2.7 Activities of Visiting Researcher

(1) Professor Shainberg I. (Jan. 1996 - Jul. 1996)

A Summary of Conducted research

The Response of Low and High Swelling Smectites to Sodic Conditions

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Swelling and dispersion of clays are the primary processes responsible for the degradation of soil physical properties in the presence of exchangeable Na. The relative importance of these processes was evaluated by studying the response of low and high swelling smectites to sodic conditions. Smectite from Ariake bay sediments in Japan represented the low swelling smectite and clay from Kamenoselandslide in Japan represented high swelling smectite. Changes in hydraulic conductivity (HC) and clay dispersivity of soil-sand mixtures (10, 20, and 30g of sediments mixed with 90, 80, and 70g of sand, respectively) as a function of total electrolyte concentration (TEC) (0.05 and 0.01M Cl^- and distilled water, DW) and sodium adsorption ratio (SAR of 0, 10, and 20) of the percolating solutions were measured. In the low swelling smectite, no changes in HC was measured in the electrolyte solutions (TEC≧ 0.01M Cl^-) at the three SAR values. When the low swelling smectites were leached with DW, the HC of the Ca^- smectite increased, whereas the HC of the SAR 10 and 20 treatments decreased. Clay dispersion and migration out of the 10% soil column was substantial. The increase in HC in Ca mixture of low swelling smectite leached with dilute solutions was due to the collapse of the open microstructure which prevails in electrolyte solutions. In this mixture, clay dispersion was the main process responsible to HC deterioration under sodic conditions. In the high swelling smectite mixtures, gradual decrease in the HC was measured as the TEC decreased and the SAR increased. In the high swelling smectites, swelling was the main process responsible to HC deterioration in electrolyte solutions with TEC≧0.01M Cl^-. Swelling increased with an increase in clay percentage, ESP and decreasing TEC. Smectites dispersion was prevented when TEC exceeded the flocculation value of the clay. Clay dispersion increased with increase in clay ESP and it affected the HC of the porous media only when the pores are fine and the dispersed clay plug the conducting pores.

※ to be published in April, 1997 in Soil science

Summary of the seminars Following seminars

Following seminars were held :

① Effect of Soil Properties and Water Quality on the Hydraulic Conductivity of Soils

② Effect of Soil Properties and Water Quality on Crusting, Infiltration, Runoff and Soil Erosion

③ Colloidal Properties of Soil Clays

④ Soil Conditions and Soil Structure Improving Soil and Water Conservation

The content of the seminars are summarized as follows:

Effect of Soil Properties and Water Quality on the Hydraulic Properties of Soils

The effects of Na and electrolyte concentration in relation to hydraulic conductivity, infiltration, crusting, runoff, erosion and hard setting are discussed from which it emerges that the effects of Na are manifested in measurable and often sizeable proportions down to very low levels far below those previously used to define sodic soils. The primary processes responsible for physical degradation are swelling at relatively high levels and clay dispersion throughout the range of exchangeable Na percentage (ESP). Provided that the total electrolyte concentration (TEC) is below the critical flocculation concentration (CFC), clays will disperse spontaneously at high ESP values, whereas at lower ESP levels, inputs of energy are required for dispersion. The TEC of the ambient solution, because of its effects in promoting clay flocculation is crucial in determining soil physical behavior. With increasing levels of ESP, correspondingly increased levels of TEC are required to maintain the clay in a flocculated state. Even at very low ESP values, clay can disperse, provided that the TEC is correspondingly low, which means that sodic behavior can and often is exhibited by soils in humid regions. Because falling raindrops transfer energy to the soil surface, clay dispersion takes place at lower ESP levels than required for dispersion within the soil body. Thus infiltration rate (IR), due to crust formation at the surface, is much more sensitive to Na than is hydraulic conductivity (HC). As a result of crust formation, IR is reduced, resulting in increased runoff and erosion. The effects of weathering of soil minerals resulting in the production of sustained levels of electrolyte in certain soils in relation to clay dispersion and its consequences are also discussed.

At relatively low levels of ESP and low ambient soil solution concentrations, physical properties improve in a rather spectacular manner to additions of electrolyte. Thus application of gypsum is a suitable ameliorative strategy. In addition, use of synthetic polymers to stabilize aggregation has also proved useful in improving the physical behavior of these soils.

Colloid Properties of Clay Mineral in Saline and Sodic Solution

Swelling dispersion and the rheological properties of clay are affected by the composition of exchangeable cations and by the electrolyte concentration. Absorbed sodium ions form a diffuse double layer, create high swelling pressures, and form single clay platelets which tend to persist in dilute solution.

The low swelling pressure between Ca-clay platelets prevents their dispersion, and due to electrostatic attraction between the bivalent cations and negative surfaces, the platelets stack into tactoides or quasicrystals. Each tactoid consists of several clay platelets, with a 0.45-nm-thick film of water on each internal surface.

In a mixed Na/Ca system, introducing a small amount of sodium (ESP<1.5) into a largely Ca-saturated clay has little effect on the swelling. A large amount of sodium (ESP>15) brings about a breakdown of the tactoid and intensive swelling. Conversely, the electrophoretie mobility of the clays and the flocculation value are very sensitive to small amounts of exchangeable sodium. However, it should be remembered that clay dispersion can take place only when the electrolyte concentration is below the flocculation value. These phenomena suggest that when sodium is introduced into Ca-montmorillonite, the sodium ions concentrate on the external surfaces of the tactoids ("demixing"), thus sharply increasing the zeta potential of the clay. In a montmorillonite soil with a given experimental ESP, the ESP at the external ESP, as a result of "dermxing" . This phenomenon explains the pronounced effect of sodium, even in clays and soils with low sodicity.

Organic Polymers and Reducing Seal Formation and Furrow Erosion

Water soluble polyacrylamides (PAMs) have been proposed as soil amendments for reducing seal formation, runoff and erosion on soils exposed to rain or sprinkler's drops, and for halting irrigation-induced erosion in furrow irrigated agriculture. Recent interest has centered on very high molecular weight (l0-15 x 10^7 g mol^-) with low to moderate anionic charge (10-20 mol%) Polymers.

Addition of small amounts of polymers (10-20 kg ha^-), either sprayed directly onto the soil surface or added to the applied water, stabilizes and cements together aggregates at the soil surface thereby increasing their resistance to seal formation. The infiltration rate of a polymer-treated soil subjected to distilled water rain is two to three times that of a non-treated soil. The efficacy of anionic polymers in preventing seal formation is enhanced when the soil clay is maintained in a flocculated state. The latter is achieved by addition of electrolytes (either in the "rain" water or phosphogypsum addition) in the soil solution at the soil surface. Combined application of anionic polymers with electrolytes result in final infiltration values of ～25 mm h^{-1}, which are 10 times higher than the control.

Furrow irrigation-induced soil erosion is a serious threat to sustainable irrigated agriculture globally. Recent field studies have demonstrated the small concentrations of polymers dissolved in irrigation water appreciably reduce soil loss from irrigated furrows and increase net infiltration. Applying PAM at 10 g m^{-3} in irrigation inflows during the furrow advance period was one of the most effective treatments. Treatment with 1.3 kg ha^{-1} reduced furrow sediment loss by 94% and increased net infiltration by 15%.

(2) Professor Farah S.M. (Feb.1 996 - Jan. 1997)

Summaries of the seminars

Following seminars were held :

① The Agricultural Research Corporation in Sudan

② The Gezira Irrigation Scheme in Sudan

③ The Problem of Salinity and Its Management

④ Water and the Problem of an Expanding Population

The contents of the seminars are summarized as follows:

The Agricultural Research Corporation in Sudan

The establishment of the Agricultural Research Corporation (ARC) in Sudan goes back to the turn of this century. Experimental work started in 1902 in the Northern Province to explore the possibility of growing cotton under irrigation. This was followed by similar work in the south for rain -grown cotton. When trials showed that cotton can grow successfully in the Gezira, the Gezira Research Station was established in 1918 to serve the development large scale cotton growing scheme in the Gezira. After independence the agricultural research expanded to encompass activities in different crops and different ecological zones in the country. After World War Ⅱ nutritional needs forced intention towards experimental work on mechanized grain production in the rainfed areas. At present the ARC has linkages within and outside the country.

During the past four decades the ARC was able to build a strong and dedicated number of scientists who were trained in highly respected institutions mainly in the United Kingdom and USA. From its 300 qualified scientists 220 are involved in research activities in the country while the rest have joined other national, regional and international organizations.

Research programs include developing a complex and comprehensive set of technologies for improving food, feed and industrial crops. However, research efforts vary between crops depending on availability of resources. The activities consist of on-station trials which are managed by the scientists and on -farm research by the scientists in collaboration with farmers, extentionists and production scheme managers.

The research areas include the following

1. Introduction and genetic evaluation

2. Production factors e.g. cultural practices, water requirements and mechanization
3. Protection factors on insects, diseases and weeds
4. Post-harvest e.g. crop losses, marketing, processing and nutrition
5. Socio-economics

The irrigated sector attains most of the total time available by scientists amounting to about 51% compared to 15% in rainfed, 15% in food research, 10 % in forestry, 5% in fisheries and 4% in wild life.

Technology transfer is implemented through two main approaches: (a) vertical and (b) horizontal.

The vertical approach deals with technologies which are developed as on-station research. When approved by the respective technical committees consisting of researchers, production scheme managers university academic staff and extentionists the recommendations are sent to the schemes for implementation.

The horizontal approaches is based on verification and economic evaluation on on-station results as demonstrated in farmers fields to convince farmers through field days on the validity of the research recommendation.

During the past three decades ARC has generated a wealth of improved technologies related to fiber crops, cereals, oil crops, grain legumes, vegetables, fruits, sugar cane, forestry, fisheries, wild life and food technology.

ARC has now proposed a number of approaches to develop its resources to implement strategic options and organizational and structural adjustments.

The GEZIRA Irrigation Scheme in SUDAN

The Gezira Irrigation Scheme is the largest irrigated scheme under one management in the world. It is located in the triangle between the Blue and White Nile rivers south of Khartoum. It is fed by gravity from Sennar Dam which was built in 1925 on the Blue Nile. It started with a small area of 126000 ha in 1920 and researched its present area of about 0.9 million ha. The area is divided into 102000 tenancies with an average area of 8 ha. It was designed with the aim of producing cotton, but later sorghum Dolicous lablab, a legume were added in the cropping system to provide food for the tenants and maintenance of the soil fertility, respectively. At the beginning half of the area was in fallow. At present due to intensification and diversification by addition of wheat, groundnuts, fodder and vegetables the cropping system is as follows;

Cotton - Wheat -Groundnuts/Sorghum/vegetables -fodder -fallow each leg of the rotation occupies 20% of the total area. The scheme is run jointly by the Ministry of Irrigation (MOI), which is responsible for providing the irrigation water and the Sudan Gezira Board (SGB), which is responsible for the agricultural operations and for determining the irrigation water requirements.

The cropping intensity in the Gezira has increased from about 40% in 1960 to the present 80%. This intensification resulted in a considerable increase of water released through the irrigation system and silt deposition into the canal system -a problem which the MOI was not able to cope with effectively. The field efficiency in the Gezira is estimated at about 75%, and the overall efficiency at 70%. This value is the highest found in the surface irrigation projects. The main reasons are the high clay content of the soil and the design of the distribution system. In spite of the high efficiency of the system yields of crops namely wheat and cotton are 2-3 times bellow the yields achieved in the research stations. The equity of water distribution is high from top to tail of the minor canals. However, the negative effects of such variations could be reduced if the major and minor canals are kept clean from silt and weeds.

Some suggestions for improvement of the production system are as follows:

1) return to the night storage system.
2) rehabilitation of the drainage system.
3) use of scientific methods for the water indents.
4) charging tenets on actual volume of water delivered and not on the number of irrigation or area cropped.
5) more freedom to farmers to grow the crops they consider more profitable.
6) increase of the participation of the farmers in the water control at the field out let pipe.
7) more research to develop alternative methods of water application at the farm level.
8) introduction of other crops in the rotation with the aim of changing planting dates and avoiding over lap of crop establishment with heavy rains during the rainy season and water shortage during the dry season.

The Problem of Salinity and Its Management

The salinity problem

Salinity is a problem which is influencing crop productivity more than any other naturally occurring substance. About 25 and 35% of the cultivated lands are saline and sodic, respectively relatively greater area exists in the low rainfall regions. The salts are either naturally occurring or accumulate through groundwater, runoff or irrigation water.

Salinity becomes a problem when accumulated salts start to interfere with the growth of most crop species. Saline soils are characterized by having an electric conductivity greater than 4 mmoh/cm, exchange sodium percentage less than 15 and pH less than 8.5.

Salinity affects plant growth as a result of (a) reduced water uptake, (b) physiological disturbances of tissue metabolisms and (c) inhibition of absorption of essential cations. The ultimate result is a reduced size and/or yield of the plant. However plants differ in their response to salinity with regard to portion or stage of development. Moderate salinity may improve quality of some products e.g. sugar content of melon and beets.

Methods of salinity control

No single method is sufficient to control salinity of a particular situation but various factors e.g. climatic, agronomic, engineering, social and economic aspects need to be considered. Of the methods proposed are the following :

1-Crop species

As crop species differ in their response to salinity, the cropping system can be changed by a crop which suits the particular situation using rootstocks is of particular importance specially for fruits as they control the uptake of toxic salts.

2-Soil factors

2.1 Fertilization

Addition of nitrogen and phosphorous were reported to reduce salt tolerance of some crops e.g. corn, however, fertilizers, being, for the most part soluble salts, their use has to be carefully monitored regarding type, time of application and placement.

2.2 Water

When first added irrigation water minimizes salt concentration but with subsequent water reduction through evaporation and transpiration soil water potential decreases and stress builds up on the plants. Therefore timing of irrigation is important in minimizing salinity problems, but excessive irrigation should be avoided in order not to create waterlogging conditions.

2.3 Reclamation

With good drainage addition of more water than the crop's water requirements can leach the salts from the soil, otherwise soil amendments e.g. gypsum may become necessary to improve the permeability of the soil prior to leaching.

3.Climate

Most crops will tolerate harmful effects of salinity when the air temperature is cool. Low root temperature also enables plants to avoid uptake of toxic ions e.g. sodium and chloride, which are antagonistic to essential cations like calcium, magnesium and potassium.

High relative humidity also favors the ability of crops which are sensitive to salinity, but not to the tolerant ones.

4.Cultural practices

Good land preparation to facilitate uniform infiltration of irrigation water is very useful in controlling salinity.

In case of furrow -irrigation salts tend to accumulate in the center of the beds. Therefore planting two rows on a raised bed near to each shoulder will place the seeds away from the area of greatest accumulation. Also increasing seeding rate will help to encounter the loss of stand, but may also require thinning and cost considerations. Increasing the depth of water in the furrows can also reduce the salt hazards.

The choice of method of irrigation e.g. flood, sprinkler or drip irrigation is also important in solving salinity of particular situations.

Water and the Problem of an Expanding Population

Water is a finite resource. Although its quantity is nearly 1400 million km^3, 97.5% is salt water, 1.8% is ice and 0.3% is underground water, which leaves only 0.4% in rivers, lakes, soil, atmosphere and living organisms.

When water evaporates from the surface (land and sea) to the atmosphere the land surface receives some 40000 km^3 more than what has evaporated from its surface. The annual amount of water usable for the human population is about 9000 km^3 i.e. on average 1 800 m^3/person/year, of which only 800 m^3 is actually consumed, but even this does not apply to the people in the drier areas of the world.

Causes of Water Scarcity:

1) many areas are naturally with low rainfall. nearly 600 million people live in regions with less than 300 mm/year.
2) land degradation resulting from over-grazing and desertification causes excessive runoff and loss of water back into seas and floods that cause nearly 40% of all deaths from natural disasters.
3) as population increases the share per individual decreases; the same will happen if demand per individual increases.

   In 1940 total water use was 1000 km^3/year, in 1990 was 4130 km^3/year and is expected to reach 5 folds by year 2000.

Water and Agriculture:

1.Rainfed Agriculture (RA):

RA produces two-thirds of the world crops, but due to ove utilization of soils and their miss management, yields are very low and nearly one third of the earth's land is suffering from land degradation and desertification.

1.2.Methods to improve RA:

A. Crop rotations to optimize water use and nutrients.
B. Planting high yielding, short maturing and drought tolerant crop species.
C. Water harvesting and water conservation techniques to increase availability and efficiency of water.
D. Manipulation of planting dates and application of supplementary irrigation to avoid moisture stress at critical growth stages.

2. Irrigated Agriculture (IA):

IA occupies l/6 of the world's arable land, but provides more than l/3 of the total crop production. Unfortunately, land suitable for irrigation is becoming scarce and construction of irrigation works is becoming expensive, thus reducing the values of agricultural products. Another problem is poor management of water during convieance and at the farm level.

2.1. Methods to Improve IA:

A) Using more of the runoff.

B) Utilization of more groundwater with cheap energy sources e.g. wind and solar.

C) Use of sprinkler and drip irrigation techniques where appropriate.

D) Training of farmers and cuarging them the real price of their water consumption.

E) Land leveling and canal lining to increase the water use efficiency

Implementation of option " A " through building dams may have positive as well as negative effects. While building dams would provide cheap electricity and allow gravity irrigation, it will hinder navigation, create water - borne diseases and displace local inhabitants.

3. Groundwater (GW)

Gw is another resource which could be utilized for reducing water scarcity but requires certain precautions as follows:

A) Extraction should not exceed replenishment.

B) Water table should not fall drastically.

C) Subsiding of land and drying up of wells may take place.

D) Intrusion of salt water into fresh water is also a possibility.

4. Other resources

Drainage water and treated water from cities and industry are means of increasing water for agriculture and general use, however, attention should be given to controlling salinity and spread of disease organisms.

From what has been stated in this article it may be concluded that water scarcity in future would result due to the fact that an expanding population is using ever increasing quantities of a finite resource. However, the potential for water saving is enormous if all users are urged to manage their supplies in order to ensure that future generations live in a world of water security not water scarcity.