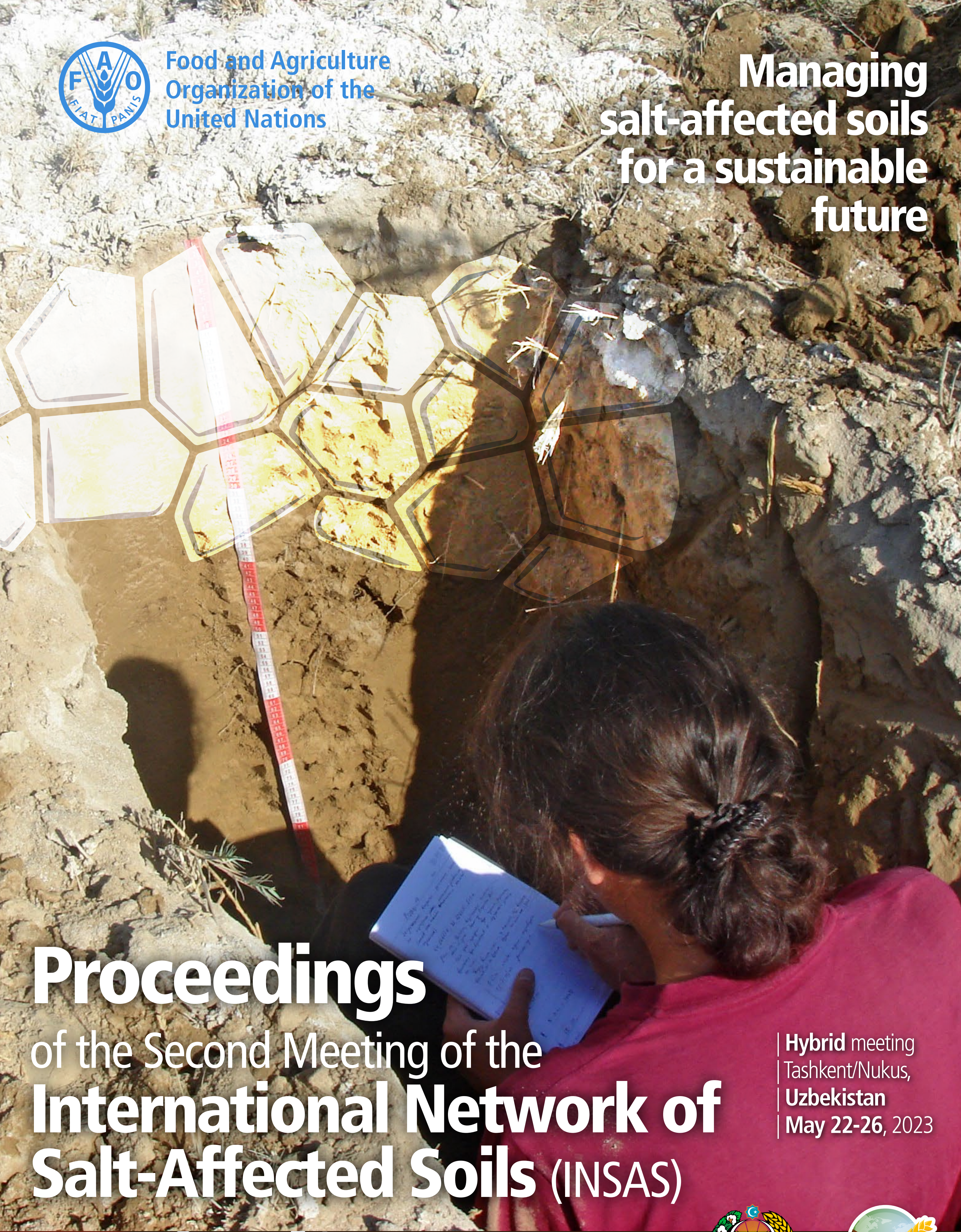
Food and Agriculture Organization of the United Nations

Managing salt-affected soils for a sustainable future



Proceedings

of the Second Meeting of the International Network of Salt-Affected Soils (INSAS)

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GLOBAL SOIL PARTNERSHIP

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Contents

Physiological and biochemical evaluation of quinoa genotypes against salinity, drought and heat stress

G. ABBAS, Centre for Climate Research and Development, COMSATS University Islamabad, Pakistan; F. AREEJ, S. AFZAL , B. MURTAZA, M. AKRAM, Department of Environmental Sciences, COMSATS University Islamabad, Vehari Campus, Pakistan; M. SAQIB, Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan; K.H.M. SIDDIQUE, The UWA Institute of Agriculture and School of Agriculture and Environment, The University of Western Australia, Perth, WA, 6001 Australia

Keywords: salinity, high temperature, drought, quinoa, oxidative stress, climate change

INTRODUCTION

More than 20 percent of irrigated land and more than 6 percent of the terrestrial areas around the world are affected by soil salinity, rendering it a serious environmental issue (Qadir *et al*., 2014). Pakistan is also suffering from the salinity problem, and approximately 10 Mha, or 12.9 percent of the country's total land area, is severely affected by salinity. Drought and heat stress are aslo environmental stressors and plants are often subjected to severe water and heat stress, especially in semi-arid and arid environments (Jacobsen *et al*., 2009; Lesjak and Calderini, 2017) which may lower crop yields. The current study was planned to address the three objectives. Firstly, evaluate the effects of salinity, drought, and high temperature on the growth and yield of various genotypes of quinoa. Secondly, explore quinoa genotypes' physiological and biochemical mechanisms against salinity, drought, and high temperature. Lastly, to recommend the best quinoa genotypes for cultivation on salt-affected soils facing drought and temperature extremes.

METHODOLOGY

Four genotypes of quinoa namely A7, Titicaca, Vikinga, and Puno, were grown in pots containing either normal (non-saline) or salt-affected soil and exposed to drought and elevated temperature treatments.

RESULTS

Plant and physiological attributes and yield decreased more profoundly under the combined stresses of drought, salinity, and high temperature than the individual treatments. Under the combined treatment of drought, salinity, and heat, the shoot biomass of A7, Puno, Titicaca, and Vikinga declined by 27, 36, 41, and 50 percent, respectively compared to control plants. Similar trends were observed for grain yield, chlorophyll content, and stomatal conductance of the four quinoa genotypes. An elevated concentration of Na while decreased K contents were recorded in the quinoa plants exposed to the combined application of these three stresses. Moreover, the contents of hydrogen peroxide (H_2O_2) in the quinoa genotypes A7, Puno, Titicaca, and Vikinga were 7.3, 6.9, 8, and 12.6 folds higher than in control plants. In order to overcome the oxidative stress, all the four quinoa genotypes observed an increasing trend in the antioxidant enzyme activities: CAT, SOD, and POD.

DISCUSSION

Quinoa is a salt-tolerant plant, but high salt concentration along with sodicity reduced biomass and grain yield in quinoa. Poor soil physical properties and a higher quantity of exchangeable Na rather than Ca + Mg on the exchange sites of soil are the main reasons for poor growth performance of quinoa on salt-affected soils. Salinity, drought and heat combined effects were more detrimental to quinoa physiological attributes and plant growth than either of the stresses applied alone. Even though quinoa is a relatively drought-tolerant crop, severe water stress has been reported to lessen the biomass and yields of this halophyte. Quinoa growth is affected by drought and is affected by the intensity of the drought, genotypes, and other environmental factors. The flowering of quinoa is negatively influenced due to high temperature stress. The optimal temperature for plant growth is 25 °C, whereas high temperature at anthesis accompanied by drought stress resulted in limited production of quinoa grains by the Titicaca cultivar. These three stresses caused the oxidative stress that was mitigated by overproduction of antioxidant enzymes.

CONCLUSIONS

Among the genotypes, A7 produced the highest biomass, which could not be translated to improved grain production. We concluded that Puno and Titicaca were more tolerant genotypes than Vikinga for cultivating on salt-affected soils prone to drought and heat stress.

ACKNOWLEDGEMENTS

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Salt regime of soils under drip irrigation in orchards of Ukraine

Yu. AFANASYEV, National Scientific Center «Institute for Soil Science and Agrochemistry Research named after O.N. Sokolovsky», Ukraine; M. ZAKHAROVA, National Scientific Center «Institute for Soil Science and Agrochemistry Research named after O.N. Sokolovsky», Ukraine

Keywords: Chernozem Calcic, drip irrigation, Kastanozem Haplic, salinization, sodification

INTRODUCTION

The production of agricultural products in the conditions of southern Ukraine requires the use of water reclamation (Status, 2018). Drip irrigation is one of the best ways to provide moisture to the soil, but technological features impose certain restrictions on its use and require more careful control of the irrigated land condition.

METHODOLOGY

Irrigation water and irrigated soils (southern chernozems and dark chestnut soils) were investigated under drip irrigation of the Odesa and Kherson regions of Ukraine. The research objects are young orchards three years after the start of irrigation. Soil samples for chemical analyses were collected at the end of each growing season into account the differential impact of drip irrigation on the soil – in the formed moistening zones and non-irrigated spacing from a depth of 0–25 cm. A method of soil salinity assessment was the analysis of the 1:5 soil-to-water extract. The degree of sodicity was determined by the sum of exchangeable sodium and potassium. Water samples were collected four times during the vegetation period.

RESULTS

The Odesa region, soil is Chernozems Calcic.

Water from a well is used to irrigate an orchard. It is limitedly suitable and unsuitable (in certain periods) for irrigation due to the danger of salinization, sodification and toxic effects on plants (according to national standards). The content of toxic water-soluble salts increased to 0.15–0.20 percent, exchangeable Na++K+ – to 3.7–3.9 percent in the near-stem zone of trees and near the dropper. Subsequent irrigation with these waters increased the development of salinization and salinization processes in these sites. The development of such processes was not noted in non-irrigated interrows.

The Kherson region, soil is Kastanozems Haplic.

Surface water is used for drip irrigation. It is suitable and limitedly suitable (in certain periods) for irrigation. Irrigation did not cause significant changes in the composition of water-soluble salts. Their content near the dripper and the non-irrigated interrow did not change and amounted to 0.9–0.11 percent, toxic salts – 0.06–0.08 percent. The content of exchangeable Na++K+ increased slightly near the dripper and at the border of the hydration contour and was 2.4–2.9 percent (low degree of sodicity). There were no changes in the interrow.

DISCUSSION

In southern Ukraine due to the scarcity of fresh water, drip irrigation often is carried out by brackish water. Agriculture with drip irrigation is an effective strategy to increase crops productivity in different countries with insufficient moisture, but the use of brackish water for irrigation leads to secondary salinization and sodification of the soil, increasing the spatial differentiation of soil properties.

CONCLUSIONS

During drip irrigation of orchards with low-quality water for three years, we observe soil salinization and sodification at the near-stem zone of trees and near the dropper. Periodically using limitedly suitable water, we observe soil sodification near the dropper. Regular control of the irrigation water quality is necessary.

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Mixed agroforestry systems for saline landscape restoration in Karakalpakstan, Central Asia

N. AKINSHINA, National University of Uzbekistan named after Mirzo Ulugbek, Tashkent, Uzbekistan; K. TODERICH, International Platform for Dryland Research and Education, Tottori University, Japan; N. MATSUO, Mie University, Tsu city, Mie pref., Japan; A. AZIZOV, National University of Uzbekistan named after Mirzo Ulugbek, Tashkent, Uzbekistan; R. BABAJANOV, Karakalpak Botanic Garden named after Amir Temur of Academy of Science of RUz, Buston, Karakalpakstan, Uzbekistan; E. BERDIEV, Tashkent Botanic Garden named after F.N. Rusanov of Academy of Science of RUz, Tashkent, Uzbekistan; O. MYACHINA, Institute of inorganic chemistry, Academy of Science of RUz, Tashkent, Uzbekistan; A. KHALMURZAYEVA,Tashkent Botanic Garden named after F.N. Rusanov of Academy of Science of RUz, Tashkent, Uzbekistan; M. BAKHSHI, Tashkent Botanic Garden named after F.N. Rusanov of Academy of Science of RUz, Tashkent, Uzbekistan; S. LUKYANOVA, National University of Uzbekistan named after Mirzo Ulugbek, Tashkent, Uzbekistan; J. BABAJANOV, Karakalpak Botanic Garden named after Amir Temur of Academy of Science of RUz, Buston, Karakalpakstan, Uzbekistan; T. ILYASOV, National University of Uzbekistan named after Mirzo Ulugbek, Tashkent, Uzbekistan; E. ZEYBERT, National University of Uzbekistan named after Mirzo Ulugbek, Tashkent, Uzbekistan; M. MUMINOVA, National University of Uzbekistan named after Mirzo Ulugbek, Tashkent, Uzbekistan; E. KUTIBAEVA, National University of Uzbekistan named after Mirzo Ulugbek, Tashkent, Uzbekistan

Keywords: soil salinization; agroforestry; sustainable plant communities, halophytes, phytomelioration

INTRODUCTION

Degraded deforested landscapes and lack of water are the main problems of Karakalpakstan. This poses a serious threat to the development of the region, since the income of the majority of the population depends on the productivity of agricultural and pasture lands and the recreational value of landscapes. Enormous efforts are expended to combat salinization and soil degradation; the main methods used remain technical and physico-chemical measures. Agroforestry can be seen as a promising technology for landscape reconstruction, restoration of saline degraded lands and agricultural development (Krishnamurthy *et al*., 2019; Fahlstrom *et al*., 2000; Tscharntke *et al*., 2011). The purpose of the study was to develop an appropriate technology for landscape restoration using agroforestry methods on degraded and saline lands and its approbation in the conditions of Karakalpakstan.

METHODOLOGY

It is proposed to create sustainable plant communities including trees, shrubs and herbs, as analogues of natural ecosystems; to combine technologies of forestry, agriculture and gardening in one common system to recover soils, increase their productivity and improve food security of local population. Special attention is paid to honey plants and medicinal plants, because it would provide an opportunity to get additional income and motivate the local communities to landscape restoration by plant growing, and provide basis to develop beekeeping, tourism and etc.

Two experimental plots (model gardens) have been established in Karakalpakstan: (1) in the delta of the Amudarya river and (2) in the Nukus region on the border with the Kyzylkum desert; the area is about 6 ha.

Field tests and laboratory studies of chemical composition of soil and plant biomass are being carried out. The qualitative composition of the soil and salt accumulation in different plant species are being studied.

RESULTS

During the first year of the project, a geobotanical survey of the territories, chemical and microbiological analysis of soils were carried out. The content of humus in the soil varies from 0.3 to 1.6 percent. Very low content of gross nitrogen and phosphorus. It was revealed that the soils have a sulfate-chloride type of salinity. The salinity pattern is very mosaic and heterogeneous. The project areas in 2nd-site are saline and degraded to a greater extent, 1.5–4.99 percent versus 0.08–1.2 percent in the 1st-site region.

The list (range) of salt-, drought-, frost-resistant plants suitable for given agroforestry systems is scientifically substantiated. In both areas, a variety of woody and herbaceous plants were planted - seeds, seedlings, seedlings, rhizomes. Observations are being made.

On site 1, a nursery has been created to obtain own seedlings.

Plants that accumulate the largest amount of salts in their vegetative shoots and are resistant to salinity and other stress factors of the region are preliminarily determined. The most suitable agricultural techniques and irrigation technologies are being tested.

DISCUSSION

A key point is the creation of sustainable plant communities using different life forms, mostly perennial. An important role here is also played by annual salt-accumulating halophytes, which gradually help to remove salt from the soil. Gradually they will be replaced by more valuable plants.

CONCLUSIONS

Work is underway to create the most effective combinations of plant communities (perennial plants + annual valuable cultivated plants + ground cover halophytic or medicinal wild underutilized plant resources). The ideal task is to create gardens of continuous flowering on the site of degraded landscapes.

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Impact of soil amendments on salt accumulation in rhizospheric soil and the tolerance of quinoa to high salinity

M.R. BOURHIM, Center of Agrobiotechnology and Bioengineering, CNRST Labeled Research Unit, FST, Cadi Ayyad University, Marrakech, Morocco; A. HIRICH, African Sustainable Agriculture Research Institute, Mohammed VI Polytechnic University, Benguerir, Morocco; S. CHETO, Agrobiosciences Program, Mohammed VI Polytechnic University, Benguerir, Morocco; A. QADDOURY, Center of Agrobiotechnology and Bioengineering, CNRST Labeled Research Unit, FST, Cadi Ayyad University, Marrakech, Morocco; C. GHOULAM, Center of Agrobiotechnology and Bioengineering, CNRST Labeled Research Unit, FST, Cadi Ayyad University, Marrakech, Morocco / Agrobiosciences Program, Mohammed VI Polytechnic University, Benguerir, Morocco

Keywords: Chenopodium quinoa, salinity stress, growth, soil amendments, rhizospheric salts

INTRODUCTION

Soil salinity accumulation can cause many disruptions to soil, nutrients uptake, plant growth, and crop yield in sensitive species (Derbali *et al*., 2021). Therefore, actual agriculture rely on growing alternative crops that can tolerate this kind of adverse abiotic stress, such for example the quinoa (Chenopodium quinoa). Although, despite its salinity tolerance, its performance could be negatively affected under high salinity levels. Thus, our study aims to assess the effects of some soil amendments for reducing salt accumulation in rhizosphere soil and on improving quinoa tolerance level to salinity (200 mM of NaCl).

METHODOLOGY

Three quinoa varieties (Puno, ICBA–Q5 and Titicaca) were considered and grown under greenhouse conditions in pots containing 1.6 Kg of agricultural soil added with five amendments; Biochar “Bc”, compost “Cp”, black soldier insect frass “If”, cow manure “Fb” and phosphogypsum “Pg”, with a negative control “C(-)” and a positive control “C(+)” with no amendment. Twenty days after sowing, the plants were irrigated with saline water at 16 dS/m of NaCl except the “C(+)” that was irrigated with distilled water. At the panicle formation stage, the trial was assessed.

RESULTS

The results showed that salinity stress induced negative impacts on the quinoa plants for all the tested agro-physiological parameters in the three varieties compared to their positive controls. However, most of these parameters were significantly improved by the application of soil amendments compared to “C(-)”. For instance, in Puno, biomass was increased by more than 90 percent, and total nitrogen and phosphorus contents by more than 300 percent when soil was amended with “Bc”. Yet, for Titicaca, the most important improvement was noted in the potassium amount which was 606 percent better with the “Pg” amendment compared to “C(-)”. Besides, ICAB-Q5 amended with Bc showed an improvement of 222 percent for K content. Furthermore, the amendments induced significant decrease of electrical conductivity in the rhizospheric soil, compared to the bulk soil, for all the tested varieties. Particularly, for the soil amended with “If” the electrical conductivity in the rhizospheric soil, compared to the bulk one, was reduced by 115 percent for Titicaca, 113 percent for Puno and 117 percent for ICBA–Q5. Overall, differences between the studied varieties were noticed mainly between Puno and Titicaca presenting the highest performances when amended with If, Bc and Pg.

DISCUSSION

The positive impact of the amendements on tolerance of quinoa plants to salinity could be attributed, among others, to their ability to retain salt ions and exclud them from the rhizosphere and thus avoid exessive salt uptake by plants. Our explanation was supported by the results showing the reduction of electrical activity in the rhizospheric soils when added with the tested amendments.

CONCLUSIONS

The tested soil amendments improved the quinoa tolerance to salinity stress under greenhouse conditions with difference between varieties. The soil amendment reduced the salt accumulation in the rhizospheric soils. The amendment with insect farss, Biochar and Phosphogypsum were recommended for Puno and Titicaca varieties showing the highest performance.

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Methodological contribution to the mapping of environmental susceptibility to soil salinization in dry regions

F.C.CASTRO, Federal University of Ceará; A.M. SANTOS, University of Pernambuco; F.R. NASCIMENTO, Federal University of Ceará

Keywords: salt accumulation; dry regions; Cartography.

INTRODUCTION

The process of soil salinization is the result of environmental characteristics and/or anthropogenic actions, being responsible for the degradation of thousands of hectares of soils in semiarid and arid regions, resulting in wasting in agricultural production (Sahab *et al*., 2021; Wei *et al*., 2021). In the Brazilian semiarid region, hundreds of hectares of land affected by the salinization process. Mapping areas susceptible to salinization can prevent soil loss due to the accumulation of salts. In this context, the aim of this study is to present a methodology for mapping the environmental susceptibility to salinization of soils in semiarid regions.

METHODOLOGY

The methodological proposal takes into account the combination of several attributes that make up the natural physical system, such as soils, relief, geology, potential evapotranspiration and the attribute that characterizes land use. The information was cross-referenced from a simple mathematical model run in QGIS software. The action response is a map showing the environmental susceptibility to salinization at five levels (very low, low, medium, high and very high). The mapping was submitted to Kappa statistics to verify the degree of success between the mapped susceptibility and the situation in the field. The methodology was tested in two areas with different scales of analysis and contexts of land use and occupation. The first was applied in five municipalities in the microregion of Petrolina, state of Pernambuco. The second area was in the Quilombola community of Cupira in the municipality of Santa Maria da Boa Vista, Pernambuco. All areas in Brazil (Castro, Araújo and Santos, 2019).

RESULTS

In all areas, it was possible to trace the profile of susceptibility to salinization. For the municipalities in the microregion of Petrolina, 40 percent of the land has medium to high susceptibility to salinization. Regarding the validation of the methodology, the statistics were favorable, with more than 70 percent of the sampling points salinized in the field corresponding to areas on the maps with high and very high susceptibility to salinization.

DISCUSSION

Another important factor was that the areas with higher degrees of susceptibility to the development of soil salinization have, in the combination of attributes, Fluvisols, Solonetz, flat relief and practice of irrigated agriculture.

CONCLUSIONS

The methodology proposed and used to analyze the susceptibility to salinization is easy to apply and could map the reality of semiarid lands regarding the process of salt accumulation.

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Ecological reclamation of saline-sodic wasteland in China

X.J. DU; Q.L. LV; T.R. ZHOU; X.Q. REN; S.W. HU, College of Resources and Environment Sciences, China Agricultural University, China

Keywords: Saline sodic land, Reclamation, Modified organic-inorganic material, Sustainability, Productivity

INTRODUCTION

The area of the saline-sodic land is 833 million hectares globally and China accounts to 99 million hectares, according to the latest data. Owing to the high salt content, high viscosity, poor water permeability, strong cohesion and soil dispersion, the saline sodic soils are not suitable for planting. To ensure food security as well as sustain the ecology, the technologies restoring the saline-alkali soil are highly demanded to release the potential productivity of such vast wasteland resources. Conventional saline-alkali land improvement technology includes improvement of water conservancy project, physical improvement, biological improvement, plant salt tolerant plants, and chemical improvement. Each segments emphasizes its own importance and neglects to consider all sectors comprehensively, which lead to the huge gap between the research and practical use.

METHODOLOGY

In the last decade, our team has always been devoted on rehabilitating the health of saline-sodic soils and proposed a new paradigm. Basically, to achieve the optimal reclaiming performance, systematically integration of water conservancy projects, soil improvement, fertilization and planting management, is a fundamental rule to follow. Besides, we have developed independent intellectual properties on our own: (1) Developing a new type of modified organic-inorganic material as amendment, (2) Inventing tailored controlled-release fertilizers for crop nutrients, slow-released seed treatment agents and anti-salt/alkali stress resistance materials throughout the crop growing cycle to restore the nutrient balance (Liu *et al*., 2020). These techniques have been granted over 15 Chinese patents and most of patents have been transferred to industry.

RESULTS

Integrated with other techniques, the microenvironment was additionally reshaped owing to the improved bacterial and fungal community abundance and structure (Feng *et al*., 2021; Du *et al*., 2022). After a single input, the severe saline alkali wasteland has been restored into fertile land. Crops such as rice, corn, sorghum, mung beans, oil sunflowers, sugar beets, and grass are growing well. The yield of crops is much higher than conventional approach, and no further continuous investment is required. Overall, the reclamation improves soil quality, restore the soil productivity and increase carbon sequestration capacity of salt-affected soils, which solidifies the guarantees for food safety and mitigate climate change.

DISCUSSION

Notably, we use modified natural polymer material as backbone which provide abundant available source of calcium ions to replace excess Na+ on the soil colloids complex. The organic moieties from the amendment can aggregate particles and increase soil porosity consequently. By means of substitution, Na+ is exchanged and go with runoff of fields or leach into deeper soils along with irrigation water, which brings the reduction in the repulsion between soil particles. Besides, nutritional balance was restored after comprehensive reclamation by using various controlled release fertilizers.

CONCLUSIONS

No further continuous input of amendment is required, which implies sustainable cycle has been reconstructed, and further operation will be run by relying natural conditions. This technology is applicable to not only in China, Central Asia, South Asia, but also Middle East, Australia, South America. We anticipate the paradigm can play its role in reclaiming global saline-alkali land, which can increase the supply of new cultivated land and food for the world.

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Efficacy of PRIMEO humic-fulvic acid plus chelate micronutrients in pechay

G.R. GABISAY, Schools Division of Victorias City/College of Agriculture and Forestry, Central Philippines State University-Victorias Campus

Keywords: humic-fulvic, bioavailability, ligands, chelate, pechay, sandy soil, bio-active, photo-active

INTRODUCTION

Many Nitrogen, Phosporus, Potassium (N, P, K) agricultural fertilizers lack enough essential microelements to meet plant needs. The need for the agriculture industry to explore new ways of fertilizing the plants continue, and with the need of developing new blends of it with microelements or microelements alone that will meet crop requirement.

The most effective way to supplement the deficiency of micronutrients had been the micronutrient chelates. The humic-fulvic acids are being tapped as naturally occurring ligands or chelator for its effectivity in various pH ranges. These are organic substances made up of nitrogenous complexes comprising decayed amino acid and aromatic complexes of carboxyl (COOH-) and phenolic (OH-) groups that indirectly affect soil aggregation as it holds ionized salts preventing leaching. Chelate micronutrients improve the bioavailability of micronutrients and can contribute to crop quality and yield. Chelate nutrients are less reactive to soil conditions and can enhance nutrient uptake and utilization since micronutrient ion is surrounded by a larger molecule called a ligand or chelator. Thus, the micronutrient now is protected from oxidation, precipitation, and immobilization, enhancing utilization. PRIMEO humic – fulvic plus chelate micronutrients will provide the microelement needed of the crops in wide soil pH ranges of Philippines soils; rendering the availability of copper (Cu), iron (Fe), manganese (Mn), and zinc (Zn) even at high pH over 7.5, and Boron (B), and molybdenum (Mo) even at low pH. This micronutrient deficiencies occur within the growing season, and due to pH, in deficient crops with high micronutrients demand, in alkaline soils (that limit their availability), alluvial soils- or soils deposited by surface water, weathered acid soils that are prone to leaching and low organic matter soils, and thus the best way to apply micronutrients is through foliar application as inorganic water-soluble micronutrient soil application is often ineffective for correcting micronutrient disorders. Foliar application remediate the crop in a few days. The liquid form can improve nutrient availability.

OBJECTIVES

In order for PRIMEO Humic – Fulvic Plus Chelate Micronutrients to be accredited in Fertilizer and Pesticide Authority (FPA), the PHIL. AQUA HYDROPONICS PRIME VENTURES CORP., would like to:

Generate parametric data on the average leaf size, number of leaves per plant and average marketable yield per hectare of pechay to be submitted to Fertilizer and Pesticide Authority (FPA) that will serve as the basis in granting the Product Registration Permit.

METHODOLOGY

SITE DESCRIPTION

The Bacolod City site was located in Barangay Granada, with an elevation of 158 m above sea level from coordinates S 770 37’ W, 90.06 m. Granada is situated at approximately 10.6660, 123.0345, in the island of Negros. Granada is situated southeast of Hacienda Loygoy 1 and northeast of Purok Star Apple. Granada is 10 kilometers north-east of the heart of the City of Bacolod. It is bounded in the east by

Barangay Alangilan; in the West by Barangay Estefania; in the north by the city of Talisay; in the southeast by the Municipality of Murcia and in the southeast by Barangay Vista Alegre. And it is known for its coolness. The site has a sandy loam soil.

The site was previously planted with hot pepper.

It has an average annual precipitation of 272.50 mm between March and May, the average rainfall was 153 mm and 241 mm, respectively.

The average temperature was 27.75 °C.

SELECTION OF CROP VARIETY

The pavito variety was used in the study.

TIME OF STUDY

The study commenced in December 2022 (wet season) and February 2023 (dry season) after the approval of experimental use permit (EUP).

RESEARCH AND EXPERIMENTAL LAY-OUT

An area of approximately three hundred forty four (344) square meters was laid out using a Randomized Complete Block Design (RCBD) and was further divided into four (4) blocks. Each has 0.25-meter space between plots and one (1) meter path between blocks.

RESULTS

A highly significant season, treatment, and season*treatment effect. The dry season doubled the yield than the wet growing season. All of the treatments were highly significantly heavier than the control. For the wet season, the heaviest was the T6 (PRIMEO alone). Treatments showed phytotoxic effect with inorganic fertilization treatments except T3 (226–47–0 and half recommended rate PRIMEO). For the dry season, T4 (full RR + full product RR), T3 (full RR+1/2 product), T5 (full RR + 1 1/2 product) had significantly the heaviest yield. For the season*treatment effect, T3 and T6 seems effective at small amount because of the moisture available during the wet growing season. During the dry season, all treatments with inorganic fertilization were highest in yield because of the available nitrates for use by the ligands.

DISCUSSION

Season had significant effect in yield, the available moisture during the wet season render the fertilizers applied effective at small amount. Whereas, during the dry season, inorganic fertilization gives ample supply of Nitrogen for the use of ligands after crop removal by the wet season. Wet season application was foliar spraying and soil drenching while dry season application was only by soil drenching of fertilizers and PRIMEO.

CONCLUSIONS

After through evaluation of the parametric data collected, it was concluded that all of the levels of PRIMEO are effective in increasing the yield of pechay. It is strongly suggested to use soil drenching to be the method of PRIMEO application, in 1500 ml water per 10 m^2.

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Features of the distribution of nematodes on saline sierozem-meadow soils

L.A. GAFUROVA, N.S. PAXRADINOVA, O.X. ERGASHEVA, National University of Uzbekistan, Uzbekistan

Keywords: sierozem-meadow soils, phytonematodes, salinization, ecological-trophic group, humus

INTRODUCTION

Nematodes are soil organisms, they are directly related to soil properties. Phytonematodes actively participate in the process of mineralization of substances in soil, ensure soil fertility, and are a source of nitrogen in soil and they are bioindicators that ensure soil fertility and determine the state of the environment (Malaxov, 1982; Romanenko, 2000).

METHODOLOGY

The main methods of phytohelminology, parasitology, and the methods of comparative analysis, statistical and biometric research methods were used in the study

RESULTS

An analysis of phytonematodes by genera identified in irrigated sierozem-meadow soils of varying degrees of salinity showed that Tylenchida, Dorylaimida, Aphelenchida genera are diverse in species and abundance of nematodes. Representatives of the Tylenchida family were especially numerous in our samples. The Enoplida, Rhabditida, Plestida, and Mononchida genera were very rare compared to other genera.

Parasitic species are inoculators that attack plant tissues (Kiryanova, 1971). In our pararhizobiont samples, there were Prizmatolaimis dolichurus, Prizmatolaimis primitivus, Ironus ignavis, Mylonchylus solus, Eudoraylaimus elegans, Eudoraylaimus monohustera, Eudoraylaimus obtusicaudatus, Eudoraylaimus pratensis, Eudoraylaimus parvis, E. sulphasae, Eudoraylaimus sp., Mesodoraylaimus bastian, Drepanodorus laetificanus species. The total number of pararhizobiont specimens (136) was 11.6 percent compared to the number of other nematodes. Eudoraylaimus parvis and Eudoraylaimus elegans species dominated in abundance. Pararhizobionts were found in large numbers in highly saline soils.

Devisaprobionts are incomplete or semi-saprobionts, they live in a humus environment. Among the representatives of this group, three species were found - Cephalobus persegnis, Eucephalobus laevis, and Plectus parietinus. Devisaprobionts constantly migrate in the soil, expanding the area of decomposition. They are more common on weakly and moderately saline soils than on highly saline ones.

DISCUSSION

Representatives of this group have a rough cuticle, strong growths on the head, with which they have the ability to tear plant tissues. Among the representatives of this group, three species were found - Cephalobus persegnis, Eucephalobus laevis, and Plectus parietinus.

Non-specialized phytohelminths are 12 species out of 304 and account for 25.9 percent; this group includes Aphelenchus avenae, Aphelenchoides limberi, Aphelenchoides parietinus, Aphelenchoides xyloplilus, Cryptaphelenchus latus, Aglenchus agricola, Tylenchus davaini, Filenchus filiformus, Tylenchus clavicaudatus, leptosomes s Fylenchus, Tylenchus sp. Ditylenchus species are also included. Non-specialized phytohelminths are more common in slightly saline soils.

CONCLUSIONS

On irrigated sierozem-meadow soils, phytonematodes differ in their ecological-trophic composition. In humus soils, the biocenotic complex of nematodes is composed of saprophages. As a result of studying the fauna of phytonematodes on irrigated sierozem-meadow soils with varying degrees of salinity, it was determined that the composition of their species and ecological-trophic groups depend on the type and degree of soil salinity.

ACKNOWLEDGEMENTS

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Study of some crops tolerance and phytodesalination potential for sustainable saline agriculture

K. GHAZARYAN, Faculty of Biology, Yerevan State University, Republic of Armenia; A. HARUTYUNYAN, Faculty of Biology, Yerevan State University, Republic of Armenia; H. MOVSESYAN, Faculty of Biology, Yerevan State University, Republic of Armenia

Keywords: Hydroponic culture, salinity stress, plant salt tolerance, phytodesalination

INTRODUCTION

Large areas of arable land are withdrawn every year due to salinization, which is the result of a combination of natural and anthropogenic factors (Ivushkin *et al*., 2019). This process especially develops in arid and semi-arid climatic regions with high groundwater table, poor quality of irrigation water, traditional irrigation methods implemented with improper drainage systems. Soil high salinity reduces agricultural productivity, affecting crop yields. Cultivation of salt-tolerant plants is regarded as an innovative approach for desalination and remediation of salt-impacted agricultural soils. From this point of view, the effects of irrigation water with different concentrations of NaCl on some growth traits and development of wheat, oat, emmer, and barley under hydroponic conditions were studied and compared. Basing on the studies on accumulation of ions in plants and their resistance to salt stress, the phytodesalination potential of crops at increasing NaCl concentrations in root medium was assessed.

METHODOLOGY

Wheat, oat, emmer and barley were grown at six different degrees of salinity (0, 100, 200, 300, 400, 500 mM NaCl) in a hydroponic system that was set up under greenhouse with strictly maintained experimental conditions: natural daylight, 25–35 °C and 60–70 percent relative humidity. Thirty days after completion of salt treatment all plants were collected and some morphological and physiological parameters of plants were investigated (Al Hassan *et al*., 2016; Hayat *et al*., 2020).

RESULTS

Study results demonstrate different tolerance capability of wheat, oat, emmer and barley to increasing concentrations of NaCl in the root medium. There was significantly more adverse effect of rising level of root medium salinity on main growth attributes, relative electrolytic leakage, leaf succulence, chlorophyll content index, photosynthetic rate, and transpiration rate of emmer compared with barley, oat and wheat. The results of the present study prove that the ability to tolerate salt stress is a function of ion accumulation and the capacity to uptake K^+ by roots and transfer it to the leaves. Significant increase in Na^+ noted in the leaves of wheat, oat and barley under salinity stress was concomitant with the increase in K^+ concentrations, which indicated the activation of some physiological adaptation mechanisms. However, in the leaves of emmer, along with the increase in Na^+ content, a decrease in K^+ concentration was observed.

DISCUSSION

Thus, emmer was impacted the most followed by wheat, oat and barley at the highest level of root medium salinity. And since emmer is the most sensitive to salinity stress it will be impractical to grow it on salinized soils. Growing of comparatively tolerant species like oat and barley may be more appropriate and realistic; accordingly they could be the better choice for saline agriculture. It should be mentioned that oat, in addition to salt stress tolerance developed larger biomass and accumulated more Na^+ and Cl^- in shoots comparing with the rest of studied crops, therefore it had the strongest phytodesalination capacity.

CONCLUSIONS

Considering the fact that barley and oat accumulate large amounts of ions in their above-ground parts and that they are survivable and productive, these plants could be assumed as promising tolerant and salt accumulating crops for further research in the field of sustainable crop production and concurrent phytodesalination.

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Chenopodium album as a perspective plant for saline soil phytoremediation

K. GHAZARYAN, Faculty of Biology, Yerevan State University, Republic of Armenia; G. MARGARYAN, Faculty of Biology, Yerevan State University, Republic of Armenia; H. MOVSESYAN, Faculty of Biology, Yerevan State University, Republic of Armenia

Keywords: Soil salinization, phytodesalination, NaCl, salinity stress, plant salt tolerance

INTRODUCTION

Soil salinity is a serious environmental problem and a major factor that decreases agricultural productivity and poses a challenge to the agricultural capacity to sustain an increasingly growing population. Over recent years, the intense raise in soil infertility due to salinization of soil is a consequence of inappropriate irrigation and other anthropogenic operations (Slama *et al*., 2015). On this basis, it is very important to prevent the process of soil salinization, as well as to remediate already saline soils. The present paper discusses the novelty of Chenopodium album in the context of reducing salt stress.

The objectives of the study were: 1) to investigate the growth responses of C. album over a range of soil salinities in two different soil textures, 2) to analyze some morphological indices, photosynthetic characteristics, and ionic contents, 3) to determine its phytodesalination ability at different concentrations of NaCl.

METHODOLOGY

Salt tolerance potential and phytodesalination ability of C. album growing in the same salt-affected soil of two different textures (clay and clay loam) over a range of salinity (non-saline (ECe is 0–2 dS/m), slightly salinized (ECe is 2–4 dS/m), moderately salinized (ECe is 4–8 dS/m), highly salinized (ECe is 8–16 dS/m), and extremely heavily salinized (ECe >16 dS/m) of two different rates: extreme1 (ECe is 16–20 dS/m) and extreme2 (ECe is 25–30 dS/m)) (Brown *et al*., 1954) were studied and compared.

RESULTS

Results demonstrate that C. album has high adaptability and tolerance to extreme salt stress. Morphological and physiological characteristics promoted the stress tolerance of this plant. The studied attributes of growth such as stem diameter, shoot length, fresh and dry masses in the process of salinity increasing altered differently in clay and clay loam soil types. In particular, according to investigated growth traits, plants growing in clay soils showed a better adaptation reaction than plants growing in clay loam soils, and an increase in the main part of studied indices was observed until reaching high degree of salinity, after which the plants showed symptoms of stress in all the growth parameters. Under the most favorable soil conditions for the studied plants (clay soil) they did not just avoided dehydration of root and shoot and undergo suppression in various growth traits under saline stress but even considerably enhanced.

DISCUSSION

It is worth noting that, despite the fact that there was an inhibition of some physiological parameters of plants under the salt stress conditions, such as photosynthesis and transpiration rates, the plants retained survivability even if exposed extreme degrees of salinity. Observed intensive accumulation of salt ions by plant further promote the feasibility of C. album for phytodesalination of saline degraded soils basing on the fact that the maintaining of the plant growth and function under long-term NaCl stress is indicative of the tolerance ability.

CONCLUSIONS

Obtained results may be the input to give a new comprehension of an alternative phytotechnology for sustainable functioning of saline agriculture and remediation of saline soils by tolerant and abundant biomass yielding plant C. album. However, future research should be carried out to ascertain previously unexplored key traits of C. album and to open up possibilities for enhancing its salinity tolerance and soil desalination potential.

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Reclamation of saline soil using subsurface drainage system, Golestan region, the Islamic Republic of Iran

K. GHORBANI

Keywords: subsurface drainage, modeling, salinity level, reclamation.

INTRODUCTION

Evidences indicate that due to growing in the population of world, the amount of demand for agricultural products are yearly increasing. On the other hand, in order to sustain and increase agricultural products and ensure to achieve food security, it is necessary to improve and develop healthy and fertile soils . For this purposes, more efforts need to preserve and sustain important components and valuable area. Numerous investigations and studies indicate that the salinity level of land is expanding and increasing, and this process can be considered a serious threat to the country's food security

METHODOLOGY

The drainage system was designed to implement using a numerical model named Modflow in combination with GIS, to achieve the expected results. Salinity level of soil and also drainage water decreased significantly by implementing of the drainage system .

To evaluate the performance of the project, samples were taken monthly from the drainage water and surface soil at a depth of 30 cm and were analyzed in the laboratory

RESULTS

The results demonstrated that the salinity level of water and soil has significantly decreased in a range of 50 to 70 percent during a year.

In another survey, it indicated that with the implementation of the drainage system, the amount of wheat products meaningfully increased from 500 kg/hectare to 2500 kg/hectare yearly.

DISCUSSION

Collected data and obtained result were discussed.

CONCLUSIONS

Evidences indicate that due to growing in the population of world, the amount of demand for agricultural products are yearly increasing. On the other hand, in order to sustain and increase agricultural products and ensure to achieve food security, it is necessary to improve and develop healthy and fertile soils . For this purposes, more efforts need to preserve and sustain important components and valuable area. Numerous investigations and studies indicate that the salinity level of land is expanding and increasing, and this process can be considered a serious threat to the country's food security. In the Islamic Republic of Iran, although a significant area of the country's land suffer from saline, especially in the north of the Islamic Republic of Iran due to the high level of underground water or in some cases waterlogging and ponding agricultural lands are highly exposed to destruction and the crop is facing a decrease. In a case study,   reclamation of saline soils in the north of the Islamic Republic of Iran was implemented using surface and underground drainage systems.

The drainage system was designed to implement using a numerical model named Modflow in combination with GIS, to achieve the expected results. Salinity level of soil and also drainage water decreased significantly by implementing of the drainage system .

To evaluate the performance of the project, samples were taken monthly from the drainage water and surface soil at a depth of 30 cm and were analyzed in the laboratory. The results demonstrated that the salinity level of water and soil has significantly decreased in a range of 50 to 70 percent during a year.

In another survey, it indicated that with the implementation of the drainage system, the amount of wheat products meaningfully increased from 500 kg/hectare to 2500 kg/hectare yearly. Therefore, the implementation of the drainage system can not only prevent the spread of soil salinity, but also protect the agricultural lands of the region from the progress of salinization.

Beside of the decrease in soil salinity, the crop productions were increased. Cycling of drainage water after a period of desalination is one of the other steps of the project that has been experienced in this project and can be used for application.

In-field assessment of soil and water salinity with geophysics and geostatistics

L. GOLOVKO, Landviser LLC, USA; A. TRUBIN, Czech University of Life Sciences, Czech Rep; S. ORUNBAEV, American University of Central Asia, Kyrgyzstan; Y. MANSTEIN, OOO KB Electrometry, Russian Federation; L. POZDNYAKOVA, Moscow State University, Russian Federation; A. RUSAKOV, Y. SIMONOVA, Saint-Petersburg State University, Russian Federation

Keywords: electrical geophysics, in-situ soil salinity mapping, groundwater monitoring, geostatistical interpolation, regional GIS modeling

INTRODUCTION

Climate change and human activities impact soil and water resources stressing communities worldwide. Extreme weather events are causing floods and droughts, leading to problems with soil and groundwater salinization. Many historically densely populated and agricultural areas are particularly vulnerable to climate change and subjected to saltwater inundation and secondary salinization. Detailed maps of the subsurface are necessary to manage and ameliorate saliny but difficult to obtain, as salinity is dynamic and highly spatially variable. Our group has been developing several on-ground geophysical instruments and geostatistical approaches (Pozdnyakova and Zhang, 1999) for studying soil and groundwater salinity around the world for the last 20 years.

METHODOLOGY

Climate data are readily available globally and, when combined with hydrological and topographic GIS, the risks of waterlogging and secondary salinization can be assessed using water and solute transport models. However, to calibrate such models, information about physical properties of subsurface soil layers is needed at several points in the landscape. Electrical geophysical methods are ideally suited for obtaining detail information about soil profiles. Our portable LandMapper device (Golovko *et al*, 2010), which measures electrical resistivity (ER) or electrical conductivity (EC) was widely used in soil and groundwater studies since it measures EC in a wide rang, both in the laboratory and during field mapping and 1D vertical electrical sounding (VES) to 30 m depth. Despite the versatility of the VES method in soil and groundwater studies and the portability of the LandMapper, other geophysical methods must be applied, especially when a large area needs to be mapped quickly and in detail for regional hydrological modeling. The non-contact instruments of multi-frequency electromagnetic induction (FEMI), such as AEMP-14 and Geovizor are perfectly suitable for large-scale mapping.

RESULTS

The field geophysical methods were used to study the dynamics of groundwater movement, water table, and soil salinity in the Russian Federation, Kyrgyzstan (Orunbaev *et al*, 2021), Iraq, Indonesia, the coasts of Texas, Puerto Rico, and Florida, and show their universal applicability for site assesments. Large-scale soil and climatic data from open sources can be used to model groundwater and soil salinization risks on a regional scale. Information on soil profile organization is necessary for more detailed modeling on a local scales. Field geophysical methods for measuring electrical parameters are promising for rapid mapping and monitoring of soils, providing boundary conditions and calibrations for hydrological modeling.

DISCUSSION

Using large-scale data from open sources has limitations for detailed local modeling of water and salt movement in soils. The geophysical methods can be used for quantitative and qualitative characterization of soils and groundwater. The development of a combined methodology of several geophysical methods for multi-depth EC mapping, which is universally applicable to any ground conditions, suitable for both mapping and monitoring, easy to use, and supported by field experiments and research in geophysics and soil science is needed and underway.

CONCLUSIONS

Several geophysical instruments were used for soil assessment, interpolated with geostatistical methods, and combined with other open data showing a great potential for fast assessment and management of saline soils and hydrology of vulnerable ecosystems.

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Landviser LLC and OOO KB Electrometry has developed the instruments used in this research.

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Plantation and utilization of halophytes with saline water irrigation in the Thar Desert of Pakistan

B. GUL

Keywords: Halophytes, Climate change, Utilization, Soil rehabilitation, Bio-saline agriculture, Salt tolerant

INTRODUCTION

The Thar Desert is Pakistan's largest and the world's 17th largest desert; located in the southeastern of Pakistan and covers an area of nearly 200,000 square kilometres. It has one of the largest coal fields in the world that has not yet been thoroughly mined. The China–Pakistan joint venture coal mining started in 2015 is the flagship project of the energy and infrastructure construction plan along the CPEC. While the project is driving local economic development, it also inevitably has some negative impacts on the ecological environment, such as vegetation destruction, and soil and air pollution, which has caused problems for the livelihoods of local farmers and herders. Residents in the Thar Desert region live on aquaculture and traditional agricultural cultivation; however, agricultural production is constrained by water shortages. Only a few crops can be planted during the rainy season from July–September. Production technology is backward and production yield is relatively low. The vast majority of residents are in poverty. Meanwhile, a large amount of salt water is produced in the local coal mining process, but it cannot be utilized due to technical limitations. Therefore, developing saltwater agriculture by screening and introducing salt-tolerant economic plants and using a high-yield planting model suitable for local natural environments are the best choice to improve the agricultural production and ecological environments in this area. Therefore, this collaborative project aims to develop a non-conventional cropping technology based on salt-tolerant local plants and salty-water utilization to ensure food security in the Thar desert.

The difficulty in using salt water is how to reduce the adverse effects of salt brought into the irrigation process on soil quality and sustainable use. This project starts with the screening of salt-tolerant plant varieties and the natural soil salt-washing by rainfall, identify the effects of saltwater irrigation on the growth and yield formation of salt-tolerant plant, and reveal the salt-water movement law in "saltwater irrigation-precipitation washing salt" processes, thus forming a sustainable utilization mechanism of saltwater resources and forming a continuous technical system of "saltwater irrigation – high-yield cultivation of salt-tolerant plants – development and utilization of salt-tolerant economic plants", which can effectively implement the comprehensive utilization of saltwater resources and establish a new model of saltwater agriculture development to improve local agricultural production and improve the living standards of local farmers and herdsmen. We expect that the outcomes of this highly innovative international project will be multipronged. In general, the success of this project will not only help ensure food security for the poor masses of the Thar region but will also contribute towards human resource development for arid-saline agriculture and improve the overall environment of the area.

This Joint research project will be implemented by Dr. Muhammad Ajmal Khan Institute of Sustainable Halophyte Utilization (DMAK-ISHU) of the University of Karachi in Pakistan and Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences (XIEG-CAS) in China. Sindh Engro Coal Mining Company Limited (SECMC) of Pakistan was committed to providing land for experimental trials, demonstration sites, and a greenhouse for three years (approved duration for the project). This project is ongoing, and we made significant progress during the 1st year.

The project's scope is to Introduction an adaptability assessment of salt-tolerant economic plants for the Thar Desert. This research aims to develop a non-conventional cropping technology based on salt-tolerant local plants and salty-water utilization to ensure food security in the Thar desert.

METHODOLOGY

Field trips and surveys: Initially, field trips to the Thar desert were done to select the study site and collect water and soil samples for different chemical and physical analyses. A reconnaissance survey was also conducted to collect information about the local vegetation of the Thar Desert. Field trips of Karachi's coastal and inland saline areas also have been done for the seed collection of the potential halophyte species.

Water Analysis: The mining water will be used for irrigation purposes in this project hence water samples were collected and analyzed for electrical conductivity (EC), pH, and ion concentrations (Na+, Cl-, K+, and NH4+).

Soil Analysis: Soil samples were collected for physical and chemical analyses before selecting the site for the experimental trials. Soil moisture and inorganic content were measured by drying soil in the oven at 105 oC and muffle furnace at 550 oC respectively. At the same time, soil electrical conductivity (EC), pH, and ion contents (Na+, Cl-, K+) were measured in 1:5 water-based soil extracts. Soil water holding capacity was also measured.

Land Preparation: Sindh Engro Coal Mining Company Limited (SECMC) provided one acre of land for experimental trials and the establishment of crop demonstration sites. Land preparation (i.e., land clearing and levelling) for the plantation has been done. After land clearing and levelling, a drip irrigation system was installed.

Reconnaissance survey for vegetation: A reconnaissance survey was conducted to collect information about the native vegetation and to identify the local species for their economic potential. The survey areas included the coal mining areas Thar Block II and nearby villages named Sehri, New Sehri-Das, and Thario Hal-e-Pota in IslamKot.

Seed Collection and Cleaning: Field trips to different coastal and inland saline areas have been done in Karachi to collect the seeds for potential economically important halophytes.

Screening of halophytes and crops for stress tolerance: Seeds of different halophytes were sown in loamy soil plus manure-filled plastic trays (3.5-litre cubes) and irrigated with distilled water. After one month, healthy seedlings of similar size were transplanted into plastic pots (six litter cubes; three individuals per pot) containing sandy soil. Plants were grown in environmental conditions: (Temperature: 37 ± 1 ^{o}C; Relative humidity: 50±5 percent; Light intensity: 1000–1200 µmol m^{-2} s^{-1}). Plants were irrigated with half-strength Hoagland's solution. Hoagland's nutrient solution was refreshed every after one week. Salinity treatment was started after 30 days of seedling acclimatization. Plants were exposed to different salinity treatments (0, 100, and 200 mM NaCl). Salinity treatments were introduced gradually i.e. 50 mM NaCl/day for halophytes and 25 mM NaCl/day for glycophytic crops to avoid osmotic shock. Plants were harvested after one month from the final highest salinity i.e. 200 mM NaCl was achieved.

Parameters studied:

Growth Parameters studied: Plants from each salinity treatment were harvested after one month to study various morphological, physiological, and biochemical attributes. All experiments were performed on five biological replicates. After harvest, plants from each treatment were rinsed with distilled water to remove the salt and sand particles to determine the shoot and root length, number of leaves, leaf length, and shoot fresh weight (FW). To determine the shoot's dry weight (DW), freshly collected samples were weighed and placed in an oven at 60 oC until a constant weight was achieved. Shoot moisture content was determined by using the following equation:

Moisture content (percent) = {(FW-DW)/FW}x100

Where FW is the fresh weight of the shoot, DW is the dry weight of the shoot.

Plant samples were collected in liquid nitrogen for biochemical analysis and stored at the frozen temperature in the ultra-low freezer (-80 oC) until used.

Photosynthetic Pigments: Fresh leaves were crushed with the help of mortar and pestle by using liquid Nitrogen, homogenized into 5 ml of 80 percent ice-cold acetone, centrifuged at 10,000rcf, the supernatant was collected, and absorbance was recorded at 645, 663, and 480 nm for chlorophyll a, b, and carotenoids.

Chlorophyll fluorescence: Chlorophyll fluorescence was estimated on fully developed leaves using a pulse-modulated fluorometer (PAM 2500, Walz, Germany). The leaf was dark-adapted for 25 minutes using leaf clips. The minimal fluorescence (Fo) value was measured after applying light flash (< 0.1µmol photon m−2 s−1) on the dark-adapted leaf, while the maximal fluorescence (Fm) value was obtained by imposing a saturating pulse (10,000 µmol photons m−2 s−1) for 0.6s. The Fo and Fm values were used to calculate the maximum photochemical quantum yield of PSII (Fv/Fm = Fm-Fo/Fm).

Lipid peroxidation and hydrogen peroxide: The malondialdehyde (MDA) content, a commonly used damage (stress) marker, was determined according to the method of Heath and Packer (1968). Fresh leaves were homogenized into 3 percent ice-cold trichloroacetic acid (TCA). TCA extract (0.5 ml) was mixed with 0.5 ml of 0.5 percent thiobarbituric acid (TBA) prepared in TCA (20 percent,) and absorbance of the reaction mixture was measured at 532 nm and 600 nm on a spectrophotometer (DU530 Beckman Coulter UV/Vis).

Agronomic trials of selected species in the field:

Agronomic trials were done at the site of Sindh Engro Coal Mining Company Limited (SECMC). SECMC provided one acre of land for experimental trials and the establishment of crop demonstration sites (Figure 1). Land preparation (i.e., land clearing and levelling) for the plantation has been done. After land clearing and levelling, a drip irrigation system was installed.

Plantation model: Selected halophytes and crop plant species were planted in plots of 5 m x 5 m sizes at a 50 cm x 50 cm distance between rows. Subsequently, drip irrigation was applied fortnightly in quantities enough to keep the root zone moist. To diminish soil salt content, Suaeda fruticosa was used as a salt scavenger intercrop.

Parameters studied:

All the above-mentioned salt tolerance screening parameters were studied in the field.

RESULTS

Soil and water analyses:

The soil of the poorly developed study area needed more moisture and organic content. Soil electrical conductivity is ~169 ppm. The pH of the soil is 7.5 + 0.1. Soil contains a very high concentration of ions, particularly Na+ was found in higher quantities. water samples were taken from all three sources: the main reservoir (Greywater), canal, and tank near the study site for irrigation purposes. The tank has maximum electrical conductivity i.e. 6.24 dS/m. water samples also contain high salt concentrations, particularly high Na+ concentrations.

Reconesence survey:

The study area has low plant diversity, and the predominant vegetation is xerophytic. The most abundant trees were Prosopis cineria, P. juliflora, and Acacia senegal. The most dominant shrubs were Aerva javanica and Calotropis procera.

Screening of halophytes and crops for stress tolerance:

Test species: To screenout the plants for their salt tolerance, three glycophytic crops i.e. Pennisetum americanum, Sorghum bicolor, and Zea mays were grown in different NaCl concentrations (0, 100, and 200 mM) under controlled greenhouse conditions (Table 3a). While four halophytic grasses Panicum antidotale, Phragmites karka, Typhha domingensis, and Urochondra setulosa were also screened out for their salt tolerance (Table 3b). The crop species are selected based on their utility as food and fodder. While halophyte grasses were selected on the basis of their biomass and antinutritive analyses we have previously done.

Growth responses: Shoot and root length, length of leaf, and the number of leaves in crop species significantly decreased with increasing salt concentration, and almost all crops had low biomass at 200 mM NaCl (Figures 6a, 7a, 8a, and 9a). Shoot and root length, length of leaf, and the number of leaves in halophyte grasses also decreased with increasing salt concentration but the overall biomass of halophyte grasses was significantly higher than crop species. The shoot fresh and dry weight of both glycophytic crops and halophyte grasses showed decreasing trend with increasing salinity. However, this decrease was more pronounced in glycophyte crops than in halophytes. The moisture content of the shoot slightly decreased at higher salinity (200 mM NaCl) in all crops. All halophyte grasses maintained the moisture content of their shoot under saline conditions and showed a slight decrease at 200 mM NaCl concentration.

Photosynthetic pigments: In glycophytic crops, photosynthetic pigments showed significant variations under varying salt concentrations. Pannesatum americanum Chlorophyll content was higher under low saline medium while decreased at 200 mM NaCl (Figure 13a). The chlorophyll content of Sorghum bicolor showed a linear decrease with increasing salt concentrations. However, Zea mays had significantly higher chlorophyll content at high salinity treatment than the non-saline (0 mM NaCl) and low saline (100 mM NaCl) treatments. The chlorophyll b content of all crops also followed a similar trend. Conversely, halophyte grasses' chlorophyll a and b contents showed varied responses under varying salinity. The chlorophyll a and b contents of Panicum antodotale showed a slight decrease at 200 mM NaCl. The chlorophyll content in Phragmites karka increased with increasing salt concentration; however, chlorophyll b was found higher at low salinity (100 mM NaCl) and comparable at 0 and 200 mM NaCl treatments. The chlorophyll a and b contents of Typha domingensis showed a decrease at 200 mM NaCl. In the case of Urochondra setulose, chlorophyll content increased, while chlorophyll b content showed decreasing trends with increasing salt concentration. The chlorophyll a and b ratios were found to be higher at high salinity in all plants studied except P. americanum. The carotenoid content increased with increased salt concentrations in all plants studied.

Chlorophyll fluorescence: The maximum quantum yield of photosystem II (Fv/Fm) of crop species is nearly 0.6, while at 200 mM NaCl concentration, it decreased to 0.52. However, in the halophyte specie, the value of Fv/Fm is higher than in the crops, which range from 0.78 to 0.8. The effective quantum yield of photosystem II (YII) of crops was found to be lower in saline conditions however, in halophyte grasses, the YII declines only at 200 mM NaCl treatment. The relative electron transport rate (ETRr) in crops also decreased under salinity, while the ETRr of halophyte grasses only showed a slight decrease at 200 mM NaCl concentration.

Stress and damage markers: The MDA content in all crop species linearly increased with increasing salinity however, in halophyte grasses, the MDA content only increased at high salt (200 mM NaCl) concentration. The accumulation of hydrogen peroxide (H2O2) in all crop leaves showed a similar increasing trend, like MDA content. While the accumulation of H2O2 in leaves of halophyte species only increased at 200 mM NaCl treatment.

Agronomic trials of selected species in the field:

Growth Responses: On the basis of results obtained from the tolerance screening experiments two glycophytic crops and two halophyte grasses were selected for plantation purposes in the Thar desert. For the agronomic trial, we planted two crops and one halophyte grass. The glycophytic crops include Pannesatum americanum, and Sorgham bicolor while the halophyte grass used for the agronomic trial is Panicum antidotale. Among all plants, P. antidotale showed maximum biomass in the field and attained maximum height with the highest number of leaves compared to glycophytic crops (Figure 22 and Table 4). However, in the case of crops, P. americanum showed better growth than S.bicolor.

Chlorophyll fluorescence: The maximum quantum yield of photosystem II (Fv/Fm) of test species grown in the Thar desert ranges between 0.5 to 0.6. However, the effective quantum yield of photosystem II (YII) ranges between 0.44 – 0.53 (Table 4). The relative electron transport rate (ETRr) of crops was found to be lower than the ETRr of halophytes.

DISCUSSION

The Thar Desert lies between 24° to 28° N latitude and 68° to 71° E longitude occupying an area of about 35126 km2. Physically the desert stretches over the eastern districts of the Sindh Province. The climate of Thar Desert is characterized by dry hot summers and pleasant dry winters. The area has received no uniform rainfall for the last couple of years (NOVA weather). This depleted the drinking water sources, and people were thus compelled to move away from their traditional territories in search of water.

Halophytes are plants capable of successfully completing their life cycle under saline conditions (Khan & Qaiser, 2006). Flowers and Colmer (2008) have been more specific in restricting the halophytes to a group of "plants that survive and reproduce in the environments where the salt concentration is around 200 mM NaCl or more". Hence, three glycophytic crops i.e. Pennisetum americanum, Sorghum bicolor, and Zea mays, and four halophytic grasses i.e. Panicum antidotale, Phragmites karka, Typhha domingensis, and Urochondra setulosa were grown in different NaCl concentrations (0, 100, and 200 mM) under controlled greenhouse conditions. Grasses play an important role in land stabilization and animal nutrition, soil protection, and sand dune fixation. Therefore, planting grasses constitute an important part of any rangeland rehabilitation program. Salinity stress negatively affects the growth and development of plants by retarding a number of physiological and biochemical functions (Flowers & Colmer, 2015).

All the selected species grow and produce considerable biomass even at 200 mM NaCl concentration. Our results indicate that the optimal growth of glycophyte crops was found in non-saline conditions to low salinity, while halophytes showed good biomass at low salinity. Although the high salinity reduced the growth and biomass production in all selected plant species, this decline was quite marginal for the halophyte grasses. One of the primary determinants of livestock production in biosaline agriculture is the amount of edible biomass produced. Salinity has both osmotic and specific ion effects on plant growth. The high salt environment may cause a loss of water from the cells and a decrease in turgor. Different halophytic grasses displayed a classical dose-dependent response under salinity as in Phragmites australis (Gorai *et al*., 2010), P. communis (Gorai *et al*., 2007), Spartina maritima (Naidoo *et al*., 2012) and Pennisetum clandestinum (Muscolo *et al*., 2003).

Resistant plants increase their chlorophyll content to prevent photosynthetic machinery from damage, reduce ionic toxicity and maintain water status (Acosta-Motos *et al*., 2017). Salt-sensitive plants like

Hordeum vulgare decreased chlorophyll a and b content, while halophyte grasses studied increased their chlorophyll a and b content with increasing salinity, which show stress resistant behavior of P. karka as reported by Khosravinejad *et al*., 2008 and P. antodotale as reported by Koyro *et al*., 2015.

NaCl treatments significantly affected chlorophyll fluorescence parameters in all test species. The potential quantum yield of crops' PSII (FV/Fm) linearly decreased with increasing salinity, while halophytes showed a slight reduction or remained unchanged with increasing salinity. a similar trend was also observed in some moderate (Gossypium hirsutum and Hordeum vulgare) to high salt tolerant (Suaeda salsa) plants (Lu *et al*., 2003). However, in salt-sensitive plants (Sorghum vulgare and Apium graveolens) photochemical efficiency decreased with an increase in salinity). The decline in ETR showed stress resistance and protection from ROS at the cost of growth, which is in accordance with the growth responses of our test species. Similar low ETR was also reported in Aster tripolium, Spartina patens, and Distichlis spicata to prevent plants from photo-damage.

Many metabolic processes produce H2O2, which is a reactive oxygen species and harmful byproduct to cells and tissues, so it must be rapidly converted into other less harmful substaces to prevent tissue damage. A significant effect of salinity on MDA and H2O2 content of all plant species tested was found. With increasing salinity treatments MDA and H2O2 also increased in both glycophytic crops as well as halophyte grasses but this increment was more pronounced in glycophyte crops in comparison with halophytes. In halophytes, this protection at moderate salinity may be achieved by proper oxidative balance with the help of secondary plant products like phenolic compounds, as observed in Cakile maritima (Ksouri *et al*., 2007).

Choosing suitable salt-tolerant economic plant varieties is the basis for the development of saltwater agriculture. Salt-tolerant crops (halophytes) and short-growing crop varieties (Glycophyte/conventional crops) that can effectively use the short window of the growing season at Thar desert were selected for agronomic trial to check their best adaptability for the local environment and needs. Initially, two glycophytic crops and two types of halophyte grasses were selected for plantation purposes in the Thar desert. For the agronomic trial, we planted two crops and one halophyte grass. The glycophytic crops include Pannesatum americanum, and Sorgham bicolor while the halophyte grass used for the agronomic trial is Panicum antidotale. Among all plants P. antidotale showed maximum biomass in the field and attained maximum height with the highest number of leaves however, in the case of crops, P. americanum showed better growth than S.bicolor. Our data indicate that all these selected species were successfully grown in the harsh climatic conditions of the Thar desert and produced considerable biomass. Furthermore, we can improve the biomass production and yield of tested crops and make them better adapted to the harsh conditions of Thar desert, which is the second-year plan of this project.

CONCLUSIONS

The environmental conditions are very harsh in the Thar desert for plant growth and development, and mass-scale cultivation of plants is very difficult not only due to the shortage of water but high temperatures, high light intensities and poor nutrient availability in the soil, further devastating the conditions for the plant growth and development. Results obtained from the screening of cops and halophytes for their salt tolerance helped us to identify some potential candidates for the plantation in the hostile environment of the Thar. Based on the results obtained, we selected two glycophytic crops and one halophyte fodder grass for the initial agronomic trials at the Thar desert. For the plantation in the Thar desert, we have designed a cropping system to achieve successful mass-scale cultivation with sustainable use of available resources. Results obtained from the initial agronomic trials.

at the Thar desert are also very promising and give us hope for better crop development in the future. The species selected for the trails successfully established the harsh prevailing conditions and aclimed accordingly. Although biomass production is lower than their native habitat condition in future experiments, we will try to optimize its growth and yield production.

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Estimation of cotton root zone soil salinity using different models

Y. HASHEMINEJHAD, Academic Staff Member, Khorasan Razavi Agricultural and Natural Resources Research and Education Center

Keywords: Cotton, Deficit Irrigation, Salinity, Sowing date, Modeling

INTRODUCTION

At the farm scale, reducing evaporation and transpiration through low irrigation and identifying sensitive stages of growth has been introduced as one of the ways to improve water productivity (Jalota *et al*., 2006). Several studies have shown that deficit irrigation reduces the plant's luxury consumption and minimizes water use without or with little yield loss (Li *et al*., 2019). Various strategies are used for deficit irrigation (English *et al*., 1990). Since transpiration has a direct relationship with the absorption of carbon dioxide, photosynthesis, and as a result, growth and production, therefore water absorption is based on transpiration or, for more convenience, it is expressed on the basis of evapotranspiration. One of the deficit irrigation strategies is based on the ratio of actual transpiration to potential transpiration. By changing the relative transpiration potential, it is possible to choose the optimal level of irrigation where the water requirement is minimum and the water yield and productivity is maximum. Simulation of growth and performance using agro-hydrological models provides the possibility of testing different strategies and selecting the optimal strategy.

The SWAP (Soil, Water, Atmosphere and Plant) model is an agro-hydrological model for simultaneous simulation of water movement, solute transport, heat flow and plant growth at the field scale (van Dam 2000). Irrigation management in saline conditions requires applying more water for leaching. The minimum fraction of the total water consumption that must be included in irrigation to control the salinity of the soil in the root zone within the plant's tolerable limit is called leaching requirement (Richards, 1954). At the same time, the amount of leaching in the farm may be less, equal, or more than the leaching requirement. Leaching less than the leaching requirement leads to the accumulation of solutes in the soil and the crop yield decreases, while leaching more than the leaching requirement leads to water losses, as a result, water productivity decreases in both cases. Various methods and equations are used to determine the leaching requirement, and new evaluations using models have shown that these methods overestimate the leaching requirement, especially in small quantities(Letey *et al*., 2011).

Sowing dates can also affect water productivity. An early planting date increases dry matter accumulation, while increasing the water requirement, while a late planting date, depending on the climatic conditions, can lead to a decrease in plant yield and a decrease in irrigation requirements. In both cases, water productivity is impacted by planting date (Das *et al*., 2014). The purpose of this research was to investigate different low irrigation strategies and planting dates using the recalibrated SWAP model, WatSuit model and conventional model (Ayers and Westcot, 1985) for cotton under saline irrigation conditions. The impact of these strategies on salt accumulation in the root zone, leaching fraction and crop yield has been discussed.

METHODOLOGY

The implementation of this research has included four steps: the first step was the calibration of the model based on field information; The second step was the implementation of different scenarios (deficit irrigation, salinity and planting date) in the recalibrated model; the third step was the comparison of different scenarios in terms of water consumption, cotton yield, leaching fraction and water productivity and the fourth step was to evaluate the effect of different deficit irrigation scenarios on salinity buildup in the root zone.

For the calibration step, daily meteorological data from the Sabzevar synoptic station, soil hydraulic coefficients from the RETC model (Van Genuchten, Leij *et al*. 1991) for a loamy soil and data from some fields under cotton cultivation in Sabzevar city were used. This information included planting date, planting density, irrigation management, leaf area index at different stages of the growing season, pollination date, maturity date and yield. Reference evapotranspiration was calculated using the FAO-Penman-Monteith method (Allen *et al*., 1998).

Calibration was done in three steps (van Lier *et al*., 2018): in the first step, by changing the degree-day coefficients needed to complete the pollination and harvest stages, the dates of these stages were matched to the actual dates; In the second step, by changing the coefficients of photosynthesis efficiency and conversion efficiency, the leaf area matched the actual values, and finally, in the third step, by changing the coefficients of dry matter distribution towards the storage organ, the yield value matched the measured values. At this step, to ensure the recalibration of the model, the plant and soil results were compared with the results of other researches and models.

In the second stage, various scenarios that affect water productivity were evaluated through modeling. These scenarios include deficit irrigation at six levels (conventional irrigation, half interval and conventional irrigation volume, 100 percent potential transpiration, 90 percent potential transpiration, 80 percent potential transpiration and 70 percent potential transpiration; irrigation water salinity at two levels 4 and 10 (dS m^{-1}).

Conventional irrigation in Sabzevar region includes irrigation after planting, 24 days after planting, and then irrigation at 12-day intervals until the beginning of October, and 10 cm irrigation depth was considered for each irrigation. In the half interval treatment and conventional irrigation volume, irrigation including after planting, 24 days after planting and then irrigation in a 6-day cycle with a depth of 5 cm was meant.

Finally, the effect of these scenarios on the accumulation of salts in the root zone of cotton in the soil was evaluated using three models of: conventional (Ayers and Westcot, 1985), WatSuit (Rhoades *et al*., 1992) and SWAP (van Dam, 2000) models. Conventional and WatSuit models are considered as the steady state models and SWAP model is considered as transient state models.

RESULTS

Table 1 shows some important soil and plant characteristics used in the calibrated model. Soil hydraulic properties for a soil with loam texture were estimated by RETC model and plant coefficients were taken as a first estimate from WOFOST model (Van Heemst, 1988). These values were adjusted in such a way that, the pollination date is predicted in the middle of August and the physiological ripening date at the end of October. These dates are compatible with the agricultural calendar of the region.

Table 2 shows the effect of different irrigation and salinity scenarios on the components of water productivity and leaching fraction. According to this table, reducing the interval and volume of irrigation by half, in non-saline conditions, has increased the yield by 270 kg/ha compared to conventional irrigation conditions. While the same operation under saline conditions has resulted in an increase in yield of only one kg/ha. Obviously, in saline conditions, plant growth and yield decrease, as a result of which transpiration decreases and the contribution of evaporation increases in each cycle of irrigation. This issue can be seen by comparing evaporation under two salinity conditions.

The highest yield and water productivity in non-saline conditions are related to relative transpiration treatment equal to 100 and 90 percent, and in saline conditions, relative transpiration treatment is 100 and 70 percent, respectively. The amount of water used in these treatments in non-saline conditions is from about 8000 to 11000 m^3/ha and in saline conditions from about 12000 to 25000 m^3/ha. At the same time, in the superior treatment (relative transpiration of 70 percent), the predicted water requirement is 11,600 m^3/ha and less than 12,000 m^3/ha in conventional conditions. As a result, managed deficit irrigation in both cases is able to increase water productivity compared to conventional irrigation.

The remarkable issue is that in non-saline conditions, the volume of irrigation in the conventional method is more than irrigation based on relative transpiration. While in saline conditions, irrigation based on relative transpiration predicts a higher amount of irrigation than the conventional method. In this way, in non-saline conditions, irrigation based on relative transpiration is considered less irrigation than conventional irrigation, but in saline conditions, only in relative transpiration of 70 percent, the amount of irrigation is less than conventional irrigation.

As an example of the effect of leaching fraction on the accumulation of solutes in the root zone, the effect of irrigation scheduling based on relative transpiration rate of 100 percent in irrigation water salinity of 4 (dS m^{-1}) on soil salinity in the root zone as predicted by three models is shown in Figure 1.

It is worth noting that based on all three models soil salinity increases downward in the root zone. This is mainly due to the basic assumption of 40–30–20–10 water absorption pattern in the sequential quarters of the root zone, which causes the decreasing trend of LF and increasing trend of salinity buildup in the root zone. The SWAP model is able to predict the upward flux of water and solutes due to capillary rise, which leads to the accumulation of salts on the soil surface.

DISCUSSION

The leaching requirement is calculated based on (Ayers and Westcot 1985) for water salinity conditions of 4 and 10 (dS m^{-1}) as 12 and 35 percent, respectively. A look at the results of the leaching fraction in different treatments (table 3) shows that the scenarios of 90, 80 and 70 percent of relative transpiration rate under non-saline conditions do not meet the required leaching based on the overall prediction and to avoid salt accumulation it is necessary to apply extra leaching, while under saline conditions, all deficit irrigation scenarios meet the LR. This contradiction seems to be related to the share of transpiration in total water demand. Under non - saline conditions, major portion of applied water is directed to transpiration and the crop yield is higher than saline conditions, while under saline conditions the crop yield decreases due to the salinity stress and as a result transpiration decreases too, which decreases the crop water demand. This situation leads to more leaching of salts from the root zone.

WatSuit model considers the effects of precipitation and dissolution on the concentration of solutes in the root zone. The overall effect of this assumption leads to the dissolution of some precipitated salts under slightly saline and high LF conditions and precipitation of soluble ions under high salinity and low LF values. As a result the salt content in the root zone predicted by WatSuit model may be lower than conventional model under high salinity and low LF values. These conditions is reflected in table 2, where the mean root zone salinity predicted by WatSuit model under ECiw= 4 dS/m and LF of 3 percent is about 10.7 dS/m, while this prediction for the conventional model is about 18.78. SWAP model did not consider the accumulation of salts in the evaluated depth, because in considers deep soil profile without drainage problems, which leads to accumulation of salts in deeper layers of soil.

CONCLUSIONS

In irrigation with fixed intervals and depth (such as the majority of common agriculture in the country), it is not possible to manage the frequency and volume of irrigation. While farmers can halve the frequency and volume (time) of irrigation by agreement. In most areas of Sabzevar, a 12-day irrigation cycle is common. The results of this research showed that halving the irrigation cycle to six days and the irrigation depth to 5 cm can increase yield, especially in non-saline conditions. At the same time, the same operation in salty conditions mainly leads to an increase in evaporation losses and as a result, the amount of solute leaching decreases, which can even reduce the crop yield.

The managed deficit irrigation methods can significantly increase the water productivity due to the adaptation of irrigation to the actual needs of the plant. The results of this research showed that the highest level of water productivity in non-saline conditions occurred in deficit irrigation conditions in relative transpiration of 70 percent

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Synergistic effects of potassium and cultivars to improve rice (*Oryza sativa* L.) productivity under moderate salinity conditions in Central Viet Nam

H.T.T. HOA, Faculty of Agronomy, University of Agriculture and Forestry, Hue University; H. REHMAN, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan

Keywords: K+/Na+ ratio, paddy rice, saline soil, salt tolerance, yield

INTRODUCTION

Rice (*Oryza sativa* L.) is more susceptible to salinity than other cereals. High sensitivity has been observed both at the vegetative and reproductive stages of rice (Ahmadizadeh *et al*., 2016). Employing salt-tolerance involves growing salt tolerant varieties and application of fertilization strategies especially potassium can decrease detrimental effects of salinity in rice (Tantan *et al*., 2021). The present study was conducted to find the appropriate rate of K fertilizer on the performance of two rice varieties grown under moderate saline condition in paddy fields of Viet Nam's central region.

METHODOLOGY

Two seedlings of salt tolerant rice cultivars (OM8104 and MNR3) were transplanted to the paddy field (6–8 dS m^{-1}) on December 15, 2017 (wet season) and June 10, 2018 (hot season). Rice cultivars were kept in main plots and five rates of K (0, 25, 50, 75, and 100 kg K_2O ha^{-1}) and in sub-plots following split-plot arrangement with three replications. The 100 kg N; 50 kg P; 8 tons of farmyard manure (FYM) and 500 kg lime ha^{-1} were applied as urea (46 percent N), thiophosphate (7 percent P), and potassium chloride (50 percent K), respectively. Lime ($CaCO_3$, 56 percent CaO) was broadcast and incorporated to a soil depth of 0.2 m before transplanting rice for two weeks. Soil salinity dynamics were monitored at 15, 30, 45, 60, 75, 90 days after transplanting (DAT), before and after the experiment. Whole plant K+ and Na+ contents including dry matter were determined at the panicle initiation stage. At maturity stage, yield and its components were detremined following standard methods.

RESULTS

Application of 50 kg K_2O ha^{-1} increased K^+ accumulation, decreased Na^+ accumulation, increased K^+/Na^+ ratio in shoots at booting stage in both crop seasons increasing plant salt tolerance. The same K rate also produced rice yield (7.57 and 5.25 tons ha^{-1} for OM8104 and 7.35 and 5.18 tons ha^{-1} for MNR3) in the wet and hot seasons.

DISCUSSION

Controlling soil fertility, especially K under saline soils condition is considered one of the most important methods on the evaluation of tolerance of plants to salinity stress. Likely, Rice varieties have different adaptability to salinity conditions, and the mechanism of rice adaptation to salinity is closely related to selective uptake among ions, especially monovalent cations like Na^+ and K^+. Potassium content in shoots is one of the important traits to determine the salt tolerance in rice. High potassium contents of rice plants at the booting stage are evident that saline tolerant varieties have lower Na^+ content at this stage than susceptible varieties associated with its uptake. Rice varieties that can effectively absorb K^+ potassium are better able to block and eliminate Na^+ (Flokard *et al*., 1999).

CONCLUSIONS

Potassium fertilization is an extremely important factor to promote physiological and biochemical processes helping plants grow better under saline soil conditions. The present study proposes suggests the application of 50 kg K_2O ha^{-1} fertilizer application to improve rice production under moderately saline soils of Central Veitnam.

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The impact of new technology on the biological activity of saline soils and the yield of rice

M. IBRAYEVA, S. DUISEKOV, A. SULEYMENOVA, U.U. Uspanov Kazakh Research Institute of Soil Science and Agrochemistry

Keywords: saline soils, new technology, soil biological activity, yield, rice.

INTRODUCTION

Kazakhstan has 35.8 million hectares of saline soils or 16.6 percent of the total area of agricultural land. Saline soils cover 2.4 million hectares of arable land, 0.16 million of which are in the Kyzylorda region (Consolidated analytical report…, 2020). As is known, 88 percent of the republic's rice crops are located on the territory of the Kyzylorda region, where every third resident is involved in the rice industry in some way. The degree of mineralization and qualitative content of groundwater are differentiable as a result of vertical water and salt exchange in rice soils. Hydrocarbonate-sulfate-sodium waters form beneath riverbeds with concentrations of up to 1 g/l; hydrocarbonate-chloride-sulfate-sodium waters form beneath interchannel depressions with dense residues of up to 3 g/l; and chloride-sulfate-sodium waters form beneath flat ridges with dense residues of 3 to 7 g/l. During the spring-summer period, alluvial-meadow soils become saline from the surface. According to the type of salinity, the soils of this region are chloride-sulfate, with a large predominance of sulfates. The main part of the salt reserve is concentrated in crusty-puffy solonchaks of flat watershed ridges (Otarov, 2005).

METHODOLOGY

Methodology.In the Shieli district of the Kyzylorda region, the Tonkerys peasant farm is located, based on the level of salinity of 20 hectares of soil of which we have chosen to introduce the "NTOZ–2" technology - a new technology for the development of highly saline and alkaline soils. This technology is designed to increase the fertility of saline soils, as well as the productivity of rice crops. The method consists in plowing chopped straw up to 3 t/ha and pre-treating rice seeds special plants with a 40 percent ameliorant solution for one hour.

RESULTS

After the application of the technology, 6.1 percent of the farm's 20 hectares of land fell into the category of non-saline soils, the area of slightly saline soils increased, while the area of medium and highly saline soils reduced. Sowing rice according to the NTOZ–2 stimulated plant growth and had a positive effect on the biological activity of rice soils in varying degrees of saline soils, the intensity of soil respiration increased, in strongly saline soils it is lower than in medium and slightly saline ones. NTOZ–2 stimulated the development of denitrifying bacteria, and the potential activity of denitrification of rice soils increased sharply. Yield of rice improved by 28.7 percent, demonstrating the efficiency of the NTOZ–2 technology. This is also supported by the economic efficiency calculation, which found that the introduction of technology resulted in a net profit of 57,430 tenge/ha.

DISCUSSION

The use of "NTOZ–2" made a profit and reduced the degree of soil salinity. The use of this technology in subsequent years will lead to a further decrease in soil salinity and can be replicated in other rice-growing farms in the region.

CONCLUSIONS

The application of the technology reduced soil salinization increased their biological activity and gave an increase in rice yield and profit.

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Salinity Transformation Approach for Progress: An integrated approach for salinity, groundwater, soil and agriculture

F. ISLAM, Wageningen University and Research, Netherlands; I. AMERICA, Deltares, Netherlands; C. TERWISSCHA van SCHELTINGA, Wageningen University and Research, Netherlands; B. BRUNING, The Salt Doctors, Netherlands; M. FANECA SANCHEZ, Deltares, Netherlands; A. de VOS, The Salt Doctors, Netherlands

Keywords: Food System Aproach, Integrated Water Resources Management

INTRODUCTION

Introduction: Wageningen University and Research (WUR), Deltares and The Salt Doctors started an initiative to make a joint vision for action in bringing the worlds of agriculture and water management in saline-affected areas together. There is a need for a clear approach that can be followed to identify possibilities in a region where salinity is a (possible future) threat. We see great potential in bringing the worlds of agriculture and water management closer together; sometimes salinization can be limited or prevented by more sustainable groundwater use, sometimes agriculture needs to be adapted, and sometimes both. This requires an integrated approach and a focus on action. This initiative focusses on groundwater related salinity and action towards sustainable food production and groundwater use in salt-affected areas. We see the stepwise approach as a guideline that can be used to identify action perspectives, involving various stakeholders, in a region where salinity is a threat.

METHODOLOGY

Combining the Food Systems Approach (FSA) (WUR) and the framework of analysis for integrated water resources management (IWRM) (Deltares) in saline affected areas with groundwater use for irrigation can be particularly useful in addressing the interdependent challenges of food and water security.

STAP can be visualised by a circle (Figure 5), where one starts at step one (the inception phase) and after completion of the circle is back at the inception phase. This is intentionally as by going through the circle multiple times, a more refined and in-depth approach to tackle the problem can be achieved and transformation can take place. In addition, every step of the way may change the perceived problems and solutions, so flexibility is required to always be able to go back one or more steps to develop the strategy that best fits the situation.

Inception: identifies the subject of the analysis (what is to be analyzed and under what conditions), the objectives (the desired results of the analysis) and constraints (its limitations). In this phase stakeholders should be identified and engaged in the decision-making process.

Specific aspects related to groundwater, food, and salinization: which elements of salinity related to crops, what are the elements of groundwater specific for this location and what are the soil salinity levels in the target area or region

Analysis: analysis of present and future food & water system situations. Major activities in this phase typically include data collection and modeling. Relevant data that needs to be collected depends partly on the scale the project is looking at. The models will be used to try and quantify present and future system characteristics. These characteristics can be based on multiple economic, environmental, and/or social criteria, to name a few. It is key to analyze the system situations from different perspectives and different levels (spatially and time-oriented). To provide insight in uncertain futures, scenarios may be developed that describe the future boundary conditions for the system.

Specific aspects related to groundwater, food, and salinization:

- What are the business opportunities today and in the future?
- What is the water use for current and future conditions?
- What are the current water and soil salinity levels? How does it fluctuate throughout the year?
- Are farmers/and or policy makers aware of the salinity problems?
- What action, if any, is undertaken to mitigate or adapt to soil and/or water salinization?
- What is the freshwater availability today and in the future?
- What are the causes of salinization and freshwater shortages?
- What is the food demand now and in the future?
- Is there enough water to ensure food security now and in the future? (this question needs to be linked to a scale level!)
- What technology is available now to increase freshwater supply?
- What are the current farming practices, perceived limitations and possibilities?

Understanding: Enhance the understanding of the interlinkages between the food & water systems and their various characteristics. In this phase a common 'picture' of the relevant components needs to be sketched to find the gap between the freshwater and food demand and availability in the current and future states. This includes:

- A description and schematic overview of the food & water system elements.
- Identification of causal processes and system dynamics (synergies and conflicts).

This will also force the implementors of the project to think about which aspect of salinization they will focus the most: will the focus of the measures be on water salinity or crop yield or salinity in soil or multiple of these. Try to understand where critical tipping points / decision points are within the envisioned pathways as well.

Understanding the situation, available resources and exact wishes and demands also steer the availability of potential solutions, and naturally evolves into the next step.

Explore: explore measures that can be taken to fill the gap between the freshwater and food demand and availability in the current and future states and how to deal with future increased salinization risks. Information needs to be gathered on the implementation time, duration, spatial extent and effectiveness for the different measures. Possible measures are:

- Conservation and efficiency measures
- Water reuse and recycling
- Managed Aquifer Recovery
- Install drainage
- Salt tolerant seeds for crops and vegetables
- Improved soil management
- Improved farming methods (i.e. crop rotation, increasing SOM, using mulch etc.)
- Create awareness on water usage and shortages
- Adaptive and nutritious diet in the future
- Low cost, energy efficient and locally made technologies for desalination

Once the potential measures have been identified, a selection and prioritization of the preferred measure or measures is needed.

Prepare: An implementation plan will be developed which provides details on the necessary steps to implement the measure or set of measures. The plan should include what will be done, by whom, when, and how it will be financed, etc. . Additional work may be needed before decisions are made, including conducting feasibility and design studies and environmental and social impact assessments (ESIA). Promotion of the selected strategy is needed to gain public acceptance of the proposed measures. Finally, institutional arrangements will have to be made to ensure smooth implementation.

Implementation phase: during the implementation phase the actual implementation of the project and the interventions that have been selected will take place. Continuous monitoring and evaluation are needed to accommodate the transition process and acknowledge socio-economic dynamics and environmental changes during the implementation.

Learning is key in this stepwise approach. It is therefore important that every step is evaluated and progress in monitored. This will allow for correction, stimulation or cease of activities when needed.

Learning at each step: what went well, what problems had to be overcome?

Adjustment: monitoring during the process

What are go or no-go moments?

The above steps can be taken at different spatial scales, such as local/community scale or regional/national scale. Based on the level of the action foreseen, the process will look very different – both in time as well as in scale: a river basin scale action may take more time than a field level scale action. Additionally, the resources that can be spend to analyze the situation will be very different. Both from a water systems perspective, as well as from a food systems perspective.

RESULTS

- Reasonable easy to fill in steps one till four from a more general perspective.
- Difficult to add specifics related to salinity from a national perspective.
- It is important to take investors/funders along in the process otherwise step five and six are difficult.
- It is important to draw pathways within the process, using scenario analysis. By communicating this to the world and telling the story you're able to bring stakeholders along and gain their trust.
- Several iterations are required to deduce the most suitable plan.
- Sometimes there are actions that come in several steps. For example, monitoring should be started in step two (analyzing) to have a base line and should be reassessed or adapted in step six (implementation) to monitor the performance of the measures.
- To understand how the plan will be financed, the stakeholder analysis is required.
- There are overlaps between the food system and integrated water resource management approach and both need to be considered in an integrative way.
- The integration of groundwater, food systems, and soil is important for the policy makers.
- The circular design of the stepwise approach suggests that it can be completed several times during one project, getting more and more detail along the way and in that way refining the approach and solutions more and more to the specific details of the particular case.

DISCUSSION

This initiative has been a fruitful exercise for all the NWP&NFP partners that participated in the workshop. It was insightful to see how people from different backgrounds emphasize different aspects of the case study, and also suggest different types of measures. Additionally, participants indicated that the workshop was a good networking event for all.

CONCLUSIONS

The circular design of the stepwise approach suggests that it can be completed several times during one project, getting more and more detail along the way and in that way refining the approach and solutions more and more to the specific details of the particular case.

Combining the Food Systems Approach (FSA) (WUR) and the framework of analysis for integrated water resources management (IWRM) (Deltares) in saline affected areas with groundwater use for irrigation can be particularly useful in addressing the interdependent challenges of food and water security.

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Experience of sugar sorghum cultivation on saline soils of rice growing systems in Kyzylorda region

A. KARABAYEVA, Food and Agriculture Organization of the United Nations, Kazakhstan; V. ZABOLOTSKYH, Food and Agriculture Organization of the United Nations, Kazakhstan

Keywords: Sugar sorghum, diversification of crop production, soil salinity, phytomelioration

INTRODUCTION

According to recent estimates, the area of saline soils in Kazakhstan exceeds 110 million ha, or 41 percent of the country. In Kyzylorda region, more than 73 thousand hectares of irrigated land have a high degree of salinity.

With this high share of saline soils, exacerbated by harsh climatic conditions, it is imperative to find new technological solutions for rehabilitation and rational use of land resources. Crop diversification in the region with a bigger range of salt-tolerant crops is one of the ways to mitigate farming risks. One of the promising salt-tolerant crops, given the regional conditions, is sugar sorghum.

So, the objective of this work was to assess the effectiveness of sugar sorghum as a crop phytomeliorant in rice crop rotation systems in Kyzylorda region.

METHODOLOGY

Sugar sorghum was cultivated in 2021–2022, on the paddy fields of two ha, after rice. The sorghum plots were arranged in the checkerwise order, alternating with irrigated rice plots, with sugar sorghum grown without vegetative irrigation. Studies were conducted on the experimental fields of the Rice Research Institute in the Syrdarya district and "Talapker" farm in the Zhalgash district of Kyzylorda region. Soils of the plots are gray-brown saline soils with the sulfate type of salinity. To assess the effect of sugar sorghum on soil's salt regime, the total content of highly soluble salts and soil acidity level in 0–60 cm layer were measured before sowing and after harvesting by the water extraction method.

RESULTS

Prior to sowing, the soil of the plots had a high degree of salinity, the total content of salts in the water extract was 0.848 percent in the first and 0.802 percent in the second year of sorghum cultivation. After harvesting, the total content of salts decreased by 47 percent on the plot of the Rice Research Institute in 2021 and by 45.9 percent on the "Talapker" farm in 2022, which in absolute values was 0.405 and 0.368 percent and corresponded to the medium degree of salinity. Analysis of the pH level of water extract showed a slight decrease in soil alkalinity from spring to autumn. Thus, in 2021 the pH changed from 7.61 before sowing to 7.52 by harvesting of sugar sorghum, in 2022 – from 7.80 to 7.61. Under these conditions, the yield of green mass of sugar sorghum was 27 and 29 t/ha.

DISCUSSION

Cultivation of sugar sorghum is important for the irrigated farming zone (Ding *et al*., 2018) Lower salt levels in the soil during cultivation of sugar sorghum is due not only to the absorption of salts by plants, but also to the elevation of dissolved salts by ascending capillaries from deeper soil horizons. High projective coverage of sugar sorghum plants shades the soil and reduces the temperature on its surface, while vertical rise of saline groundwater and evaporation from the soil surface is slowed down significantly.

CONCLUSIONS

In the conditions of Kyzylorda region, sugar sorghum can be successfully cultivated in rice crop rotation systems without vegetative irrigation. With high soil salinity, sorghum forms 27–29 t/ha of green mass. Reduction of soil salinity after sorghum cultivation is due to the salt removal by plants and slower secondary salinization processes.

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Health risks and source identification of heavy metal pollution in soil around marble processing plants in Malakand District of Pakistan

Asghar KHAN, Department of Botany, Islamia College University, Peshawar, Pakistan; Muhammad Saleem KHAN, Department of Botany, Islamia College University, Peshawar, Pakistan; Ghulam SADDIQ, Department of Physics, Islamia College University, Peshawar, Pakistan; Qaisar KHAN, Material Chemistry Laboratory, Malakand University at Chakdara, Pakistan; Kishwar ALI, College of General Education, University of Doha for Science and Technology, Doha, Qatar; David Aaron JONES, College of Health Sciences, University of Doha for Science and Technology, Doha, Qatar; and Muhammad Ezaz Hasan KHAN, College of General Education, University of Doha for Science and Technology, Doha, Qatar

Keywords: Heavy metals, Agricultural soil pollution, Marble industry, Source identification, Assessment of health risk, Compositional data analysis (CoDa)

INTRODUCTION

Soil is an important natural resource that plays a substantial role in national security by producing food and providing habitat for terrestrial species. However, the introduction of hazardous chemicals such as radioactive elements, nanomaterial pollutants, and heavy metals affects soil resilience and soil biodiversity. The accumulation of heavy metals (HM) at higher concentrations in agroecosystems poses a major threat to soil microbes and disrupts the distribution and structure of the microbial community. Furthermore, the toxicity of HM in the soil also disrupts the morphological and physiological processes of crops by reducing growth rate, nutrient imbalance, stomatal movement, and inhibition of photosynthesis. In human and animal body tissues, soil heavy metals accumulate through the food chains. Heavy metals such as iron (Fe), chromium (Cr), copper (Cu), magnesium (Mn), and zinc (Zn), in appropriate amounts, play a key role in enzyme structuring, and synthesis of vitamins and hemoglobin. However, additional levels of Fe, Cu, Mn, Cr, and Zn can have a toxic effect. Likewise, HMs such as arsenic (As), palladium (Pd), and cadmium (Cd) are toxic even in small amounts, destroying essential elements in the body, inhibiting and competing with enzymes for binding sites, and causing impairment of the body's immune system. In addition, the accumulation of HMs in human body systems causes serious effects such as nephrotoxicity, neurotoxicity, hypertension, infertility, and carcinogenicity. For the production of healthy crop and ensuring the health security of farmers, researchers, soil managers, livestock and common people, it is essential to study agricultural soils contaminated with marble waste (Khan *et al*., 2021). Therefore, the current study aimed to (i) evaluate the extent of HM contamination in agricultural soils with associated health risks for people working in and around marble processing plants and (ii) identify potential sources of heavy metal contamination in soil using a compositional multivariate technique.

METHODOLOGY

Collection of samples of surface water

The agricultural soils in the study area are sandy loam. A total of 63 (21× 3) surface soil samples at 0–20 cm depth was collected from 21 locations by a quincunx sampling pattern using a hand auger. Finally, after thorough mixing of the five soil subsamples, a one-kilogram composite sample was prepared and sealed in clean, labeled polyethylene bags. Soil samples were air-dried, mechanically ground, sieved through a 2 mm sieve and stored for further analysis.

Analytical methods

Th soil samples were analyzed for HM concentration by inductively coupled plasma–optical emission spectrometry (ICP–OES). pH, electrical conductivity (EC), total dissolved solids (TDS), were measured using standard methods of American Public Health Association (APHA).The associated risks from exposure to heavy metals were calculated by USEPA ecological and health risk indices. Pollution sources were studied using compositional data analysis (CoDa) to understand the changing behavior of heavy metals in soil samples (Egozcue *et al.*, 2018).

Statistical methods

Descriptive statistical characteristics including mean, standard deviation (SD), standard error (SE), skewness, kurtosis, and coefficient of variation (CV) of the 19 elements were calculated using SPSS software (version 25 for Windows). Compositional data analysis approaches such as centered log-ratio (clr) transformation, variation matrix, clr-biplot, coda-dendrogram, and factor analysis were applied to establish a linear relationship between the variables and differentiate the source of contamination in agricultural soils.

RESULTS

Physicochemical properties of soil

The pH ranges were 7.3 to 9.0 with a mean value of 8.3. EC and TDS values range from 213.3 to 556.6 µs/cm and 2231 to 1072.67 mg/L with mean values of 374.60 and 635.80.

Heavy metal concentration in soil

The mean concentrations of Ca, Al, Mg, Fe, K, Ti, P, Mn, V, Sr, Cr, Cu, Ni, Si, Co, Zn, As, Zr and Cd are 19881.50, 10914.30, 5420.71, 4699.71, 2105.70, 600.50, 292.0, 149.3, 39.21, 35.14, 27.0, 20.10, 18.40, 12.5, 6.0, 5.8, 5.3, 3.0 and 2.0 mg/kg, respectively (Table 1). Calcium, Al, Mg, Fe, K and P show the highest concentrations in the range of 12650–29250, 5100–23250, 2438.5–8050,1075–13200 ,734.5–3990.5 and 65.5–805.5 mg/kg, respectively (Table 1). The maximum concentration of Ca (29250 mg/kg) and P (805.5 mg/kg) exceed the world normal averages (Table 1). The concentration ranges (mg/kg) of Ti (125.50–1471.0), Mn (68.50–315.50), V(16.50–59.0), Sr (13.50–60.50), Cr (13.0–40.0), Cu (6.50–40.50), Ni (12.50–27.0), Si (1.50–25.50), Zn (0.50–19.0), Co (2.0–11.0), As (2.0–10) and Zr (1.0–4.50) vary widely and are within the world normal averages.

Assessment of heavy metal pollution in soil

The pollution index (Pi) results show Pi values > 1 for As and Cd, respectively. Based on Nemerov's synthetic contamination index (NSCI), the heavy metal concentration varied from 1.20 to 4.11 with a mean of 2.55. The index of Geo accumulation (Igeo) ranked in decreasing order of Cd (1.274) > As (0.663) > Cu (0.09) > Co (0.062) > V (0.061) > Cr (0.060) > Ni (0.054) > Mn (0.035) > Ti (0.026) > Sr (0.24) > Zn (0.012) > Zr (0.004). The results of the ecological risk factor (Eri) range from 2.5 to 65.5 for As, 10 to 450 for Cd, 0.53 to 2.89 for Co, 0.29 to 0.89 for Cr, 0.72 to 4.5 for Cu, 0.08 to 0.37 for Mn, 0.92 to 1.99 for Ni, 0.25 to 0.91for V and 0.01 to 0.2 for Zn. The measured values of the potential ecological risk (PERI) in the analyzed soil samples ranged from 18.52 to 511.35 with a mean value of 217.49.

Assessment of Potential Health Risk

The ADD values (mg/kg/day) of Al (1.40E-01), Fe (6.01E-02), Mn (1.91E-03), V(5.01E-04), Cr (3.44E-04), Cu (2.57E-04), Ni (2.35E-04), Co (7.49E-05), Zn (7.37E-05), As (6.76E-05), Zr (3.59E-05), and Cd (2.44E-05) were found higher in children via the ingestion route. Likewise, in adults, the ADD values (mg/kg/day) of Al (1.50E-02), Fe (6.44E-03), Mn (2.05E-04), V (5.37E-05), Cr (3.68E-05), Cu (2.75E-05), Ni (2.52E-05), Co

(8.02E-06), Zn (7.89E-06), As (7.24E-06), Zr (3.85E-06) and Cd (2.61E-06) were also high via the ingestion route.

For non-carcinogenic risk, the hazard quotient (HQ) values of Al, As, Cd, Cr, Co, Ni, Cu, V, Fe, Mn, Zr, and Zn for adults and children were < 1.0. The hazard index (HI) value from ingestion, inhalation and dermal exposure to the heavy metals was > 1.0.

Ingestion, inhalation, dermal and total cancer risk (TCR).

Considering at the three routes of exposure to soil heavy metals, the total carcinogenic risk (TCR) for adults ranged between 1.2E-10 and 7.4E-05, while that for children ranged from 5.6E-10 to 6.9E-04. The carcinogenic risk via ingestion exposure route to Cr, Ni, Cd, and As exceeded the USEPA threshold of 1×10^{-4} to 1×10^{-6} in children and adults.

Looking for associations and heavy metal source

A normalized variation matrix is used to show the linear association for the chemical parts. Values below 0.2 indicate linear association or proportionality, while variations above 1.0 suggest a lack of linear relationship between elements. In the current study, values below 0.2 for Al versus K (0.07), Mn (0.12), Ni (0.17) and Cr (0.18), Cr versus V (0.09), Sr (0.14), Ni (0.16) and K (0.17), Sr versus V (0.12), Ca versus Ni (0.17) and K versus Sr (0.18), indicating a binary linear relationship. A clr-biplot based on a centered logarithmic transformation (clr) was constructed to interpret the inter-elemental association and source identification of HM in agricultural soils. The biplot explains 62 percent variation on (PC1 vs PC2) and 53 percent on (PC1 vs PC3) of the examined elements. A strong element association between Mn-P-Ti, Al, and K, Mn, P, and Ti was observed. Similarly, Cu, V, Sr, Cr, Mg, Ni, and Co form another association. A close relationship between Zn, As, Cd, and Zr forms a separate group. Fe and Si form another association because their rays also point in the same direction.

DISCUSSION

Physicochemical properties of soil

The pH values indicating a slightly alkaline nature. pH values above 6.5 to 8.5 are suitable for crop growth but lead to nutrient imbalances and alter the solubility of many toxic substances. Electrical conductivity (EC) is a measure of water's ability to conduct electricity and indicates the number of total dissolved solids (TDS). Based on the EC level, 25 percent of the soil samples were above the permissible limits (400 µs/cm). TDS concentration in all samples exceeded the permissible limit (450 Mg/L). The increase in EC and TDS is due to long-term use slightly saline water for irrigation and may increase the salinity risk in the soils of the study area.

Heavy metal concentration in soil

The maximum concentration of Ca (29250 mg/kg) and P (805.5 mg/kg) exceed the world normal averages. likewise, the Cd concentration (4.50 mg/kg) exceeds the food and agriculture organization (FAO) limit of 3.0 mg/kg. The apparent concentrations of As, Cd, Co, Cr, Cu, Ni and V recorded at all points here are likely to be of concern for soil and human health.

Assessment of heavy metal pollution in soil

The pollution index (Pi) results show that Pi values > 1 for As and Cd indicate a slight enrichment of soil sites in the study area. The contamination of soil sites might be linked to road traffic, MPPs, and car repair shops that emit pollutants into the surrounding atmosphere. Based on Nemerov's synthetic contamination index (NSCI), 38 percent of the soil samples were slightly contaminated, 29 percent moderately contaminated and 33 percent heavily contaminated. The Igeo values of As, Cu, Co, V, Cr, Ni, Mn, Ti, Sr, Zn, and Zr classified the soil sites as slightly to moderately polluted. The Eri values for Cu, Co, Ni, V, Cr, Mn, and Zn in the soil sites were below 15, indicating low ecological risk for these metals. However, for As moderate ecological risk was found in 52.38 percent of the soil sites. The soil sites (42.85 percent) were classified as very high ecological risk, 23.80 percent as considerable ecological risk, 14.28 percent as moderate ecological risk and 14.28 percent as low ecological risk. The main contribution to PERI appeared to be Cd (83.8 percent), followed by As. It was shown that the contribution rate of heavy metals to PERI correlates not only with their concentration but also with their toxicity response factors.

Assessment of Potential Health Risk

Non carcinogenic risk

In the current study, higher ADD values (mg/kg/day) were found in children than in adults for the three routes of exposure to heavy metals. This suggests the susceptibility of children to non-carcinogenic health risks more than adults. Children living around small mining areas were at higher risk than adults. Based on HI scores, children are more susceptible to non-cancerous. Similarly, a higher non-carcinogenic risk for children than adults owing to contaminated soil near mining areas supporting our current study results.

Ingestion, inhalation, dermal and total cancer risk (TCR).

It is evident that the TCR for Cr is comparatively higher than other metals suggesting that Cr has a considerably greater potential carcinogenic risk. The TCR for Co fall within the safety limits of 1×10^{-4}, indicating no apparent carcinogenic risk.Cr and Ni contribute significantly to carcinogenic risk in children and consequently children are at higher risk than adults.In the current study, the carcinogenic risks from Cr and Ni are possibly linked with the combustion of fossil fuel, battery workshop, and emission of marble dust.Despite the carcinogenic or non-carcinogenic risk, children have been found to be more vulnerable to the potential health risk attributed to the presence of HMs in the soils surrounding MPPs. This suggests that children are more susceptible to adverse health effects from exposure to HMs as they have more oral ingestion from hand to mouth (Nawab *et al*., 2015).

Looking for associations and heavy metal source.

In the current study, values below 0.2 for Al versus K, Mn versus Ni and Cr, Cr versus V, Sr, Ni and K, Sr versus V, Ca versus Ni and K versus Sr, indicating a binary linear relationship. The variability of Al explains the strong significant influence on the concentrations of K, Mn, Ni, and Cr. Also, strong element associations between Mn-P-Ti, Al, and K, indicating a combination of geogenic and anthropogenic origin. The Mn, P, and Ti are superimposed, and Ti could be associated with the co-precipitation of TiO2, MnO, and P2O5 found in marble powder and fertilizers. Cu, V, Sr, Cr, Mg, Ni, and Co association can be linked to vehicle emissions and industrial activities. A close relationship between Zn, As, Cd, and Zr could be associated with smelter activities and regular usage of inorganic fertilizers.

CONCLUSIONS

The present study highlighted the importance of waste emissions from marble processing plants (MPPs), which contain essential and non-essential elements. The elevated concentrations of cadmium (Cd), phosphorus (P), arsenic (As), and calcium (Ca), which exceed safe limits, are potential threats to surrounding agricultural soils, crops, and particularly to agricultural fields and the marble industry workers. This study uncovered an accumulation of As and Cd causing moderate to severe soil pollution. Prolonged exposure to As, Cd, Cu, Co, Cr, Fe, Mn, Ni, V, and Zn via ingestion and inhalation route is more harmful to the health of children and adult population. Anthropogenic activities such as marble stone crushing and marble waste disposal are the main source of heavy metal contamination of agricultural soils. The results of the present study are intended to capture safety measures when working in MPPs and the agricultural soils surrounding them. MPPs must be moved promptly from agricultural fields to industrial areas to ensure food safety and protect soil and human health. In addition, appropriate management strategies and surveillance programs to study soil HM contamination are recommended for the implementation of security measures to protect soil and human health.

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Soil salinity and soil structure dynamics under land cover/land use changes in a RAMSAR saline inland wetland : case study in Bazer-Sakra Sabkh, Setif, North-East of Algeria

Y. LOUADJ, Department of Agronomic sciences, University of Ferhat Abbas Setif 1, Algeria; A. SEMAR, Department of soil sciences, Higher National School of Agronomy (ENSA), Algeria; S. BELGHEMMAZ, Department of Ecology and plant biology, University of Ferhat Abbas Setif 1, Algeria.

Keywords: Soil salinity, Soil structure, Slakes test, Structural stability, Land use/lanc cover, Saline inland wetland, Bazer-Sakra Sabkra

INTRODUCTION

Soil structure is a dynamic and fundamental property to the functioning of natural ecosystems and agroecosystem, however, in a saline environment, soil structure can be degraded which affect the soil quality of these ecosystems.

METHODOLOGY

The methodology consists of sampling soil according to two depth 0–20 cm and 20–40 cm in different land cover: saline site (one profile), cropland area (four profiles) and a Tilled Fallow (two profiles). In total , 14 soil samples has been sampled and characterized by measuring pHwater (1/5) Total Calcium carbonate, Soil particle size distribution, Electrical conductivity using diluted extract (1:5), and estimated saturated soil paste using a simple linear regression determined between EC sp and EC 1/5 in the same area, soil structural stability in two hydric states (humid and dried in the air) for fine aggregates (2 mm) and Slakes application tested on humid aggregates (cm).

RESULTS

Our results show that the soil pH is alkaline to very alkaline in all samples with values ranging from 8.76 to 9.21; the majority of a soil sample has medium calcium carbonate content, regarding the soil texture, the soil of cropland has a loam to silty texture and soil of saline area are clayey. With regard to soil salinity spatial variation, our result shows the low value of EC1/5 in cropland ranging from 74 .06 uS/m to 557. 32 uS/m and high value in the saline area (1.11 dS/m and 1.33 dS/m). however, this tendency has changed when converting this measured value to soil paste extract using the linear regression with r2 =0.96; which shows saline value for most of the cropland soil samples ranging from (0.633 dS/m to 4.74 dS/m) and very saline value in the saline area: 9.21 dS/m and 11 dS/m for the surface horizon and subsurface horizon respectively. Moreover, the soil salinity profile shows a tendency of increase with the depth of soil salinity (Descending) in the cropland area and a tendency to decrease with the depth of soil salinity in the saline area (Ascending). Finally, the soil structural stability of fine aggregates shows a different trend with regard to the hydric state, in fact, our results show a higher soil stability index in the dry state than humid state despite the fact the overall soil stability index is relatively medium contrary to Soil Slakes Test which show a stable state of soil aggregates except in tilled fallow sample and saline area sample.

DISCUSSION

Soil structure is a dynamic property affected by intrinsic factors such as (soil salinity, soil texture, organic matter content, and hydric states) and external factors such as humectation and desiccation cycle and land use/land cover (Quirk, 2001). our results showed that soil structural stability is low at the humid state contrary to a dried state, these results can be explained by the dispersion phenomena of clay due to osmotic pressure between soil salinity of aggregate and distilled water (Rangasamy, 2018). this behavior is more pronounced in soil sampled in sabkha than the other land cover/land use (wheat-cultivated land and fallow land cover)

CONCLUSIONS

EC of saturated paste estimated by regression equation of EC of 1/5 soil: water extract is a better estimator of soil salinity dynamic,

Soil structural state assessed by Soil structural stability test in water has shown that the hydric state has an influence on the behavior of soil aggregates in water;

In conclusion, this research should continue by developing a more robust regression equation between EC 1/5 and EC of saturated paste by introducing the effect of season and land use/cover effect in order to better diagnoses soil salinization in these fragile ecosystems of inland wetland, moreover, soil structural state monitoring according to the state of salinity and land cover/land use will provide a better understanding of the evolution of soil structure in these ecosystems affected by land use/land cover change.

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Evaluation of the phytodesalination capacity of four halophytes for a saline-sodic soil

J. MAMANI FLORES and D. ANDRADE FORONDA, Facultad de Ciencias Agrícolas y Pecuarias, Universidad Mayor de San Simón, Bolivia.

Keywords: salinity; sodicity; phytoremediation; bioremediation; halophyte

INTRODUCTION

Sodic and saline-sodic soils have an excess amount of sodium (Na^+) and soluble salts + Na^+, respectively. Phytoremediation can be considered a low-cost alternative for chemical amelioration. Halophytes are plant species with a significant removal capacity of salts and Na^+ from salt-affected soils. The study aimed to evaluate the potential of four halophytes to desalinize a saline-sodic soil.

METHODOLOGY

The soil (ECe of 47.0 dS m^{-1} and 3.4 g Na^+ kg^{-1} soil) was collected from the High Valley of Cochabamba-Bolivia. The assessed halophytes were: *Suaeda fruticosa* Moq, *Sesuvium portulacastrum*, *Atriplex hortensis* and *Kochia scoparia*. The pot experiment was carried out under non-leaching conditions for 70 days and using 37-day-old seedlings.

RESULTS

The results showed that all the species significantly decreased the soil ECe compared to the control and soil before. S. portulacastrum was the most productive in terms of biomass (1.65 t DM ha^{-1}); however, S. fruticosa Moq was the most efficient for Na+ uptaking with a phytoremediation capacity of 0.24 t Na^+ ha^{-1}.

DISCUSSION

Overall, the native halophytes (*S. fruticosa* Moq and *S. portulacastrum*) performed more effectively than the alien species (*A. hortensis* and *K. scoparia*) in soil desalination and productivity.

CONCLUSIONS

S. fruticosa Moq and *S. portulacastrum* might be suitable for reclaiming saline-sodic soils in the study area.

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The important role of silicon in saline soil

M.A. MAMASOLIEVA, L.A. GAFUROVA, National University of Uzbekistan, Uzbekistan

Keywords: Silicon, salinity, antioxidant enzymes, microbiology analysis

INTRODUCTION

Although silicon (Si) is not generally considered an essential element, it is important for plant growth and development, Si uptake by plants can mitigate biotic and abiotic stresses (Thakral *et al*., 2021). Si plays a very important role in stimulating the biochemical properties of plants and increasing productivity in adverse climatic and soil conditions (Sahebi *et al*., 2015). During salt stress, Si prevented oxidative damage by increasing the activity of antioxidant enzymes

METHODOLOGY

The experiments were carried out in the Bukhara region of the Republic of Uzbekistan, which has an area with saline soils. Initially, it was aimed at studying the effect of Si preparations on the biological and microbiological properties of saline soil. The increase in soil fertility can be explained by the improvement of biological processes of the soil.

The activities of peroxidase, polyphenol oxidase, and catalase were determined by standardized procedures as reported in Methods in Applied Soil Microbiology and Biochemistry (1995). A unit (U) of enzyme activity was defined as the µmol/g soil/h of substrate hydrolyzed by 1 g of dried soil at 30°C h^{-1} (Schinner *et al*.,1995). Autoclaved soils were used as a control to estimate spontaneous or not enzyme-mediated enzymes of substrate. All results are the mean of three determinations. Soil microorganisms were determined by the method of Hotam S. and Chaudhary (Chaudhary *et al*., 2013).

RESULTS

Enzymatic activity of soils treated with silicon fertilizers was compared with the enzyme activity of control - untreated soils.

The results showed that soil treatment with silicon fertilizers had a good effect on enzyme activity. For example, the activity of peroxidase in untreated soil is 0.36 µmol/g soil/h, while in the version treated with Si, it is 0.55 µmol/g soil/h. it has been. This result was also observed in polyphenoloxidase and catalase. Their index was found to increase by 0.26 and 0.38, respectively, compared to the untreated variant. Si-fertilizers had a very positive effect on the dynamics of the number of soil microorganisms. The number of actinomycetes in the control was 501, in the experimental version- 798. There were 1348 and 501 aminonitrifiers, and oligonitrophils in the control, respectively, and 2037 and 711 in the experimental one. The results were studied in 1000 counts per 1 g of soil.

DISCUSSION

Such high results in the activity of soil enzymes and microorganisms were recorded in soils treated with Si fertilizers, that is, in saline soils. This increases the demand for Si fertilizers today. It is known from the literature that fertilizers are absorbed in the soil through the seed sheet. in this research work, cotton seeds were planted in the soil after 12 hours of treatment with Si fertilizers. In this case, the Si in the post part of the seed may have affected its biological processes by being absorbed into the soil. in the following works, it was aimed to study the effect of Si fertilizers on soil and plant material and to study its effect on biochemical processes through the absorption of Si from soil into plant tissues.

CONCLUSIONS

Our findings have important implications for understanding the impact of soil enzymes on the structure and function of soil microbial communities and how soil degradation is associated with specific soil microbiota.

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The modern state of the halophytic vegetation of the Southern Aral Sea Basin in the destabilised natural environment

N.K. MAMUTOV, Karakalpak State University named after Berdakh, Uzbekistan; P.R. REYMOV, Karakalpak State University named after Berdakh, Uzbekistan; Ya.G. KHUDAIBERGENOV, Karakalpak State University named after Berdakh, Uzbekistan; V.A. STATOV, Karakalpak State University named after Berdakh, Uzbekistan

Keywords: salt tolerate plants, halophitic fodder plants, Aral Sea, genetic resources

INTRODUCTION

The environmental conditions of saline soils and salt marshes in the Southern Aral Sea Basin are very heterogeneous. The saline soils and solonchaks of the hydromorphic and automorphic series are distinguished on the basis of moisture conditions. In addition, depending on their genesis, they differ in the type and degree of salinity, the position of saline horizons in the soil profile, the mechanical composition, the density of compaction and other characteristics. However, their common and characteristic feature is the presence of mobile, water-soluble salts. (Treshkin and Mamutov, 2005).

METHODOLOGY

We analysed a lot of various archive resources as well as published data from papers and monographs, data bases and our own field geobotanic surveys during last five decades to gather full dataset regarding soils, plants and watering in the region allowing statistical processing with acceptable reliability.

RESULTS

The collection and systematisation of scientific literature data on halophytic plants growing in the Southern Aral Sea Basin showed that species of the genera Sasola, Climacoptera, Atriplex, Suaeda, Haloxylon, Halostaschys, Ceratoides, Koshia, Artemisia, Halocharis, Halothamnus, Aeliropus and others growing wild in saline areas play an important role in the formation of halophytic phytocenosis on saline soils. (Mamutov , 2002).

Halophytic vegetation is widespread in the Southern Aral Sea Basin due to the special conditions of saline habitats. For normal development in the conditions of the Southern Aral Sea Basin, plants should not only be salt-tolerant but also drought-tolerant. Halophytes, which are best adapted to the haloxerophytic conditions of deserts, have such characteristics. They include many valuable fodder plants suitable for phytomelioration of low-productivity pastures and the dry Aral Sea bottom. The usual habitats of halophytes are saline soils of varying degrees and solonchaks of different genesis (residual, typical, meadow), extensive takyr-like plains. (Novikova and Mamutov, 2003).

DISCUSSION

The cultivation of halophytic plants in the Southern Aral Sea Basin on the basis of collector-drainage can become a source of production of protein-rich, energy-dense fodder, raw materials for medicinal oils, as well as an effective means of natural reclamation of degraded agricultural landscapes. The halophytes of the Southern Aral Sea Basin also contain natural dyes, vitamins, alkaloids and saponins. Some of the halophytes are rich in sodium carbonate.

CONCLUSIONS

Comparative analysis of the regional experience in the development of halophytes in culture shows that they have not only a wide range of ecological and biological characteristics, but also a wide range of opportunities for economic use. In conclusion, it should be noted that the genetic resources of the region's halophytes are of interest as a source of fodder, oil-bearing, medicinal and ornamental plants, as a source of energy, biomelioration and phytomelioration of the dry Aral Sea bed.

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Biochar application in saline soils to increase wheat germination success in central Mexico

L. MEDINA-OROZCO, Tecnologico Nacional de Mexico.

Keywords: abiotic stress, soil degradation, RECSOIL

INTRODUCTION

Wheat is one of the most important crops globally. The decrease in wheat production is associated with factors that include; reduction of land areas, climate change and abiotic factors that generate stress in the plant. The salinity and drought of the soil are reflected in the reduction in the germination rate and therefore in the production. The technologies used to increase the germination rate are based on biotechnology, soil organisms and seed priming; however, techniques such as the use of biochar have been scarcely studied (Miransari and Smith, 2019; Semida *et al*., 2019). Mexico reported during the year 2021, a planted area with wheat about 553,825 ha, 73,911 ha are rainfed and the rest irrigated, with yield of 1.92 t/ha. Much of the wheat cultivation is carried out in soils with salinity problems. The results are limited to the central region of Mexico and applicable to Vertisols. The main objective of the study was to evaluate the effect of biochar on the germination rate and soil water retention in the early stage of wheat cultivation.

METHODOLOGY

Wheats of the Urbina S2007 variety were planted in 19 L pots with 600g of soil with a pH of 8.0, the climate is of the sub-humid temperate type with summer rains, an average temperature of 19°C and annual rainfall of 796 mm. The trial consisted of 60 pots with two seeds each, and an experimental design of three complete blocks with a control (T0) and a treatment (T1). T1, consisted of the addition of 1 percent (w/w) of crushed biochar. The biochar was obtained from the pyrolysis of corn cob biomass at temperatures of 600 ºC. The seed was obtained with the certifying institute in Mexico. Germination in the trial was evaluated according to the Zadoks scale (Z0, 09/99). Soil water retention (SWR) in the soil was performed using the lysimeter technique. Soil pH was measured before and at the end of the experiment (2:1 ratio).

RESULTS

The seed germination rate was 62.5 percent in T1 and 25 percent in T0, values adjusted to the maximum possible value of 96 percent, with statistical difference ($p = 0.01200$). The SWR presented values for T1 of 525.5 ± 27.2mL in contrast to (T0), where the average value was 420 ± 41.9mL. in other words, SWR increased by 21 percent. The values are statistically significant ($p = 0.00001$). The pH values for the soil, after the experiment, were 8.5 and 8.0 for T1 and T0 respectively.

DISCUSSION

Biochar presented a significant effect on germination, Semida *et al*., 2019, report studies with 100 percent increase rates in germination of sunflowers, with applications of 1 percent (w/w) of biochar, possibly due to changes in the characteristics of the soil after the application of biochar; while for wheats in trials without soil, the germination rate is low. Probably one of the variables that explains the increase in the germination rate is the SWR, by increasing the amount of water available to the plant in the early stages of development. Opposite to what was expected in saline soils, the pH presented an increase in its value, however, the potential effect of biochar on the absorption of sodium from the soil solution and the increase in the absorption of nutrients (Ali *et al*., 2017), explain the increase in the germination rate.

CONCLUSIONS

Biochar has potential to increase wheat germination in saline soils and is an alternative strategy to other complex options such as biotechnology and seed priming.

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Iranian soil resource, extent of soil salinity and strategies for saline soil management

J. MIRZAVAND, General Director of Soil Department, The Islamic Republic of Iran, Ministry of Agriculture-Jahad, Deputy of Water & Soil, National focal point of GSP

Keywords: Salinity, Soil management, Iran

INTRODUCTION

The Islamic Republic of Iran is located in West Asia. Total area at this country is 1.648 million km^2 (Land: 1.636 million km^2 and Water: 0.012 million km^2).The existing century is marked with global scarcity of water resources, environmental pollution and increased Stalinization of soil and water. About 90 percent of the Islamic Republic of Iran is arid and semi-arid with summer temperatures in the interior reaching as high as 55°C. The average annual rainfall ranges from less than 50 mm in the Central Plateau to more than 1600 mm on the Caspian Coastal Plain, with a 250 mm national average. Less than 2 percent of Agricultural land in the Islamic Republic of Iran is very good and up to 60 percent is poor and medium for cropping.

Estimates suggest that about 34 million ha, including 4.1 million ha of the irrigated land, are salt-affected in the Islamic Republic of Iran as the consequence of naturally occurring phenomena (causing primary or fossil salinity and/or sodicity) and anthropogenic activities (causing secondary salinity and/or sodicity) (FAO, 2000).

METHODOLOGY

Source of salt in the Islamic Republic of Iran soil A: Natural

Geological composition of the parent material of the soils.

Stream salinity causing salinization of surface water resources, mainly due to natural conditions.

Wind-borne salinity resulting from strong winds, blowing most part of the year in the Central Plateau.

Seawater intrusion, which occurs mostly in coastal areas where seawater enters the inland channels or inundates coastal lowlands by tidal waves.

Low rainfall and high potential evapotranspiration as a consequence of extreme temperatures.

Source of salt in the Islamic Republic of Iran soil B: Anthropogenic

Irrigation with saline and/or sodic waters without adequate management practices in areas of extreme water scarcity.

Lack of drainage facilities, which are the key to appropriate disposal and reuse of saline drainage water generated by irrigated agriculture.

Unsustainable pumping of groundwater through over-exploitation of saline aquifers.

Inadequate irrigation management practices with freshwater such as over-irrigation, particularly in areas with no or limited drainage, resulting in rising water tables and waterlogging problems.

Over-grazing of the pastures and other vegetation resulting in exposure of soils to greater risks of salinization.

RESULTS

Strategies for Salinity Management:

1) Assessment and Monitoring Programmes (There is a need to use modern approaches such as Geographical Information Systems (GIS) and Remote Sensing (RS))

2) Salt Leaching and Drainage Interventions (Experience in the Islamic Republic of Iran)

3) Crops and Crop-assisted Management Approaches (Potential Alternative Crops for Cropping Systems (Experience in the Islamic Republic of Iran) (Maleki *et al*., 2022))

4) Chemical Amendment and Fertilizer Use

DISCUSSION

Future Perspectives:

1) Saline Agriculture (Halo-Culture): An Opportunity for Saline Soils and water Use

2) Formation of the Command Center for Preservation of Agricultural Lands

3) Satellite Based Survey of Agricultural Lands (online services by Use of GIS and RS based systems)

4) Cadaster for Agricultural Lands (1:2000 scale)

5) Collecting data and Up-to-date information about soil characterization of farm holders by the means of questionnaires and field survey

CONCLUSIONS

Without a comprehensive and long-term strategy adaptable to the prevailing economic, climatic, social, as well as edaphic and hydrogeological conditions, it is not considered possible to meet the future challenges of irrigated agriculture using poor-quality water and saline soil management or production with saline condition. We need to establish a National and /or International Workgroup for find answer of the questions about agricultural lands problems under saline condition.

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Adaptation and promotion of climate resilient technologies to improve productivity of salt affected lands based on quasi-real-time monitoring system

T. MUKIMOV, Uzbek Research Design Institute (UZGIP); G. KHASANKHANOVA, Uzbek Research Design Institute (UZGIP),Tashkent; U. ABDULLAEV, Uzbek Research Design Institute (UZGIP); S. KHAMZIN, Uzbek Research Design Institute (UZGIP); R. IBRAGIMOV, Uzbek Research Design Institute (UZGIP); T. KHUJANAZAROV, Disaster Prevention Research Institute, Kyoto University, Kyoto, Japan

Keywords: Soil salinity, climate resilience, land use planning, water management, quasi-real-time monitoring, Amudarya Delta

INTRODUCTION

Adaptation measures and preparedness of local communities for climate change require increased efficiency of water use and evaluation of soil salinity. Agricultural yields of traditional crops across drought -and salt-prone agro-landscapes have reportedly declined by 20–30 percent due to soil salinization impact and extensive water use for irrigation (Khaitov *et al*., 2020). There are also essential gaps and needs for harmonization and standardization of existing databases, such as knowledge sharing and provision of advanced climate-resilient technologies. Reliable knowledge and information on these processes are available but scarce and with limited open access. For the effective restoration and reclamation of saline landscapes, the adaptation and scaling out of innovative approaches and technologies of climate-sustainable agriculture is a strategic priority and socio-economic significance. In the frame of the Blue-Satreps Uzbekistan Japan project, we focused on adaptation and promotion of innovative approaches and climate-resilient technologies for quasi-real-time water resources management and soil salinity monitoring system based on climate scenarios and land use planning. Innovative GIS/RS approaches, tools, and methods were applied to facilitate quasi-real-time monitoring systems on farming, soils, salinity, water, and benefits of halophyte and NCCs cultivation on abandoned saline agricultural farmer lands.

METHODOLOGY

The project adapts an innovative system of crop, soil, and land monitoring in quasi-real time using GIS technics, remote reflectance spectroscopy, various devices, soil sensors, hyperspectral observations from drones, MODIS, GCOM-C Landsat, and Sentinel 2 imagery. Seed sowing of halophytes was conducted in late fall-early winter after the first atmospheric precipitation and wetting of the top 15–20 cm soil that supports wild halophytes to get a good seedling establishment and plant vigor. The efficient use of soil moisture and winter-spring rainfall combined with minimum land preparation and involvement of high fodder productive halophytic species is innovative for the restoration of degraded croplands affected by salinity. The optimum seeding depth was less than about 1.0–2.0 cm for most of the halophytic species.

RESULTS

A multi-dimensional approach was used to select a representative model site for a quasi-real-time and salinization extent monitoring system. The Demoplot "Karabuga" is located on the southern edge of the “A. Dosnazarov" in the Karauzyak district, which is part of the reclamation system served by the main collector KS-3 in Northern Karakalpakstan. The collector-discharge KS-3, 105.5 km long, is located in the middle part of the Kyzketken irrigation system between the Kegeyli and Ishimuzyak canals, serves 28300 hectares of land (Q max = 36.6 m^3/s) on the right bank of the Amudarya River. The climate in the area is sharply continental with hot and dry summers and cold winters. The average January temperature is from -5 to -8 °C. The minimum temperature in winter is -38 °C. The average temperature in June reaches +26–+28°C and in July and August +50°C. The average rainfall is 100 mm per year.

Geomorphologically the agro-landscape of the research area is composed of fine soil deposits (loam, sandy loam, sand). The slope of the surface to the north, and northwest is 0.0002. According to the peculiarities of genesis and morphology, deflationary-accumulative and erosional-accumulative relief types are distinguished. The groundwater table is directly dependent on the regime of the canals, on average, and varies 0.8–2 m, reaching 3.0–3.5 m at a distance from the canal in non-irrigated areas on the borderline with the Kyzylkum desert. Four Circular halophytic mixed farming (CHMF) scenarios are being evaluated (phenotyping screening) at the Karabuga site to test and adapt quasi-real monitoring of soil salinity, the water-salts-plant balance including phenology and monitoring of growth, green biomass accumulation, and grain yield parameters of halophytes and non-conventional (NCCs) crops. Work is done by Uzbek Research Design Institute (UzGIP) in collaboration with Kyoto University, Kobe University, Chiba, Tottori, and Mie Universities, Japan.

DISCUSSION

The best time for halophytes seeding is from November to February during the cold and wet weather. This was important to only start seeding after the cold weather has settled in, as ants and rodents are hibernating and will not collect, store, or eat the seeds. In addition, seeds undergo natural stratification under low winter temperatures. Low air temperature stimulates seed germination under field conditions. Atriplex nitens, Salsola schlerantha, Salicornia europaea, annual and perennial Salsolas, Suaedas species, Kochia scoparia showed a high seed germination, survival rate, and rapid growth rate and accumulation of biomass among 53 wild halophytes species evaluated during two vegetation seasons under limited irrigation. Psammohalophytes, such as Haloxylon, Calligonum, Aellenia subaphylla, Stipa, Agropyron , Kochia prostrata ,which under natural conditions are well adapted to sandy soils, were poorly adapted on alluvial meadow soils in southern Priaralie.

CONCLUSIONS

Upper soil profile and bulk density indicate significant compaction of soil, which negatively influences root growth and root penetration of halophytes, especially at the seedling emergence stage. Further investigation is required on the assessment of irrigation needs, evapotranspiration, soil moisture, crop growth status, water stress status, etc. Visualization and assessment of the efficiency of irrigation, as well as places where conversion of halophytes is desirable. Scenarios for different land use conditions under different climate change and soil salinization impacts are crucially needed in further investigation to find optimal cultivation techniques for the promotion CHMF on saline farmer lands.

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Exploring farmers' perception, knowledge, and management techniques of salt-affected soils to enhance rice production on small land holdings in the United Republic of Tanzania

M.M. OMAR, United Republic of Tanzania Agricultural Research Institute (TARI), Mlingano Centre, P. O. Box 5088, Tanga, United Republic of Tanzania; M.J. SHITINDI, B.H.J. MASSAWE, Department of Soil and Geological Sciences, Sokoine University of Agriculture, P.O. Box 3008, Chuo-Kikuu, Morogoro, United Republic of Tanzania; K.G. FUE, Department of Agricultural Engineering, School of Engineering and Technology, Sokoine University of Agriculture, P. O. Box 3008, Chuo-Kikuu, Morogoro, United Republic of Tanzania; O. PEDERSEN, Department of Biology, University of Copenhagen, Universitetsparken 4, 2100 Copenhagen, Denmark; J.L. MELIYO, United Republic of Tanzania Agricultural Research Institute (TARI), P. O. Box 1571 Dodoma, United Republic of Tanzania

Keywords: Improved livelihoods; Irrigation schemes; Soil health; Salt stress; Indigenous Management Practices

INTRODUCTION

Salt-affected soils are among the key constraints to land productivity in irrigated rice schemes, posing a decline in grain yield. This study was conducted to explore the farmers' perception, knowledge, and management practices of salt-affected soils in selected rice irrigation schemes of the representative districts in the United Republic of Tanzania. Whereas salt-affected soils were perceived as one of the constraints in the studied irrigation schemes, the extent of coverage and the severity of the effect are rarely documented. Therefore, the primary hypothesis of this study is that salt-affected soils could have an effect on rice production across irrigation schemes; and that farmers differ in perception, knowledge, and coping mechanisms.

METHODOLOGY

The Participatory Rural Appraisal (PRA) approach was employed to explore the farmers' information from Mbarali, Iringa, Same, and Moshi districts, whereby 323 rice-growing farmers were interviewed using semi-structured questionnaires. Moreover, 120 farmers were involved in focus group discussions, along with 24 key informants.

RESULTS

Our study showed that a majority (78 percent) of farmers attributed a decline in rice yield largely to salt-affected soils. The perception of farmers on the extent to which they experience salt-affected soils in their rice farms differed significantly ($\chi^2 = 50.373$; $p < 0.001$). In contrast, farmers' responses on salt-affected soils across the districts were not significantly ($\chi^2 = 6.133$; $p = 0.408$) different, which is an interesting result indicating that salt constraints were equally important in rice-producing irrigation schemes.

DISCUSSION

The extent of salt-affected soils and the decline in rice grain yield in rice-growing areas are considered to be increasing across the studied irrigation schemes, which are located in diverse physiographic and agro-ecological zones. Salt-affected soils have been the major constraint to rice production, resulting in low grain yields and/or total losses under extreme conditions. Under normal conditions (i.e., irrigation water availability, the tiny incidence of diseases and pests; and the application of fertilizers) with unnoticeable levels of salinity or sodicity, farmers' reported harvest ranges from 3.2 t/ha to 3.8 t/ha. Whereas, under the effect of salt-affected soils, farmers' harvest ranges from 0.4 t/ha to 0.95 t/ha, depending on the levels of salinity or sodicity. The present study found that some fields have been abandoned, and farmers are progressively shifting to cultivating other crops in upland areas. These findings corroborate with a study by Kashenge-Killenga *et al*. (2014) that found a decrease in rice grain yield in irrigation schemes in the United Republic of Tanzania is attributed to high levels of salinity and sodicity (i.e., ECe ranged from 4–15 dSm^{-1} for saline soil and a sodium adsorption ratio (SAR) of 10–34 for sodic soil).

CONCLUSIONS

Enhancing farmers' knowledge and providing effective and affordable management technologies can improve rice production in small land holdings affected by salts.

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Soil salinity assessment in the south of the steppe zone of the Russian Federation based on multi-temporal high-resolution satellite images

K. PROKOPYEVA, Lomonosov Moscow State University, Russian Federation

Keywords: QuickBird, SuperView-1, soil salinity assessment, solonetzic complexes, principal component analysis (PCA), NDVI, Caspian lowland

INTRODUCTION

Remote assessment of soil salinity is a rather complicated task; therefore, work in this area is necessary and important. Knowledge of the relationship between spectral characteristics and soil salinity makes it possible to use satellite images for mapping and identification of salinity.

This study is devoted to the development of models that can be used to assess soil salinity in the natural solonetzic complex (Republic of Kalmykia, Russian Federation) using multi-temporal high-resolution space images and principal component and multiple linear regression methods.

METHODOLOGY

The studies were carried out on a key site located in the virgin territory within the Caspian lowland. Field work was carried out in 2010, 2011, and 2021. A 64-m-long transect was laid from the center of one round depression to the center of another. Wells 1–2 m deep were drilled and samples were taken for electrical conductivity ($EC_{1:5}$) analysis. The weighted averages were calculated for the 0–30, 0–50, and 0–100 cm layers.

Images from the QuickBird (2007) and SuperView-1 (2021) spacecraft with a spatial resolution of 2 m were used. The analysis of high-resolution multi-temporal images was carried out in the SAGA GIS program using the Resampling module by the B-spline method and the Principal Component Analysis (PCA) module (Bahrenberg, Giese and Nipper, 1992). The PCA module makes it possible to work with multi-temporal images and highlight the main components (datasets) for further comparison with salinity data.

Mathematical analysis of the relationship between the principal components and soil salinity was carried out by multiple linear regression in the STATISTICA program.

RESULTS

The results of data analysis show that the first three eigenvalues account for almost 97 percent of all variance.

All three soil layers have relationships between certain components and salinity, since the regression coefficients (B) and multiple correlation coefficients in general (mult. R) are significant ($p \leq 0.05$). The R^2 value is closest to unity for EC in the 0– 100 cm layer ($R^2 = 0.83$) and shows that almost all variance is explained by this model. The model describes the data well.

Verifying the models based on the control sample showed that it was the best for EC in the 0– 50 cm layer (at $R^2 = 0.87$), while the lowest RMSE value was typical for EC in the 0–30 cm layer. The models built based on the PCA work well on the control sample.

DISCUSSION

In the multivariate analysis, approximating models were selected for different soil layers. The PCA is used to reduce the number of parameters while keeping important information as components. In this regard, insignificant parameters were removed one by one from each model and the models were rebuilt until all the coefficients turned out to be significant. These models can be used to map soil salinity.

CONCLUSIONS

The analysis of remote data was used as a basis to calculate principal components. It was found that the first three components explained almost 97 percent of the entire space image variance.

The models built on the basis of the analysis between salinity and the main components of the satellite image by the multivariate regression method describe soil salinity well according to remote sensing data (R^2 of the model is 0.68, 0.77, and 0.83 for the 0– 30, 0–50, and 0–100 cm layers, respectively).

When tested on the control independent sample, the constructed models showed good convergence between the predicted and real data.

In this study, models have been developed that will be useful for assessing the salinization of soils in the solonetzic complex of the dry steppe using high-resolution satellite images.

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Sequenced glutathione and organic biostimulant application reduce accumulation of toxic sodium and detoxification of heavy metal contaminants in wheat under saline soil

H. REHMAN, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan; M. RADY, Department of Botany, Fayoum University, Fayoum 63514, Egypt

Keywords: Organic biostimulants, heavy metal accumulation, toxicity, sodium, antioxidants

INTRODUCTION

Soil salinity accounts for accumulation of excessive and toxic sodium and chloride reducing availability of macro- (N, P, K, Ca) and micro-nutrients (Zn, Fe and Mn) conversely improving uptake of deleterious heavy metal (Cu, Pb and Cd) contaminants in crop plants (Wang *et al*., 2014). This study investigated the potential of glutathione (GSH), moringa leaf extract (MLE) and water (H_2O) applied in sequence as seed priming and foliar on plant nutritional status, and grain accumulation of essential elements and concomitant detoxification of deleterious heavy metals in under saline condition.

METHODOLOGY

The experiment was conducted under natural saline condition (9.10 dS m^{-1}) using wheat (*Triticum aestivum* L.,) cv. Sakha 93 in comparison to normal soil 2.14 dS m^{-1} for two growing seasons. The antioxidant, glutathione (GSH; 1 mM) and organic biostimulant moringa leaf extract (MLE; 3 percent) were applied in sequence as seed priming and foliar spray on wheat plants including water spray (H_2O) and without any treatment treated as controls. All recommendations of wheat crop were followed as by Egyptian Ministry of Agriculture and Land Reclamation. Plant leave samples were collected at 75 days after sowing for measurement of growth traits, physiological and biochemical analyses and for yield traits at harvest maturity.

RESULTS

Sequenced application of MLE, GSH and H_2O with MLE and/or GSH expressed highest accumulation of beneficial macro-(N, P, K, Ca) and micro-nutrients (Zn, Fe and Mn) by concomitantly reducing the deleterious Na+, Cu, Pb and Cd concentration in wheat plants at booting stage under saline condition. These sequenced applications also showed increased grain nutritional concentration of Zn, Fe and Mn and reduced Cu in wheat under saline conditions.

DISCUSSION

Use of organic biostimulants as an effective remediation strategy has increased widely to increase resistance for abiotic stress tolerance and crop production. This study evident the counteractive effect of GSH and MLE to reduce the uptake of heavy metals in wheat plant and subsequent accumulation in grains under saline conditions. Sequenced applied GSH as antioxidant and/or MLE as plant based biostimulant improved grain yield, plant and grain nutritional status can be attributed to increased osmotic adjustment, ionic homoeostasis and activation of antioxidant defense system in wheat under saline conditions (Rehman *et al*., 2021).

CONCLUSIONS

The integrative use of GSH and/or MLE can be best detoxification strategy for reducing uptake of toxic sodium and heavy metals contaminants in wheat under soil-plant dynamics of saline condition

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Optimizing leaching practice in saline and sodic soils using modelling approach

M. REZAEI, Soil and Water Research Institute (SWRI), Agricultural Research, Education and Extension Organization (AREEO), Karaj, The Islamic Republic of Iran; H. REZAEI, Soil and Water Research Institute (SWRI), Agricultural Research, Education and Extension Organization (AREEO), Karaj, The Islamic Republic of Iran; R. MIRKHANI, Soil and Water Research Institute (SWRI), Agricultural Research, Education and Extension Organization (AREEO), Karaj, The Islamic Republic of Iran; N. DAVATGAR, Soil and Water Research Institute (SWRI), Agricultural Research, Education and Extension Organization (AREEO), Karaj, The Islamic Republic of Iran;

Keywords: Leaching; salinity and sodicity, Soil hydraulic properties; Irrigation management; Modelling; Hydrus

INTRODUCTION

To promote crop productivity the accumulated excessive soluble salts in the rootzone of arid and semi-arid irrigated soils, needs to leach. Traditional leaching requirement (LR) calculation and application seems not to be the appropriate and effective practice in such regions (Corwin *et al*., 2012). Therefore, this study aims at evaluating the leaching practice and optimizing LR in saline and sodic soils using modelling approach by taking into account the transient conditions in the southeast of the Islamic Republic of Iran with sever salinity and sodicity conditions.

METHODOLOGY

To do so, after characterizing and evaluating soil physio-chemical properties of 312 soil profiles of Sistan Plain, a total of eight profiles /sites were selected for leaching studies. Field Leaching experiments were carried out in August to September 2019 by intermittent/consequent flooding method using PRG cylinders with 100 cm diameter and 50 cm height. At each site four cylinders were installed. The depth of the applied water was 100 cm (4 intervals of 25 cm). Thus, the first, second, third and fourth got 25, 50, and 100 cm water, respectively. After each interval, soil samples from 0–25, 25–50, 50–75, 75–100 and 100–150 cm were taken from one of them and Inion and cation and ECe and SAR were determined. Then, next 25 cm water was applied to remained cylinders. The chemical composition of applied water were characterized as well. The Hydrus 1D model using UNSATCHEM module (Šimůnek *et al*., 2016) was calibrated and validated by applying sensitivity analysis and inverse solution using observed data and statistical criteria. Then the optimum leaching requirement and timing were determined at each site.

RESULTS

Results showed tempo-spatial variation in soil physical and hydraulic properties (Rezaei *et al*., 2021). Sensitivity analysis indicated that the model output are mostly sensitive to soil saturated hydraulic conductivity (Ksat), and hydrodynamic coefficient (D). Moreover, the model successfully predicted soil EC and SAR and water and solute movement through soil profiles. Results showed soil salinity and sodicity began to increase just after 40 days of applied water in 40 percent of the soil profiles. We found three sites needed less water (20, 30 and 40 cm) to reach the EC to 4 dS/m and SAR to 6 (wheat threshold tolerance). Whereas, two sites needed more than 150 cm of water. Less applied water could only leach the solutes of topsoil (0–25cm). Result also indicated that two soils cannot be reclaimed potentially and available water should allocated to the suitable land for sustainable production.

DISCUSSION

It has been noticed that in three saline-sodic soils, SAR of root zone was increased; therefore more attention in water management is needed in such sites. In layered alluvial soils of studied sites, the major limiting factor of water and solutes movement is the sharp changes in soil hydraulic and physical properties. Consequently, preferential flow was noticed. Result suggested that leaching practice should be applied before cultivation and during growing season and might done after harvesting with proper amount of water as suggested by the calibrated model for each site.

CONCLUSIONS

The study showed that applying modelling strategy is the effective and promising approach in evaluating leaching practices. It significantly help outlining the leaching requirement and application guidelines considering plant growth, transient condition, irrigation nonuniformity, preferential flow, supplied water composition, deep percolation and atmospheric demands in salt-affected soils.

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Monitoring salt affected soils by NIR spectroscopy in the Colombian Caribbean banana plantations

C. RINCÓN, Universidad Nacional de Colombia – Sede Medellín, Facultad de Ciencias, Facultad de Ciencias Agrarias, Escuela de Geociencias, Colombia; J.C. LOAIZA ÚSUGA, Universidad Nacional de Colombia – Sede Medellín, Facultad de Minas, Escuela de Geociencias y Medioambiente, Colombia; Y. RUBIANO, Universidad Nacional de Colombia – Sede Bogotá, Facultad de Ciencias Agrarias, Colombia; D. CASTAÑEDA; Universidad Nacional de Colombia-Sede Medellín, Facultad de Ciencias Agrarias, Departamento Ciencias Agronómicas, Colombia.

Keywords: Landscape, Sodicity, geostatistics

INTRODUCTION

Colombia have more than 14 million of hectares affected by salts; this affectation is one of the most important degradation problems in the Colombian Caribbean region. With 14.000 hectares in banana the Zona Bananera municipality become in an important pole of agriculture development in the country, generated more than 20.000 direct jobs. However, this zone is in dangerous by salts affectation by salts due to agriculture expansion and grasslands implementation in costal wetland areas, increase the pressure on the use of available water directly affecting underground water. The high costs of soil affected soils maps has led to the ignorance of the current state of the problem. Near Infrared spectroscopy (NIR) is an alternative for the study of soils affected by salts in the Caribbean region, because is faster and cheaper methodology. The main objective of this study was to know salts affected soil distribution in the banana crops, through the combination of (Geographical Information Systems) GIS and NIR. Through the relation soil and landscape was possible to stablish the salts dynamics, stablishing a sampling methodology using geostatistical tools and spectral analyses for estimate the spatial variability and salts affectation patterns. Our results shown the effectiveness of use of current techniques than spectroscopy combined with GIS information in the diagnostic of soils affected by salts in the Colombian Caribbean Region.

METHODOLOGY

MATERIALS AND METHODS

Study area

Zona Bananera municipality is located in the Magdalena Department, north of Colombia (Caribbean region) between Sierra Nevada of Santa Marta and Cienega Grande of Santa Marta (10.7922° N, 74.1710° W). The banana plantations are the most important economical activity in the last two centuries. Nevertheless, in recent years agriculture expansion affected conservation wetlands and mangrove areas near to the coast line. The use of coastal soils and groundwater pressure increase soil salinity problems. The predominant soil orders are Entisols and inceptisols from alluvial and colluvial sediments, product of fluvial and coastal wetlands activity in the Cienega Grande of Santa Marta during Holocene and Sierra Nevada of Santa Marta in the Pleistocene. Soil moisture regimen is ustic except in wetlands (aquic), soil temperature is isohipertermic, mean precipitations is 1332 $mm.year^{-1}$, evapotranspiration is 1825 $mm.year^{-1}$.

Soil Data

During January to March 2022, 450 soil samples under banana plantations at 30 cm depth were collected and georeferencing. The study variables were Ca^{+2}, Mg^{+2}, K^{+}, Na^{+}, pH, Electric Conductivity (EC), Exchangeable Sodium Percentage (ESP), and Sodium Adsorption Ratio (SAR) as preliminary parameters. Satellite images from Sentinel 2 mission (downloaded March 2022), Digital elevation map from Alospalsar 2010 (12.5 resolutions meters), aerial photographs from 1960–2006 (Agustin Codazzi Colombian Geographic Institute – IGAC), Geological maps (Colombian Geological Service – SGC), and morphometric parameters from SAGA GIS were combined using geostatistics in Arcmap through Geostatistical Analyst tool, to elaborate the maps of measured variables.

Geomorphology

The geomorphologic units were stablished according to the geopedological system of Zinck *et al*. (2016). The geomorphologic map at semi-detail scale (1:25,000) for 44.000 hectares detailed geomorphological units until five hectares. Mountains and hills systems were delimited according to the slope classification through SAGA tools. Terrace fans, alluvial fans and terraces were delimited using slope and aerial photographs; water bodies than wetlands, lakes, and rivers were delimited using sentinel images. Lithology were obtained from Colombian Geological Service (SGC).

Soils and Landscape

Banana plantations were delimited through Maximum Likelihood (ML) classification supervised in GRASS GISS. 240 samples were taken with 11 Sentinel 2 bands, ifferentiate six kinds of soil uses; Banana, palm, urban zones, lakes, rivers and surfaces without cover, created a polygon for banana crops delimited some areas to manually. The zones with banana were matched reach 14,000 ha for eight geomorphic units; a type soil profile was characterized per each unit, confronted with 32 soil boring (40 total field observations). The soils profiles were described according to Soil Survey Manual (SSS, 2017). The soil sampling size was calculated through Matérn Model, given the spatial variability of some soil properties like Ca^{+2}, Mg^{+2}, K^{+}, Na^{+}, pH, and EC from 216 georeferencing samples according to Rincon-Rodriguez *et al*. (2021). Due to low EC values, pH was selected as the principal variable for sampling determination.

Sampling design

Result of many simulations to calculate the size of soil samplings through the Mater Model 247 points were selected. The verisimilitude for detecting spatial structure was 87 percent. The Hypercube Latin Sampling Conditionate (HCLSc) was the sampling design used (Minasny & McBratney, 2006). The soil variables selected were pH, EC, Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}, parental material, and slope, HCLSc was adjusted by the boundary.

Soil analyses

pH, EC, Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}, SO_4^{2-}, Cl^{-}, CO_3^{2-}, HCO_3^{-}, SAR, and ESP were analyzed in twenty horizons for eight soil profiles. The soil samples were analyzed in the Soil Laboratory of the Universidad Nacional de Colombia – Sede Bogota. For 247 samplings of the spectrum model pH and EC were analyzed; other variables than Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}, SAR and ESP were obtained from geostatistical analyses as results of interpolation maps trough soil data

Spectral analyses

Soil samplings were air dried for 72 hours, grinder and sieved through 2 mm sieve. For NIR three lectures per sample were made and analyzes from 1000 until 2500 nm among four intervals, using Nirflex 500 Buchi (1000–2500 nm). The soil samples were analyzed in the Soil Laboratory of the Universidad Nacional de Colombia – Sede Medellin. The spectrums were analyzed using R studio, smooth using Savitzky & Golay (1964) methodology. The models used were Soft Independent Modeling of Class Analogy (SIMCA), Partial Linear Square- discriminant analyses (PLS-DA), and Orthogonal Partial Linear Square- discriminant analyses (OPLS-DA). The model validation was done with 60 percent and the calibration with 40 percent. The Kennard-Stone algorithm was used to select the validations sampling using Mahalanobis and D.wards distance. The covariables used in the models were Height, parental material, slope, terrain form. The independent variables were pH, and EC; another variables than Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}, SAR and ESP were added to spectral model as a result of maps interpolation from the auxiliary data.

Geostatistical analyses

Ordinary kriging (OK) model was used to interpolate, pH, Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}, SAR, and ESP; (Ok) allowing know the different soil salinity types. The model was adjusting for the parameters of the variogram per each variable (Nugget, sill, and range). Exchanges bases, ESP, and SAR predicted by OK model and were added to the spectral models.

Soil and Landscape Relationship

Entisols were the most frequently soils order in the Zona Bananera, with Ap/C1/ C2 horizons; close to the SNSM the soils have contact with the rocks was Loamy sand Lithic Ustipsamments, this soil does not have salt affectation. In CGSM the soils had clay and silty textures. Redoximorphic and gleization process were presents in the Alluvials and Fluvio-marine terraces, under fine textures and surface water table. Inceptisols are most frequently on the Alluvial terraces and fans in the lower positions; Ap/ Bw/ BC/ C is most frequently sequence horizons. The presence of Bm (cemented horizons) at 30 to 60 cm depth (associated to the HCO3 concentration) were present in CNGS. subangular blocky (fine and medium) structure is strong to weak in, except in sodic soils typical in low areas. Apex and body of Recent-alluvial fan.

RESULTS

Soil and Landscape Relationship

Entisols were the most frequently soils order in the Zona Bananera, with Ap/C1/ C2 horizons; close to the SNSM the soils have contact with the rocks was Loamy sand Lithic Ustipsamments, this soil does not have salt affectation. Near to the CGSM the soils had clay and silty textures. Redoximorphic and gleization process were presents in the Alluvials and Fluvio-marine terraces, under fine textures and surface water table. Inceptisols are most frequently on the Alluvial terraces and fans in the lower positions; Ap/ Bw/ BC/ C is most frequently sequence horizons. The presence of Bm (cemented horizons) at 30 to 60 cm depth (associated to the HCO3 concentration) were present in CNGS. subangular blocky (fine and medium) structure is strong to weak in, except in sodic soils typical in low areas. Apex and body of Recent-alluvial fan.

had Typic Ustipsamments and Typic Ustifluvents with not salts affectation. Low part of Recent-alluvial fan had Typic Haplustepts with low EC, neutral pH and low salts concentration. In depth in the C1 horizon (60–100 cm), the sodium concentration was > 2,5 meq/l. The low Alluvial terrace third level in Typic Halaquepts, Ap and C1 horizon showed sodium >2.51 meq/l, and moderate EC in the Ap; BCg1 and Cg horizons had a low EC. The Typic Endoquepst in the same geomorphological position had neutral pH, low EC and moderate sodium concentration > 2 meq/l. The fluvio-marine of second-level were the main geomorphology unit associated with salt concentration. The Typic Durustepts (1266 ha) in these terraces, presented the highest Cl, SO4, and HCO3 concentrations especially in the Bm horizons, saline crusts on the surface where saline sodic soils are the mainly salt affection. The Typic Ustifluvents (200 ha) under the Fluvio-marine terrace of first level, has high sodium and HCO3 concentration, low EC; Banana areas were reduced around 200 hectares in 2022 due to the height salt concentration. The interpolations maps of pH and EC shown 2812 hectares (19,86 percent) moderately basic, 1807 hectares (12.76 percent) basic, 131.54 hectares (0.92 percent) slightly alkaline. The EC shown medium values 2–4 ds/m in1560 hectares (11 percent), very slightly saline > 4 ds/m in 80.34 hectares (0.56 percent). The 54.9 percent

(7770 ha) have not salinity problems. The exponential model was the better model to interpolate exchanges bases, SAR, and ESP.

Spectral results

The best spectral model to predict salts affected soils was OPLS-DA, with R^2 of 0.98 for calibrated model and 0,84 for validated model. Then PLS-DA with R^2 of 0.96 for the calibration model and 0.78 for the validation model. For SIMCA the R^2 was 0.94 R^2 for calibration and 0.23 for validation. The SIMCA model shown the higher sensitivity; And Mahalanobis distance shown the better behavior in the OPLS-DA model. However, had seven outliers when the model could not predict, height was the most important covariable in this model.

DISCUSSION

The soils affected by salts were presents in the Fluvio-marine deposits. The wetlands receding during Holocene formed tidal flats, where the high concentration of calcite and chloride had favored different salt concentration; low slopes (0–3 percent) and low rainy did not aid salts leaching. The high Cl concentration in these marine deposits was associate to the tidal flat and ancient mangrove forests, and not affect all the geomorphological unit. It's a specific problem associated to old settling basins, where the high EC values (>70 dS/m) was due to white alkali on surface. The sodicity is the most important affectation in Zona Bananera, it was more frequently in low lands between 0–12 meters sea level. When water table fluctuations favored salt accumulation. The neutral pH is common in some areas under gleization and redoximorphic process. pH values lower than 8,5 was associated with the presence of $CaCO_3$ and sodic soils for the study site.

HCLSc was useful in the soil sampling, the selected sites by the algorithm allowed selected the representatives samples. OK shown be a great tool for salts parameters interpolation. SAR and Ca^{+2} had the higher spatial variability, requiring a larger number of samples. This reply could be related to parental material and variable trend. The OPLS-DA model was improved with variables and covariables addition. The most important covariable was the height, this was related with salts concentration in the low lands in the wetlands proximity. According to Savitzky and Golay (1964), with the first derivate was the better pretreatment, due to elimination of noise. Mahalanobis distance resulted favorable to the model and decreases the sensitivity. However, this model could be better if including other variables like soil texture.

CONCLUSIONS

1. Parental material, weather and the slope were the most important factors in relation to incidence of soils affected by salts in the Zona Bananera.

2. The high concentration of chlorides and bicarbonates were related to soil and geomorphology relation in the low fluvio-marine terraces.

3. Parental material, slope, and water table fluctuations conditioned the high presence of soils affected by salts in fluvio-marine terraces.

4. Sodicity was the most frequently salts affected soils in Zona Bananera, especially in the wetlands and low lands areas.

5. The relation between soil and landscape from geopedological point of view was a very useful methodology in the soils affected by salts sampling.

6. Near-infrared spectroscopy (NIR) made possible to know with precision and economy the presence of soil affected by salts.

7. The proposed methodology in this study needs calibration and validation using samples for conventional methods in order to improve the accuracy.

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Soil salinity detection and mapping under climate and land cover changes between 2000 and 2022: Sminja case study (Tunisia)

K. SAAD, National Engineering School of Sfax, University of Sfax, Tunisia, A. Kallal, National Engineering School of Sfax, University of Sfax, Tunisia; T. SAHLI CHAHED, National Center for Mapping and Remote Sensing, Tunisia

Keywords: Tunisia, Soil salinity, Remote Sensing, climate change

INTRODUCTION

Salinity is one of the most brutal environmental factors limiting the productivity of crop plants because most crop plants are sensitive to salinity. This natural phenomenon results in significant losses in agricultural production, particularly in arid and semi-arid areas of the world.

Soil salinity is expected to affect the world more vigorously and extensively in the coming years. The development of salt-affected soils in the arid regions is a major cause of land degradation. Soil salinity monitoring is essential for effective management and planning of agricultural activity in salt-affected soils. Assessing soil salinity can help with irrigation planning and ensure proper water management, leading to better crops and increased profitability. Truthful data obtained through earth observation and evaluating the changes in soil salinity are crucial for agricultural productivity growth and efficient soil management.

The study focuses on the Sminja area in north-eastern Tunisia, which suffers from soil salinization. The researchers used remote sensing techniques to process satellite images acquired from Landsat 7 and Landsat 8 sensors. They collected 50 geo-referenced soil samples representing different soil salinity classes during the 2021 field campaign. Various indices were tested and correlated with the results obtained from the soil samples.

The main objectives of the study are to project soil salinity trends and levels under the impact of climate change from 2000 to 2022, validate the selected and used semi-empirical predictive model, and correlate the results with land cover changes between 2000 and 2022. The study aims to provide an understanding that soil salinity depends on climate change and help the government better plan future management strategies for the region.

METHODOLOGY

The Sminja area in north-eastern Tunisia suffers from soil salinization. In this regard, remote sensing techniques were used in the processing of satellite images acquired from Landsat 7 and Landsat 8 sensors. During the field survey, 50 geo-referenced soil samples were collected representing different soil salinity classes (non-saline, slightly saline, moderately saline, strongly saline, and very strongly saline). Various indices were tested and correlated with the results obtained from 50 samples taken at a depth between 0.20 m and 0.30 m during the 2021 field campaign. The soil salinity trends and levels were projected under the impact of climate change from 2000 to 2022. The laboratory analysis of soil samples was accomplished to measure the electrical conductivity (EC-Lab) to validate the selected and used semi-empirical predictive model. The results are statistically analyzed ($p < 0.04$) to conclude whether the changes are significant between the predicted salinity (EC-Predicted) and the measured ground truth (EC-Lab).

RESULTS

The results show that the moderately saline soils increased (from 22.5 percent in 2000 to 27.1 percent by 2022 based on the homogeneity test; from 22.1 percent in 2000 to 32.4 percent by 2022 according to the linear regression model). Moreover, highly saline soils would increase (from 11.3 percent in 2000 to 12.6 percent by 2022 based on the homogeneity test; from 11.9 percent in 2000 to 12.7 percent by 2022 according to the linear regression model). These results were correlated with land cover changes between 2000 and 2022. The results of this study provide an understanding that soil salinity depends on climate change and help the government better plan future management strategies for the region.

DISCUSSION

The results of the study show that soil salinization is a significant issue affecting agricultural productivity in the Sminja area of Tunisia. The increase in moderately and highly saline soils between 2000 and 2022 indicates the urgent need for effective management strategies in salt-affected areas. The use of remote sensing techniques and semi-empirical predictive models can provide accurate data on soil salinity levels and help in monitoring and managing salt-affected soils. The results also highlight the impact of climate change on soil salinization, and the need for proper planning and management of water resources and irrigation systems in arid regions.

CONCLUSIONS

In conclusion, the study demonstrates the impact of climate change on soil salinization and highlights the need for effective management strategies in salt-affected areas. The use of remote sensing techniques and semi-empirical predictive models can provide accurate data on soil salinity levels and help in monitoring and managing salt-affected soils. The results emphasize the importance of regular monitoring and assessment of soil salinity to ensure sustainable agricultural practices and increased profitability.

The study also underscores the critical role of soil management in the face of climate change and the need for more research in this area to develop effective strategies for sustainable agricultural practices. The results of the study can help the government and other stakeholders better plan future management strategies for the Sminja region and other areas affected by soil salinization. Overall, the study highlights the need for a concerted effort to address the issue of soil salinization in the face of climate change, and the importance of sustainable agricultural practices for ensuring food security and economic development.

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Possibilities of enhancing gypsum ameliorative efficiency during chemical reclamation of Soda Solonetz–Solonchaks

S. SAHAKYAN, National University of Architecture and Construction of Armenia, Armenia; A. SARUKHANYAN, National University of Architecture and Construction of Armenia, Armenia; T. YEDOYAN, National University of Architecture and Construction of Armenia, Armenia

Keywords: Soda Solonetz–Solonchaks; chemical reclamation; gypsum; ameliorative efficiency; sulfuric acid; hydrochloric acid; distillery dreg

INTRODUCTION

Gypsum as an ameliorant is widely used for chemical reclamation of alkaline soils, which is explained by its low cost, neutral reaction and environmental safety. However it is shown, that ameliorative efficiency of gypsum during chemical reclamation of Soda Solonetz–Solonchaks (SSS) is extremely slow and often ineffective (Abdel-Fattah and Merwad, 2016). This fact connected with gypsum lower solubility (23 mmol L^{-1}), in conditions of high content of water-soluble and exchangeable sodium. It has been shown, that in order to create filtration flow over the soil profile, a concentration of 60–80 mmol L^{-1} of calcium and magnesium ions in soil solution is required, which cannot be reached by gypsum application (Sahakyan *et al.*, 2022).

The purpose of the study is to enhance the ameliorative efficiency of gypsum during the chemical reclamation of SSS.

METHODOLOGY

After creating filtration flow along the soil profile, gypsum at the required doses has been applied using ameliorants such as sulfuric and hydrochloric acids, as well as distillery dregs (cognac production waste). The SSS characterized by high alkaline reaction (pH 8.5–11), alkalization (ESP =30–70 percent), salinization (EC=10–22 mS cm^{-1}).

RESULTS

Application of 0.5 percent sulfuric acid. The maximum penetration of acid solution into the soil during the chemical reclamation with sulfuric acid does not exceed 8–12 cm from the surface of soil. Under low solubility of newly formed gypsum, it is accumulated in the upper layer of soil. Due to higher solubility of magnesium sulphate during the acidification process, the soil dealkalization and the increase of the filtration rate of soil solutions are observed. After application of sulfuric acid with dose of 25 t/ha, or 5000 m3/ha in form of 0.5 percent solution, the gypsum by the norm of 125 t/ha is necessary to use and carry out leaching of soils.

Application of 0.25 percent hydrochloric acid. The effect of solutions with different concentrations of hydrochloric acid during chemical reclamation and leaching process of SSS is studied. The 0.25 percent solution of hydrochloric acid is able to create a sum of Ca + Mg ions in soil solution with concentration of 70 mmol L^{-1}. After application of hydrochloric acid with a dose of 12.5 t/ha, or 5000 m3/ha in form of 0.25 percent solution, the gypsum by the norm of 125 t/ha is necessary to use and carry out soil leaching.

Application of distillery dreg (DD). DD contains 5.647 g/l of organic acids, which total titratable acidity is 104 mmol L^{-1}. The experiments show, that it application in dose of 5000 m^3/ha gives opportunity to create filtration flow over the soil profile, decease alkaline reaction and sodium content of soil. After that, the gypsum with a dose of 125 t/ha is necessary to use and carry out leaching of soils. In order to reduce the transporting costs, it is proposed to condense DD five times.

DISCUSSION

The combined use of various acidic ameliorants bay low doses (12.5–25.0 t/ha) with gypsum, makes it possible to accelerate the process of soil dealkalization and increase the efficiency of gypsum application in the field of chemical reclamation of SSS.

CONCLUSIONS

The results obtained make it possible to reclaim SSS using ameliorants that provide economic efficiency and environmental safety.

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Development and calibration of geo-spatial techniques for monitoring of soil salinity in agricultural landscape of Punjab

Z.A. SAQIB, Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan; M.H. CHOUDHARY, GIS Centre, University of the Punjab, Lahore; J. AKHTAR, University of Sahiwal, Sahiwal; I. AHMAD, Soil and Water Testing Laboratory, Department of Agriculture, Punjab, Multan

Keywords: Soil Salinity, Remote Sensing, Irrigated, Punjab

INTRODUCTION

Salinity intrusion affects agricultural activities in many parts of the world(Shammi *et al*. 2019). Pakistan located in semiarid and arid region and this problem particularly acute here. High soil salinity leads to inhibition of crop growth and as consequence, decrease of yields. A prime step is to map its spatial extent and classify the severity of salinity in the affected areas for sustainable agricultural planning. Recent days, utilizing the satellite data and remote sensing techniques for monitoring soil salinity has become more common, efficient, and economical especially in developed countries. Thw aim of study was to assess soil salinity status in the irrigated agriculture region of Punjab, Pakistan.

METHODOLOGY

This study of soil salinity assessment was carried out in the complex agricultural system of Punjab. Hence, two data sets were used; 1) simultaneous sampling soil data collected especially in this project using old salinity map prepared by WAPDA as baseline and 2) recent Landsat 8 satellite image as RS data to get final output. Soil samples were analyzed to obtain ECe and the coefficient of determination between ECe of soil content and spectral reflectance bands at the location of the sampling points on Landsat 8 were investigated. The OLI data were preprocessed and soil salinity map was derived based on soil salinity indices. Accuracy assessment of RS was conducted using field data for validation before developing the salinity indices. Finally based on validated RS data, soil salinity map of four districta of Punjab province were developed.

RESULTS

There was a high variation of EC in the whole study area. The EC for the whole dataset varied between 1.1 and 88.7 dS m^{-1}. The mean and median were 30.73 dS m^{-1} and 23.88 dS m^{-1}, respectively with standard deviation (SD) of 15.46. The visual analysis and validation of these classes by reference to the field data (ground truth) which revealed a good conformity. The summary of salinity level, extent of the area in hectare and percentage was estimated from satellite data and found that highly salinized soils are distributed mainly in the Jaranwala Tehsil and around and out of the Faisalabad city (Tehsil). The salinity statistics of Faisalabad district shows that bare salinity shares 645 km^2, while the Agricultural salinity area is 96 km^2 and other area is 5194 km^2. The results demonstrated that about 13 percent (0.7 Mha) of the soil in Faisalabad district is affected by salinity in different degrees, indicating that soil salinization has been becoming one of the major threats to local agriculture and human activities in the study area.

DISCUSSION

The response of vegetation spectral index and salinity spectral index to EC was affected by many factors including vegetation coverage, salt tolerance, soil moisture, and soil type (Metternicht and Zinck, 2003).

The result may vary greatly under different environmental conditions with a better result for vegetation spectral index in areas with high vegetation cover while spectral indices opposite of this (Allbed *et al*., 2014). Therefore, although the vegetation spectral index and salinity spectral index showed satisfactory results in monitoring salinity all over the world (Zhang *et al*., 2021), it is worth noting that there is no universal spectral index that can show a satisfactory result in any environmental conditions (Allbed *et al*., 2014).

CONCLUSIONS

This work shows that satellite or remote sensing data and geospatial techniques could be used for assessing soil salinity data in agricultural areas following suitable methodology. Morover, RS data (Landsat 8 and Sentinel-2 images) was used for calculating of various spectral indices and assessment of soil salinity and its accuracy was found statistically acceptable when validated and compared with ground data or laboratory analyses (EC). It is also found that the values of NIR band and some salinity indices developed from RS data are highly correlated with soil salinity (EC) data from field and lab. The output of the project will be available to farmers and other stakeholders using web based platform (website) having soil salinity maps and other related information on

Such updated regional-scale inventories of salinity will provide information for better water management decisions to support agriculture management especially in this climate change scenarios as in future due to frequent and longer water shortages, soil salinity is also likely to become more severe and widespread in agricultural lands.

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Prospects of rehabilitation of salt-affected lands using trees

M. SAQIB, G. ABBAS

Keywords: salt-affected land, salinity , trees, acacia, sodicity, phytoremediation

INTRODUCTION

Salt-affected lands are largely unproductive due to the physical and chemical properties which are not favorable for growth of most of the plants. However, the salt-affected area is increasing and is estimated to be over 800 mha (Munns, 2005) which makes a significant part of the world land. Therefore, the use of salt-affected lands is not only important for food security but also for environmental improvement and climate change resilience. This study explores the use of diverse tree species for the rehabilitation and utilization of salt-affected lands.

METHODOLOGY

Salt-affected lands are largely unproductive due to the physical and chemical properties which are not favorable for growth of most of the plants. However, the salt-affected area is increasing and is estimated to be over 800 mha (Munns, 2005) which makes a significant part of the world land. Therefore, the use of salt-affected lands is not only important for food security but also for environmental improvement and climate change resilience. This study explores the use of diverse tree species for the rehabilitation and utilization of salt-affected lands.

RESULTS

Salt-affected lands are mostly lying barren due to their unfavorable chemical and physical properties. However, there are salt tolerant plants including different tree species which can be grown on these lands as has been observed in the present study. These trees are good source of timber, biomaterials and bio-energy. The barren salt-affected lands contribute negatively to environmental sustainability and climate change resilience. However, the growth plants growing through phytoremediation improve the health of these soils and reduce climate change effect in these areas. Different trees used have different ability to grow and remediate salt-affected lands.

DISCUSSION

Salt-affected marginal lands and water are the resources for which opportunities are increasing as population is increasing with increasing demands to meet the high living standards in Pakistan and elsewhere (Corbishley and Pearce, 2007). Growing salt tolerant plants particularly trees is a sustainable approach which is low cost and environment friendly. In calcareous saline-sodic/sodic soils the removal of Na^+ from soil colloids occurs as the H^+ ion release from roots (Saqib *et al.*, 2020) enhances the dissolution of $CaCO_3$ leading to release of Ca^{+2}.

CONCLUSIONS

Ecological rehabilitation of salt-affected barren lands is possible through growing salt tolerant plants including trees as observed in this study. This approach is low cost and user friendly approach as it can be used at small as well as large scale in Pakistan and around the world.

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Curbing the salinization of arable land and agronomically restoring salt-affected soils, a food security challenge: assessment and prospects, the case of Senegal in West Africa

J.H.B. SENE, Institute of Environmental Sciences, Faculty of Sciences and Techniques, Cheikh Anta Diop University; E. FAYE, Higher Agricultural Training Institute, Alioune Diop University of Bambey, Senegal; A.K. TINE, Senegalese Agricultural Research Institute

Keywords: Senegal River, Sine-Saloum River, Casamance River, salt-affected soils, salt-affected soil restoration

INTRODUCTION

The Senegal–Mauritania sedimentary basin in West Africa is cut by four major rivers: Senegal, Sine–Saloum, Gambia and Casamance. These are flowing into the Atlantic Ocean. The transgressions and marine regressions of the recent Quaternary, the weak dips of the basin and the climate pejoration make that they are invaded by the waters of the Ocean, causing the salinization of the waters and the soils. The State of Senegal estimates the area of salt-affected soils at more than one million seven hundred thousand hectares, or nearly 45 percent of the country's arable land. This salinization, accompanied in some cases by acidification, compromises the food security of the populations of many areas of the country, especially on islands. Indeed, the loss of agricultural land through salinity and/or acidity in a context of constant population growth has a direct negative impact on poverty. To curb the salinization of the land and recover soil that has become unsaturated, local communities and the State of Senegal supported by technical and financial partners, research, NGOs, etc. have implemented several technologies. This work involves taking stock of these technologies, briefly assessing their impact and proposing solutions to reverse the trend of land salinization.

METHODOLOGY

The literature review has made it possible to make an inventory of the hydro-mechanical, chemical and biological technologies implemented in the watersheds of Sine-Saloum and Casamance. The impact of these technologies was assessed using physico-chemical data and local population perception data. Where the physico-chemical data (electrical conductivity, pH, exchangeable bases, ion balance, exchangeable sodium percentage, sodium absorption ratio) exist, they have been compared with that of the reference situation, that is, before the implementation of the technologies. Surveys were carried out to assess the perception of local actors on the impact of these technologies. Finally, focus groups and semi-structured interviews with resource persons (technical agents of the State, researchers, farmers, etc.) have made it possible to propose solutions to reverse the trend of expansion of salinization of land.

RESULTS

It appears that a lot of effort has been made, a lot of experience gained through the combination of local and scientific knowledge. However, the salinization of land is not declining, which requires the identification and implementation of innovative salinity control technologies. The results show that there is much to be done and four main priorities have been proposed for a global and integrated approach to the problem of salt-affected and/or acid soils. These include (i) salt soil inventory and mapping, (ii) scaling of salt-affected soils remediation technologies, (iii) introduction of innovative technologies including biosaline agriculture, and (iv) training and research.

DISCUSSION

The development of synergies between the different structures and organizations working in the field of the fight against the salinization of land and the optimization of resources have become an imperative to curb this important ecological scourge.

CONCLUSIONS

Reversing the trend of land salinization will require strong political will and institutional arrangements based on a holistic approach.

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Dr Alfred Kouly Tine, Senegalese Agricultural Research

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Sustainable management of calcareous sodic soil through combined application of chemical and organic amendments in Bihar, eastern India

S.P. SINGH, Dr. Rajendra Prasad Central Agricultural University, India; S. TIWARI, Dr. Rajendra Prasad Central Agricultural University, India; S.N. SUMAN, Dr. Rajendra Prasad Central Agricultural University, India; Y. SINGH, Rani Lakshmi Bai Central Agricultural University, India; S. JHA, Dr. Rajendra Prasad Central Agricultural University, India; S.S. PRASAD, Dr. Rajendra Prasad Central Agricultural University, India; M. KUMAR, Dr. Rajendra Prasad Central Agricultural University, India; K.M. SINGH, Dr. Rajendra Prasad Central Agricultural University, India

Keywords: Calcareous sodic soil, sustainable management, gypsum, Rice, Wheat, Sulphitation-Pressmud, Dhaincha

INTRODUCTION

Excess soluble salts in soil adversely affect the plant growth and development and are called as salt-affected soils. South Asia, including India, has about 52 m ha salt-affected area (Sharma and Singh, 2015). In the state, Bihar, about 4 lakh ha is suffering from different levels of sodicity/salinity and mostly calcareous in nature having excess free $CaCO_3$ associated with Na rich minerals. For calcareous sodic soils, pyrites are superior amendment over gypsum both in respect of both yield and soil properties (Singh *et al*., 2011). The availability of pyrite is very limited. Therefore, the other cheaper available amendment, gypsum, could be a good option among the farmers. Application of gypsum supplies soluble calcium directly and also indirectly by solubilizing insoluble calcium carbonate of soils in presence sulphur. Thus, to evaluate the response of gypsum alone and with pressmud and green manure (Dhaincha) in calcareous sodic soils, trials were conducted in farmer's fields.

METHODOLOGY

Trials were conducted in 10 ha area of 49 farmers of Muzaffarpur district (Bihar). Six combinations viz. T1 – Untreated control, T2 – gypsum @ 4 Mg ha^{-1}, T3 – Sulphitation Press Mud (SPM) @10 Mg ha^{-1}, T4 – gypsum @ 4 Mg ha^{-1} + PM @10 Mg ha^{-1}, T5 – gypsum @ 4 Mg ha^{-1} + Green manure (dhaincha) and T6 – gypsum @ 4 Mg ha^{-1} + PM @ 10 Mg ha^{-1} + Green manure (dhaincha) were applied and mixed in surface soil. After leaching of salts with irrigation water, the Dhaincha was sown and incorporated in to the soils after 35 days. The first crop salt-tolerant rice (Usar Dhan-3) was grown after reclamation. Initial as well as in final values of pH, EC, organic carbon, available P, available K, SAR and ESP in soils after harvest of each crop were analyzed using standard procedures.

RESULTS

Application of gypsum alone or in combination with organics significantly improved the crop yield of both rice and wheat over untreated control. The two years mean rice grain yield was recorded maximum in treatment T6 (3.8 t ha^{-1}) followed by T5 (3.2 t ha^{-1}), T4 (2.9 t ha^{-1}), T3 (2.6 t ha^{-1}), T2 (2.3 t ha^{-1}) and T1 i.e. unfertilized control (1.9 t ha^{-1}). While, wheat grain yield was maximum in treatment T6 (4.5 t ha-1) followed by T5 (3.9 t ha^{-1}), T4 (3.6 t ha^{-1}), T3 (3.1 t ha^{-1}), T2 (3.0 t ha^{-1}) and T1 i.e. unfertilized control (1.9 t ha^{-1}). The physico-chemical properties of soils were improved due to application of both chemical and organic amendments.

DISCUSSION

Application of chemical (gypsum) along with organics (sulphinated pressmud and green manure) amendments gave more pronounced impact on crop production and soil fertility in comparison to alone application of gypsum. Organic amendments not only enhance the organic carbon but also increase the efficiency of chemical amendment by releasing organic acid which helps in enhancing solubility of insoluble calcium (Singh *et al*., 2011). The exchangeable Na+ ions are replaced by Ca^{2+} and improved soil aggregation and water infiltration. The crop roots also provide channels in soils through which amendments could move downward and enhance the ameliorating effect (Brady and Weil, 2002).

CONCLUSIONS

The current findings indicate that the calcareous sodic soil improved much better with application of organics than the gypsum. The farmers of calcareous soils in eastern India may get maximum benefit by opting the application of gypsum (@4 Mg ha^{-1}) along with sulphinated pressmud (@ 10 Mg ha^{-1}) and green manure (Dhaincha) followed by gypsum (@4 Mg ha^{-1}) + Dhaincha; gypsum (@10 Mg ha^{-1}) with sulphinated pressmud; sulphinated pressmud (10 Mg ha^{-1}) and gypsum (@Mg ha^{-1}).

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Cropping patterns for the sustainable use of poor quality irrigation water in agriculture

P. SINGH, Indian Agricultural Research Institute, Jharkhand, India; S. KUMAR, Indian Agricultural Research Institute, Jharkhand, India

Keywords: Irrigation water, salinity, cropping pattern

INTRODUCTION

The anticipated shortage of fresh water supply to agriculture sector in the 21st century is likely to enhance globally the utilization of relatively poor quality water for irrigation. The poor quality ground waters occur extensively (32–84 percent) in the arid and semi-arid parts of India and their indiscriminate use poses serious threat to the sustainability of natural resources and environment. Salts from higher salinity irrigation water can accumulate rapidly in the top few centimeters of the soil due to surface evaporation, particularly if a high water table is also present and the climate is hot and dry. Under such conditions, seed germination, seedling development and yield may be seriously reduced(Akram *et al*. 2021). Possibilities have now emerged to safely use water otherwise designated unfit. These options primarily consist of: selection of crops, cropping patterns and crop varieties that produce satisfactory yields under the existing or predicted conditions of salinity and sodicity.

METHODOLOGY

Cropping Pattern for utilizing Poor Quality Irrigation Water

a) Selection of Crops

b) Cropping Sequence For Utilizing Saline Water

c) Tree Species

d) Cropping Sequence For Utilizing Sodic Water

e) Growing crops with low water requirements

f) Irrigation method

RESULTS

Cropping patterns for the sustainable use of poor quality irrigation water in agriculture are beneficial compared to other methods due to efficient resource optimization, soil health preservation, increased crop productivity, environmental benefits and economic advantages

DISCUSSION

Cropping Pattern for utilizing Poor Quality Irrigation Water

a) Selection of Crops

For successful utilization of saline water, crops which are semi-tolerant to tolerant such as mustards, wheat and cotton as well as those with low water requirement are recommended.

b) Cropping Sequence For Utilizing Saline Water

Cropping sequence is critical step in mitigating saline conditions. We have to take those crops which water requirement is less or they are tolerant to salinity or alkalinity.

c) Tree Species

In cases where it is neither feasible nor economical to use saline water for crop production, such water can be used to raise tree species especially on lands those are already degraded.

d) Cropping Sequence For Utilizing Sodic Water

Based on the expected ESP to be developed, the suitable crops can be chosen from the list of sodicity tolerant crops

e) Growing crops with low water requirements

When the irrigation water tends to create a sodicity problem, it is advisable to use small quantities of water.

f) Irrigation method

When using low quality water, drip irrigation has several advantages over other irrigation methods.

CONCLUSIONS

Ultimately, by fostering the adoption of appropriate cropping patterns and sustainable water management practices, we can optimize the use of poor quality irrigation water in agriculture. This will not only help in meeting the ever growing global food demand but also ensure the long-term sustainability of agricultural systems and the natural resources they depend on.

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Methodological challenges of salinity quantification by electrical conductivity of soil solutions

A. SMAGIN, Lomonosov Moscow State University, ILAN RAS, Russian Federation; K. PROKOPYEVA, Lomonosov Moscow State University, Russian Federation; T. KALNIN, Lomonosov Moscow State University, Russian Federation; N. SADOVNIKOVA, Lomonosov Moscow State University, Russian Federation.

Keywords: salinity, water content, electrical conductivity, water dilution, soil-water saturation, soil bulk density, modeling.

INTRODUCTION

Express conductometric assessment of salinity using the electrical conductivity of the liquid phase of the soil is widely used all over the world. In this regard, the purpose of our study was to compare the GOST methodology in the Russian Federation with a soil-water ratio of 1:1 and the classical Richards methodology with an assessment of the electrical conductivity of a soil solution in the state of water saturated.The novelty of the study in comparison with (Sonmez *et al*. 2008) consisted in using not only an empirical, but also a physically-based approach to compare these two methods based on the theory of dilution of soil solutions.

METHODOLOGY

We have studied the electrical conductivity of different textural classes (from sands to loams) of varying degrees of salinity (from unsalted to very saline) of Uzbek soils (Protic Arenosols; Terric Fluvic Cambisols;Terric Fluvic Salic Cambisols; Haptic Solonchaks) using Hanna HI 98304 DIST 4 and SanXin DS11 C conductometers in soil-water dilution 1:5 (GOST of the Russian Federation - EC1) and in soil solution extracted by vacuum from water-saturated soil (EC2).Statistical and mathematical data processing was carried out in the S-Plot-11 program using a package of nonlinear regression and ANOVA tests "Regression Wizard".

RESULTS

The results revealed a nonlinear relationship between EC1 and EC2 indicators of the form $EC2 = -0.3623*EC1^2 + 9.4854*EC1$ over the entire range of EC2 variation from 0.8 to 80 dS/m. At low EC values, the EC2/EC1 ratio exceeds 7–9 units, and at high values they tend to 3–4 units. This dynamics reflects the fundamental nonlinear dependence of electrical conductivity on the concentration of the electrolyte with an extremum and a decrease in EC at a high concentration of the solution.To explain the results obtained, a theory of dilution of the soil solution based on the ratio of porosity and effective humidity at different proportions of water and soil is proposed.

DISCUSSION

Comparison with known empirical studies has shown the advantage of a new approach for recalculating the results of the assessment to a standard unsaturated state, as a physically based assessment of soil salinity.

CONCLUSIONS

Estimation of salinity by electrical conductivity strongly depends on the dilution of the soil with water. This relationship can be successfully described based on the theory of soil solution dilution

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Basic agrophysical characteristics of soils in Karakalpakstan

O.G. SULTASHOVA, Karakalpak State University named after Berdakh, Uzbekistan; T.G. KALNIN, M.V. Lomonosov Moscow State University, Faculty of Physics and Soil Reclamation, Eurasian Center for Food Security MSU, Russian Federation; A.A. KEUNIMJAEVA, Karakalpak State University named after Berdakh, Uzbekistan

Keywords: Agrophysics, site reconnaissance, innovation, ameliorants, halophytes, loam, sandy loam

INTRODUCTION

The Republic of Karakalpakstan is located in the northern part of Uzbekistan and occupies a large part of the Amu Darya delta and the Ustyurt plateau. The Republic of Karakalpakstan is rich in land resources. Land resources have a very important strategic importance for sustainable development of the Republic of Karakalpakstan. In the following publication we consider the spring results of the study of agrophysical properties of soils. (Nazarov, 2002)

METHODOLOGY

From 23 to 30 September 2022, joint Russian-Uzbek expedition research was carried out in Prearalie and on the dried part of the Aral Sea bed as part of a research project on the Prearalie. During the field trip eight sites were studied: two on the dried part of the Aral Sea and six in the Amudarya river delta. On the former bottom of the Aral Sea, points under the karabarak bush and community with phytogenic tamarix tubercles were investigated. Shortanbai, Karabuga, Koibak, Ellikkala sites were investigated in the Amudarya river delta, on the territory of the International Innovation Center of Priaralie (IICP) and on the territory of the Academy of Sciences of the Republic of Uzbekistan. The main tasks of the field studies were: reconnaissance of the area, description of vegetation and soils, selection of the site in accordance with the requirements for field tests with innovative soil ameliorants, taking soil samples for laboratory analyses and specification of physical and chemical properties.

RESULTS

In the Amu Darya River delta, soils are formed from stratified alluvial deposits of different granulometric composition, depending on which the degree of moisture, profile salinity and vegetation changes.

Further study of agrophysical properties of soils was selected by field tests in the main agrophysical characteristics of irrigated and non-irrigated soils of Karakalpakstan.

DISCUSSION

Due to the lack of water resources in most massifs of the Amu Darya lower reaches, where soils salinized to varying degrees are predominantly spread, essentially leaching irrigation is not carried out or is carried out on limited areas with insufficient water norm for desalinization of the root-habitat strata (Nazarov, 2002; Reimov, 2009; Mamutov, 2017). Because of this and non-compliance with optimal irrigation regime of cultivated crops, slow, but stable in time activation of salt migration processes in root zone takes place.

CONCLUSIONS

Rigid conducting of "limited" water allocation leads to total supply of collector-drainage and groundwater to irrigated fields without consideration of their quality (salinity, chemical composition, pollution degree), which further aggravates meliorative productive capacity of irrigated soils and reduces yield of cotton and other plants.

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Sustainable saline agriculture based on circular halophytic mixed farming

K. TODERICH, Tottori University International Platform for Dryland Research and Education, Japan, ktoderich@tottori-u.ac.jp; N. MATSUO, Graduate School of Bioresources, Mie University, Japan; N. AKINSHINA, National University of Uzbekistan, Uzbekistan; T. KHUJANAZAROV, Disaster Prevention Research Institute, Kyoto University, Japan; G. KHASANKHANOVA, Uzbek Research Design Institute (UZGIP) Uzbekistan; A. QURBANOV, Karakalpakstan Institute of Agriculture and Agrotechnology; B. JOLLIBEKOV, Karakalpakstan Institute of Agriculture and Agrotechnology; K. PROKOPYEVA, Eurasian Center for Food Security

Keywords: soil salinity, salt removal, alluvial clay loamy soils, halophytic farming, Aral Sea Basin

INTRODUCTION

Halophytes (salt-loving species) are cultivated on saline croplands to restore degraded landscapes and to enhance food security by providing increased productive food biomass, grain for human consumption and livestock feeding, medicinal, technical products, where each product has market value (Yamanaka *et al*., 2020, Caparros *et al*., 2022). Aral-Caspian phytogenetic resources of wild halophytes and its cultivation technology packages are not precisely known, which makes it difficult to adapt to saline farming (Toderich *et al*., 2018). In frame of Joint Japan-Uzbekistan Satreps project we focus on development of a Circular Halophytes Mixed Farming (CHMF) model to improve agroecosystem resilience and enhance food production of salt-affected farmer lands.

METHODOLOGY

Climate of the target research area is dry sharply continental with hot summer and cold winter. Chemical analyses of soil samples were performed at the Analytical Laboratory of Uzbek Design Institute (UZGIP) by standard methods. Seed germination of wild halophytes was investigated at Arid Land Research Center, Tottori University. Plant height, fresh (FW) , water content (W) and dry (DW) biomass were assessed for aboveground parts. CropStat program was used for analysis of variance.

RESULTS

The target farmer lands affected by secondary salinization is located in Delta of Amu Darya ((43° 2.048'N; 60° 0.803'E)). Fluvisol, gleyic, cambisol, calcaric and fluvisol, gleyic, calcaric, sodic with a heavy texture within topsoil (0~30cm) of chloride-sulfate type moderate ~high salinity (EC 6~12 dS/m) were described. The nutrient content of the soil was poor and characterized by 0.8 percent of humus, 2.1 mg/kg of $N\text{-}NO_3$, 28.5 mg/kg of P_2O_5, 157 mg/kg of K_2O in the 0~50 cm soil layer. In the 50 ~100 cm soil layer, the composition was 0.6 percent of humus, 1.2 mg/kg of $N\text{-}NO_3$, 25.2 mg/kg of P_2O_5, and 122 mg/kg of K_2O. Native wild halophytes (Kochia scoparia, Atriplex nitens, Climacoptera aralensis, Suaeda salsa, Salsola sclerantha, Salsola dendroides, Salicornia europaea, Alhagi pseudalhagi) were cultivated on abandoned salt-affected farmlands in various combination with non-conventional cash crops, such as Sorghum bicolor, Penisetum glaucum, Setaria italica, Chenopodium quinoa, Hibiscus cannabinus and Amaranthus retroflexus var. virescens in a strips-alley cropping and agroforestry system (Elaeagnus angustifolia and Morus trees). Our studies proved that halophytes accumulate and/or excrete salts through special plant tissues/salt glands/trichomes. Criteria for (year-round) cultivation of succulent's halophytes should be based on their salt removal capacity (ca. 8.0 g-NaCl eq/kg-dry soil extraction per one vegetation cycle).

Green biomass, produced with one irrigation under soil salinity as 18 dS/m varies within 34-55 t/ha^{-1} at harvest, which correspond to 13–20 t DM/ha. Atriplex nitens, Salsola sclerantha and Kochia scoparia showed the highest seed germination and seedlings survival rate and green forage yield. The highest seed germination (approximately 89 percent) under field conditions was observed for Atriplex nitens with a rapid growth rate and accumulation of green biomass and good-quality seeds. Low field seed germination of about 25 percent was observed for Suaeda salsa, Salicornia europaea, and Climacoptera aralensis.

DISCUSSION

Wild halophytes in a mixed farming on salt affected farmlands with a limited irrigation produced huge amount of green biomass. Re-growth capacity of halophytes makes suitable for multi-cutting and hay production. Grain qualities are not affected by toxic salts that allowing to gradually introduce these species in livestock feeding system. The heavy texture of clay-loamy soils, however, is less suitable for cultivation of wild halophytes.

CONCLUSIONS

The continuous cultivation of halophytes reverses the salinization levels and eventually reclaim the lands towards alternative agricultural use. CHMF is expected to facilitate farms in the Aral Sea Basin region to replicate the halophytic farming practices, which in the long run, increases agricultural products for the domestic and global markets. Further investigation on scheduling irrigation and integrate surface/groundwater resources will be created to calculate the salt dynamics balance. A dynamic economic analysis of the scheme and its implications would become an important socio-economic factor and governmental policies in the region, where cultural and political constraints are crucial.

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Quality Assessment of mine ponds and soil heavy metal levels of two Biafran villages in the vicinity of active and abandoned lead mines

A.O. UWANURUOCHI

Keywords: contaminated, inherent, exposure, soil quality,

INTRODUCTION

The concept of soil quality seeks to assess the condition and sustainability of soil in its capacity to function as a primary home and sources of managed or natural ecosystems to sustain plant and animal life. Soil characteristics are important to understand quality of essential water and air and other natural cycles which support human health and habitation.

This study uses data from a mine survey thesis to provide for quality assessment of pond water, agricultural crops (Okra) found in the vicinity of the mines which are being used in the mine villages for domestic usage. The objectives were to estimate the quantity of heavy metals taken up by agricultural crops grown in the vicinity of the mines, with Okra as a test crop and the quantity of heavy metals in the water from the mine pits of Ikwo province Biafra. Okra was grown in soils taken from three locations (zero meters, 20 meters, 40 meters away from three mine pits) Isiagu Mine, Enyigba Mine and Abandoned mine (on Mr Lazarus's property). Another test soil from an Adjacent farm land that is at least two kilometers away from any mine was used as control.The Okra seeds (sourced from Mr Lazarus at Enyigba) were planted in the soils at the green house complex of National Root crops research Institute Umudike. It was well managed watered and measurements taken over 180 days. Measurements taken were germination percentage, growth rate measurements, leaf count, length of plants, date of first budding, date of flowering and weight of harvested whole plant. Soils were sampled pre and post planting. Harvested whole plants were also processed, dried for laboratory analysis after their weights were measured.

Water taken from the mine pits were also sent for laboratory analysis.

Soil, water and plant matter analysis were done at the Soil, Water, Fertilizer and Plant laboratory of the Federal Ministry of Agriculture and Rural Development Ahiaeke Research center Umudike.

METHODOLOGY

This study focused only on a measure of heavy metal content of the okra crops and heavy metal content of the pond water at the mine pits of Enyigba.

Two evaluation methods were considered, the single index method and the Composite index (Nemerow) method.

The single Index method is based on the ratio between heavy metal concentration and a reference value. Reference value is taken from grade II agricultural soils as specified by the Standards for Environmental Quality of regulating nation (China).

The Nemerow composite Index method takes into account all the individual evaluation factors while highlighting the most contaminant heavy metal in the analysis.

Soil quality evaluation criteria used is the National Environmental Protection Agency of China (2001).

RESULTS

Mean concentration of Pb, Cd, ZN and Fe in study soil samples:

Mean levels of Heavy Metals in soils: Abandoned mine Enyigba mine, Isiagu Mine, Adj. Farm

Lead 20.2 55.0 80.7 6.5 Cadmium 1.371 1.191 1.671 1.190 Zinc 15.88 20.11 13.49 10.17 Iron 8.68 9.67 7.72 6.17

Mean Concentration of Pb, Cd, Zn, Fe in study plant samples: Abandoned Mine Enyigba mine Isiagu Mine Adj farm Lead 2.21 3.84 8.22 0.95 Cadmium 3.05 2.03 2.02 0.93 Zinc 2.74 4.02 1.96 2.22 Iron 2.33 1.16 3.34 2.87

Plant conversion factor (PCF) was calculated based on the equation of Liang et. al., (2011) Nutrient Abandoned mine Enyigba mine Isiagu Mine Adjacent Farmland

Lead 0.13 0.07 0.11 0.19

Cadmium 2.22 1.06 1.21 0.50

Zinc 0.17 0.20 0.15 0.22

Iron 0.27 0.12 0.43 0.47

Quality of water in open mine pits Enyigba Isiagu Abandoned mine LSD TSS (mg/l) 559 383 777 170.7 Turbidity (nm)1.662 1.224 1.130 0.2874 Chlorine (mg/l)12.9 21.1 34.2 6.58 Ca (mg/l) 20.19 24.06 33.15 5.789 K (mg/l)0.558 0.612 0.90 0.1904 Na (mg/l) 3.15 3.73 1.48 0.678 Ammonium N (mg/l)9.87 5.9 14.05 5.116 Pb (mg/l) 10.77 7.24 2.79 5.023 Zn (mg/l) 8.25 8.56 1.87 4.122 Mg (mg/l) 9.42 6.89 7.60 1.016

DISCUSSION

The result showed a preferential order of heavy metal nutrient uptake in the order of Cd>Fe>Zn>Pb which may had been affected by the inherent properties of the mine soils. The Isiagu mine had a very high pH levels of average 2.5 and 3.3 in the Enyigba mine pit. This affected nutrient uptake by the okra plants planted in soils taken from the mine pits. The Plants summarily died out one to three days of germination thereby providing no plant matter for analysis in soils taken directly from inside the mines, at the end of the study period 180 days. Plant matter used for analysis where okra planted in soils taken from the vicinity of the mines 0–10 meters, 10–20 meters, 20–30 meters and 30–40 meters away from the mine pits.

There was rapid increases of uptake of heavy metals by the okra plants in soils taken farther away from the mine pits 10 meters 20 meters and 40 meters away from the mine pits. There may had been a synegernic effect of acidity and heavy metal toxicity leading to rapid death and poor performance of okra seedlings in the 0 to 10 meters at the vicinity of the mines.

In Isiagu mine which recorded pH of 2.5 there was soil lead levels of 80.7mg/kg but no okra plant-lead-uptake as there were no surviving seedling to test. But the plant lead uptake at 40 meters of 0.11mg/kg was less than that obtained at the abandoned mine site pH 5.5 at Zero meters, with a soil lead content at 20.2 mg/kg and plant lead uptake at 0.13ug/kg.

There are very high levels of suspended particles in the ponded water of the mine pits. The abandoned mine pit having the highest levels of total soluble solids. This particular pit was regularly being used by the family of Lazarus for household sources of water. their assertion that they do not drink the mine water was not believed by researcher.

CONCLUSIONS

Exposure of the natives to lead through water sources especially from ponded water taken from inside the mine pits must be discouraged as it a direct pathway to contamination of food and drinking water sources in the homes. Exposure of the natives to lead and other heavy metals that occur in the soils of Enyigba Biafra, is confirmed from food crops planted in the vicinity of the mines. It is apparent that with time, health conditions may pose a difficulty which would be a direct result of the open air mines of Ikwo in Biafraland. Exposure to lead from their mining activities through inhalation of the heavy metals was not considered in this study owing to the lack of equipment and technical know how to conduct that part of this study.

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Putting salt-affected soils on the EU policy agenda

P. VAN TONGEREN, Vrije Universiteit Amsterdam, Netherlands; A. VAN HOLST, Ministry of Agriculture, Netherlands; P. VELLINGA, Vrije Universiteit Amsterdam, Netherlands; K. NEGACZ, Vrije Universiteit Amsterdam, Netherlands.

Keywords: salt-affected soils, EU, policy and instruments, saline agriculture, EU Common Agricultural Policy

INTRODUCTION

Salt-affected soils are becoming an increasingly critical environmental issue in the European Union (EU). However, current EU policy documents scarcely address this issue, and legal instruments that specifically address salt-affected soils are only adopted in some EU member states (FAO, 2023). This study examines existing supranational policies, frameworks, and legal instruments and presents a way forward based.

METHODOLOGY

The research methods employed in this study included content analysis of the policy documents and 17 semi-structured interviews with experts in agriculture, policy, academia, and public affairs. For the data analysis, grounded theory was used which involved open coding, axial coding, and selective coding. Based on emerging themes, recommendations for future pathways were formulated.

RESULTS

The relevant EU policy landscape included the Common Agricultural Policy (CAP), the European Green Deal (EGD), the EU Soil Strategy 2030, and the EU Biodiversity Strategy 2030. Only two of the ten CAP key objectives include salt-affected soils in their strategy documents (European Commission, 2023). The EGD and the Farm to Fork (F2F) strategy do not explicitly mention salt-affected soils or saline agriculture (European Commission, 2019). The EU Soil Strategy for 2030 and the EU Biodiversity Strategy for 2030 briefly hint at salt-affected soils making up the ecological challenges of their respective strategic domains, but concrete policies to prevent and mitigate salt-affected soils are not covered in these strategies. Hence, there is a policy gap at the EU level, and opportunities arise for policymakers to give saline agriculture a more prominent place on the future EU policy agenda. Since the CAP has a four-year policy cycle, there is ample opportunity to give salt-affected soils a more prominent place on the CAP for 2027. Similarly, the EU Soil Strategy 2030 and the EU Biodiversity Strategy 2030 could incorporate policies supporting salinity adaptive or wider mitigative measures into policy at the EU level. The interviewees unanimously agreed that salinisation is an urgent issue on the international agenda. However, adaptation strategies are not being discussed as frequently as they should be.

DISCUSSION

This study recommends framing salinity issues and solutions in a wider policy perspective and include stakeholders most affected by salt-affected soils to support a wide, inclusive sustainable transition. Policymakers should further explore possibilities to include the narrative of salinisation in existing policy frameworks, such as the CAP, making sure a long-term vision is adopted, thus ensuring transformative change. Specific policies and legal instruments at the EU level should include: 1) Agenda setting, 2) Contextuality, 3) Farmer unions and co-op consultation, and 4) Holistic and transdisciplinary focus.

CONCLUSIONS

In conclusion, there is a policy gap at the EU level regarding salt-affected soils. Our research shows that putting saline agriculture on the EU policy agenda will contribute to a coherent long-term vision on preventing land degradation, ensuring food and water security, and sustaining biodiversity . Salinity issues and solutions should be framed in a broader context, including a wide range of stakeholders.

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Mapping the severity of soil salinization potential in Israel

E. VOLK, A. MAOR, A. NAHLIELI, G. ESHEL, Dept. of Soil Conservation and Drainage Ministry of Agriculture, Israel

Keywords: Mapping severity soil salinization potential Israel

INTRODUCTION

Irrigation is one of the main drivers for soil salinization especially in the case of poor drained soils. The threat becomes grater with intenssive irrigation of marginal water. This is the case in Israel where more than 60 percent of the irrigation water is based on treated wastewater (TWW). This situation lead to installation of tile drainage systems in order to be able continue growing crops. The investment in these systems accumulated to more than nine million USD in the last five years only.

METHODOLOGY

A mapping effort based on a GIS analysis has been performed in order to estimate the extent of risk for soil salinization in the agricultural land as a result of intensive irrigation with low water quality and high water table. Agricultural plots soils were categorized by three groups of severity as predictors of salinity and drainage problems. This was based mainly on soil texture and field slope, for example clayey soils in valleys. This division categorized the risk for soil salinization of agricultural plots by severity.

RESULTS

This analysis suggests that 9 percent of the agricultural land in Israel is expected to suffer from severe risk of salinization as a result of high water table. An additional 33 percent of the agricultural land is of a moderate risk.

DISCUSSION

The GIS classification shows an agreement between the plots classified with severe problems to plots containing massive tile drainage systems. Similarly, the plots classified as expected to have moderate problems contain less massive tile drainage systems, and the plots classified to have minor expected problems contain small systems.

CONCLUSIONS

This kind of analysis may serve as a policy tool for future water quality allocation. In order to make this information accessible to the public, we created an interactive online map showing the potential groups.

https://arcg.is/1mW9Xa0

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Ministry of Agriculture, Israel

The views expressed in this information product are those of the author(s) and do not necessarily reflect the views or policies of FAO.

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Policy and agronomic practice of sustainable management of salt-affected soils in Ukraine

L. VOROTYNTSEVA, National Scientific Center «Institute for Soil Science and Agrochemistry Research named after O.N. Sokolovsky», Ukraine; S. BALIUK, National Scientific Center «Institute for Soil Science and Agrochemistry Research named after O.N. Sokolovsky», Ukraine; M. ZAKHAROVA, National Scientific Center «Institute for Soil Science and Agrochemistry Research named after O.N. Sokolovsky», Ukraine; R. PANARIN, National Scientific Center «Institute for Soil Science and Agrochemistry Research named after O.N. Sokolovsky», Ukraine

Keywords: ameliorant, fertility, sustainable management, salt-affected soils

INTRODUCTION

In Ukraine irrigation by brackish water is the cause of soil salinization. There are about 350 thousand hectares of salt-affected soils on irrigated lands (Baliuk S. at al, 2020). Sustainable management of salt-affected soils should primarily be decided at the state level through the formation of a state system of control over their condition, use and protection.

The state the objectives of the work are the indicators and components of the system of sustainable management of salt-affected soils in Ukraine.

METHODOLOGY

Researches were carried out in Steppe zone of Ukraine on secondary salt-affected soils. Monitoring of irrigated soils was carried out according to national normative documents and methods. At the same time, the interconnected system "irrigation water-soil-plant" was studied.

In field experiments the effectiveness of a system of agronomic practices on restoration of salt-affected soils and the sustainable management was studied. It included such methods as soil leaching, deep ploughing (to 75 cm), chemical amelioration (by different Ca-containing amendments), selection of crops on their salt tolerance, вioremediation.

RESULTS

Policy and legal instruments for sustainable management of salt-affected soils should be based on their monitoring, diagnostics of the properties and condition. In Ukraine, by the Decree of the Cabinet of Ministers of Ukraine standards for environmentally safe irrigation have been established. They determine the possibility of irrigation based on water quality and soil properties so as not to degrade properties, soil quality, ecosystem services.

We developed the Concept of sustainable management of reclaimed lands. It includes organizational issues of formation of the state system of balanced management of reclaimed lands at different levels of organization and power. The sustainable management system includes five blocks: informational, organizational, technological, economic and regulatory (Baliuk *et al*., 2020).

The information block includes monitoring and diagnostics of the state of lands, the creation of information databases.

The technological block includes a complex of differentiated synergistic measures to protect and increase the fertility of saline soils.

Deep ploughing to 75 cm ensured the saturation of the absorbed complex with calcium (from 7 to 3.9–4.8 percent of exchangeable cations), an increase in the buffer capacity of the soil. The crop yield increased by 21–38 percent.

Ca-ameliorants increased the carbonate content of the soil (from 1.5 percent to 2.7 percent), improved the cation-anion composition of the water extract and soil adsorption complex. Crop yields increased by 10 to 30 percent.

DISCUSSION

One of the instruments of state policy on the SSM is the development of strategies and state programs in the field of land reclamation, the achievement of a neutral level of land degradation. At the legislative level, it is necessary to improve existing and develop new, more effective laws on the protection of soils and their fertility (Singh, 2021; FAO, 2017).

CONCLUSIONS

A system of sustainable management of saline soils in Ukraine has been developed. It includes five blocks and is aimed at the rational use and increasing the fertility of these soils.

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Evaluating crop-specific responses to drought and salinity stress from remote sensing

W. WEN, Institute of Environmental Sciences (CML), Leiden University, The Netherlands; J. TIMMERMANS, Institute of Environmental Sciences (CML), Leiden University, institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Lifewatch ERIC, vLab & Innovation Centre, The Netherlands; Q. CHEN, Institute of Environmental Sciences (CML), Leiden University, The Netherlands; P.M. VAN BODEGOM, Institute of Environmental Sciences (CML), Leiden University, The Netherlands.

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INTRODUCTION

Food security is threatened by co-occurring stresses (e.g. salinity and drought) under global climate change. Traditionally, the tolerance of crops is evaluated in highly controlled small-scale experiments involving only a limited number of crop types. To increase our understanding in actual agricultural tolerances, plant functioning, as observed by functional traits, need to be performed in real-life scenarios for as many crops as possible. Remote sensing is presently the only tool capable of monitoring such plant functional traits simultaneously over large areas. The aim of this research therefore is to evaluate the crop tolerances to jointly drought and salinity stress across various plant functions in real-life conditions.

METHODOLOGY

In order to assess stressed areas and non-stressed areas, we generated a co-occurrence map of drought and salinity by superimposing a drought map in 2021 with a topsoil salinity map across the whole United States of America. A pair-wise method was adopted to estimate the difference between observations subjected to stress and un-subjected observations. Then, based on five retrieved traits including LAI, FAPAR, FVC, Cab, and Cw using Sentinel-2 remote sensing observations, we characterized the tolerance of eight crops to various drought and salinity stress conditions. The main effects of stress, month as well as three potentially confounding factors (soil, climate zone, and region) and their interaction were determined for five traits. Moreover, the response of crops to drought and salinity stress for five traits from March to October were evaluated separately. Also, the onset of stresses (drought, salinity, and their combination) on five traits was analyzed for each crop separately.

RESULTS

We indeed observed that stress impacts strongly depended on time. In addition, we observed that crops were more sensitive to combined drought and salinity than to individual stresses, although stress impacts varied significantly between species and time. Of the individual traits, LAI was triggered first by stresses, followed by FAPAR and FVC, and Cab and Cw were the last to respond to stresses. In comparison to other species, almond demonstrated greater resilience to combined drought and salinity, whereas soybean and maize were more drought tolerant.

DISCUSSION

Co-occurring drought and salinity showed exacerbating effects on crop traits in most cases. The crop responses to drought and salinity are highly dependent on the moment. Such variation is consistent with physiological knowledge showing that the sensitivity to specific drivers depends on the growth stage.

Aside from the significant impact of the moment in the growing season, drought and salinity also affect crops differently depending on their species. In general, for all eight crops, LAI was triggered first by drought and salinity stress, followed by FAPAR and FVC, and Cab and Cw were the last to respond. It can be an interesting approach for local farmers or the government to timely assess crop health. In this way, it gives farmers an open-source tool to monitor crop growth conditions and adjust field management based on evidence.

CONCLUSIONS

We established a quantitative foundation for simultaneously assessing the responses of various crops to the occurrence of stresses, alone and collectively at large scale and under actual agricultural conditions. Consequently, we contribute to monitor food security and guide food production in a timely and non-destructive way by remote sensing.

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Changes in the water-soluble salts content in the calcic chernozem under irrigation with brackish waters

M. ZAKHAROVA, National Scientific Center «Institute for Soil Science and Agrochemistry Research named after O.N. Sokolovsky»; A. NOSONENKO, National Scientific Center «Institute for Soil Science and Agrochemistry Research named after O.N. Sokolovsky»

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INTRODUCTION

For the soil-loess thickness of the Central and Southern Steppes of Ukraine, the residual-accumulative type of salt distribution is the most characteristic. It is characterized by the differentiation of the profile into the upper non-saline part and the lower saline part. Irrigation with brackish water changes the distribution of salts in the soil profile. The purpose of the study is to determine the peculiarities of the dynamics of the content of water-soluble salts under irrigation with brackish water.

METHODOLOGY

The study was carried out on Calcic Chernozem in the fields of the Danube-Dniester irrigation system (DDIS) under irrigation with brackish water (13 years) and non-irrigated conditions (Odesa region of Ukraine). Soil samples for chemical analyses were collected at the beginning and the end of each growing season (3 years). They were taken from depths of 0–25, 25–50, 50–75, 75–100, 100–150, 150–200 and 200–250 cm. Irrigation water samples were collected four times during the vegetation period. A method of soil salinity assessment was the analysis of the 1:5 soil-to-water extract.

RESULTS

The mineralization of irrigation water is 1–2 g/dm^3, its composition is chloride-sodium.

In the non-irrigated soil, all water-soluble salts are distributed evenly to a depth of 200 cm, from which the gradual increase in $MgSO_4$ content begins. The content of water-soluble salts ranges from 0.07 to 0.09 percent, and toxic salts from 0.03 to 0.06 percent.

In the soil-loess thickness of irrigated soil, a seasonally reversed type of saline regime was noted: the accumulation of salts in the root layer of irrigated soils and the desalination of this layer during the off-vegetation period under the influence of precipitation.

Ions introduced with irrigation water are distributed over the entire profile and accumulate in different soil layers: the maximum of Cl^- noted in the 100–150 cm layer; SO_4^{2-} - 50–100 cm, Mg^{2+} - 75–200 cm, Na^+ - at depths 0–75 and 150–250 cm. The upper accumulative horizon of water-soluble salts was formed in the 50–150 cm layer, the composition of salts in it is chloride-sulfate (in the lower part - sulfate-chloride), magnesium-calcium. In the 0–50 cm and 200–250 cm layers, sodium sulfates and hydrogen carbonates predominate. The total content of water-soluble salts increases to 0.10–0.12 percent, toxic - 0.07–0.10 percent.

DISCUSSION

Studies of salt regimes in irrigated soils are relevant to evaluate the possibility and preventing the development of degradation processes (Vargas *et al.*, 2018). Researches are the basis for the soil-ecological substantiation of the use and expansion of irrigation areas in Ukraine, and the elaboration complex of measures on the improvement of soil fertility under irrigation.

CONCLUSIONS

Irrigation of Calcic Chernozem with brackish water leads to the periodic accumulation of water-soluble sodium salts in the upper layers of the soil, which creates a danger of its irrigation sodification.

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Land and Water Division
GSP-secretariat@fao.org
www.fao.org/global-soil-partnership

Food and Agriculture Organization of the United Nations
Rome, Italy

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