Management of Salt Affected Soils of the Middle Sao Francisco River Valley

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Introduction

Soil and water are two basic resources for crop production. However, the lack of adequate management of these resources has caused a decrease in the potential productivity of soils all over the world. In the semi-arid areas of Northeast Brazil, improper irrigation management and bad drainage systems have caused an increase in salt affected areas. In addition, the characteristics of the soils and the improper use of mineral nutrients have also contributed to the increase in the salt content of the irrigated areas. The present paper briefly discusses the main aspects that have contributed to the salinization of irrigated soils in the semi-arid Northeast Brazil.

Characterization of the region

Northeast Brazil is a very important region for the development of the country. It has an area of about 1,600,000 km² extending from the State of Maranhão to the State of Bahia where three different climate types occur. The sub-amazon type (tropical humid) occurs in the State of Maranhão and in some areas of the State of Piaui. The second climate type is found along the coast, where agriculture is favored by a humid strip of littoral climate with annual regularity. The third has semi-arid characteristics and penetrates into vast territories in the interior, comprising about 1,000,000 km². This area, known as the "Drought Polygon", extends beyond the Northeast boundaries, reaching the North region of the State of Minas Gerais (BORGES, 1985).

The semi-arid comprises an area of about 54% of the northeast Brazil, corresponding to 11% of the country's territory. The climate of the region is characterized by erratic rainfall in three to five months, with the annual average ranging from 400 to 800 mm (although in some areas variations from 250 mm to approx. 1,000 mm occur). The annual average evaporation is about 2,000 mm with a potential evapotranspiration of 2,600 mm (VALDIVIESO & CORDEIRO, 1985). This situation is influenced by high temperatures (23 °C to 27 °C) and low air humidity (below 50%). Geologically the area is characterized by a crys-

talline substrata, and the soils are generally shallow, poorly developed, and low in organic matter. Although xerophytes predominate, the vegetation cover varies which leads to a special type of vegetation known as "caatinga".

The problem

In reality, the natural conditions occurring in the semi-arid Brazil are due to its climatic characteristics, mainly those related to the rainfall pattern. The erratic rainfall occurrence and distribution cause problems to the semi-arid inhabitants (BORGES, 1985). Thus, irrigation is highly necessary and it is probably the only way to change the scenery.

Rather than attempting to improve crop adaptation to dry habitats, the main strategy for using arid lands for agricultural purposes is the improvement of the environment for the crop. This has been accomplished throughout history from simple to complex irrigation systems, which seek to improve the level of soil moisture during part or all of the growing season to the point where mesophytic species can grow in otherwise xeric habitats. However, problems may arise due to the climate, topography, soil and water characteristics and management.

Salinity in arid and semi-arid regions is always related to irrigation. Salinity refers to the presence of salts, generally chlorides, sulphates and carbonates of sodium, calcium, potassium and magnesium. The relative abundance of those ions can have a major consequence, in terms of solution/precipitation reactions that affect the soil properties and consequently crop growth.

Salt affected soils are brought about by several factors that become effective when the natural vegetation is removed. In this case, the water removed from the soil through transpiration decreases, which leads to a rise in the water-table. As this water evaporates, salts are deposited on the soil surface. Also, the presence of hardpan decreases soil permeability and causes enclosed drainage without outlet. Moreover, salts from the neighbouring ground are transported by the soil solution to the soil surface and are deposited there. In addition to these facts, the changes in the water-table bring salts that accumulate on the soil surface due to poor quality water, improper irrigation management, and lack of drainage systems. The latter are probably occurring in some irrigation projects of the Northeast Brazil.

Little is known about the salt affected soils in Northeast Brazil and the total area is probably underestimated, although the importance of the problem has been recognized. Water deficiency exists almost during the whole year,

contributing to the build-up of soluble salts and exchangeable sodium. PEREIRA (1983) mapped 91,115 km² of salt affected soils corresponding to 9.4% of the total 1,110,000 km², from the State of Bahia to the State of Ceará. It includes solodic planosols, solodized solonetzes, solonetzic solonchaks and halomorphic soils (Table 1). However, other soils are not considered, mainly those

Table 1.
Area of salt affected soils occurring in seven states of the Northeast Brazil (in km²)

Soil type	CE	RN	PB	PE	AL	SE	BA	Total
Solodic Planosol	12,708	3,690	944	5,163	3,370	2,098	30,516	58,491
Solodized Solonetzes	8,436	4,064	2,769	2,654	393	1,013	5,161	24,490
Solonetizic Solonchaks	450	837	-	-	-	-	-	1,287
Halomorphic soils	18	-	-	-	-	-	-	18
Other soils	1,645	-	-	-	120	520	4,544	6,829
Total	23,257	8,591	3,713	7,819	3,883	3,681	40,221	91,115
%	25.5	9.5	4	8.6	4.3	4	44.1	100

Source: PEREIRA et al,, 1986,

from irrigation projects in operation (oxisols, vertisols etc.), and alluvial soils of the river valleys (MELLO et al., 1967). Salinization of these soils has been observed following the occurrence of sodium in the exchangeable sites. According to GÓES (1978), about 30% of the irrigated areas near rivers are salt affected. However, this value may be underestimated. In fact, CORDEIRO (1978), and CORDEIRO et al. (1988) suggested that 24% of the area in the São Gonçalo (PB) irrigation project is salt affected even without taking into consideration the sites that have been abandoned due to high salt contents (Tables 2 and 3). The situation is similar in other irrigation projects of the Northeast, where big areas are out of operation because of the unfavorable conditions for growing crops.

The oxisols of the region are generally shallow and the formation of hardpan and/or rocky cover limits the natural drainage. Irrigation on these soils and heavy rainfall shortly raise the water-table. Indeed, it was observed in both Bebedouro (PE) and Tatui (BA) irrigation projects that the soil was close to field

Table 2.
Percentage of salt affected soils of different EC, ESP and pH, observed in 1294 ha of the São Gonçalo Irrigation Project, PB

Depth	ECe, dS/m				ESP		pH		
cm	< 3.9	4-11.9	12-19.9	≥20	<15	>15	< 6.9	7-8.4	≥8.5
0-30	95.98	3.63	0.15	0.23	81.76	18.24	33.77	62.75	3.48
30-60	96.37	3.63	0.00	0.00	74.57	25.43	29.60	63.75	3.48
60-90	95.76	4.01	0.15	0.08	72.47	27.53	31.15	59.44	9.41
Mean	96.04	3.76	0.10	0.10	76.27	23.73	28.17	62.06	6.43

Source: CORDEIRO et al. (1988)

Table 3.
Physical-chemical characteristics observed in 1294 ha of the salt affected area of the São Gonçalo Irrigation Project, PB (in hectares)

Depth	ECe, dS/m				ESP		pH		
cm	< 3.9	4-11.9	12-19.9	≥20	<15	>15	< 6.9	7-8.4	≥8.5
0-30	1242	47	2	3	1058	236	437	812	45
30-60	1247	47	0	0	965	329	383	828	83
60-90	1242	52	2	1	940	357	404	771	122

Source: CORDEIRO et al. (1988)

capacity at 30 cm depth, even after three to four months without irrigation and rainfall. In these soils evaporation is an important means of reducing surface soil humidity. However, artificial drainage is necessary to drain and improve the condition of these soils.

The alluvial soils of the irrigation projects have extreme horizontal and vertical variability, both physically and chemically. They are, in general, medium to heavy textured soils with good fertility but poorly drained. Besides, many of these soils show, originally, high salt content and the situation has worsened with the irrigation outcome.

In some of the Northeast areas, the irrigation water comes from surface reservoirs (açudes) that store water during the rainfall season. This water is generally considered to be of good quality. Despite this fact, salinization has been detected in some projects (Table 4). According to PEREIRA et al (1986), the São

Francisco River is the main source of water with low salt content, classified as C_1S_1 (Table 5). Under good management conditions this water should not cause irrigation problems. However, an increasing salinization of the irrigated soil profile has been observed and consequently, of the salt affected areas due to salt imbalance caused by drainage problems. Water from wells is sometimes used, but the high salt content may limit its application for irrigation purposes unless highly salt tolerant species are cultivated

Table 4.
Percentage of salt affected areas irrigated with water from surface reservoirs (açudes) occurring in projects of Northeast Brazil

Irrigation projects /State	Irrigated area (ha)	Salt affected area (ha)	Percentage
Morada Nova (CE)	2,880	1,100	38
Vaza Barris (BA)	1,016	153	15
Lima Campos (CE)	502	41	8
Arco Verde (PE)	321	105	33
Calderões	416	52	12
Boa Vista (PE)	154	41	27
Sumé (PB)	147	89	61
Cachoeira (BA)	142	43	30
São Gonçalo/PB	1,340	373	28
Total	6,918	1,997	29

Table 5.
Percentage of salt affected areas occurring in projects irrigated with water from the São Francisco River

Irrigation projects /State	Irrigated area (ha)	Salt affected area (ha)	Percentage
Gorutuba (MG)	5,171	50	1.0
Mandacarú (BA)	421	40	10.0
Tourão	10,000	100	1.0
Bebedouro (PE)	2,272	300	1.3
Maniçoba (BA)	4,398	250	6.0
Curaçá (BA)	4,454	250	6.0
Ceraíma	713	150	21.0
Estreito (BA)	1,450	100	7.0
Barreiras (BA)	2,229	100	4.0
Nilo Coelho (PE)	15,000	350	2.0
Total	46,108	1,690	4.0

The experimental approach

According to the available literature, the research methods have been focused on characterization (CORDEIRO, 1978), leaching requirements, soil reclamation, utilization of saline water and crop salt tolerance (VALDIVIESO & CORDEIRO, 1985). In this context, research efforts must also be applied toward cropping systems on irrigated areas, soil specificity, climate and water. These studies will improve the use of the available water resources, permitting the expansion of the existing irrigated areas.

Due to the need for improving the utilization of the edafic and hydrologic resources in the Northeast Brazil, there is a great interest to generate and/or adapt technologies that allow a good irrigation management of salt affected soils and the reclamation of abandoned areas. However, the Brazilian experience in irrigation and management of salt affected soils still has to grow. Unfortunately the advanced techniques currently available from other countries are not totally applicable here due to climatic and soil diversity and different economic, social, and cultural aspects, which occur in the region. In this context the Brazilian Agricultural Research Agency (EMBRAPA), through the Agricultural Research Center for the Semi-Arid Tropic (CPATSA) has developed a program aiming the maintenance of the productive capacity of irrigated soils, with other governmental and international institutions, such as the Development Agency for the São Francisco Valley (CODEVASF) and the Food and Agriculture Organization of the United Nations (FAO).

CPATSA was established in 1975 and is located in one of the driest areas of Northeast Brazil, where the mean annual rainfall is only 400 mm and is distributed during three to five months. The research staff consists of 85 research scientists working in cooperation with several development and research institutions. Research facilities support the projects, including library, greenhouses, several laboratories such as, entomology, plant pathology, soil and water, plant physiology, tissue culture, seed analysis and microcomputing. Its main objective is to generate and/or to adapt technologies for the agricultural development of the semi-arid Northeast without unfavorable impacts on the environment.

FAO is supporting CPATSA to strengthen its experimental programme on adopted soil management practices. A collaborative project has been initiated in 1993 on Management of Salt Affected Soils of the São Francisco River Valley. The objective is to study the condition of the soils in relation to fertility, salinity and drainage and bring into general use efficient management techniques for increasing the productivity of salt affected soils in the semi-arid

region of the Middle Sao Francisco River Valley - Northeastern Brazil. The field work is being conducted in the Maniçoba Irrigation Project on a sub-surface drained area. The results will contribute to a better performance of traditional crops such as, tomato, melon, watermelon, grape and mango.

Concluding remarks

In the Northeast Brazil, about 30% of the irrigated areas under operation is salt affected due to inadequate irrigation management and/or improper drainage systems. Soils reaching an EC more than 8 dS/m are generally abandoned, which leads to the acceleration of salinization process. However, it is necessary that factors causing salinization of a specific area be qualitatively and quantitatively understood before the appropriated management strategy is applied. Management need not necessarily attempt to control salinity at the lowest possible level but rather to keep it within limits, in accordance with sustained productivity. Practices for the control of salinity may include:

- Selection of crops or crop varieties that will produce satisfactory yields under conditions of salinity;
- Application of land preparation and planting methods that help to control salinity;
- Irrigation procedures that maintain a relatively high soil-moisture regime and that periodically leach accumulated salts from the soil;
- Maintenance of appropriated water conveyance and drainage systems.

The crop type, water quality and soil properties determine, to a great extent, the management practices required to control salinity or even to optimize the production of salt affected soils in the Northeast Brazil.

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