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NEW SZÉCHENYI PLAN

Screening for salt tolerance in four *Atriplex* species

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Salinity tolerance is defined as the ability of plants to continuously grow under salt stress condition. It is a multigenic complex trait. Considering the great complexity of the mechanism and magnitude of variation in this trait at intra-specific and inter-specific levels, it is difficult to identify one single criterion for screening large population and this led to the quest for rapid screening techniques for salinity tolerance. Screening in the field is difficult, due to spatial heterogeneity of soil physico-chemical properties and seasonal fluctuations in rainfall. Assessment of salinity tolerance of halophytes is more complicated than in agronomic and horticultural plants and no consistent criterion has been used as are used for glycophytes. Keeping in view this idea, pot experiment was conducted for screening four *Atriplex* species (*A. halimus*, *A. nummularia*, *A. canescens* and *A. lecolada*) under different levels of salinity (0, 1000, 3000, 6000 and 12000 mg l^{-1}) of NaCl grown in soils collected from Al-Jazeera northern Irrigation project (Nineveh Province, Iraq) using simple indirect selection criteria such as dry weight, water content, net NaCl transport, ability for accumulation of Na^+ and Cl^- and selectivity for Na^+ over K^+ . Based on results of this study, *A.halimus* was more efficient with respect to the above selection criteria and showed best salt tolerance performance on overall basis.

Keywords: salt tolerance, Atriplex, screening, Sodium chloride, selectivity.

Exploiting the potential of halophytes from "Ria Formosa" salt marshes (South Portugal) to improve the soil and develop ecologically sound saline agriculture

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Nowadays soil salinity has become an important issue in agriculture, which is also one of the most urgent global problems to provide enough water and land for meeting world's food needs. The potential of some halophytes to desalinize soils, and consequently permit the reuse of soil for usual cropshas been recognized. Halophytic plants, including *Salicornia ramosissima* and *Sarcocornia perennis* are consumed today in Europe as fresh or cooked gourmet foods. Several studies with these species reported their high nutritional content and therapeutic applications. In the salt marshes of Algarve region, Portugal, the supply of those plants is limited because they are not extensively cultivated and are harvested usually from the wild. However, those crops can be cultivated in salinized soils making possible to exploit soils currently unsuitable to agricultural use, particularly along coastal areas. The objective of this work was to find the nutritional quality and acceptability by consumers of *S. ramosissima* and *S. perennis* from "Ria Formosa" for use as fresh salad or as green salt. Both species showed good quality and acceptance by consumers. This research may aid determining new crops for export. This can be a new chain of halophyte crops resistant to salt rich environment, enhancing the profits of farmers residing in the semi-arid region of Algarve. Also those halophytic species will enable the rehabilitation and restocking of salt-affected lands, using the appropriate soil and irrigation management.

Keywords: *Salicornia ramosissima, Sarcocornia perennis,* salinized soils, food quality.

Use of aboveground electromagnetic induction meter for detecting salinity gradients and indurated soil layers in a volcanic landscape

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Introduction

In some volcanic landscapes salts accumulation can appear in the bottom parts of the relief as a consequence of the downward transport of the solutes released from rock weathering. Such geochemical process can result in the appearance of mineral-zonation belts according to their relative solubility. Electromagnetic induction (EM) is a non-invasive technique that can help in quick surveying of landscapes, producing a primary magnetic field that induces a secondary magnetic field if some conductors are present into the soil. The measurement integrates the induced secondary magnetic field from a volume of soil that depends of the sensor geometry. Using the Geonics EM38 sensor, the effective depth of measurement extends to 2 meters that is appropriate for soil survey and agricultural applications. The instrument allows two geometry configurations, vertical and horizontal modes, which integrate soil and geologic material response from different depths.

Study area and methods

An andesitic hill in Central Mexico is surrounded by rings of entisols, calcids, salids and argids arranged in the downhill sense. A bottom-top longitudinal survey has been performed measuring with a Geonics EM38 meter, both in vertical and horizontal mode, as well as surface temperature with an infrared thermometer, in 95 points along a distance of 762 meters, positioning each measurement with GPS-WAAS enabled (HDOP<3meters). Several soil samples were taken to relate the bulk EM ECa with ECe of the saturated paste.

Results and Conclusions

Three distinct zones were clearly discriminated through the analysis of the EM38 raw signals and soil surface temperature: a first area of saline alkaline soils with halophytes and *Cactacea*, a second area of non saline soils with petrocalcic horizon where halophytes are absent, and a third area of shallow less developed soils with moderated slope, at the bottom part of the hill. The measurements provided data for the bulk soil conductivity at every point, showing salinity gradients, areal heterogeneity, detecting the appearance of petrocalcic horizon and computing if salinity is in topsoil or in the bottom soil.

Delimitation of less favoured areas insalt affected regions of Hungary according to common european biophysical criteria

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In our paper we present the multiple approaches for the identification and delineation of Less Favoured Areas in Hungary (LFA) -especially in salt affected regions- according to the common biophysical criteria related to soil.
Delimitation of LFA is suggested to be carried out by using common biophysical diagnostic criteria on areas of low soil productivity and under poor climate conditions all over Europe. The operational implementation of the criterion system elaborated by JRC is under member state competence. This process requires the existence of adequate national spatial information systems on soils and climate with appropriate data structure and spatial resolution as well as proper methodologies for their analysis.
Incidence of naturally handicapped areas can be predominantly attributed to soil conditions. The nationwide Kreybig legacy, which was digitally processed and developed into the Digital Kreybig Soil Information System (DKSIS) has at least three major advantages in the present context as compared to any other possible Hungarian datasets:
- The main objective of the original mapping is almost the same as that of present LFA assignment.
- It is the most detailed nationwide spatial dataset covering the whole area of the country.
- The database contains utilizable information to fulfil all the soil related criteria, and due to their spatial features they can also be used for countrywide regionalization of these criteria.
To define salinity and sodicity within "*Soil chemical properties*" criteria, the EU Commission has proposed 3 parameters with different thresholds:
(i) Salinity (salt content); ECe $\geq$ 4 dS/m, or
(ii) Sodicity (exchangeable Na %) $\geq$ 6 ESP, or
(iii) pH$\leq$ 5.
(i) To define areas meeting **salinity** (salt content) sub criterion the following approach was used (1) from the DKSIS soil profile database those elements (and related areas) were selected, where in the soil layers the salt content expressed in salt weight% were appropriately high. The salt content expressed in salt weight% can be converted into conductivity values using the saturated material water content values (SP value) (USDA methodology). The SP value similarly to the Arany-index (KA) (plasticity index commonly used in Hungarian practice) is in strong correlation with soil physical classes, its value is approx. 10% higher than KA value (Búzás, 1993). With a linear transfer function (Filep, 1988) the electrical conductivity (ECe) can be calculated as follows:
salt% = ECe * SP/1000 *0,797; *where SP value was taken as 1,1KA.*
(ii) To find eligible areas for **sodicity** sub criterion the following approach was used: from DKSIS Profile database elements with special laboratory data were selected.

The DKSIS profile database contains about 1600 soil layers with data for exchangeable cation content. Most of these profiles specifically characterize salt-affected regions. There was valuable information concerning the sodicity criteria for approx. 1000 soil layers. The ESP value was calculated on the internationally accepted way, as a ratio of exchangeable Na (cmol(+)/kg) and CEC (cation exchange capacity, cmol(+)/kg).
Soil profiles satisfy the sodicity criteria, if the ESP value equalled or exceeded 6 in the profile.

Comparing physiological properties of forage halophytes

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Land salinization is a major limiting factor for conventional crop production, especially in arid and semi-arid regions of the country. In Iran, vast amounts of saline lands, shortage of fresh water resources, secondary land salinization and a broad diversity of halophytic species has imposed a necessary demand on utilizing saline soil and water resources. To evaluate some halophytes as forage crop physiologically, an experiment was conducted at Salinity Research Station of Chah-Afzal, Yazd, Iran. In this experiment, some halophytic species were propagated in the greenhouse and transferred to the field after land preparation. The statistical design was complete randomized block with three replications. During the growth season all plants were irrigated with saline water of 7 dS/m. In the end of experiment some physiological parameters were determined including water content, ash per cent, canopy broadness and some mineral elements (Na, K, Cl). Results show that halophytes are significantly different. Comparing forage halophyte species studied here showed that *K. indica*, *S. aculeta* and *A. halimus* could be considered as the most promising species in forage production. This is due to high forage yield, low ash content, low amounts of Na and Cl ions, broad canopy and so on. Considering the fact that high salt content in halophytes has caused some limitations in forage palatability, more attention should be focused on *S. aculeate* because of having low ash content and also low K/Na ratio.

Keywords: halophytes, forage, salinity, physiology

Comparison of the emergence rate, establishment ability and yield of some halophytes under saline conditions

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In Iran, vast amounts of saline lands, shortage of fresh water resources and potential of halophytes for forage production has generated a great interest in utilizing these species as a substitute for convenient forage resources. In order to introduce suitable halophytes for forage production, an experiment was conducted on 14 halophyte species in the greenhouse and in the saline land located at Chah-Afzal Salinity Research Station of NSRC, Yazd, Iran. In the greenhouse experiment, seedling emergence percentage and emergence rate were studied. In the saline land, 2-month old seedlings of halophytes with high emergence percentage were planted at 1.5 ×1.5 m spacing in the form of complete randomized block design with three replications and were irrigated with saline water (8 dS/m). All plants were harvested six months later and some characteristics including amount of seedling establishment, yield and yield components were measured. Results showed that both *Kochia indica* and *Atriplex halimus* are suitable species for forage production under saline conditions due to high rate of emergence, high amount of establishment, high forage yield and so on. These species may be suggested for forage production and rehabilitation of rangelands under saline conditions.

Keywords: forage halophyte, forage, salinity, yield, growth

Comparison of different irrigation systems for the production of halophytic forages

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Halophytes are plant species that grow naturally in saline habitats. They can produce forage for feeding the animals and can make a significant contribution to mankind and to human food security. Utilization of saline soil and water resources for halophytes production as forage crop has been the subject of many studies. In this experiment five species of halophytes namely, *Atriplex canescens*, *A. halimus*, *A. lentiformis*, *A. nummularia* and *Kochia indica* were evaluated for forage production under different irrigation systems (furrow, bubbler, drip) in the form of split plot design with three replications at Sadooq Salinity Research Farm of NSRC in Yazd, Iran. All plants were irrigated with saline water (14dS/m) and several cuttings weremade every 3-4 months at the height of 30 cm from soil surface.Results showed that furrow and bubbler systems had the most positive effect on forage production in comparison to drip system. In most cases, no marked difference was observed between furrow and bubbler systems. Comparison of all forage halophytes for forage yield indicated that *A. canescens* had the highest forage yield followed by *A. halimus*. No significant difference was observed between other saltbushes in terms of forage yield.Therefore, based on the criteria used for introducing the best irrigation system, bubbler could be chosen as the best one, however, other factors especially the initial investment cost, maintenance and the availability of water resources should be considered, as well.

Keywords: halophyte, irrigation systems, forage, WUE, salinity

Effect of Nitrogen and Phosphorous fertilizers on the growth of some forage halophytes

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In Iran, vast amounts of saline lands, shortage of fresh water resources and potential of halophytes for forage production has generated a great interest in utilizing halophyte species as a substitute for convenient forage resources. In order to study the effect of nitrogen and phosphorous fertilizers on yield and yield components of five halophytic species, namely *Atriplex nummularia, A.lentiformis, A. halimus, A.canescens* and *Kochiaindica*, aplot experiment was conducted in National Salinity Research Center, Yazd, Iran. The experiment was arranged in triplicate with a split-plot factorial design with the five halophyte species as main plots and three levels of Nitrogen (0, 25, 50 kg N/ha) and three levels of phosphorous (0, 25, 50 kg P_2O5/ha) fertilizer as sub-plots, using saline water of 14 dS/m electrical conductivity. Nitrogen and phosphorous were applied in the form of ammonium nitrate and triple super phosphate, respectively. Application of nitrogen fertilizer showed a significant effect on shoot fresh weight, stem, leaf and total dry weight of the tested halophytes. The highest yield and yield components of the tested halophytes were obtained at maximum nitrogen application rate. On the other hand, application of phosphorous fertilizer did not increased yield and yield components of the tested halophytes, except for *Kochiaindica.* The results for interactive effect of nitrogen and phosphorous on yield and its component indicate that for all levels of phosphorous, nitrogen fertilizer increased yield and yield component of all the halophytic species.There was not any consistent effect over all three nitrogen levels of applying of phosphorous on yield and yield components of the studied halophytic species. It should be noted that *Kochia indica* produced maximum shoot fresh weight (40.2 tons/ ha.year) followed by *A. canescens* (23.6 tons/ ha.year), *A. halimus* (10.16 tons/ ha.year), *A. nummularia* (8.97 tons/ ha.year) and *A. lentiformis* (7.76 tons/ ha.year), respectively.

Keywords: halophyte, fertilizers, forage, yield, salinity

The behaviour of a Hungarian Solonetz soil contaminated by organic pollutants

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Nowadays, unfortunately, more and more crude oil pollutes the environment, thereby altering physical, chemical and biological properties of soils. Surfactants are widely used in e.g. pharmacy industry and households, respectively in remediation by enhancing the sorption of organic pollutants on soil particles.
In this investigation a Hungarian Solonetz soil's Atterberg limits, plasticity index, saturated hydraulic and oil conductivity, oil retention and air permeability were measured on natural sample and after treated it with a cationic surfactant. The applied organic liquid was Dunasol 180/220, which is an aromatics free distillation product. The used cationic surfactant was cetylpyridinium chloride (CPC). The needed amounts of CPC were determined by static equilibrium experiments to coat the soil particles with a monomolecular layer of the surfactant which hereby became hydrophobic.

Keywords: oil, Atterberg limits, conductivity, retention, surfactant

Soil salinity assessment

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Soil salinity is typically characterized in order to represent the high spatial and temporal variability in the field. Soluble ions are transported downwards in the landscape by surface water or groundwater and by soil solutions. Part of those ions can be precipitated in the soil or at its surface as solids by concentration of the solution, exchanged by ions adsorbed on clays, or incorporated into solution by dissolution of pre-existing soil minerals. The concentration and composition of the soil solution is highly dependent of the soil moistening/drying cycles that occur along the year. Salts concentration is not homogeneous in a soil profile and the maximum concentration can change from depth to surface, from the leaching season to the dry season, by vertical reactive transport.

Salt-affected soils can be delineated inside a region (small scale mapping) using remote sensing and photointerpretation; salinity can be mapped at very detailed scale at plot or farm scale using geophysical survey techniques, or described at sub-horizon detail in a soil profile. The information obtained can be used in very different ways as for taking the decision of implementing a new irrigation/drainage system that alleviates the salinity in a cultivated farm, or for investigating geochemical processes at Earth surface, including soil formation, or to investigate the spatial distribution of halophytes according to their tolerance to salinity.

The survey plan design should serve the main objective of the study, take into account the most suitable technique, the number of samples that should be taken and analysed, as well as how many times the survey should be repeated for providing the information for constructing a conceptual model that reflects the reality as close as possible, according to the objectives.

There are diverse instruments available that can be used for measuring soil salinity. Some of them are mobile and can perform quick measurements at affordable cost, offering the possibility of repeating the measurements at different moments of the year. Most instruments used for assessing soil salinity do not measure the same soil property (apparent soil electrical conductivity ECa, soil magnetic susceptibility, soil dielectric constant, water electrical conductivity ECw, etc) nor measure the same soil volume, and must be calibrated for providing an estimation of the soil saturated paste extract ECe what is used as reference in most studies.

Using the appropriate methodology and GIS, nowadays it is possible to produce high resolution 4-D maps of soil salinity.

Keywords: soil salinity, geophysical survey, mineralogy

Natural history and nature conservation at Büdös-szék (Pusztaszer)

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Büdös-szék is a temporary saline lake east from Pusztaszer village, originating as the lateral deflection of the late Dong stream. At first it was preserved as a local nature reserve by the municipality of Pusztaszer in 1960. Some years later it was preserved as a national protected nature area, in 1965, covering 443 hectares in total.
It became the part of the Pusztaszer landscape protection area in the Kiskunság National Park Management Centre, under increased protection. Thanks to its significant natural values now Büdös-szék is an area protected by the Ramsar Convention and the Natura 2000 Network (HUKN20019, HUKN10007) also.
Grazing has significant role in formation the vegetation of the salt affected grassland. There are now 300 Hungarian Grey cattles, and 140 water buffaloes at the animal breeding site of the Kiskunság National Park. The grazing and trampling of these animals is part of the management of this area.
The typical plant association at the Büdös-szék is "Artemisiasaline puszta". Typical halophyte species are *Salsola soda, Suaeda pannonica, Salicornia prostrata, Limonium gmelinii, Artemisia santonicum, Festuca pseudovina, Achillea asplenifolia, Agrostis stolonifera, Bolboschoenus maritimus*.
The real natural value of the Büdös-szék is its avifauna. The protected area is an important habitat for the nesting, migratory and overwintering bird species also.
Presence of 232 bird species has been proved by the regular observations by today, 80 from these are nesting species.
Typical bird species are: *Recurvirostra avosetta, Himantopus himantopus, Platalea leucorodia, Egretta alba, Egretta garzetta, Ardea cinerea, Charadrius alexandrinus, Pluvialis squatarola, Chlidonias hybridus, Chlidonias niger, Chlidonias leucopterus, Limosa limosa, Tringa totanus, Vanellus vanellus, Numenius arquata, Larus ridibundus, Anser anser, Falco vespartinus*. Several cranesrest at the shore in autumn. Migrating wild geese and wild ducks visit the saline lake in winter
Büdös-szék is endangered by some invasive plant species. The most aggressive among them are: *Robinia pseudoacacia, Ailanthus altissima* and *Asclepias syriaca*. Other problems are the low number of the grazing animals. National Park Management Centre use mowingas part of its grassland management.

Vertebrates of the Lake Bulukhta coast (Northwest Caspian Lowland)

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Lake depressions that occur in drainless plain of the Volga-Ural interfluve provide valuable biotope, species and ecosystem diversity. Different semi-aquatic, pioneer, meadow and shrubby communities are formed in riparian lands of salt rivers and lakes.
Our researches were carried out in 2001 – 2012 on the eastern shore of the salt lake Bulukhta (Russia, Volgograd region, district Pallasovsky). This lake belongs to the drying up water bodies such as shore. Vertebrate population is well studied for the lakes of this type. In such lakes abundance of water birds depends on presence of islands suitable for nesting, on water-level, on shoreline feature and width of reedbed zone. In the presence of water,flocks of nesting, wandering and feeding birds appear in the shallows water and shallows. Rookeries of *Larus ridibundus*, *L. cachinnans*, *L. canus*, *L. genei*, *Glareola nordmanni*, *Tringa totanus*, *Gelochelidon nilotica* and other species form on islands. At high water-level islands are flooded, shore line is swamped and small islands are cut off from shore. Rookeries move from flooded islands to the swamped areas.
The western coast of the Bulukhta unlike most of other lakes coasts is not complicated by modern flows, shoreline is not indented, and coastal slope is protected by shallows from surf. The semi-aquatic system consists of several typical communities extended along the shore. The altitude of the lake terrace is 18.5 m. It is ended by the high coastal slope (up to 1.8 m) and isn't flooded.
There are the following communities with a decrease of soluble salts content in soil body from the salt-marshes of the lake bottom to the lake terrace:
1) Glasswort (*Salicornia europaea* L.) zone is found on the external edge of the shallow. Its width is 3 – 40 m. This area is flooded in spring every year. It is visited by sandpipers gathering insects brought by the wind.
2) Reedbed (*Phragmites australis* (Cav.) Trin. ex Steud) zone is found on the high part of the shallow. Its width is up to 40 m. It is not found everywhere and flooded at high water-level. There are some species of ducks, *Ixobrychus minutus*, *Botanurus stellaris*, *Acrocephalus* and *Panurus biarmicus* (L.) nesting here. Wild boar (*Sus scrofa*) is found here. At high water-level some species of birds move from islands to this zone.
3) Sea aster (*Aster tripolium* L.) zone is found also on the high part of the shallow. Its width is up to 20 m. It is not found everywhere and flooded at high water-level. There are coveys of *Numenius arquata* and nests of *Motacilla flava*. *Mus musculus* visit this area at summer and autumn. It is favourite area for *Meles meles* and *Sus scrofa* feeding.
4) Tamarisk (*Tamarix laxa* Willd) bushes arefound on the terrace coastal slope. Its width is 5 – 50 m. There are *Circus pygargus*, *C. aeruginosus* and *Pica pica* nesting here. During migration more than 20 passerine species rest here. *Mus musculus* and *Microtus rossiaemeridionalis* are common here. *Crocidura leucodon* visit this area. There are settlements of *Microtus socialis* in bush gaps. *Bufo viridis* and *Vipera ursinii* are registered here. *Vulpes vulpes* and *Canis lupus* build their holes in coastal slope. Other rare, forest species such as *Erinaceus concolor*, *Mustela nivalis* and *M. ermine* are also registered here.

5) Halophytic subshrubs (*Halimione verrucifera* (Bieb.)Aell, *Halocnemum strobilaceum* (Pall.) Bieb., *Atriplex cana* C.A.Mey) zone is found on the lower edge of the lake terrace. Its width is up to 40 m. There are settlements of social vole and *Meles meles*, nests of *Melanocorypha calandra*, *Calandrella cinerea* and *C. rufescens* and single settlements of *Spermophilus pygmaeus*. *Bufo viridis*, *Lacerta agilis*, *Natrix natrix*, *Vipera ursini*, *Elaphe dione* are common here. *Erinaceus hemiechinus* is registered here.

So there is only one community suitable for water birds nesting of the five semi-aquatic communities of the lake Bulukhta, the reedbeds. However, even in case of flooding and shortage of nesting islands, only a few species of birds occupy reeds. Tamarisk bushes determine the preservation of rare forest species and attract migratory forest birds, but are indifferent to species of wetlands. The halophytic subshrubs zone is populated by species common to the drainless plain, and social vole finds here the optimal conditions of existence.

Keywords: semi-aquatic communities, birds, mammals, Lake Bulukhta

After fire recovery of natural Tamarisk communities on the Lake Bulukhta shore (Northwest Caspian Lowland)

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In the Volga-Ural interfluve scrub patches are associated with saline river valleys, ravines and lake coasts. By now natural scrubs of *Prunus spinosa*, *Spiraea hypericifolia*, *Nitraria schoberi* and *Tamarix laxa* are preserved here. Tamarisk communities play a key role as refuges for a large group of plants and animals of steppe and semidesert landscapes.

The purpose of our study was to appraise current state of the tamarisk scrubs and their stability to fire. At present we found out significant in size tamarisk scrubs only in the eastern shore of the lake Bulukhta (Russia, Volgograd region, district Pallasovsky). Our researches were carried out in 2001 – 2012.

Explored scrubs grow on part of the coast extending about 3.5 km. They are divided into 3 groups according to growing conditions:

1) communities on the coastal slope unprotected by shallow;
2) communities on the coastal slope protected by shallow;
3) communities on the flattened coastal slope.

Tamarisk bushes of the 1st and 2nd communities had a height of 1.2 – 1.5 m. Their special feature was that the long bush branches were lying on the ground and were covered by sediments and fastened by several thin shot roots. The thickness of the body at the base was not more than 8 cm. Bases of the bushes in spring were thickly overgrown by *Galium aparine*, that died off by mid-June.

Tamarisk of the 3rd community previously represented a closed stand consisting of bushes with the height of 2.5 – 4 m. The thickness of the body at the base was on the average 12 cm. From the side of the lake *Phragmites australis* get into the scrubs. In contrast to the tamarisk on coastal slope these scrubs' lower branches die when lying on the ground.

Scrubs of the 1st group were burnt in 2002 and 2004, of the 2nd group were burnt in 2005, and scrubs on the flattened coastal slope – in 2008. Tamarisk recovery in each community had its peculiarities.

Tamarisk scrubs on the coastal slope unprotected by shallow. After the death of tamarisk scrubs here coastal erosion dramatically increased. As a result of it the coastal slope retreated by about 2 m in 2006. Most of the tamarisk bases in the form of stubs, which were standing on the exposed roots, landed below the slope on the salt-marshes in the bottom of the lake. At present, only singular bushes confined to the uppermost part of the slope survive here. But obviously due to the intensified erosion of the coast they also die. This is confirmed by the absence of tamarisk scrubs in many areas of the open coast.

Tamarisk scrubs on the coastal slope protected by shallow. For the next year after the fire in 2005 from the bases of almost all bodies shoot bunches grown. By the end of June, their length was 30 – 40 cm. In 2012 burned areas differed from unburned by only a weak development of lying shoots on the ground towards the lake. There were plenty of tamarisks regenerated by seedon the slope and on the edge of the terrace in autumn 2006, but it didn't survive to the next year. At the same time on the burned area of the coastal slope in 2006 scours depth 0.3 m were fixed. On the location of such scours

gaps appeared in continuous tamarisk scrubs. At present erosion is continuing here and bushes are not restored. The weakening of erosion in these areas is likely to occur only after the regrowth and fastening on sediments of lying branches of neighbouring bushes.
Tamarisk scrubson the flattened coastal slope. As a result of fire in 2008 at a part of bushes that were closer to the lake branches and bodies died at a height of 50 – 60 cm, but the lower of them wasn't affected. The surviving branches continued to vegetate and in September regrowth of new shoots began. In autumn 2009 the height of bushes was 1 m, and by 2012 it was 1.5 m and length of some lying branches was 2 m. It is obvious that the growth of tamarisk here will continue and reach biomass that had before fire. In the middle of the scrub fire stopped. Some trunks and branches were burned and died here. In spring of 2009 from dead trunks numerous shoots began to grow. In 2012 the central part of the scrub wasn't different from the nearby lakeside scrub that was little affected by fire. However, some of the bushes have not been closed by the lying brunches and the scrub consists of separate patches. Scrubs on the border of the slope and terrace were fully burnt and not restored.
Thus, natural tamarisk scrubs of the eastern shore of the lake Bulukhta protect this coast from erosion. After fire they can only be restored in the area protected from surf. In favourable environments tamarisk actively restore and vegetative rejuvenation of plants occurs.

Keywords: *Tamarix laxa*, Bulukhta, restoration.

Diagnosis of ecological indicators for in situ conservation of cliff dwelling endemic sea lavender *Limonium multiflorum Erben*

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The sea lavender *Limonium multiflorum* Erben (*Plumbaginaceae*) is a perennial aneuploid tetraploid species (2*n* = 4x = 32, 34, 35, 36) endemic to marlstone sea-cliffs of the Portuguese coastline (Erben 1978; Róis et al. 2012). Its populations are mainly found in sites of Community importance for the Mediterranean biogeographical regions in the West, being most of them composed of few individuals and exposed to human disturbance, particularly urban development. In order to diagnose the reproductive ecology and ecological indicators favourable to the development of *L. multiflorum*, we choose the largest known *L. multiflorum* population within its restricted distribution range and used a set of permanent plots covering a physiographic gradient. We investigated reproductive features and20abiotic and biotic requirements for the persistence of *L. multiflorum*. Results showed that the highest number of plants and seedlings occurs in close proximity to the coastline. All plants selected randomly for reproduction investigations show very high male sterility albeit they produced hundreds of seeds, a characteristic of apomixis (asexual seed production). We also found that the presence of the species is seemingly correlated with proximity to the coastline and exposed rocks where competition with other species is very low. To guarantee the success of long-term conservation strategies for *L. multiflorum* it will be necessary to restrict human-driven changes along the coastline, insure vegetation control and perform genetic characterization of *L. multiflorum* germplasm before re-introduction of genotypes, as means to avoid change in evolutionary population trend in consequence of its reproduction mode.

Soils and vegetation as indicators of ecosystem recovery in a former saline exploitation following its irrigation with seawater

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The abandonment of saline exploitations is one of the main causes leading to the degradation of associated salt marshes. During the management of the salt industry, the ponds are regularly flooded with saline water that permits the existence of a typical wetland ecosystem with halophyte vegetation. However, when the activity ceases, the ecosystem may suffer intense desiccation and degradation. In that case, the establishment of an irrigation program might be a management practice suitable to increase the moisture and recover the ecosystem. The Agua Amarga salt marsh (SE Spain) is located in a former saline exploitation in which seawater was pumped for commercial extraction of salt between 1925 and 1975. The abandonment of the exploitation led to a deterioration of the ecosystem that was aggravated from 2003 up today, due to the construction of two desalination plants nearby the salt marsh, which led to a fall in the groundwater level. In 2009 an irrigation program started by pumping seawater into the old saline ponds. Different zones of the marsh are irrigated at different rates, in order to provoke heterogeneous environments. A monitoring program of vegetation and soils was established in order to evaluate the effectiveness of the irrigation program in the ecosystem recovery.

In spring 2010 a total of 76 relevés of vegetation were taken in the salt marsh. With these data a map with 10 different environments/types of vegetation was made. In addition, the visual aspect of the plants was evaluated in order to estimate the damage of the vegetation due to the dryness of the marsh until 2009. In spring 2011 and 2012, 38 of the 76 relevés were selected as representative of the environments/types of vegetation of the salt marsh and data of species cover were recorded again. Additionally, new relevés of vegetation were taken when necessary in zones newly colonised by the vegetation in 2011 and/or 2012. In winter 2011, spring 2012 and summer 2012 a total of 63 surface soil samples were taken in the salt marsh representing the 10 environments/types of vegetation. With this sampling scheme, spatial and temporal gradients of salinity and moisture were analysed. In addition, soil samples were extracted from 60 cm depth in selected sites in order to evaluate the effects of the groundwater and flooding on soil profile (redoximorphic features were described). Edaphic gradients and soil-plant relationships were analysed by means of Principal Component Analysis (PCA) and the results were summarised in a model that can be useful for improving the management of the salt marsh. The irrigation program is favouring the recovery and diversity of the ecosystem. Vegetation cover in the marsh increased, and the existence of prolonged flooding periods in some areas favoured the growth of submerged species and the death of non-adapted species. Moisture and salinity were the main factors influencing the gradient and explained most of the soil-plant relationships.

Keywords: soil-plant relationships, gradients, management, coastal wetland, PCA.

Forest-groundwater interactions in Great Hungarian Plain

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Forest cover in the Great Hungarian Plain increased during the last century. The hydrological effects of trees that they can extract water from much deeper soil layers by their deep roots. So forest cover causes water table depression and subsurface salt accumulation above shallow saline water table in areas with a negative water balance.
The impact of forest cover is examined by a systematic study, which analysed a lot of factors, like climatic water balance, water table depth and salinity, three species, subsoil layering and stand age. At the stand scale 18 representative forested and accompanying non forested plots are monitored intensively. In this paper dataset of some plots was compared. On the basis of the research it can be stated that the water table was lower, and the amplitude of daily fluctuation of water table was significantly larger than under the herbaceous vegetation in the growing season. Both results demonstrate greater groundwater use of forest.
Larger forest groundwater use is not proportional to salt uptake, therefore salt accumulates in soil and also in groundwater as can be measured at the representative monitoring sites as well. In the long run this process can result in the decline of biological production or even the dry out of some parts of the forest. Greater groundwater uptake and salt accumulation effect can be especially true under the more significant drought conditions of global climate change.
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Keywords: groundwater evapotranspiration, diurnal fluctuation, forest

Salinity in agriculture: irreversible constraint or possible resource? Romanian experience

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Nowadays, salinity and drought are two major factors affecting plant productivity and plant distribution. Dealing with salinization represents a very difficult business and requires a well-established long term strategy. Most likely, salinization was involved in the fall of some famous ancient civilization, but today continues to put under the question the future of agriculture in an obscure scenario of global crisis and food insecurity. In Romania, there are about 520,000 hectares of saline, alkali and salt-affected soils, but these values are no doubt subjected to a certain degree of relativity. Actually, the history of "saline agriculture" in Romania is mainly related to the period 1950-1990. Despite the fact that there were some early and scattered data regarding the possibility to ameliorate these salinized areas – especially *via* non-biologically methods – the attempts to remediate them, in a systematic manner, were conducted starting from the end of '50s. These efforts have been incorporated by the new installed political regime in the frame of entire agricultural strategy, in order to increase the arable surface of Romania by exploiting all potential resources. Thus, salt-affected and marshy surfaces have been included. A special attention was paid on salinized areas affected by secondary salinization mainly induced by irrigation systems. Apart from agro-technical methods used in order to decrease the salt contents from these areas (salt leaching, gypsum treatments, and drainage methods), several species were also tested for selecting those suitable to be economically cultivated in natural salinity conditions. Thus, a large number of species have been used with encouraging results, in the terms of productivity. Here, we can mention some crops (rice, sugar beet, and salt tolerant maize and sun flower cultivars), fodder (sorghum, *Puccinellia distans*, alfalfa, *Lotus corniculatus*, and other leguminous species), and ornamental woody species. The last mentioned species were also taken into account due to their capacity to prevent the soil erosion (*Elaeagnus angustifolia*, *Cornus sanguinea*, *Cotinus coggygria*). But preliminary and promising results have been also reported for several other species, but their efficiency in the field will have been expected to be recognized during the years. Sometimes, these biological "methods" were accompanied by mechanical methods or chemical supplies in the soil. Of course, the efficiency of these attempts, in the terms of costs and incomes is disputable; today it's very difficult to assert that all these efforts were profitable, although some chemical compounds, for instance, were residuals originating from various factories. Anyway, after 1990, when communism has been collapsed in Romania, a large part of this work was abandoned and the entire agriculture suffered important and unexpected changes. In the present, the precise surfaces of salt-affected areas, as well as the status of "saline agriculture" are difficult to be quantified, due to a relative gap of data, from 1990 until present. Salt-affected areas are mainly confined to the inland and not to the littoral, so the use of salt water (*stricto sensu*) for irrigation has not been considered in the Romanian agriculture, as is the case of many countries threatened by intense salinization and aridization. In this situation, salt water – pure or diluted, would play a pivotal role in irrigation systems.
Keywords: salinity, agriculture, remediation, strategy

Ecology of halophytes in a Romanian endangered nature reserve

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Salt areas from Valea Ilenei (Leţcani) occupy a surface of about 10 ha; this nature reserve is located 4 km from Leţcani railway station, next to Iaşi-Dorohoi railways at the confluence of Valea Ilenei and Bahlui rivers. Yet it is a small nature reserve, several species are included in the *Red Book* of Iaşi district, such as: *Lepidium crassifolium, Petrosimonia triandra, Plantago schwarzenbergiana*. In addition, although very interesting and attracting from botanical point of view, little has been done in respect of studying halophytes distribution and their ecology. Salt areas do not have a uniform distribution; their zonality is strongly influenced by local environmental factors: soil humidity and salinity, rainfall and elevation of salt-affected surfaces. Our ecological observations, conducted from 2006, revealed a halophytic transition starting from the wettest and saline area to the elevated areas, where the soil humidity and salinity decreased. Therefore, three micro-habitats were delimited and described. 1. Wet micro-habitats, seasonally flooded, located in shallow depressions. Nearby river, a band with *Phragmites australis* is located; hygro-halophyte, such as *Bolboschoenus maritimus, Juncus gerardi, Carex distans, C. vulpina, Alopecurus arundinaceus* can be also found. These species were previously described by us as *amphibious* halophytes. Strictly related to salinity and soil humidity, *Salicornia europaea, Suaeda maritima* and *Aster tripolium* were also observed. *Salicornia* and *Suaeda* are succulent species, with less developed mechanical tissue; therefore, they require water for growth and development. Rarely, *Atriplex prostrata* and *A. littoralis* may be found in less humid areas. Here, soil salinity, measured as electrical conductivity in the plants' rhizosphere, has values ranging from 2.39 to 11.82 dS/m^{-1}. 2. A large, heterogeneous micro-habitat, connecting the previous area to the third, the most elevated micro-habitat, which is far away by the river. Here, *Lepidium crassifolium* vegetates, a typical rare halophyte, preferring wet, marshy areas; it is a perennial species, with deep underground system, thus allowing reaching the water table. *Halimione verrucifera* has been found in compact, free of vegetation patches. On the driest, elevated surfaces, *Aster linosyris, Limonium gmelinii* and *Artemisia santonica* can be found. All mentioned species have been also investigated from anatomical and ecophysiological point of view (data not shown). Their adaptations are strictly related to environmental factors, revealing the intimate plant-environment connection. Measured electrical conductivity has values in the range of 2.29 to 10.56 dS/m^{-1}. 3. Meso-hygrophilous meadows, less or moderately salinized, extended on a large surface, where many species were observed, but their adaptations and ecology are not closely related to salinity factor: *Dianthus* species, *Allium vineale* and many *Fabaceae* species.
This small, but fascinating nature reserve needs further studies, in order to get a complete picture of halophytes distribution, since the vegetation aspect is changing every year, due to climatic conditions, but also to the anthropic impact.

Keywords: ecology, salinity, halophytes, adaptations

The effect of used thermal water on soils at Zalakaros area

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One of the main direct and indirect receptive medium of percolating water that arises in the course of the utilization of thermal water is the soil. Percolating to the ground may change the physical and chemical parameters of the soil. The nascent environmental damages may extraordinarily meaningful if the recipient is situatedin a sensitive area that is important in terms of nature conservation.
The health resort of Zalakaros functions since 1956. The used thermal water releases into a natural recipient, from where it flows into the Kis-Balaton Lake, which represents highly important environmental value.
At our University we examine the surface water quality of the area from 2007. In December 2007 we selected six control points between Kis-Balaton Lake and the health resort, next to the canal. Water samplings were collected monthly from these points. Temperature, total salt content and the different composition of ionic concentration (sodium, potassium, calcium, magnesium, chloride, sulfate) of the samples were examined according to the Hungarian Standards. The alkalinity and total hardness were determined also from water samplings. Isotopiccomposition of samples were measured at the Institute for Geological and Geochemical Research, Research Centre for Astronomy and Earth Sciences Hungarian Academy of Sciences.
In this poster we would like to show results of the surface water quality.

Keywords: thermal water, water quality, isotope analysis.

Linking salts, groundwater, and vegetation in the (hyper)plains of South America

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Across the world, very flat sedimentary regions or "hyperplains" (regional slope < 0.1%), tend to host stagnant hydrological systems that restrict net liquid water losses and favour salt accumulation. Based on examples from the hyperplains of Southern South America this presentation shows how the natural distribution of salts in these landscapes is strongly controlled by the surface and ground water balance, shifting from (i) widespread deep accumulation in dry regions to (ii) focal surface accumulation in lowlands in semiarid-subhumid regions to (iii) flushing and evacuation in humid and regularly flooded regions. This natural climatic gradient, however, is highly dependent on its associated vegetation types, changing rapidly when they are altered by humans.
In the dry Chaco woodlands, vadose salt pools located below the rooting zone (2-6 m of depth) were built-up over millennia as a result of the lack of deep drainage, but become flushed towards the phreatic aquifer in a few decades following clearance and cultivation, as shown by deep coring at four locations with multiple woodland-crop paired stands. Rising groundwater levels, as shown by geoelectrical profiling and boreholes, combined with the on-going deforestation suggest that surface salinization, as seen under similar conditions in Australia, is an important environmental risk that needs consideration and careful monitoring in this region (shift from condition i to ii).
In the subhumid grasslands of the Pampas, soil moisture, water table level and sap flow measurements indicate that the establishment of tree plantations switched the water balance from positive to negative. This switch created "islands" of high groundwater discharge and salinization that behave like virtual discharge lowlands in spite of being located in relatively high landscape positions. The intensity of this process is higher with drier climate, shallower water tables, coarser soil textures, and higher salt tolerance of tree species. These results suggest that massive afforestation in the Pampas could create conditions like those seen in the Chaco dry forests (shift from ii to i). In the Parana river delta, a highly positive water balance sustained by periodic fluvial floods maintains a salt-free landscape. There, however, the establishment of polders that interrupt the flood regime shift the water balance from positive to negative, triggering a slow salinization process that hampers tree production four decades after floods were controlled (shift from iii to ii). Observations in these hyperplains highlight the dynamic nature of the salt pools that they host and their intimate link with groundwater and vegetation. Reciprocal links between these three components (salts-groundwater-vegetation) need to be considered in order to explain unexpected salinization processes as well as the elimination of naturally salt-affected ecosystems following land use changes.

Keywords: Chaco, dryland salinity, land use change, Pampas, water table dynamics.

Some physical and chemical properties of salt-affected soils in tree plantation

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Soil salinity is one of the most widespread soil degradation processes on the Earth and one the main physiological threats to ecosystems. Salt-affected soils often occur on irrigated lands, especially in arid and semiarid regions, where annual precipitation is insufficient to meet the evaporation needs of plants. Salt-affected soils are the major cause of desertification.

This research has been carried out to determine the effects of salty irrigation water on soil in the tree plantation and changes of some physical and chemical properties of salt-affected soil. This research has been investigated under field conditions, in an experimental area in Ankara. In this research, various tree species such as poplar, willow, acacia species and clones and salty irrigation water pumping from Ankara Stream have been used. This experimental area has been irrigated by Ankara Stream with salty water for many years until the end of 2007.

Growing tree species have been observed during two years. Changes of some physical and chemical properties of salt-affected soil in 2006 and in 2007 have been investigated. Soil samples have been taken from different depths to determine some soil properties such as texture, pH, EC, lime content (% $CaCO_3$), organic matter (% OM) and nitrogen (% N). Irrigation water samples have been collected from different point of Ankara Stream. Irrigation water amounts depend on precipitation and liquid wastes.

According to results of analysis of irrigation water both in 2006 and 2007; pH values of irrigation water are neutral, EC values are highly saline (category 3). Both values of pH and EC are close to each other. Results obtained from soil samples show that soil texture is mainly clay and clay loam, pH values change from 7.91 to 8.37. EC values are low and non-saline. $CaCO_3$content is small. Organic matter and nitrogencontent is low.

Phenological observation shows that there is not any problem for tree growing because of soil buffering capacity and salt tolerance of trees. Fast growing plant species, poplar, willow, acacia, are salt-tolerant plants and they tolerated negative effects of salty water.

Keywords: Soil, soil properties, salt-affected soils, salty irrigation water.

Prediction of the water retention of salt affected soils in Csongrád County according to the available soil map information

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Pedotransfer functions and rules developed for salt-affected soils represent a special group of soil hydrological estimation methods. This particularity originates from the unique physico-chemical properties of these soils, which have a fundamental influence on soil water characteristics and related land management options too. Literature shows that besides particle size and pore size distribution, chemical properties of the soils are also essential to describe the water retention of these soils.
The aim of the current study was to predict water retention of salt-affected soils at -0.1, -33, -1500 and -150000 kPa matric potentials and plant available water content. The CHAID method was used for developing pedotransfer rules based on ordinal and nominal soil properties as available from soil maps.
Different data sources (1:10.000 and 1:100.000 soil maps and the georeferenced National Pedological and Crop Production Database, acronymed AIIR) were used to draw the available water content map of the salt-affected soils of Csongrád County.
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Keywords: salt affected soils, soil maps, pedotransfer rules, soil water retention, available water content, soil climate sensitivity

Soil-ecological conditions of natural Tamarisk plantations growth on the coast of saline Lake Bulukhta in Pricaspian Lowland of Russia

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In woodless semidesert of northern part of the Volga-Ural interfluve areas of natural woody-shrub vegetation (*Prunus spinosa, Nitraria* sp., *Tamarix laxa, Rhamnus cathartica*) occur in valleys of salty small rivers, beams and shores of saline lakes.
Lake Bulukhta is placed in northern part of Precaspian lowland. It has a residual-erosive origin, the complex configuration of the sea line dismembered by superficial gullies and here and there complicated with suffosion-karstic phenomena. The lake is very shallow, during most of year it is represented by a salt-marsh, with free water cover only in a small part.
The soil mantle of east coast had been studied by means of three topo-ecological catenas, located at plots with a various constitution of a coastal slope. These catenas began from the border of vegetation at the bottom of lake and ended at the surface of the second terrace. The highest positions of these catenas are occupied with "Solonchakous Solonetzes", the depth of groundwater table here is about 4 m. Down the slope "Quasi-gley Solonchakous Solonetz" soils are formed; groundwater table occurs at the depth of 1.8 m. At the bottom of the slope on the flat surface chestnut solonetzic soils are formed, their profile is washed out from salts down to the depth of 43 cm. It is caused by inflow of water from elevated positions. Directly in front of the coastal ledge meadow-chestnut salt-affected soils are formed, with well-marked humus horizon. Shallow water table (1.34 m) and strongly saline groundwater (34 g/l) determines the active salinization of the lower part of the soil profile. The bottom of lake is occupied with "Shor Solonchak", characterized by high salinity from the surface.
The plantations of tamarisk (*Tamarix laxa* L.) are formed on the meadow-chestnut salt-affected soils of a coastal slope. Depth of groundwater table is here 70–100 cm, and their mineralization is 17–21.6 g/l. Depending on a steepness of coastal slope, the height and a density of tamarisk plantations varies. In case of a flat shore the strip occupied with tamarisk, reaches 50 m width, and the height of separate bushes compounds 2–3 m (1.5 m on the average). At a well-marked coastal ledge the tamarisk strip is narrowed to 10–12 m, and the height of bushes decreases to 50–130 cm.
Despite good adaptiveness of tamarisk to hot and arid conditions, ability to tolerate severe salinization of soil and groundwater, now there are no conditions for its seed renewal on lake Bulukhta coast. All plantations here have a vegetative origin. It allows us to assume, that the studied plantations are relict preserved here throughout hundreds of years, and only the good ability of tamarisk for vegetative restoration and its high tolerance to unfavourable environmentalfactors allows this shrub to persist in these conditions. So, these plantations require preservation as their extinction will lead to decrease of the biodiversity of the region, and also will reduce erosional-preventive stability of coastal slopes.
This study was supported by the Russian Foundation for Basic Research (project № 12-04-31041).

Keywords: salt-affected soils, Pricaspian Lowland, solonetzes, semidesert, tamarisk

Economic importance of Turkey's endemic halophytes

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Turkey has 78 million hectares of land area and 4 million hectares of this area is affected by salt. Considering the limited agricultural areas it is very important to protect halophytes in Turkey and in the world. The flora of Turkey is relatively rich; the number of plant species distributed in Turkey is close to the number of plant species when compared with European continent. In recent years according to the researchesin Turkey 12 000 taxon of plants have been determined and the ratio of endemism is 34.4%. Halophytes comprise important group among these endemic plants.
The high salt concentration in the soil affects the plant life negatively, but some plants (halophytes) are resistant to salt concentration in the soil. Halophytes are plantsadapted to high salt conditions and they also sustain their lives in these conditions. Many endemic plants in saline soils in Turkey are found around Salt Lake (Tuz Gölü).
In the past, the importance of halophytes could not be understood because of the negligence and they were thought to be an obstacle to agricultural production. In recent years, the importance of the halophytes are understood in areas such biological diversity, erosion, landscape, animal feed, glue, food, fuel, essential oil and etc. Then studies on the adaptation trials and resistance to salt mechanisms of halophytic plants have gained momentum. These plants which have very important contribution to the national economy are naturally grown in certain areas in Turkey and many of them are endemic. In this study some of the endemic halophytic plants of Turkey and their economic value are investigated.

Keywords: halophyte, economy, endemic, Turkey.

Influence of soil salinization on the growth of *Quercus robur* in the forest-steppe zone

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The aim of the work was to elucidate (i) what parameters of soil salinization restrict the distribution of *Quercus robur* and may mark the boundary between the oak forest and salt tolerant herbal vegetation and (ii) how in general soil salinization influences the development of trees and forest stand.

The studies were performed at the Tellerman experimental forestry of the Institute of Forest Science Russian Academy of Sciences (111°20′53″N, 41°58′35″E, and 160 m a. sl.) on the native bank of the Khoper River. Main areas of the interfluves and slopes of the native bank were occupied by gray forest soils, solonetzic soils were observed on some small areas of upper parts of gentle slopes. These sites were without forest stand and were covered by herbal vegetation with prevailing wormwood in the plant associations. The oak forests vicinal to the opened areas had low productivity rating. The oak forests of high productivity ratingwere developed on the gray forest soils located on slopes of the native bank.

The analysis of water extracts of soils under the oak forest and under the herbal-wormwood opened solonetzic sites have revealed that the soils of both sites had weak salinity deeper than 50-60 cm. The salinity of soils of both sites was similar (about 10 mmol/ 100 g soil); however the composition of salts differed. The soil under herbal-wormwood opened solonetzic site had mixed sulfate-soda type of salinization: 13-20 % of SO_4^{2-}, 43 - 56 % of HCO_3^-, and 21-29 % of Na^+. The sum of Ca^{2+} and Mg^{2+} ions did not exceed 2%. The soils under the oak vegetation had mixed type of salinization with prevailing of Ca and Mg sulfates: 64-68 % of SO_4^{2-}, 4-8 % of HCO_3^-, 8-20 % of Ca^{2+}, 5-8 % of Mg^{2+}, and 7-14 % of Na^+. The content of Cl ion in both cases was small and reached 0,1 -0,3 mmol/100g soil. Therefore the restrictive parameters for the distribution of Quercus robur in the area studied were the total content of sodium, carbonate and bicarbonate ions – 7-8 mmol / 100 g soil.

In the profile of soils under the oak stands with high productivity rating readily soluble salts were absent. The oak forests adapted to saline soils and those on non-saline soils had distinct differences of their growth, productivity, and state.

The oak stands on the solonetzic and gray forest soils had the following parameters respectively: phenoforms – early and late, the age – 120 and 80 years, maximal height – 15 and 33 m, basal area at breast height (m^2 ha^{-1}) 7.5 and 24.1, crown projection area (ha ha^{-1}) – 0.18 and 0.37, leaf area index (ha ha^{-1}) – 2.9 and 3.3. The state of the forest stands considered during past 25 years changed from slightly to strongly weak and remained stable within periods up to 3 - 20 years. Maximal annual stem radial increment (2012 year) in the solonetzic forest stand was distinctly lower – 2.2 mm (including 2 layers of plant vessels) compared to that of the high productivity rating one – 3.7 mm (including 3 layers of plant vessels). There is evidence that in solonetzic forest stand during the second half of vegetation period, plastic carbohydrates are mainly stored and are used for adaptation during unfavourable periods.

This research was supported by the Russian Foundation for Basic Research (12-04-01347).

Keywords: salted soils, *Quercus robur*, adaptation, growth, state

Decomposition of organic matter in natural and anthropogenic semi-desert ecosystems

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The development of saline soils results in the change of decomposition rate and stock of organic matter which enter the soil surface. In turn these parameters condition the rate of input of nutrients into the soil and the plant nutrition supply. This influences the restoration of tree crowns, life-time, and survival of trees and determines the pastures productivity.

The goals of the work were to compare the rates of decomposition of organic matter that enter the soil surface in natural and anthropogenic ecosystems developed on soils of solonetz complexes. We studied the rate of decomposition (i) of dry parts of grass in desert and steppe natural ecosystems, (ii) of fallen leaves in 60-year plantations of oak (*Quercus robur*), (iii) excrements of sheep in natural associations intensively used as pastures during several decades. An important question was to compare the stocks of nitrogen and carbon conserved on the soil surface in various ecosystems.

Our investigations were carried out in northern part of Caspian Lowland (Volgograd region, Russia, $49^{o}25'46^{o}46'$). Natural ecosystems in this region are represented by deserted (micro hills with solonetz soils) and steppe (micro- and meso-depressions with meadow-chestnut soils) types.

Bags with plant material or sheep excrements were placed in the sites, where usually they entered in natural conditions. The structure of plant cover was conditioned by micro-relief of the surface and had a mosaic pattern. The bags with plant material were fixed on elements of relief typical for the respective plants – *Festuca sulcata* Hack and *Stipa lessingiana* Trin. & Rupr in the micro-depressions, where moistening is better due to water from melted snow (steppe type of ecosystems), and *Artemisia pauciflora* Web. and *Kochia prostrate* Schrad.– in the micro-elevations, where water regime is worse (desert type of ecosystems). Naturally the plants of the same species form spots with diameter from 0.5 m to several meters and the input of each plant kind is localized. Therefore each bag contained the plants of one kind. The bags with excrements were fixed both in micro-depressions and elevations, the bags with oak leaves – on the surface under the trees, where they were collected. The samples afterwards were composted in 6 replicates during the year. Prior and after composting the mass, moisture content, C and N were determined.

The rate of excrement decomposition was somewhat higher than that of the plant material: the residual mass in samples with excrements was 65±0.9 % of the control, about 80% - in samples with grass material, and 97±5% in bags with oak leaves. Taking into account the volume of the material which entered the surface in the ecosystems studied (Kulakova, Abaturov, 2010) it was demonstrated that in steppe associations the surface accumulates in average 1080 g/m^2, in desert ecosystems – 360 g/m^2, in pastures not more than 190 g/m^2 of plant residues and less than 60 g/m^2 of excrements.

During the decomposition the material is essentially changed. The losses of carbon were 26-30% in the sheep excrements, 29-33% in the grass litter, 32-38% in the litter of desert vegetation. The least changes were found in the oak litter – the carbon losses were 5%. The losses of nitrogen were the highest in samples of the *K. prostrate* Schrad and excrements – 61 and 43% respectively. The litter of *A. pauciflora* Web and oak lost

20-23% of nitrogen and the stocks of grasses increased by 5-25%, evidently due to the net fixation in more humid conditions.
In a result on the soil surface of steppe ecosystems 424-448 g/m^2 of carbon and 11-15 g/m^2 of nitrogen remained, on the soil of desert ecosystems – 141-160 and 5-6 g/m^2 respectively, of the oak plantations – 125 and 3 g/m^2, on pasture – 108 and 3.8 g/m^2.
Annual deposition of nitrogen and carbon on the surface of anthropogenic ecosystems decreased compared to natural steppe and desert biocenoses. In the oak plantations it occurred due to less amounts of the litter, although the rate of decomposition was lower here than in natural biocenoses, and in pastures – due to less amounts of the entered organic material and higher rate of its decomposition.
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Keywords: solonetz soils, organic matter decomposition

Water retention estimation of Hungarian salt affected soils using the MARTHA database and soil map information

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Soil water storage capacity and the efficient use of the retained water depend on a number of site-specific factors related to climate, soil, land-use and farming systems. The potential effect of climate change on soil water storage and agronomic productivity is different among ecological regions and soil types (subtypes or varieties). Data are needed on the characteristics of the projected climate change, soil properties (e.g. water retention, conductivity) and plants.
Soil water retention (SWR) at -0.1, -33, -1500 and -150000 kPa matric potentials and available water content (AWC) were estimated from information available from 729 horizons of salt-affected soils of the Hungarian Detailed Soil Hydrophysical Dataset (acronymed MARTHA). Ordinal and nominal (categorical) variables, including texture, organic matter content, calcium carbonate content, soluble salt content, pH and soil subtype classes of the soil map were used to develop pedotransfer rules with the CHAID classification tree method.
The elaborated pedotransfer rules were applied on the Hungarian 1:100 000 soil map (AGROTOPO) and the georeferenced AIIR database (National Pedological and Crop Production Database) to generate available water content map for the topsoil of salt affected Hungarian soils.
This type of maps could be basis for preparing climate sensitivity maps of Hungarian soils in the future.
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Keywords: soil water retention, soil climate sensitivity, pedotransfer rules, available water content, salt affected soils

Salt removing species as environmentally safe technique to control salinity in irrigated fields

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Soil leaching or fertilization are the conventional techniques used to control soil salination process, however they contribute highly to soil and aquifer contamination. On the other hand, the use of salt tolerant species may be very useful, but does not solve the problem of soil or groundwater contamination. An alternative way to control the salination process and to maintain the sustainability of landscape and agricultural fields is to combat the salinition problems by salt removing species - an environmentally safe and clean technique. In order to study the potential capacity to remove soil salts, five wild species *Beta maritima, Limoniastrummonopetalum, Portulaca oleracea, Tetragonia tetragonioides,*and *Lotus creticus* were evaluated for their efficiency to remove salts from a sandy soil. Plants were analysed relatively to total growth and mineral composition of the leaves. According to the results of plant growth and leaf analysis, it was seen that *Tetragonia tetragonioides* is the best salt removing species and, complementary, it has other interests, as follows: 1) high biomass production potential; 2) several harvests during the year (summer and winter); 3) high content of minerals; 4) horticultural importance, as a leaf vegetable crop; 6) easy multiplication (seed propagation) and easy crop management; 7) tolerance to drought and hot conditions; 8) soil erosion control due to its excellent soil covering. As concluding remarks, it was shown that this new technique to control salinity is a powerful and environmentally clean tool to maintain the sustainability of irrigated areas.

Keywords: *Salicornia ramosissima, Sarcocornia perenis,* salinised soils, food quality.

Inland salt marsh vegetation in Central Europe

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The main topic of the research wasthe plant-environment relations in natural and anthropogenic inland saline areas in Central Europe.The investigations covered most of the existing sites of inland halophytes in Poland, known from the literature. In order to perform the analyses in an even wider range of ecological factors, the studies were performed alsoin a few salt marshes in Germany. In the first stage habitat properties of the studied sites of halophytes were analysed. In the next stage, a general vegetation patternwas investigated and the importance of different salinity measures for the development of this pattern was compared. The subsequent analyses were carried out in order to investigate whether the species composition and cover/abundance of species in vegetation patches is related to intensity of influence exerted by particular environmental variables.For this purpose, the studied patches were grouped. It was analysed which environmental factors are the most important in differentiation of the distinguished groups, and what is the relationship between their occurrence and the local environmental conditions.

Results demonstrate that values of soil salinity expressed as EC_e recorded in the studied area in Poland indicated a gradient from non-saline (< 2 $dS \cdot m^{-1}$) to very strongly saline soils (>16 $dS \cdot m^{-1}$). The salinity was higher at the studied sites in Germany – the salinity gradient included moderately saline (4-8 $dS \cdot m^{-1}$) and very strongly saline soils (>16 $dS \cdot m^{-1}$). The same types of soil salinity were recorded both on the German and Polish salt marshes i.e. chloride, sodium-chloride, sulphate-chloride and chloride-sulphate. The most dominant ions were Na^+ and Cl^-, pH ranged between 6.8 and 8.7.

The comparison of different salinity measures and their importance in the vegetation pattern demonstrated that the largest part of vegetation variation is explained by ionic composition expressed as a concentration of ions in the soil solution. The results of CCA analysis with the forward selection and permutation test revealed that following factors differentiate the studied vegetation in a statistically significant way: location-country (Poland, Germany), the content of organic matter in the soil, general salinity expressed as EC_e, all included methods of land management/land use, soil moisture and pH, and the content of ions HCO_3^-, Ca^{2+}/Na^+, K^+, SO_4^{2-}. The analysis of variance partitioning between four categories of the factors indicate that the largest amount of species variance was explained by soil salinity, then by management type followed by soil type based on organic matter content and at the end by location of sites.

After clustering the relevés based on the species composition similarity seven main groups of phytocoenoses were distinguished. The results of discriminant analysis revealed that groups II and III comprise phytocoenoses occurring in places with the highest salinity, groups VI and VII include mainly communities on soils with a higher content of nitrogen and organic matter, and finally groups I, IV and V include communities occurring on soils with relatively higher content of bicarbonates and higher contribution of sulphate ions compared with chloride ions. In terms of species composition plant communities distinguished by the methods of numerical classification

correspond to plant associations described previously from saline areas of Europe.
Keywords: halophytes, soil salinity, ordination, CCA, CVA

Evaluation and preservation of autochthonous vegetable landraces grown on saline areas from West part of Romania

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Saline soils in western Romania comprise almost 200.000 ha. We have previously identified this type of soils by analysing their composition in Cl^-, Na^+, Ca^{++}, Mg^{++}, K^+, $SO_4^{--}$and precise mapping (Ardelean et al., 2003; 2004). In these areas the cultivation of vegetables such as onion, garlic or tomato's in household system and micro-farms is traditional but there is also a great pressure for introducing new commercial varieties for cultivation. Many farmers have stopped growing these traditional ecotypes and turned to commercial varieties, which are fast growing and shape enhanced but not necessary adapted to local environment. Nevertheless, local landraces are still cultivated because they have special qualities and are accepted by local markets. Identification of these cultivars represents a priority in breeding programs of vegetables all over the world. Conserving vegetable genetic diversity is important in the context of climate conditions and breeder needs in the area. The great diversity of vegetable types in cultivation can be also considered as a genetic resource that can be used in case of need. We have collected food vegetable (Allium sativum, Allium ascalonicum, Allium cepa, Lycopersicon esculentum Mill and Phaseolus vulgaris) landraces from 2 agro-ecological regions known for their salinity from westernRomania in order to assess their phenotypic and genetic variation and to preserve the traditional germplasm. We imposed two criteria for collection: seed saving method by local framers and no crossing for commercial reasons. The distance between each pair of populations ranged from 10 to 50 km. The number of individuals in each population ranged from 10-100. Differences between accessions were observed in the fruit traits. We employed one class of neutral genetic markers based on polymerase chain reaction (PCR): inter simple sequence repeat (ISSR) markers to assess the genetic diversity. The genetic similarity coefficients and dendogram, reflecting genetic relatedness of the landraces was established based on Inter simple sequence repeat (ISSR)-PCR fingerprint. Cluster analysis based on Jaccard's similarity coefficient using UPGMA grouped the landraces into different clusters, which were correlated with the phenotypic data. The present study is indented to identify populations to which priority should be given for dynamic conservation of landraces and make a baseline data available for farmers and breeders in this area.

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Comparison of phytohormone metabolism in model plants with different tolerance to salt stress

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Salinity may cause severe crop losses. Plant tolerance to salt stress varies among species. This study observes two species with different strategies: the salt-sensitive model plant Arabidopsis thaliana and its close relative, salt-tolerant Thellungiella halophila. Extensive knowledge of their metabolisms could help to clear diverse stress responses and to find some applicable strategy to increase salinity tolerance.
We have focused on phytohormones, which play an important role in regulation of plant growth as well as in plant stress responses. Both plant species were grown in hydroponics. This system enables analysis of apices, leaves, and roots. The levels of phytohormones abscisic acid (ABA), auxin (indole-3-acetic acid, IAA) and cytokinin (CK) metabolites were determined in Arabidopsis exposed for 1 week to NaCl in a range 2 – 150 mM and in Thellungiella influenced by a stimulatory (150 mM) and an inhibitory salt concentration (350 mM NaCl). Time course of the response was studied in the interval 15 min to 24 h.
Moderate stress caused a modest elevation of the level of stress hormone ABA and its derivatives in both genotypes. Stress induced growth suppression was associated with decrease of active CKs in apices. During severe stress, plant responses differed: Arabidopsis gradually faded and died, starting from apices; while Thellungiella preferentially protected apices, and older leaves enhanced their senescence, probably due to salt accumulation. Severe stress led to reduction of active CKs; only cis-zeatin, the cytokinin with low physiological activity, rose sharply during strong stress, more in Thellungiella. Generally, high salt concentrations caused the rise of the level of stress hormone ABA in shoots after one day. However, Thellungiella responded to stress very quickly - the ABA elevation in apices was observed already after 30 minutes. Furthermore, basal as well as stress induced ABA levels were higher in Thellungiella than in Arabidopsis. Levels of growth hormone IAA were higher, too. IAA level decreased in heavily stressed roots, simultaneously with root growth suppression.
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Keywords: *Arabidopsis*, *Thellungiella*, salt stress, phytohormone.

Performance of the SALTMED Model under different field managements

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Models can be very useful tools in agriculture water management. Not only could they help in irrigation scheduling and crop water requirement estimation, they also could be used to predict yields and soil salinization. The SALTMED model has been developed as a generic model that can be used for a variety of irrigation systems, soil types, soil stratifications, crops and trees, water application strategies (deficit irrigation, Partial Root Drying, PRD, subsurface irrigation), different nitrogen applications (fertigation, chemical-N, organic- N or crop residues incorporated in the soil) and different water qualities (fresh water; wastewater; saline, brackish or drainage water).
The model was applied using saline water for irrigating quinoa in Italy, Denmark, Morocco and Turkey, Amaranth in Italy, and legumes in Syria. The model was able to identify the salt tolerance level and the threshold values of each crop. The report will also show that quinoa and Amaranth grown in Italy were most tolerant at salinity level of 22 dS m^{-1} with very little reduction in yield even when using 25% of the crop water requirement. When using water salinity up to 40 dS m^{-1} in the Denmark study, the quinoa yield was only reduced by 17% when compared with the fresh water irrigation. The study in Turkey also showed that when using irrigation water with salinity up to 30 dS m^{-1} on quinoa, there was hardly any reduction in yield. The reduction only took place when the crop water requirements were dropped to 33% of the full irrigation. The results showed the possibility of significant water saving with acceptable reduction level in yield. In contrast, legumes grown in Syria showed relatively less salinity tolerance. Fresh water and up to 5 dS m^{-1} water salinity was used to irrigate faba bean, lentil, and chickpea. Up to 5 dS m^{-1} there was very little reduction in yields. The threshold value of 50% yield reduction in lentil, chickpea, and faba bean occurred at salinity levels of 3.6 dS m^{-1}, 4.4 dS m^{-1}, and 5.4 dS m^{-1}, respectively. These results suggest that among the food legume crops, faba bean can withstand relatively high levels of irrigation water salinity followed by chickpea. These results are expected to help extensions workers and farmers in making informed decisions in selecting appropriate food legume crops and crop accessions based on their salinity tolerance and the water available as

irrigation source. In contrast to legume, the salinity levels used in different experiments on quinoa and amaranth (Italy up to 22 dS/m, Denmark up to 40 dS/m and Turkey up to 30 dS/m) did not produce a 50% yield reduction. In a study in Morocco, the crop rotations of quinoa, sweet corn and 3 legume crops were investigated. The results indicated that quinoa and sweet corn yields were higher when they were sown after fallow.

In different application, the SALTMED model was run with crop rotations with 6 periods corresponding to 2015, 2020, 2030, 2050, 2075 and 2090 for Morocco. The results indicated that the growing period will be shorter. Starting from 2015 to 2090 a reduction in growing period length of about 20 days could take place as results of increased temperature. The evapotranspiration as well as potential crop transpiration have shown to increase over the years in response to climate change. In a climate change study in Italy, the SALTMED model was employed to simulate the productivity of Amaranth A12 under different climate scenarios for the periods 2050 and 2095. The SALTMED model indicated that the length of the Amaranth growing season will decrease from 114 days under actual (2009-2010) climatic conditions to 98 days for the high emission scenarios in 2095. SALTMED indicated also that it is possible to expect a change in Amaranth sowing date from the day of the year (DOY) 100 under actual conditions to the DOY 86 by 2095.

Effect of salt stress and fertilizer treatment on seed yield and seed oil percentage of Kochia (*Kochia scoparia L*)

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Kochia is a halophyte plant that produces suitable biomass and seeds in saline and dry areas. Current study was conducted to evaluate salt stress and various amounts of mineral fertilizers (nitrogen and phosphorous) on grain yield and oil production of Kochia. Field experiment was performed as split plot arrangement based on completely randomized block design with 3 replications. Two levels of salt stress (5.2 and 16.5 dS m^{-2}) were applied with irrigated water as main plots and three levels of nitrogen (0, 100 and 200 kg ha^{-1}) and phosphorous (0, 75 and 150kg ha^{-1}) as sub plots. Based on our results salt levels significantly influenced grain yield, seed weight and oil percentage of grains. Grain yield production was remarkably declined by increasing the salinity level. However, seed weight (0.81 to 0.82 mg) and oil percentage (8.6 to 9.3 %) increased with salinity increase.

Different nitrogen and phosphorous application levels affected grain yield and percentage of oil seed. The highest grain yield was obtained under 100 kg ha^{-1} nitrogen application by 40% increase in compared to control. In addition, phosphorous application has shown a significant increase in grain yield and seed weight compared to control. Results showed that with application of nitrogen and phosphorous fertilizer, seed oil percentage declined from 9% to 8%. Interaction between salinity and fertilizer application showed that the highest seed oil percentage was related to 16.5 dS m^{-2} salinity and no fertilizer application (control), so by increasing salinity and decreasing nitrogen and phosphorous fertilizer amounts, seed oil percentage declined and grain yield increased.

Key word: salinity, seed, yield, oil.

Crop salt tolerance under brackish water irrigation as affected by root morphology

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In the dry areas of the world there is an increasing pressure to develop brackish water resources and salt-affected land for an economic and environment friendly crop production. Consequently there is a demand to design more salt-tolerant crops of improved water use efficiency and to adapt modern irrigation technique to saline conditions. In the past decades research on crop salt tolerance improvement has focused on biochemical and physiological aspects happening inside various plant tissues and to learn from halophytes. Hydroponic based experiments were the preferred research tool. It is the shortcoming of this approach that processes affecting plant water supply under saline soil conditions are blocked out. The presented concept considers the principles of vertical and lateral salt and water movement happening under brackish water irrigation. It is shown from model calculations and some experimental results that the build-up of lateral salinity gradients around roots during water depletion periods plays a dominant role in water uptake by roots and consequently crop salt tolerance. It is proposed to focus future research and breeding for crop salt tolerance on soil-based experiments, which better resemble field conditions.

Afforestation as the factor of anthropogenic transformation of Solonetz soils' salt status in Pricaspian semidesert in Russia *

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The salt status of the soils of solonetzic complex formed on clay Pricaspian Semidesert and its change under the influence of artificially created forest plantations (which are functionally necessary and socially significant) has been studied. We define the soils' salt status as an integrated characteristic, describing the presence of easily-soluble salts in the soil profile, as well as amount of gypsum, carbonates, salt stock in soils, chemical and mineralogical composition of salts. This characteristic also describes the origin of salts, their transformation and migration in the soil profile. It reflects both the result of salinization and desalinization processes, which takes place during the previous and modern soil evolution stages. Thus, the inertia of some soils' status, on the one hand, and the relevance of indicators, on the other hand, allows us to estimate the dynamics, the trend and the intensity of the processes of natural evolution and transformation of soils under anthropogenic impact. The modern soils' salt status in agroforestry systems can be characterized with eluvial-illuvial redistribution of soluble salts within soil profile (in ameliorated solonetzes, the salt leaching zone occupies the whole zone of aeration). According to the research, the content of soil salts in the top two-meter layers of ameliorated soils is about 50% and 35% of their original content (under the influence of long-term (30-40-year) agroforestry activities), 25% (during 50-year soil amelioration), with the most toxic ions Cl^- and Na^+ removed from top 1-m layer in both cases. The type of salinization is changing: with removal of chloride ions, the chloride-sulphate type of salinity is replaced by sulfate type. Morphology, microstructure, composition of soil profile, other characteristics of the soil absorption complex are also modified.
Agroforestry influence leads to formation of artificial soil complexes with a new system of related horizons..
Within post-ameliorative stage of solonetzes, the rate of soil transformation is slowed down with continuing ameliorative effects. The qualitative and quantitative characteristics, describing post-ameliorative solonetzes status, including diagnostic, dynamic, genetic, classification and ecological attributes are described.
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Keywords: salt status, afforestation, transformation, solonetzes, semidesert

Irrigation with saline water: Assessing water suitability and using models as management tools

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Increasing demands for fresh water in arid and semi-arid regions of the world compound the already unsustainable abstraction of water in these areas. Inevitably less fresh water will be available for irrigated agriculture, yet food production must be increased to sustain the projected future population in arid regions. Addressing this challenge will require not only improvements in irrigation efficiency and leaching control, but also use of low quality waters for irrigation, including treated waste waters and brackish groundwaters. Treated waste waters are typically elevated in pH and salinity as well as in sodium, boron and dissolved organic carbon. New water suitability guidelines are presented. Use of waste waters and brackish waters especially in combination with rain and fresh water, requires complex analysis and new strategies for water management including new knowledge of factors affecting infiltration and crop production and utilization of computer models that consider the numerous interactions, enabling evaluation of various practices. We utilize the UNSATCHEM model, which includes variably saturated water flow, chemical processes, calculation of potential and actual crop ET and relative crop yield. The model enables evaluation of various irrigation management practices including blending versus sequential use of saline waters, crop response to leaching management, need and timing of leaching events and transient use of waters currently considered unsuitable for irrigation, such as high B containing waters. The model simulations are used to develop and evaluate management strategies including need for amendments, need for leaching and impact on crop production. The predictions indicate that leaching needs are overestimated by current guidelines, including those used by FAO, especially where saline waters are utilized and some yield loss is inevitable. Current guidelines utilize average rootzone salinity and do not consider that under saline conditions leaching fraction is regulated by the crop water use. The results indicate that if we accept less than optimum yield, many waters considered unacceptable can be very productively utilized, and without the need for excessive leaching. Also, high boron and low quality waters can often be used under intermittent conditions, depending on soil and plant characteristics.

Keywords: salinity sodicity infiltration leaching irrigation

Factors affecting solute accumulation under forested plots in a sandy region

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With the objective of characterizing the influence of environmental factors on the solute accumulation under forested plots a systematic study is being carried out in the Great Hungarian Plain.
Data of three sites, that is pairs of control vs. forested plots established in north-eastern Hungary, showed the importance of both biotic (land use change) and abiotic factors.
In a dominantly sandy area a transect from the lowest lying control-*Quercus robur* stand (108 m asl, fine sand, with water table hit at 2.1 m) (Mp), through the control-*Robinia pseudoacacia* stand (Hs) (140 m, medium sand, with water table hit at 2.4m) to the highest lyingcontrol-*Populus x. euramericana* stand (Nyb) (156 m, fine sand, with water table hit at 2.5 m) was established.
The documented continuous presence of forests at the three sites was very different, since 1869 at the *Q robur* site, very recent (few decades) at the *R pseudoacacia* site and since 1970-s at the *P x. euramericana* site.
Compared to the control plots (arable land or grassland) the electrical conductivity of subsurface layers showed a peaky maximum at 1 m depth under the *Q robur* stand with triple increase, it did not show any peak under the *R pseudoacacia* stand and it showed a peak at 4.5 m under the *P x. euramericana* stand. Cl, Na content curves followed the same pattern. $CaCO_3$ content and pH curves were greatly affected by surface organic matter accumulation. Soil Organic Carbon (SOC) (0-1 m depth) content was greatest at the lowest lying (grassland-*Q robur*) site, was small at the intermediate lying *R pseudoacacia* and highest lying arable land- *P x. euramericana* sites. The depth distribution pattern of SOC was similar inside the pairs, except the *R pseudoacacia* site where it was very low under the trees.
Compared to the controlthere was a water table sink under trees with 0.8 m under the *Q robur*, 4 m under the *R pseudoacacia* stand and 2 m under the *P x. euramericana* stand. There was a considerable (double) solute accumulation in the water table under *Q robur*, there was none under *R pseudoacacia* stand and there was less solute under the *P x. euramericana* stand than under the control.
The factors modifying clearly hypothetical results are assumed to be coarser texture (compared to control) and stand age under recently established *R pseudoacacia*(Hs) stand and young *P x. euramericana* stand (Nyb) resulting in no solute accumulation (Hs) and less solute in the water table (Nyb) under the trees.
This research was realized in the frame of OTKA NN 79835 and TÁMOP 4.2.4. A/2-11-1-2012-0001 „National Excellence Program – Elaborating and operating an inland student and researcher personal support system convergence program". The project was subsidized by the European Union and co-financed by the European Social Found.

Keywords: water table level, forestation, solute accumulation, land use change

Salt lake (Turkey) and its halophytes: an invaluable source for understanding plant salinity tolerance

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Turkey which is located at a significant position in the world from the viewpoint of plant genetic resources and genetic diversity, is the meeting ground of three phytogeographical regions; Euro-Siberian, Mediterranean and Irano-Turanian. Due to its great variety in geomorphology, topography and climate, Turkey has large diversity of habitats, and as a result it is very rich in plant species and endemism. As per date, 8,897 plant species have been identified, and 3022 of these species are endemic. Among these endemic plants, a portion of them stands out for understanding of salinity tolerance. Salt Lake (Tuz Gölü) is located in Central Anatolia and represents a unique type of salty steppe habitat, which contains salt adapted plant species. There are at least 34 endemic species and 3 of them are known to be only in Salt Lake (local endemisms). Flora and endemism in Salt Lake is especially important, because these plants are adapted to high salinity and drought, and have the necessary mechanisms to tolerate these abiotic stresses.Therefore, these plants can be a genetic resource for the future of creating salinity and/or drought tolerant crop plants, which is an urgent need for the upcoming decade, because of inevitable consequences of the global climate change.

Keywords: Salt Lake, halophyte, endemic, salt tolerance

Increased alkalinity and salinity of the topsoil as a result of soda waste deposition

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The growth of the human population and of its needs contribute to the increasing changes in the earth's surface. Industrial activity generates the formation of large areas covered with industrial waste that can effectively contribute to the environmental changes in the surrounding ecosystems. The former Krakow Soda Plant "Solvay" (located in southern Poland) with its many years of activity also participated in this process. The result of that activity is over 80 hectares of wasteland within the area of Krakow.
In the case of reclamation of soda industrial waste, the high content of easily soluble salts and a strong alkaline reaction are a big problem. Thatwasteland was reclaimed in classical way through covering wastes with soil layer. The use of soil as a barrier separating the deposited material from the environment and also as a ground for the plant cover seems to be not effective. As studies show, a direct contact of the topsoil layer with the soda wastes results in changing the physico-chemical parameters of the soil cover. Our study was concentrated on the changes in salinity and alkalinity of the topsoil layer due to soda waste influence.
From the point of view of reclamation, such a phenomenon is unfavourable, because a long-lasting effect of soda sediments on the topsoil layer can lead to its strong salinity or alkalinity, as a result of which degradation or total decay of the covering vegetation may occur. This is an issue which is important in terms of possibilities of landfill sites management, as the sedimentation tank area of the former Krakow Soda Plant "Solvay" have become an attractive localization for an urban agglomeration sprawl.

Keywords: reclamation, soda waste, alkalinity, salinity

Research on salt-affected soils in Hungary (Past – present)

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Hungary is situated in the central and deepest part of the Carpathian Basin (CB) in Central Europe. CB is a well-defined, hydro(geo)logically closed (the only outlet is the Danube at the narrow and artificially controlled „Iron Gate") „evaporation" basin, with negative water balance (atmospheric precipitation < evapotranspiration) in its lowlands and plains. The water (surface runoff, seepage in the unsaturated zone and groundwater flow) collect the weathering products and soluble materials from the large CB water catchment area and from the deep geological horizons, and transport and accumulate these components in the soils (or in their accumulation horizons) of the poorly drained lowland territories. It is the reason of the (relatively) **large extension of salt-affected soils** in Hungary under moderately humid/arid climate.

Multipurpose biomass production has always been in the focus of the Hungarian national economy because of limited other natural resources and having *relatively and generally* favourable agro-ecological potential. One limitation for it was the low fertility/productivity of salt-affected soils. It was the reason that the history of Hungarian soil science was always closely related to the researches on the salinity/alkalinity/sodicity problem:

- analysis of the **main factors of the development** of salt-affected soils;
- definition, description and quantification of the mechanisms of salinization/alkalization/ sodification **processes;**
- **classification** of salt-affected soils on the basis of their morphological, chemical, physical, physico-chemical and agronomical **properties;**
- reason(s) of the **low fertility and agricultural productivity** of salt-affected soils;
- unfavourable (hydro)physical properties and **extreme moisture regime** (simultaneous hazard of extreme hydrological situations: flood, waterlogging and over-moistening hazard versus drought) as reasons and/or consequences of salinity/alkalinity;
- possibilities and limitations of **the improvement/reclamation/amelioration** of salt-affected soils (lime, gypsum, „digo method", other methods) and technologies for their practical applications;
- potential and real **agricultural utilization** of salt-affected lands: proper land use practices (arable land, including rice production, grassland management, fish ponds), special agrotechnics;
- preconditions of **irrigated farming** on salt-affected lands.

After the 1930's world crisis and the World War II strong efforts were made with considerable state subsidies and investments for the complex radical amelioration of salt-affected soils, using scientifically based, modern (but rather expensive), complex technologies. Later – based on economic and ecological evaluation – the centrally organized production was changed and the **improvement** of saline and alkali soils concentrated only on the „better" (moderately salt-affected) territories. At the same time special attention was paid to the **prevention** of the further extension of salinization/ alkalization processes. A comprehensive field survey–sampling–laboratory analysis–mapping–monitoring–„early alarm" system was developed and practically used before

the planning and establishment of irrigation systems, successfully preventing harmful secondary (man-induced) salinization/alkalization/sodification processes. For these researches the new tools of scientific and technical development (analytical procedures, computer technology, remote sensing, GIS, etc.) were used.

In the extreme salt-affected areas, representing high, sometimes unique ecological value (with special, endemic and protected flora, fauna, land use practices) in Europe (!!) national parks (Hortobágy, Kiskunság, etc.) and **biosphere reservations** were established and function up till now as **gene reservoir of biodiversity.**

Keywords: salt-affected soils, salinization/alkalization/sodification processes, amelioration, prevention of secondary salinity/alkalinity, saline landscapes

Do halophytes have built-in mechanisms to rapidly adapt to increasing levels of soil salinity in their natural habitats?

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Salt marshes in arid and semi-arid regions, such as those in the Spanish Mediterranean coast, are extremely interesting but also fragile ecosystems, very sensitive to the effects of global climate change, which will cause in the near future an increase in their soil salinity levels. It seems logical to assume that many halophytes now growing in these specific habitats will not withstand this change and will not survive. However, this may not be necessarily the case, as suggested by some results of our studies on the responses to salt stress, in the field and the greenhouse, of five salt-tolerant taxa – *Sarcocornia fruticosa*, *Inula crithmoides*, *Plantago crassifolia*, *Juncus maritimus* and *J. acutus*.

Sorbitol is the physiological osmolyte used by *P. crassifolia*, as established for all investigated species of the genus; this polyol accumulates at high levels in the plants, and there is a very good correlation between seasonal changes in sorbitol contents and the degree of environmental stress affecting the plants. In contrast, proline (Pro) contents are very low and do not correlate with changes in abiotic stress conditions. However, Pro biosynthesis is strongly activated in potted *P. crassifolia* plants treated with NaCl, at concentrations higher than those the plants encounter in the field (450-600 mM). Therefore, under these artificial conditions, Pro acts as a functional osmolyte, important for salt tolerance in *P. crassifolia*, contributing to osmotic adjustment and probably also as 'osmoprotectant', based on its chaperone and ROS scavenging activities.

In glycophytes, it is well established that salt stress causes oxidative stress as a secondary effect. However, no environmental-dependent oxidative stress – estimated by changes in malondialdehyde (MDA) levels – has been detected in any of the investigated halophytes. Accordingly, the observed seasonal changes in the levels of antioxidant compounds and in the specific activities of several antioxidant enzymes, were not statistically significant, in general, or did not correlate with the degree of environmental stress. NaCl treatments in the greenhouse, on the other hand, generally led to the concentration-dependent accumulation of MDA, and the activation of common responses to oxidative stress: an increase in the levels of antioxidants (total phenolic compounds and flavonoids), and the activation of the SOD, CAT and/or GR enzymes. Qualitative and quantitative differences were observed among the different taxa, with relatively lower intensity of oxidative stress and, consequently, weaker responses in the most salt-tolerant species (*S. fruticosa* and *I. crithmoides*).

These data provide evidence that some halophytes, when artificially subjected to high salt treatments, are able to activate stress response mechanisms that are not used – because they are not needed – under their present field conditions, but that will help the plants to adapt to possible increases in soil salinity in their natural habitats.

Keywords: antioxidants, climate change, environmental stress, osmolytes, salt marsh

Conventional and halophyte crop production using saline water – increasing the salt tolerance of potato and the development of sustainable cultivation of Salicornia

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TS Agri is a company specialized in field research concerning the feasibility of saline irrigation and the effects of increasing salinity on the growth and quality of conventional crops and halophytes. Two major activities of the last few years have focussed on the development of a sustainable cultivation method for *Salicornia*, especially in relation with a salt tolerant weed (*Spergularia marina*) and the improvement of the salt tolerance of potato (*Solanum tuberosum*).

The cultivation of *Salicornia* in The Netherlands is increasing every year. One of the restrictions for further growth is the occurrence of the salt tolerant weed, *Spergularia marina*. This weed prevents optimal growth of *Salicornia* and has to be separated from the harvest before *Salicornia* can be distributed. TS Agri has performed both greenhouse experiments as well as field experiments looking at the salt tolerance at the germination stage. Results have shown that by using the difference in salt tolerance at germination, it is possible to produce *Salicornia* on a large scale without the presence of *Spergularia marina.*

The majority of the salt tolerance data of conventional crops is outdated and performed with species that are no longer cultivated. New potato species were evaluated for their salt tolerance in the temperate climate zone of The Netherlands. In two consecutive years, field experiments were performed to evaluate the salt tolerance of eight potato varieties. For this the growth was evaluated at six different salt concentrations (salt concentration of the irrigation water was 2, 4, 8, 12, 16 and 20 dS m^{-1}). Results have shown that the most salt tolerant varieties that were tested showed no growth reductions even around 8 dS m^{-1} (EC_e) although the salt tolerance of potato is believed to be 1,7 dS m^{-1}.

The results of both the *Salicornia* and the potato experiments demonstrate that realistic and profitable agriculture is possible using saline soils or water. Although halophytes are the obvious choice for highly saline conditions (> 20-30 dS m^{-1}), the differences in salt tolerance between varieties of conventional crops indicate that cultivation of these crops are indeed possible under (highly) brackish conditions.

Assessment with models of the sustainability of primary production in saline environments: the quest for simplicity and transparency

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Soil salinity and sodicity development in agro-ecosystems that receive water through a combination of natural precipitation, irrigation, and groundwater capillary upflow is a complicated process. Major causes are the complexity of the flow and transport processes, the erratic behaviour of weather, and variability of soil, crop, and management. In case of sodicity, also soil structure degradation may play a prominent role. Nevertheless, there is a strong incentive to predict how salinity and sodicity will develop, to enable the assessment of sustainability of adopted soil and water management. For such aims, a range of advanced numerical software models has been developed, where each model has its own combination of strengths and weaknesses. Generally, the more advanced the models are, the more involved will be their use and computational demands. Particularly for identification of which conditions lead to soil sodicity, which is a major threat, yet may develop unrecognized until it is too late, communication of its hazard needs to be understandable and transparent, also for laymen. For this purpose, we have numerically modelled the coupled water, salt, and cation balances parsimoniously, using concepts adopted from a new subdiscipline of water research: ecohydrology. We observe that the predicted root zone salinity *C* and sodicity *ESP* gradually change to their long term average values. These long term average values are independent of the cation exchange capacity *CEC*. The rate of change depends inversely on the size of the root zone reservoir, i.e., on root zone thickness for *C*, and additionally on *CEC*, for *ESP*. Soil type can have a large effect on both the rate of approach of the long term steady state salinity and sodicity, and on the long term levels, as it affects the incoming and out-going water and chemical fluxes. Considering two possible sources of salts, i.e., groundwater and irrigation water, the long term salt concentration *C* of the root zone corresponds well with a flux weighted average of infiltrating and upflowing salt mass divided by the average water drainage. In full analogy, the long term *ESP* can be approximated well for different groundwater depths and climates. A more refined analytical approximation, based on the analytical solution of the water balance of Vervoort and Van der Zee (2008), leads to a quite good approximation of long term salinity and sodicity as found numerically, for different soils, groundwater depths, and climates.

Alkali sodic soil characterization and agricultural use in Songnen Plain, northeast China

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Alkali sodic soil, with pH over 8.5 and exchangeable sodium over 15%, is one of the predominant soil type in Songnen plain, northeast China. The area of sodium-affected soil reaches 3.42×106 ha, occupying over 14.4% of the total area of the plain. Excessive exchangeable sodium adversely affects soil structure, reduces soil hydraulic conductivity, forms seals and crust after drying and ultimately limits the land productivity. As a result, the disposable average income of the 20% farmers is only $80/a in this area. Low productivity of sodic land contributes most to the farmer's poverty. Significant progresses have been made for better management and utilization of the alkali sodic soils over decades of research and extension. Profound understanding of the characteristics of this alkali sodic soil can give sound support to the best management practices of this problem land. To characterize the physical and chemical properties, 100 soil samples were collected from the sodium affected soil area in Songnen plain, northeast China. Soil extracts of 1 to 5 soil / water were analysed for the electrical conductivity, pH, major cations (Na^+, Ca^{2+}, Mg^{2+}, K^+) , major anions (CO_3^{2-} ,HCO_3^-, SO_4^{2-} and Cl-) and exchangeable cations (Na , Ca , Mg, K). Sodium adsorption ratio was used to assess the soil sodicity. The chemical properties of these soils present high pH, high sodicity and high salinity in the surface horizon 0-20cm of the soil layer. Sodium is the predominant cation compared to calcium and magnesium, and bicarbonate is the predominant anion in soil solution. Higher bicarbonate concentration and total alkalinity are observed in the surface layer. Both sodium bicarbonate and exchangeable sodium result in alkaline reaction and high pH in soil. Low infiltration and high dispersion occur when wetted because of the high ESP. As a result, agricultural use of this soil is limited in this region.

With the increasing demand for food security in densely populated China, this degraded land attracts much more attention both from the local communities and from the central government. A national program was initiated in 2007 for agricultural development in the alkali sodic area. Total of 6.3 billion yuan(RMB) was invested to build the irrigation and drainage system and land consolidation. However, converting this alkali sodic land to productive land is challenging because of soil physical, chemical and nutritional constraints. It is necessary to break through the limitations and select and integrate the proper techniques. On the basis of field research and extension works, "type dependent strategies for alkali sodic land management and use" in the region is proposed as: (1) growing paddy rice cultivation in lower laying waterlogging alkali sodic land and in slightlyalkali sodic land with well established drainage system, (2) reclaiming intermediate alkali sodic soil withdesulfurized gypsum and growing paddy rice (3) seeding native sodium tolerant grasses (e.g. *Puccinellia tenuiflora* in severe alkali sodic lands, (4) revegetating reed *Phragmites australis*in alkali sodic wetlands.

Keywords: alkali sodic soil; constraints; agricultural use; type dependent strategy

Utilization of *Apocynum* species in salt-affected floodplains of NW China

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During the second half of the 20th century cotton was strongly promoted along the rivers of Central Asia. The irrigation agriculture resulted in wide spread soil salinization and severe water shortages within the river systems. The natural vegetation along the rivers of Central Asia is adapted to periods of water shortage, is very productive, and contains plant species with valuable utilization opportunities. The species *Apocynum venetum* L. and *A. pictum* Schrenk (plant family Apocynaceae), for example could provide several ecosystem services. Both species are considerably salt tolerant. They are used as fibre and medicinal plants. *A. venetum* and *A. pictum* yield fibres, which can be used as textiles. Furthermore, the leaves of *Apocynum* are used to produce antihypertonic tea and medicine. Both species yield fibres and leaves on considerable areas under the arid climate of Central Asia without irrigation, because they use the groundwater. Furthermore, both species can withstand higher soil salinization levels than cotton. Both species can be used and provide an income to local people under conditions, which are unfavourable for growing crops under irrigation. Such conditions provide unreliable water supply for irrigation systems and/or saline soils.

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