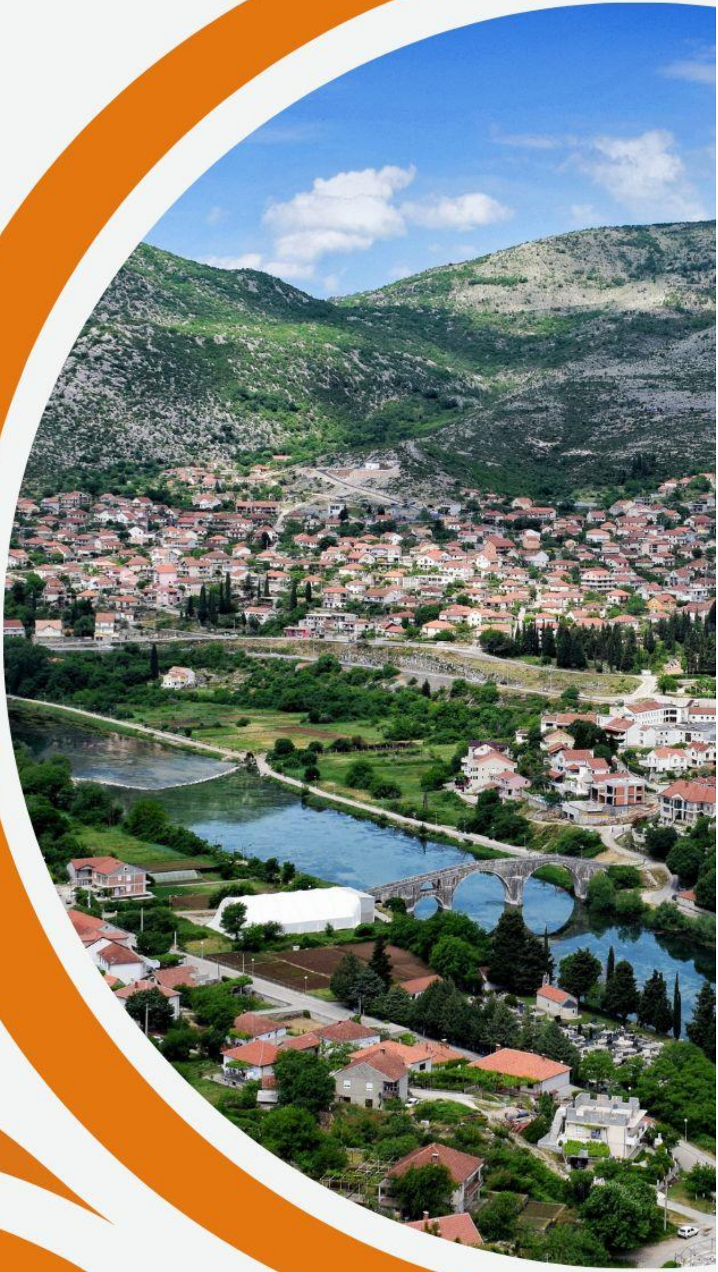
# “Knowledge exchange and sharing best practices for sustainable use of salt-affected lands”



**9-11 September 2024**

**Trebinje**

**University of East Sarajevo**

**Republic of Srpska**

# 2ND TRAINING SCHOOL

**Bosnia and Herzegovina**

| September 9<br>Day 1 | |
|---|---|
| **8:00-8:30** | **Registration** |
| **8:30-9:30** | **Welcome and opening** |
| **9:30-10:30** | **Halomorphic soils in Pannonian basin: Genesis, evolution and classification**<br>Ass. Prof. Dr. Vladimir Ćirić<br>Faculty of Agriculture University of Novi Sad, Serbia |
| **10:30-11:00** | **Networking coffee break** |
| **11:00-12:00** | **Small grain cereals breeding for abiotic stress**<br>Prof. Dr. Academician Novo Przulj<br>Faculty of Agriculture, University of Banja Luka, Bosnia & Herzegovina |
| **12:00-13:00** | **Understanding and Managing Salt in Soil Structure**<br>Prof. Dr Turgay Dindaroglu<br>Karadeniz Technical University, Türkiye |
| **13:00-14:00** | **Lunch** |
| **14:00 – 16:00** | **Introduction to economics of salt-affected soils**<br>Dr. Katarzyna Negacz<br>Vrije Universiteit Amsterdam |
| **16:00 – 16:30** | **Networking coffee break** |
| **16:30-18:30** | **Participant presentations**<br>Moderator: Prof. dr. Vesna Tunguz<br>Faculty of Agriculture, Bijeljina, University of East Sarajevo<br>Bosnia & Herzegovina |

| September 10<br>Day 2 | |
|---|---|
| **8:00-8:30** | **Registration** |
| **8:30-9:30** | **Halomorphic soils in Pannonian basin: Characteristics, amelioration and possibilities for use.**<br>Ass. Prof. Dr. Vladimir Ćirić<br>Faculty of Agriculture University of Novi Sad, Serbia |
| **9:30-10:30** | **The importance of cover crops for the sustainable use of arable land.**<br>Prof. Dr. Academician Novo Przulj<br>Faculty of Agriculture, University of Banja Luka, Bosnia & Herzegovina |
| **10:30-11:00** | **Networking coffee break** |
| **11:00-12:00** | **Mapping of Salt-Affected Soil**<br>Prof. Dr Turgay Dindaroglu<br>Karadeniz Technical University, Türkiye |
| **12:00-13:30** | **Participant presentations**<br>Moderator: Prof. dr. Vesna Tunguz<br>Faculty of Agriculture, Bijeljina, University of East Sarajevo<br>Bosnia & Herzegovina |
| **13:30-14:30** | **Lunch break** |
| **14:30 – 18:00** | **Field visit** |

| September 11<br>Day 3 | |
|---|---|
| **8:00-18:00** | **Field visit with practical exercises** |

# Training sessions

**Trainer: Ass. Prof. Dr Vladimir Ćirić**
**University of Novi Sad, Faculty of Agriculture, Serbia**
**ciricv@gmail.com**

**Field of research:** Soil science and agrochemistry

## Lecture 1 – Day 1
## Halomorphic soils in Pannonian basin: Genesis, evolution and classification

**Abstract**
Soil represents one of the most important natural resources, an invaluable good of whole humanity, not of one generation, one nation, group or individual. Soil is limited resource, it forms slowly, and in the process of degradation it destroys quickly. Halomorphic soils are soils with high content of harmful salts and/or adsorbed sodium. They are characterized by unfavorable chemical, water and physical properties and not suitable for intensive plant production. Genesis and evolution of the halomorphic soils in Vojvodina is strongly dependent on specific climatic, relief, hydrological, geological and vegetation conditions. Soil forming factors determine the direction and intensity of specific processes that take place in the soil, and as a result more or less usable halomorphic soil is formed. Three types (classification units) of halomorphic soils in Pannonian plain are considered: Solonchak, Solonetz and Solodic soil. Detailed description of morphological (soil profiles), physical and chemical properties of halomorphic soil types is necessary for the precise identification of soil type, subtype and variety.

**Learning outcomes:**
At the end of the training, students will:

- Understand nature of genesis and evolution of the halomorphic soils.
- Familiarize with key soil forming factors for creation of halomorphic soils.
- Learn how to differentiate Solonchak, Solonetz and Solodic soil.

**Prerequisites needed:** No
**Skills/equipment needed:** No

# Lecture 2 - Day 2
# Halomorphic soils in Pannonian basin: Characteristics, amelioration and possibilities for use


## Abstract

Halomorphic soils (Solonchak, Solonetz and Solodic soil) are not used in intensive agricultural production due to the presence of harmful salts, adsorbed sodium, as well as unfavorable water-physical properties. Therefore, increasing their productivity is one of the possibilities for increasing the total fund of agricultural land.

The time required for reclamation of the halomorphic soils depends on climatic conditions, applied amelioration measures, desired level for improving soil properties. Application of ameliorative measures should be based on the soil analysis as well as on specificity of each soil unit and climatic conditions of certain area, in order to achieve the highest positive effect of amelioration practice in the shortest possible period with economic justification. Impact of reclamation practice on the halomorphic soils has a considerable impact on the improvement of soil parameters and fertility increase. There are few possibilities for using of halomorphic soils in agricultural production. After ameliorations, such soils have still more or less limitations and could be used for the production of sorghum, sunflower, wheat as well as for the natural grazeland and fish ponds.


## Learning outcomes:

At the end of the training, students will:

- Learn which practice is used in amelioration of halomorphic soils.
- Have insight in mechanism and benefits of reclamation od halomorphic soils.
- Know possibilities for use Solonchaks, Solonetz and Solodic soils.

**Prerequisites needed:** No

**Skills/equipment needed:** No

**Trainer: Prof. Academician NOVO Pržulj**
**Faculty of Agriculture University of Banja Luka**
**Bosnia & Herzegovina**

**Field of research:** Biology

## Lecture 1 – Day 1
## Small grain cereals breeding for abiotic stress

**Abstract**
Cereals are widely utilized crops in world agriculture, with an overall production of 2.847 million tons being harvested globally in 2023. On a worldwide basis, rice, wheat and maize are the three most important cereal crops, which together comprise at least 75% of the world's grain production. Small grain cereals (SGS) production has been compromised by climate changes through the more frequent occurrence of extreme temperature events, which have increased water scarcity, aggravated soil salinization, caused increased plants vulnerability to diseases, and directly reduced plant fertility and decreased yield. One promising option to address these challenges is the genetic improvement of SGS for enhanced resistance to environmental stress. SGS yield improvement in regions where there is abiotic stress, which are variable in their timing and unpredictable in their intensity, is a challenge to all plant scientists, especial breeders, engaged in this area of research. To make progress in understanding the physiology of stress responses and then translate this to develop a molecular understanding and fully progress towards breeding, it is important to identify the most vulnerable aspects of growth and yield formation and focus on it. Screening for tolerance to abiotic stress under field conditions is notoriously difficult due to variability in severity, timing and duration of the stress. In the field, plants usually experience several stresses at the same time (*e.g.*, nutrient stress, pathogens), resulting in screening for the cumulative effect of different stresses and the interaction between these stress responses. Conventional breeding and selection has been very successful in steadily increasing crop yields, even without having knowledge of the underlying traits. However, breeding in stress prone environments is challenging and progress is slow. This is primarily due to the high degree of seasonal variability in temperature and rainfall, resulting in large genotype x environment interactions. Several decades of progress in genomics and genetic engineering has tremendously advanced our understanding of the molecular and genetic mechanisms underlying abiotic and biotic stress responses in SGS. This review discusses some morphological, anatomical, physiological, biochemical and molecular mechanisms of major cereal crops related to the adaptation of these crop to abiotic stress factors. It discusses the effect of abiotic stresses on physiological processes such as flowering, grain filling, photosynthesis, enzyme activity, mineral nutrition, and respiration.

**Learning outcomes:**
At the end of the training, students will:
- Have an understanding on abiotic stress in crop production.
- Learn about the effects of abiotic stress and crop management on cereal grain.
- Review details about the resilience of cereal crops to abiotic stress.
- Get familiar on the genetic response of growth phases for abiotic environmental stress tolerance in cereal crop plants.
- Learn about abiotic stress and control of grain number in cereals.
- Learn about breeding for abiotic stresses for sustainable agriculture.
- Learn the importance of landraces in cereal breeding for stress tolerance.

**Prerequisites needed:** No
**Skills/equipment needed:** No

# Lecture 2 – Day 2
# The importance of cover crops for the sustainable use of arable land


## Abstract
Soil erosion and the effects of soil erosion on the productivity of cultivated plants have become disturbing problems and the global intensity of accelerated erosion is probably greater today than ever before. About 80% of the world's arable land is moderately or significantly eroded, as winds and water annually carry away about 75 billion tons of soil from arable land. Cover crops are essentially planted to protect the soil from erosion, as it is the most effective erosion control and environmental conservation method. Cover crops are defined as crops that are used to cover and protect the surface of arable land during the period when the main crop is not present. Ideal cover crops should have the following characteristics: fast germination and sprouting, tolerance to adverse climatic conditions, ability to fix atmospheric N, deep and strong root system, production of a large amount of biomass in a short period of time, modest requirements for agrotechnical measures, absence of competition with the main crop, tolerance to harmful organisms, greater competitiveness against weeds and economic profitability for cultivation. Leguminous and non-leguminous plants are used as cover crops. The main advantage of using leguminous plants as a cover crop is their ability to fix atmospheric N that is used by the next crop, while non-leguminous plants are effective in protecting the soil from erosion, preventing leaching of nitrates and improving the physical, chemical and biological properties of the soil. In the region of the Western Balkans, cover crops are rarely encountered primarily due to the lack of knowledge and developed awareness of the necessity of sustainable management and use of agricultural land. The practice of cover crops in

the short term does not provide a significant improvement in soil quality and other advantages of their use, which is why only additional costs, work and the use of machinery are visible at the beginning. Cover crops have an efficient and high capacity to contribute to sustainable soil use and sustainable agricultural production.

## Learning outcomes:

At the end of the training, students will:

- Understand the negative effect of weather conditions on bare soil.
- Learn what are cover crops.
- Learn what are the objectives of cover crops.
- Learn what is the benefit of cover crops.
- Understand the benefits of legume cover crops.
- Understand the benefits of non-legume cover crops
- Learn about the weaknesses of cover crops.

**Prerequisites needed:** No
**Skills/equipment needed:** No

**Trainer: Prof. Dr. Turgay Dindaroglu**
**Karadeniz Technical University, Turkey**

**Field of science**: Soil science

## Lecture 1 – Day 1
## Understanding and Managing Salt in Soil Structure

### Abstract
Soil salinity is defined as high concentration of solute salts including $Na^{+}$, $Ca^{2+}$, and $Mg^{2+}$ in soils, causing more than 4 dS/m for soil electric conductivity, ESP of less than 15, pH is less than 8,5. All soils contain some amount of water-soluble salts. However, when these salts are at levels that inhibit plant growth and seed germination, they are considered saline soils. Among salt-affected soils, saline soils are the easiest to reclaim if effective drainage and good quality water are available. Soil colloids are flocculated due to the effect of salts. Flocculation is important because water moves mostly in large pores between aggregates. Also, plant roots grow mainly between aggregates. They contain some or a lot of lime. However, this lime is of little benefit to the soil because it is in an insoluble state due to the excess salts. Since soluble Na rarely exceeds half of the other cations and most salts are neutral, their reactions are neutral, and the amount of exchangeable Na is low. The most abundant exchangeable cations in saline soils are calcium and magnesium. Sodium is rarely more than half of the exchangeable salts and is therefore not excessively adsorbed.

Saline soils cause significant issues such as the loss of biodiversity and ecosystem degradation, declines in crop yields, abandonment or desertification of agricultural land, an increase in the number of dead and dying plants, an increased risk of soil erosion due to loss of vegetation cover, contamination of drinking water, weakening of roads and building foundations due to salt accumulation in the natural soil structure, and a decrease in soil biological activity due to rising saltwater levels.

The quality of irrigation water should be constantly monitored. High sodium levels (high SAR) can upset the balance of the soil. Have irrigation water analyzed for SAR and EC or request analyzes from your water provider. If the water is high in sodium, additives such as gypsum or sulfuric acid may be required. Observe your soil; Slow water infiltration or rainwater infiltration slower than irrigation water indicates a sodium problem. Soils affected by sodium may crack noticeably when dried. Perform laboratory analysis to determine soil EC and SAR or ESP values.

## Learning outcomes:

At the end of the training, students will:

- **Identification of Saline Soils:** Learn that soils are considered saline when water-soluble salts reach levels that inhibit plant growth and seed germination.
- **Impact of Salts on Soil Colloids:** Understand that salts cause soil colloids to flocculate, leading to good soil structure, adequate permeability, and generally fine textures.
- **Role of Lime in Saline Soils:** Learn that while saline soils may contain lime, its benefit is limited due to its insoluble state caused by excess salts.
- **Chemical Composition of Saline Soils:** Know that soluble sodium (Na) levels rarely exceed half of the other cations, most salts are neutral, and the amount of exchangeable sodium is low, resulting in neutral reactions in the soil.
- **Reclamation of Saline Soils:** Understand that saline soils are among the easiest to reclaim if effective drainage and good quality water are available, as they generally have good structure and permeability.
- **Exchangeable Cations in Saline Soils:** Know that calcium and magnesium are the most abundant exchangeable cations in saline soils, with sodium being less adsorbed due to its lower presence.
- **Importance of Irrigation Water Quality:** Recognize the importance of using irrigation water with low sodium levels to prevent soil destabilization and understand the need to analyze irrigation water for Sodium Adsorption Ratio (SAR) and Electrical Conductivity (EC).
- **Amendments for High Sodium Water:** Learn that high sodium irrigation water may require amendments such as gypsum or sulfuric acid to mitigate negative effects on soil structure.
- **Observing Soil Behavior:** Be able to identify potential sodium problems by observing slow water infiltration rates, especially slower rainwater infiltration compared to irrigation water, and noticing noticeable cracking in dry soils.
- **Understanding of Soil Analysis:** Understand the importance of laboratory soil analysis to determine soil EC and SAR or Exchangeable Sodium Percentage (ESP) for effective management of saline soils.

**Prerequisites needed:** No

**Skills/equipment needed:** No

# Lecture 2 – Day 2
# Mapping of Salt-Affected Soil


## Abstract

Salt-affected soils are soils that contain high amounts of soluble salt and/or sodium ions. The physical and chemical properties of saline soils can change dramatically across very short horizontal scales. The initial global distribution of these lands was first estimated at approximately 1 billion hectares in the late 1970s. There have been inconsistent updates in global distribution since then. Clearly, new reliable methods are required to improve knowledge about the status and actual distribution of salt-affected soils. The Food and Agriculture Organization (FAO) Global Soil Partnership (GSP) is leading the global mobilization to initiate the update of information from the country to the global level. GIS and RS development contributes to supporting countries in updating their national information and updating global information on salt-affected soils. One of the challenges of this approach is the uncertainties arising from the integration of data sets. The focus of this slide is to provide guidelines for harmonizing input data and approaches to mapping salt-affected soils at all levels of knowledge updating.

There are many methods in the literature for mapping salt-affected soils. There are methods based on soil type maps integrated with expert opinions, remote sensing applications and soil indicator-based methods. This slide highlights the requirements, limitations, and example applications of these methods. Emphasis has been placed on the indicator-based approach in mapping salt-affected soils because 1) the method is amenable to harmonization of procedures at the country level, 2) it develops knowledge of both salt-affected soils and soil properties relevant to salt problems, 3) the method can quantify mapping accuracy and uncertainty, 4) horizontal and vertical knowledge can be measured.



*Reference:* Omuto CT, Vargas RR, El Mobarak, AM, Mohamed N, Viatkin K, Yigini Y. 2020. Mapping of salt-affected soils: Technical manual. Rome, FAO https://doi.org/10.4060/ca9215en


**Learning outcomes:** At the end of the training, students will:

1. **Global Distribution and Update Necessity**:
   - Acknowledge the need for updated, reliable methods to improve knowledge about the current status and distribution of salt-affected soils due to inconsistent updates since the 1970s.
2. **Challenges in Data Integration**:
   - Identify the uncertainties and challenges arising from integrating different datasets and approaches by various countries.
3. **Harmonizing Data and Mapping Approaches**:
   - Gain knowledge on the guidelines for harmonizing input data and approaches to mapping salt-affected soils at various levels of information updating.

4. **Mapping Methods**:
    - Familiarize with different methods for mapping salt-affected soils including soil-type maps with expert opinions, remote sensing applications, and soil indicator-based methods.
    - Understand the requirements, limitations, and example applications of these methods.
5. **Indicator-Based Approach**:
    - Learn the reasons for emphasizing the indicator-based approach:
        - Suitability for harmonization at the country level.
        - Development of information on salt-affected soils and related soil properties.
        - Ability to quantify mapping accuracy and uncertainty.

These learning outcomes aim to provide a comprehensive understanding of salt-affected soils, their global distribution, the need for updated information, and the methods and guidelines for effectively mapping and harmonizing data on these soils.

**Prerequisites needed:** No
**Skills/equipment needed:** No

**Trainer: Dr. Katarzyna Negacz**
**Vrije Universiteit Amsterdam**

**Field of science**: Environmental policy and economics

## Lecture 1 – Day 1
## Introduction to economics of salt-affected soils

**Abstract**

Saline environments are present worldwide and range from degraded agricultural lands to highly biodiverse mangrove forests. These ecosystems provide important services to humans. Even though the economic effects of salinity, such as loss of yield and impacts on income, are widely discussed in the literature, saline agriculture, understood as a set of soil-water-plant management practices, offers a plethora of opportunities and sustainable use options for salt-affected soils.

This session provides a comprehensive exploration of saline environments, focusing on their ecosystem services, economic impacts, and sustainable interventions. Participants will gain an understanding of the unique ecosystem services provided by saline environments, such as carbon sequestration, habitat provision for specialized flora and fauna, and the maintenance of biodiversity. The module will also delve into the critical role these environments play in supporting fisheries, agriculture, and tourism, highlighting their multifaceted contributions to human well-being and the global economy.

Through a detailed analysis of the economic effects of salinity, participants will learn to assess both the benefits and challenges associated with saline environments. This includes an examination of the costs related to soil salinization, such as reduced agricultural productivity and infrastructure damage, alongside the economic gains from industries that thrive in saline conditions. By understanding these dynamics, participants will be equipped to analyze the complex interplay between environmental and economic factors in saline contexts.

The session will also emphasize the importance of proposing and evaluating sustainable interventions aimed at managing salinity. Participants will explore various strategies, such as the use of salt-tolerant crops, innovative water management practices, and ecosystem restoration techniques. Through case studies and practical examples, they will learn to critically assess the feasibility, effectiveness, and sustainability of different interventions. By the end of the module, participants will be able to develop comprehensive, context-specific strategies to enhance the resilience and productivity of saline environments, ensuring their long-term viability and contribution to human and ecological health.

**Learning outcomes:**

At the end of the training, students will:

- Understand the ecosystem services provided by saline environments
- Analyze the economic effects of salinity
- Propose and evaluate sustainable interventions in saline environments

**Prerequisites needed:** No

**Skills/equipment needed:** No