Activity: Land Degradation and Salinity Management

Lead: Atef Swelam

Progress towards outputs:

Field experiments were carried out during four cropping seasons (summer 2013, winter 2013/14, summer 2014 and winter 2014/15) to evaluate sustainable interventions to combat degradation associated with salt accumulation. Field trials were conducted with various treatments including application of gypsum, organic matter, bio-fertilizers, ammonia injection, and installation of mole drains. The required datasets (soil, water, and plant) were collected and analyses were completed and concluded that application of soil amendments had a significant effect on crop yields and the physical properties of salt-affected soils.

Combined interventions on soil amendments being implemented include conventional farmer practices: control, fertilized by urea (C+U) compared to gypsum + ammonia gas (G +Ag), gypsum + bio-fertilizer + urea (G+B+U), gypsum + ammonium sulphate (G+As), gypsum + urea (G + U), gypsum + farm manure + ammonia gas (G + F + Ag) , gypsum + mole drain + ammonia gas + farm manure + bio-fertilizer (G+M +Ag +F + B), gypsum + mole drain + ammonia gas (G + M + Ag), gypsum + mole drain + urea (G + M +U), mole drain + urea (M + U).

During summer 2013, the highest rice grain yield of 6.81 ton/ha was observed for the field trial with the application of gypsum combined with ammonia gas and farm manure treatment, while the lowest yield of 3.59 ton/ha was for application of gypsum with ammonia gas. Results also indicated that the treatment with G+M +Ag +F + B achieved the highest straw yield; and the lowest straw yield was for application of G+AG. During summer 2014 highest grain yield of 8.44 ton/ha was obtained for the treatment with gypsum combined with ammonia gas and farm manure followed by construction of mole drain at 4m spacing and combined with application of urea (7.43 ton/ha). While, the lowest value was obtained from control treatment fertilized by urea.

The application of soil amendments, installing mole drains, and ammonia injection resulted in decreasing soil bulk density and increasing total porosity values compared with controls; as well as improving the infiltration rate and cumulative infiltration compared with initial values. The reduction in soil salinity compared with the initial conditions of different treatments varies between 18% (AG+M+G) and 45% (C+U) in 2013. The highest reduction in soil salinity values was observed for the control treatment may be due to highest amount of irrigation water applied. The G+F+Ag and G+M+Ag+F+B treatments caused decreases in soil sodicity of 47 and 44%, respectively, compared to initial conditions. During 2014, highest reduction of soil salinity of 35% was observed for the control treatment.

The maximum values of total income (LE/ha), net profit (LE/ha), and economic efficiency were obtained with the G+F+Ag in both years. However, the lowest total income and WP values were recorded for the control treatment. The treatment including gypsum, farm yard manure and ammonia gas resulted in a net profit of approx. LE 1526 /Feddan (Approx. $196/acre) in comparison to the control treatment.

During winter 2013/14 and 2014/15, field trials were carried out for two crops: wheat and sugar beet. During both years the G+F+Ag treatments achieved the highest values of wheat grain (6.58 and 6.16 ton/ha) and straw yields (8.48 and 8.26 ton/ha) followed by G+M+Ag+F+B (with mole drain at 4-m spacing). The high yields may be due to the positive effects of incorporating gypsum and other amendments that liberate calcium in the upper portion of the soil profile and improve soil physical and chemical conditions.

The G+F+Ag treatment resulted in the greatest increase in uptake of macronutrients in wheat grain and straw followed by G+M+Ag+F+B (with mole drain at 4-m spacing) treatment in both years. The G+F+Ag treatment resulted in the highest NUE (34.6 kg grain/kg N). Analysis indicated that the highest water productivity of 1.34 and 1.32 kg /m^3 during 2013/14 and 2014/15 winter seasons was achieved with application of gypsum combined with injection of ammonia gas and farm manure.

For sugar beet, G+M+Ag+F+B (with mole drain at 4-m spacing) treatment significantly affected sugar beet root yields (41.5 ton/ha in 2013/14 and 40 ton/ha in 2014/15), sugar percentage, and sugar yield during both years. The increase in root yield may be due to the use of different N fertilizer sources that have considerable effect on both soil pH and solubility of cations. Results indicated also that ammonia gas was more effective than urea and other N-sources in producing higher yield. Soil salinity values decreased after harvesting wheat and sugar beet compared with the values obtained after harvesting rice (summer 2013) in all treatments except the control treatment. The highest rate of salt leaching was achieved for the G+M+U treatment.

Parallel to research station work, evaluation trials were conducted in summer 2013, winter 2013/14, summer 2014 and winter 2013/14 at the village of Shabab El-Khergeen to monitor the effect of subsurface drainage combined with mole drains on the productivity of different crops. The experiments were conducted at the Graduate area, Al-Hamoul District, Kafr El-Sheikh Governorate, Egypt. The soil of the area was clayey in texture. The soil was considered saline sodic as the EC values were > 4 dS/m and the Exchangeable Sodium Percentage (ESP) values are > 15%. Average irrigation water salinity was 0.65 dS/m. Gypsum was initially added to all plots at rate of 8 ton/ha. The experiment was initiated before summer 2013. From these experiments it was concluded that introducing the mole drain to heavy clay salt-affected soils improve the efficiency of the wider spacing drainage system. Introducing mole drains resulted in the maximum values of total revenue, net return, and economic efficiency.

Two tile drain spacings with mole drains were tested as follows:

D1: Tile drain with 20-m spacing between drains without mole

D2: Tile drain with 20-m spacing between drains with mole

D3: Tile drain with 40-m spacing between drains without mole

D4: Tile drain with 40-m spacing between drains with mole

At the initial state, soil salinity and sodicity values were high (ECe = 16.70 dS/m and ESP = 19.40, respectively). After implementing the field experiment with rice crop in one season, average soil salinity and sodicity values were reduced (13.62 dS/m and 16.17 for the treatment with mole and 20m drain space, 14.06 dS/m and 17.2 for the treatment with 40m drain spacing and with mole). After four cropping seasons average soil salinity and sodicity were reduced to 11.6 dS/m and 14.8 for the treatment with mole and 20m drain space. The observed reduction in salinity was more pronounced in the surface layers compared to deeper ones. Results indicated in general that the D1, D2, D4 treatments were superior to D3 in reducing soil salinity and sodicity, especially in the surface layers. It is worth to mention that the high value of leaching fractions (15% and 25% LR) were efficient in reducing soil salinity in comparison to traditional irrigation especially in the top layers.

The results indicate that drainage spacing of 20 m enhanced drainage efficiency, improved soil physical and chemical properties, and subsequently improved soil structure and hydraulic conductivity, which affected water movement to the drains with its load of soluble salts. Mole drains decreased soil salinity and sodicity only within the mole depth.

Progress towards outcomes:

- Soil amendment techniques tested at the plot-level in this project will offer farmers a range of possible mitigation techniques to combat salinity.
- There is usually no single way to control salinity and sodicity, therefore several practices should be combined into a package that function satisfactorily. This package should be field tested under farmer conditions. The project will be able to make some recommendations on a package combining physical, chemical and biological interventions, once the collated data are fully analyzed.
- There has been a marked improvement in skills and knowledge among team members from ARC and NWRC, particularly among the younger team members who conducted the majority of the field work. Five MSc and PhD students (two at Kafr el Sheik University, two at Ain Shams University, and one at Cairo University) are doing their research under the umbrella of this project. The capacity of these young Egyptian scientists has benefitted through their interactions with scientists from ICARDA and IWMI. It is expected that these trained scientists will eventually transfer skills gained to other colleagues and students.

Progress towards impacts:

V. List of 2015 publications and scientific outputs