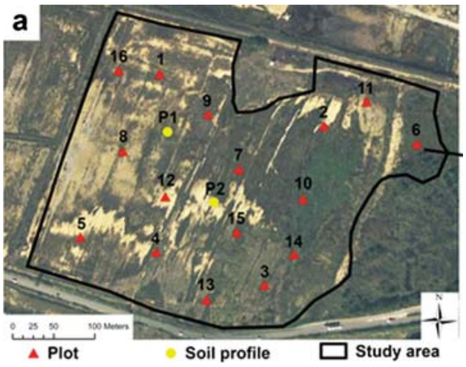
Biotechnological potential of saline soil microorganisms

Loredana Canfora

Website 1 | Website 2

a



Country and region:
Sicily

Climate conditions:
Mediterranea

Type of soil:
Salt-affected naturally soil

Main crops:
Plants well adapted to live in naturally saline soil

Irrigated/rainfed:
rainfed

Background of the salinisation problem:

A basic distinction must be made between primary and secondary salinisation processes. Secondary salinisation is usually caused by human interventions such as inappropriate irrigation practices, i.e. after the use of salt-rich irrigation water, and/or insufficient drainage. A natural secondary soil salinisation mechanism is represented by the long-term effects of tsunami waves, which can deposit salty seawater on large flooded areas with dramatic consequences for agriculture.

Innovative strategies to tackle the salinisation problem:

Naturally salt-affected soils have a biotechnological potential as a source of beneficial microorganism and a gene reserve for future biotechnological application. The understanding of soil microbial structure and diversity, of their resilience and resistance in primary salinization processes could be a exploring platform *to add market value to locally adapted varieties which are (more) tolerant to salt stress so as to compensate yield reduction* in association to belowground biodiversity exploitation.

What makes this strategy a success?

Microorganisms that occur in naturally saline habitats are supposed to share a strategy for resisting high salt concentrations, and to have developed multiple adaptations for maintaining their population active while coping with such extreme environmental conditions.

What are the potential fail factors?

The assortment and distribution of microorganisms in natural environment depend on very complex dynamics of colonisation and dispersion.

Knowledge gaps which may be solved by further research or practical testing:

1. The understanding that natural environments can serve as model systems (such as naturally salt-affected soils) for exploring the relationships between diversity and activity at the soil level in limiting situations, could be used in some kind of restoration or conservation techniques of saline environments.
2. An inventory of the current agricultural practices to better understand soil microbial resilience and resistance in primary salinization processes gaining a cognitive platform for any application of bioremediation in secondary salinization events through a microbial-based strategy.
3. Inventory of alien species as changing climate is expected to promote invasions of plants as well as of alien microbial species in soil.

REFERENCES:

Canfora L*., et al. **(2014).** Salinity and bacterial diversity: to what extent does the concentration of salt affect the bacterial community in a saline soil? ***PLoS ONE*** **9(9): e106662. doi:10.1371/journal.pone.0106662.**

Canfora L.*, et al. **(2015)**. Spatial microbial community structure and biodiversity analysis in "extreme" hypersaline soils of a semiarid Mediterranean area. ***Applied Soil Ecology*** **93C, 120-129**, *doi:* ***10.1016/j.apsoil.2015.04.014***.

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More information: whttps://ec.europa.eu/eip/agriculture/en/focus-groups/soil-salinisation

Market opportunities for crops adapted to saline conditions

•Albino Maggio
•Albino Maggio

Tomates in Campania region

Albino MAGGIO

Website 1 | Website 2

Country and region:

Italy, Campania

Climate conditions:

Mediterranean

Type of soil:

Clay-loam

Main crops:

Vegetables, tomato, leafy vegetables

Irrigated/rainfed:

Irrigated

Description of the crop and the saline conditions:

In the area of Castel Volturno – Villa Literno (Coastal areas of Campania Region) - ground water is contaminated by sea water infiltrations. Saline stress during the summer irrigated crop (tomato for fresh market and processing). No major stress for the fall-winter crops (e.g. cauliflower).

New market opportunities for the crop adapted to saline conditions:

Tomatos grown in these areas are particularly tasty, sweet and rich in antioxidants and other nutritional molecules. They could be marketed as highly nutritional vegetables if the nutritional profile is quantified, certified and properly documeted and presented to the consumers.

What factors could help to develop the market opportunity?

Informative campaign on «nutrient-dense» products. Consumers should know that vegetables from these salinized areas have an improved nutritional profile because the soil and climatic conditions along with saline stress specifically define it. A specifc label can be designed to commercialize products from these areas.

What challenges should be tackled to develop the market opportunity?

Find the right market channels that lead to consumers who appreciate these products.

Knowledge gaps to be solved to develop the market opportunity:

Better understanding of the physiological mechanisms behind the stress protection and agronomical practices that can maximize the quality of the vegetables (tomatoes) so to standardize production schemes and maximize stress induced qualities.

REFERENCES:

De Pascale, S., Martino, A., Raimondi G., Maggio, A., 2007. Comparative analysis of water and salt stress-induced modifications of quality parameters in cherry tomatoes. Journal of Horticultural Science and Biotechnology Volume 82, Issue 2, 2007, Pages 283-289. https://doi.org/10.1080/14620316.2007.11512230

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Salicornia in India

Jorge Zambujo

Website 1 | Website 2

Description of the crop and the saline conditions:

The Salicornia is a plant of which 250 species exist and is full of seeds that are used for the oil production, cosmetics, and food for cattle, among others. The Salicornia species are small, usually less than 30 cm tall, succulent herbs with a jointed horizontal main stem and erect lateral branches. Salicornia can grow in a wide range of salt concentrations (0.1–2.0 M) and can accumulate up to 40% salt of its dry weight. The oil content of the plant's seeds is about 30 % of its total weight compared with 17–20 % for the soybean, according to tests by the University of Arizona's Environmental Research Laboratory (ERL).

New market opportunities for the crop adapted to saline conditions:

The Salicornia has very high economic value, including 30% of oil, more than it is possible to obtain from soybean seeds. The oil also provides raw material for a series of cosmetic and pharmaceutical products. Besides these contents, the plantations of Salicornia will also have an ecological impact, since it absorbs carbon dioxide.

Country and region:

India, Gujarat

Climate conditions:

xxx

Type of soil:

Saline Soils

Main crops:

Salicornia

Irrigated/rainfed:

Irrigated

What factors could help to develop the market opportunity?

Climate change and the defense of sustainability are facts that are present and are determining policies and fundamentally policies related to activities with major impacts on the environment, such as agriculture. On the other hand, public awareness that we can produce plants with low environmental impacts while also recovering saline soils (bioremediation) and producing biofuels would be an important factor to develop the market.

What challenges should be tackled to develop the market opportunity?

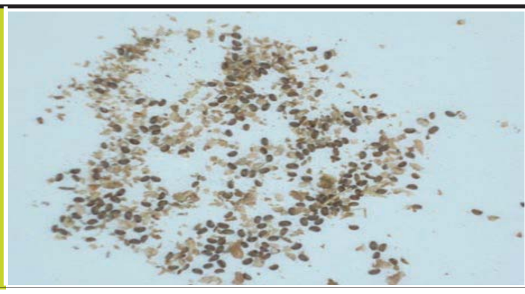
Create an integrated program that includes training in energy agricultural activity related to land improvement, harvest protection, and collection as part of the value chain that delivers biomass for refinery operations required to produce advanced liquid fuels and power.

Knowledge gaps to be solved to develop the market opportunity:

Absolutely necessary to carry on with trials to determine the best practices, the best varieties and also the best ways to produce Salicornia.

REFERENCES:

https://www.springerprofessional.de/en/alternative-biomass-from-saline-and-semiarid-and-arid-conditions/15456476
https://www.frontiersin.org/articles/10.3389/fmicb.2018.00148/full



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Opuntia ficus-indica production in arid saline environments

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www.iniav.pt | www.ars.usda.gov/research/publications/publication/?seqNo115=349202

Country and region:
Portugal, Alentejo region

Climate conditions:
Mediterranean climate: hot and dry summers and mild winters with irregular rainfall

Type of soil:
Various (granitic type)

Main crops:
Opuntia ficus-indica (L.) Miller

Irrigated/rainfed:
Rainfed and irrigated (drip irrigation)

Description of the crop and the saline conditions:

Opuntia ficus-indica (cactus pear, prickly pear) belongs to the Cactaceae family and is native to Mexico. Found in arid and semi-arid regions of South and Central America, Africa and the Mediterranean region. In Portugal, the first orchard planting was in 2009 with 200 ha. There are studies in other countries (namely USA) indicating that *Opuntia* can be grown under high saline and drought conditions and their nutritional characteristics in fruit juice (e.g., nutrients, total phenolic, ascorbic acids and pigments, and flavonoids) are not affected by adverse growing conditions.

New market opportunities for the crop adapted to saline conditions:

Fruits are appreciated for their biological attributes, nevertheless the peel generally is not used and is where the antioxidant pigments (betalains) and pectin are predominantly found. The interest for these residues from which pigments and bioactive compounds can be extracted with anti-inflammatory and antimicrobial activity, can be used in food and pharmaceutical industries. Great potential for the application of its byproduct in the development of new food products or in food enrichment (dietary fiber, thickening agent, natural sweetener and enzymatic clarification).

What factors could help to develop the market opportunity?

Health concerns and the benefits that food can bring to consumers is a reality perceived nowadays. The continued search for foods that contain compounds potentially beneficial to health, the study of these foods and their by-products, and the study of which ecotypes or cultivars can be one of the solutions for these two major concerns of today's society. Associate the production of *Opuntia* with a seal or differentiation in terms of social and environmental responsibility (production in disadvantaged areas contributing to the fight against desertification).

What challenges should be tackled to develop the market opportunity?

Increase farmers interest in investing in ecotypes or cultivars of *Opuntia* with high nutraceutical value. Increase consumers sensibility for the advantages and nutritional value of this fruit and by-products. Implementation of a "Land Bank" system on plots of land suitable for the installation of young plants.

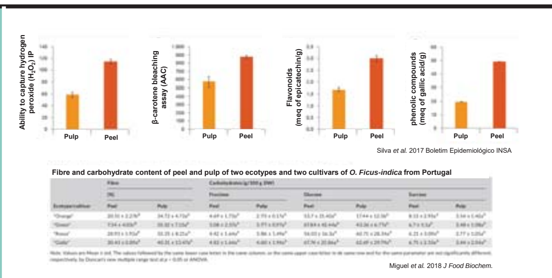
Knowledge gaps to be solved to develop the market opportunity:

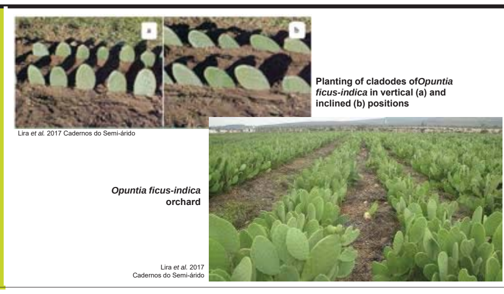
Increase knowledge on the tolerance of *Opuntia* to salinity. Increase knowledge on the nutritional value of the cladodes and the nutraceutical value from different Portuguese ecotypes of *O. ficus-indica.* Increase research to find new active compounds and their pharmaceutical and industrial applications. Test antioxidant formulations to search for possible synergistic effects.

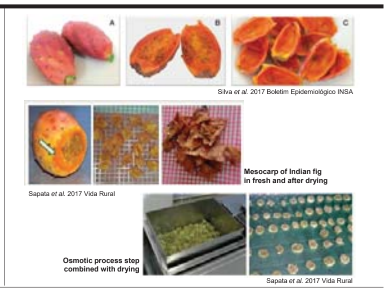
REFERENCES:

Graça Miguel M, Gago C, Valente R, *et al.* (2018) Qualitative evaluation of fruits from different Opuntia ficus-indica ecotypes/cultivars harvested in South Portugal. J Food Biochem. 2018;e12652. https://doi.org/10.1111/jfbc.12652

Centofanti T, Bañuelos G, Zambrano MC, Wallis CM (2017) Desert Plant for Saline and Drought Stricken Farmland: Assessment of Opuntia cactus Nutritional Characteristics. J Environ Bio Res. 1(1)







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Market opportunities of halophytes and salt resistant crops

Contact person: Arjen de Vos, arjen@saline-farming.com

Website 1 | Website 2

Description of the crop and the saline conditions:

So we run a production company of new crops (halophytes) that are introduced in the market, and we are testing the salt tolerance of varieties of common crops like potato, carrot, cabbage, cauliflower, beets,…Especially these common crops are very suitable for introduction in salt affected areas worldwide and have a great market potential. The halophytes can be cultivated at half or even full seawater…

New market opportunities for the crop adapted to saline conditions:

There are millions of hectares of salt affected land and millions of farmers who are struggling to make a living in these areas. Migration is already taking place due to reduce food security and reduced income. Current assessment is that, every year, salinity causes $27 billion in crop damage. If this damage is prevented by means of salt tolerant crops and tailor made cultivation strategies, then one could argue that this $27 billion is the minimum market potential. Also, abandonded salt affected areas could be turned into production again, increasing the market potential even further. By introducing saline agriculture, umemployment, malnutrition, poverty and migration can all be improved and alleviated.

What factors could help to develop the market opportunity?

Breeding crops/varieties that are even better adapted to saline conditions than the varieties that we know now. Development of tailor made adaptive farming systems

What challenges should be tackled to develop the market opportunity?

More awareness about the possibilites of crop cultivation under saline conditions, demo sites so showcase to farmers, stimulate the development of breedimng programs for salt tolerant crops

Knowledge gaps to be solved to develop the market opportunity:

What makes a crop salt tolerant and can marker assisted breeding play a role to speed up breeding programs? What is the soil salinity level of the major salt affected areas? How can soil fertility be restored in salt affected soils? How can we increase the adoption rate of salt toelrant crops among farmers?

Country and region:

The Netherlands…

Climate conditions:

divers

Type of soil:

Sand, loam

Main crops:

Potato, carrot, cauliflower, cabbage, red beet, halophytes

Irrigated/rainfed:

irrigated

REFERENCES:

www.saline-farming.com

funded by European Commission

Potato varieties adapted to saline conditions

Tineke de Vries

Website 1 | Website 2

Description of the crop and the saline conditions:

This crop is a potato variety for the tradional market in de north of Africa and the Middle east region. The seedpotato is growing in a clay soil whith no possibility to irrigate because of brownrot disease. In dry summers the roots are growing into the salt . The crop can grow under certain salt conditions without yield loss

Country and region:

The Netherlands, northern region

Climate conditions:

Oceanic climate

Type of soil:

Clay

Main crops:

Potatoes, sugarbeets, onions, wheat, barley, flowerbulbs

Irrigated/rainfed:

Seed potatoes are not allowed to be irrigated because of brownrot disease

New market opportunities for the crop adapted to saline conditions:

The potato variety can grow in every region where is only limited sweet water available. Potatoes are very nutritious and uses less water for growing than rice for example.

What factors could help to develop the market opportunity?

- Insight into the circumstances where the potatoes should grow (soilconditions, irrigation possibilities etc)
- Demofields with yield comparison
- Educating the farmers how to grow this varieties

What challenges should be tackled to develop the market opportunity?

The variety adapted to saline conditions should have better properties than comparable varieties that are not adapted to saline circumstances

Knowledge gaps to be solved to develop the market opportunity:

We need to know more about the yield potential under various levels of salination in comparison of other varieties

REFERENCES:

https://www.boerderij.nl/Akkerbouw/Nieuws/2018/4/Agrico-stopt-met-veredeling-op-zouttolerantie-271101E

funded by European Commission

This poster was presented at the 1st meeting of the EIP-AGRI Focus Group 'Soil salinisation' – May 2019
More information: whttps://ec.europa.eu/eip/agriculture/en/focus-groups/soil-salinisation

Rice production in Central Macedonia

Stelios Tamvakidis

Website 1 | Website 2

Description of the crop and the saline conditions:

The high water table level and high salinity cause a problem due to capillary rise in root zone

Agricultural activity in the Axios Delta area is intensive. Farmers are the largest water consumer of the Axios river. Over the last two decades, many farmers have switched to rice instead of cotton or vegetables, because:

- rice is very tolerant to weather conditions
- rice seeds are relatively cheap
- harvest is much easier
- rice is Tolerant to salinity but with excessive use of water

However, it demands vast amounts of freshwater (three to four times the water needed for other irrigated crops) thus, rice farmers have great interests to preserve the Axios R. water resources.

Country and region:

GREECE, Region of Central Macedonia

Climate conditions:

Mediterranean towards the coastal zone

Type of soil:

Clay soils. 90% of the cultivated rice area is characterized by pathogenic soils with high salinity

Main crops:

Rice, cotton, maize, alfalfa and cereals

Irrigated/rainfed:

Surface irrigation, basin or furrow irrigation

New market opportunities for the crop adapted to saline conditions:

Rice production in the area amounts to ~60% of the total Greek production, and takes place mainly in the Delta Area. The crop rotation from corn, cotton and vegetable to rice was the most feasible solution to farmers and environmental friendly to the preserved area

What factors could help to develop the market opportunity?

The environmental impact of the crop that is produced in a NATURA and RAMSAR Area giving job to hundreds of Local Farmes along with thousands of immigrant birds living in peace in rice fields and wetlands

What challenges should be tackled to develop the market opportunity?

The Life Cycle Anlysis and the Water Footprint of the product it may be a disadvantage to new marketing trends, but on the other side is the only crop that is tolerant to salinity and the excessive irrigation water is vital to preserve the wetlands downstreams

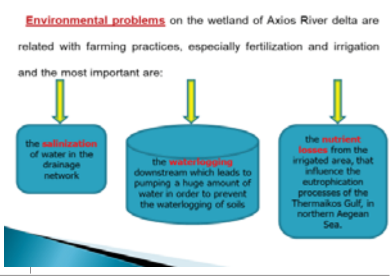
Knowledge gaps to be solved to develop the market opportunity:

The rice is of excellent quality and the production of these varieties covers the Demand in Greece and also exported to the EU

REFERENCES:

DEVELOPMENT AND APPLICATION OF A MATHEMATICAL MODEL FOR THE DYNAMICS OF WATER AND SOLUTE TRANSPORT AND INVESTIGATION OF PLANT WATER AND OSMOTIC STRESS UNDER FIELD CONDITIONS (in Greek) PhD thesis

EXAMINATION OF SOIL WATER AND SOIL SALINITY IN IRRIGATED WITH SALINE WATER CROP FIELD. (in Greek) MSc Thesis



funded by European Commission

This poster was presented at the 1st meeting of the EIP-AGRI Focus Group 'Soil salinisation' – May 2019
More information: whttps://ec.europa.eu/eip/agriculture/en/focus-groups/soil-salinisation

Salicornia in Portugal

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Country and region:
Portugal, south coastal area (Algarve). Natural reserve, traditional salt production area

Climate conditions:
Mediterranean, hot summer

Type of soil:
Alluvisols (silty clay texture)

Main crops:
Salicornia sp.

Irrigated/rainfed:
Rainfed in the presented case (irrigated fields in greenhouses are also being tested)

Description of the crop and the saline conditions:
Salicornia is an annual halophyte, native to temperate and subtropical regions, which has a high tolerance to salt. In this study, autochthonous Salicornia ramosissima and Salicornia patula were grown in abandoned saltpans (used for salt production) and salt marshes in a nature reserve.

New market opportunities for the crop adapted to saline conditions:
Salicornia species are commercialized as an high-value product for human consumption (United States and European markets). Salty taste and high nutritional value (e.g., minerals, antioxidants, and vitamins) are the main reasons for its demand, and it is advocated as an healthier alternative to mineral salt.

What factors could help to develop the market opportunity?
Productivity of current projects is modest, If productivity is increased the production price can be lowered. Establish an indication to the consumer that it is a sustainably-grown product.

What challenges should be tackled to develop the market opportunity?
The development of specific agronomic techniques for commercial growing is required: halophytes have modest productivities, propagation challenges (small and brittle seeds) woody growth of the forages, and eventual existence of harmful compounds in the seeds and leaves.

Knowledge gaps to be solved to develop the market opportunity:
Practical experience about agronomic practices under different growing conditions.

REFERENCES:
Erika S. Santos, Miguel Salazar, Susana Mendes, Marco Lopes, Joana Pacheco & Domitília Marques (2017)Rehabilitation of abandoned areas from a Mediterranean nature reserve by *Salicornia* crop: Influence of the salinity and shading, Arid Land Research and Management, 31:1, 29-45, DOI: 10.1080/15324982.2016.1230796

https://expresso.pt/actualidade/salinas-abandonadas-escondem-erva-igourmeti-no-algarve=f705567#gs.4f9253

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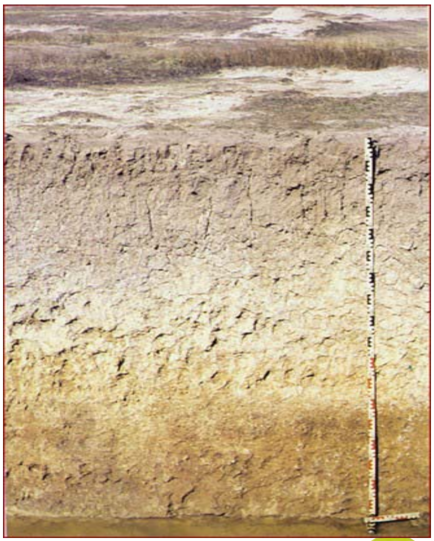
Wheat, Barley and Sunflower in Bulgaria

Contact persons: Biser Hristov

Website 1 | Website 2



Description of the crop and the saline conditions:

All saline soils have poor conditions for plant growth. The presence of salts in the soil makes it difficult for crops to take up water and nutrients. Due to physiological drought only plants of the halophyte community are grown.

Arable crop used in salty areas are wheat, barley, oats, sunflower and millet.

New market opportunities for the crop adapted to saline conditions:

Wheat , Barley , Sunflower, crops used in the region co-funded by European commission for, boosted production by capitalizing on the strengths of traditional crops and introducing new high-value crops into the market, involving local farmers in the production process, and advancing and expanding value chains to draw in infrastructure investment and strengthen export capacity.

Country and region:

Bulgaria, village of Belozem (Plovdiv)

Climate conditions:

Humid Subtropical/ Mesic- Xeric

Type of soil:

Solonetz/ Solonchaks

Main crops:

Hordéum vulgáre - Barley ;
Pasture (*Salicornia europaea, Puccinellia convoluta and etc*.)

Irrigated/rainfed:

Rainfed (old irrigation system – not used)

What factors could help to develop the market opportunity?

Conducted mentoring, training, workshops and technical assistance for private sector agribusinesses.

Developed various crop-based producer groups to provide stronger linkages between producers and buyers throughout the region;

What challenges should be tackled to develop the market opportunity?

Linking farmers to markets: EU and national authorities exposed local farmers to new markets and opportunities by organizing study tours, promotional events, and facilitating relationships between producers and buyers. These activities exposed producers to new technologies for crop production, new varieties to enhance yields and/or quality, and new crops which can achieve a high market price either at home or abroad.

Knowledge gaps to be solved to develop the market opportunity:

Market opportunities can be identified by analyzing changes in the environment with technological and scientific developments generating new business opportunities.

REFERENCES:

Popandova S (1978) Change of salt composition in the saline soils under irrigation. Theses, Institute of Soil science "Nikola Poushkarov", Sofia (In Bulgarian)

Shishkov, T., & Kolev, N. (2014). The soils of Bulgaria. Springer. eBook ISBN 978-94-007-7784-2

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