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International Workshop on Integrated Soil Management
for Sustainable Use of Salt-Affected Soils
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CERTIFICATE OF ATTENDANCE

This is to certify that the

Dr. Gilberto Gomes Cordeiro

has attended the SPUSH 2001, Fourth Meeting of the FAO Global Network on Integrated Soil Management for Sustainable Use of Salt Affected Soils, held in Valencia, Spain, 7-11 May 2001, organized by the Universitat de Valencia, the Food and Agriculture Organization of the United Nations and the International Union of Soil Sciences, presenting the country paper.

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Prof. Dr. Jorge Batlle-Sales

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Management of Soils Affected by Salt in São Francisco River Valley

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INTRODUCTION

The Northeast of Brazil is one of the biggest natural regions of great interest for developing the country. Its total land area is around 1,600,000 km^2, which extends from the State of Maranhão to the State of Bahia.

The Brazilian Semi-arid occupies an area of approximately 900,000 km^2, corresponding to 54% of the Northeast region and 11% of country territory.

According to the climate, the zone is characterized by rainfalls, which are concentrated in a period of time of 3-5 months, with average annual amount of 400-800mm. The average annual temperature varies from 23 to 27°C, and the daily thermal amplitude corresponds to 10°C. The average sun light time is 2,800 hours per year. The annual average air relative humidity is 50% and the annual average evaporation is 2,000 mm.

Crystalline and sedimentary areas that are very dissected basically characterize this zone. The predominant soils are not well developed, shallow and stony with low water holding capacity.

The native vegetation, predominantly xerophitic, is extremely diversified, which is a vegetation characteristic of the semi-arid known as "Caatinga".

In the huge Northeast scenery, the natural conditions come from an unstable climatic condition and unpredictable rainfall variation that can be plentiful or scarce, as well as concentrated or scattered. So, the rainfall distribution, in each year, brings a great expectation for the local population , because the causes remain with some unknown variations (Borges, 1985).

According to the above explained, it is evident that irrigation, in the Brazilian Northeast, is highly priority and that the irrigated agriculture probably will be the only way to adequate the region to its climatic conditions. However, some problems might show up as a result of the use of water in the irrigated areas according to the climate, soil characteristic, topography, soil management condition and management and quality of water.

Among the problems related to the irrigated areas of the Brazilian Northeast the salinization of the soil is observed frequently.

Unfortunately, there is little information available on salt affected soils in the Brazilian Northeast , although the importance of the problem has been known. The water deficit amounts to more than 2,000mm per year, contributing to the build up of soluble salts and exchangeable sodium. According to a soil survey done by Pereira (1983) from the State of Bahia to State of Ceará , in an area of 1,110,000 km^2, there were 85,931 km^2 of salt affected soils corresponding to 7,74% of the total area. The inclusions, which are common in the whole semi-arid are not considered, and includes the salt affected areas of the irrigation perimeters and the alluvial soils in the river valleys where a great part of the soil is irrigated (Mello el al. 1967). In those soils it can be observed a salinization process going on, with an accumulation of sodium in exchange complex. According to Goes (1978), around 30% of the irrigated areas in the borders of the rivers and intermittent streams, mainly in the alluvial soils, show saline problem. This situation appears in general in the irrigation projects established in the Brazilian Northeast, where huge areas are out of operation because of adverse conditions for developing and yielding good profit crops, needing to be reclaimed and put back in productive process.

In the Oxisol soils of the Northeastern region of Brazil, which generally are shallow, the natural drainage condition are limited by obstructing layers like fragipan an/or by rock layer of the wavy relief forming basins. In these soils, the water irrigation forms, in a short time, a water table and the rainfall even sporadic an in a low amount can cause conditions of excess of water for a long time. It was observed, for example, in the irrigation perimeter of Bebedouro, in Petrolina-PE, and in the irrigation perimeter of Tataui, in Sobradinho-BA, that without irrigation and three or more months after the rain period the soils remain with water near the field capacity from 30cm of depth.

In soils with impeded drainage, the evaporation is an important way to evacuate water, but when surface layer is dry the evaporation gradient is blocked, and this layer starts to act as a mulching, so artificial drainage are necessary to improve the water regime of these soils.

The sources for water for irrigation in the Northeast are surface reservoir (dams) where the water is stored during the raining season, and rivers, been in general of good quality, varying from C1to C2 and from S1 to S2. The most important source of water is the São Francisco River, which water has low amount of salt, being classified as C1S1. The use of the São Francisco River water under suitable management conditions could not cause any big problem for irrigation. However, due to unsuitable balance of salts, which is normally observed because of drainage problems, it is observed a gradual salinization of the irrigated soil profile and a progressive increase of the problem area. Underground water is also used, but most of the it show high salt concentration which some times limits its use for irrigation. The underground water from the crystalline soil material of the semi-arid, does not exists in great amount, being found in aquiferous that is not good for irrigation.

This problem might be faced seriously because of its importance and it shows as a great opportunity for research. According to the available reference point at the moment, the researches have been under taken more frequently in the areas of methodology for characterize the problem, Cordeiro (1978), demand for leaching, soil reclamation, use of saline water and crop resistance to salt, Valdivieso and Cordeiro (1985).

In this sense, the research effort might be concentrated in the knowledge of the irrigation cropping systems that have been used as well as the specifications of soil , climate and water having as objective the improvement of the efficiency in use of available water. This, together with the increase of yield and productivity per area unit will allow to enlarge the actual area under irrigation.

According to the above point of view, EMBRAPA-CPATSA together with FAO through the project Management of Salt Affected Soils of the Sao Francisco River Valley pretend to join efforts to establish a research program in order to attend , in a short period of time, the demand for technologies, mainly for the crops traditionally used in the region, like tomato, melon, watermelon, table grape and mango.

The Centro de Pesquisa Agropecuaria do Tropico Semi-Arido (CPATSA) which is a research institute of the Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA), is located in the Middle Sao Francisco River Valley, in the Northeast of Brazil, where the annual rainfall average is 400mm, being concentrated in a period of 3-5 months.

CPATSA has a research scientist team of 78 persons working integrated with some institution of development and of the Cooperative System for Agricultural Research. It has some laboratories for soil, water and plant analysis, animal health, entomology, plant pathology plant physiology, and plant tissue culture and seed studies. It has a library with a great bibliographic heap, which attends not only its research scientists but also others professionals from other institutions, graduate students and farmers.

The main mission of CPATSA is to develop and/or adapt technologies with emphasis in the development of the agriculture of the Northeastern Semi-Arid, with the objective of divulging the new options of cropping systems for areas which great potential to enhance the development of the small farmer.

Since its establishment, CPATSA has searched for a way to organize its work with emphasis in the research witch was done in the region, aiming to stimulate the relationship among research scientists, development agents and farmers through cooperation with local state governments and municipalities, and with Latin American Countries.

In the area of research of CPATSA, the emphasis has been done to preserve the environment by the study of methods of biological control of pests, reforestation of degraded areas of Caatinga vegetation, biotechnology, and works on soil salinity, sodicity and flooding in irrigated areas.

One of the research projects of CPATSA is MANEGEMENT OF SOIL AND WATER IN IRRIGATED AREAS OF THE BRAZILIAN NORTHEAST which is composed of two subprojects 1) "Evaluation of the Soil Conditions for Fertility, Salinity and Drainage of Irrigated Perimeters of Manicoba and Curacá", and 2) "Use of Saline Water for Irrigating Horticultural Crops" that contain the experimental works of the agreement established between FAO and EMBRAPA-CPATSA for the project Management of Saline Soils of the Sao Francisco River Valley.

Results of some Experiments Developed in the São Francisco River Valley

1. Use of Saline Water and Soil Conditioning in Beetroot Crop

Objective:

Considering the great potential of the underground water from the crystalline rock forming soils in the Brazilian semi-arid region and that beetroot crop has a relevant economic importance in the Northeast, the objective of this research work is to find out the alternative and possibility for the use of saline water, as well as to evaluate the effects of different levels of salt in irrigation water and the conditioning Sper Salt (polimaleic acid).

Summary:

The objective of the work, which was carried out in the Experimental Station of Caatinga of Embrapa Semi-Árido, in Petrolina-PE, was to evaluate effects of different salt levels in irrigation water and the soil conditioning Sper Salt (polimaleic acid) on beetroot crop (*Beta vulgaris, L.*) cv. Earley Wonder. Treatments were: water with 0.1, 4 and 8 dS/m and water with0.1, 4 and 8 dS/m plus Sper Salt. Results showed productivity varying from 20.00 to 65.50 ton/ha for treatment with saline water plus Per Salt and for treatment with São Francisco River water (fresh water), respectively. There was not significant difference between salinity levels 4 and 8, which productivity were 29.40 and 26.30 ton/ha, respectively. It was observed that Sper Salt was more efficient at salinity level of 4 dS/m than at 8 dS/m.

Material and Methods:

The experiment was carried out in the Experimental Station of Caatinga of EMBRAPA-CPATSA, in Petrolina-PE. The water used for irrigation came from a well with EC of 8.0 dS/m. beetroot crop *(Beta vulgaris L.)*, variety Early wonder, was seeded strait in the field. The experimental design was a randomized complete with four replicates. The treatments were: T1 - irrigation with São Francisco River water with EC of 0.1 dS/m; T2 - irrigation with saline water with EC 8.0 dS/m; T3 - irrigation with saline water with EC of 4.0 dS/m; T4, T5 and T6 were the same as T1, T2 and T3 plus the soil conditioning Sper Salt, based on 10 litters per hectare, in three application at concentrations of 10 and 5 ppm. Each plot has an 2.0 m^2 area and the plant space was 0.20 x 0.10 m. The irrigation was applied according to the crop demand based on water evaporation of Class A tank. The parameters evaluated were total yield, commercial yield, plant height, final plant stand and average weight of commercial. The results were analyzed for variance (F test) and mean comparison (Tukey test at 5% of probability).

Results and Discussion:

Table 1 shows that the commercial yield of beetroot, in function of the irrigation water quality and the soil conditioning , varied from 20.20 to 65.45 ton/ha, for T5 and T1, respectively.

Comparing the levels of salt concentration in the irrigation water it was not observed significant differences between T3 and T4 with EC of 4.0 and 8.0 dS/m, respectively, which shows that beetroot is tolerant to high levels of salinity. The satisfactory results obtained, even when it was used water with high concentration of salt, is credited to a better capacity of osmotic adaptation of beetroot (Ayres and Westcat, 1991), which allow, even in high salt concentration situation, to absorb higher amount of water in function of the osmotic adjustment that decreases the leaf water potential (McCree and Richardson, 1987).

Referring to the use of the soil conditioning Sper Salt, it was observed that in the highest level of salinity it did not show efficiency, without significant difference for commercial yield. However, in the lowest level, 4.0 dS/m, it was observed a 45.6% increase compared to T3, which shows that the soil conditioning in low level of salt in the soil can be efficient.

Table 1. Commercial yield (kg/ha) of beetroot according to the irrigation water quality and soil conditioning Sper Salt (polimaleic acid). EMBRAPA-CPATSA, Petrolina-PE, BRAZIL.

TREATMENT	COMMERCIAL YIELD (ton/ha)
T1 Irrigation water with EC of 0.1 dS/m	65.45 a*
T4 Irrigation water with EC of 0.1 dS/m + Sper Salt	51.70 ab
T6 Irrigation water with EC of 4.0 dS/m + Sper Salt	42.80 bc
T3 Irrigation water with EC of 4.0 dS/m	29.40 cd
T2 Irrigation water with EC of 8.0 dS/m	26.30 cd
T5 Irrigation water with EC of 8.0 dS/m + Sper Salt	20.20 d
C.V. (%)	22.09

*Means followed by the same letter did not differ for the Tukey test (5% of probability)

Conclusions:

The salinity of water affects significantly the yield of beetroot. However, there was not significant difference among the higher levels of salt concentration in the water, showing the high tolerance of beetroot to saline water.

The yields of beetroot of 26.30 and 29.40 ton/ha, for water with EC of 4.0 and 8.0 dS/m, respectively, are inside of the national standard productivity.

Although the use of the soil conditioning Sper Salt did not affect significantly the treatments, it induced an increase of 45.6% at EC of 4.0 dS/m, showing that the soil conditioning can be efficient in low levels of salt concentration in the irrigation water.

2. Integrated Management of Soil Aiming Sustainable Use of Salt Affected Soil

Objective:

Objectives of the work were to evaluate the integrate soil management of tomato in saline soil to increase its yield and the sustainable use of affected areas by salt in the São Francisco River Valley.

Summary:

The experiment was carried out in an area with saline problem, without artificial drainage, in the Irrigation Perimeter of Manicoba, in Juazeiro-BA. Its objective was to evaluate effects of integrate management in the productivity of tomato (Licopersicun suculentun, L), cv. IPA-5. Studied variables were: a) frequency of irrigation; b) organic matter; c) mulching; d) deep ploughing and e) Sper Salt (polimaleic acid). Treatments were: T1 - All the variables (1,2,3,4,5); T2 - Variables 1,2,3,4; T3 - Variables 1,2,3,5; T4 - Variables 1,2,4,5; T5 - Variables 1,3,4,5; T6 - Variables 2,3,4,5; T7 - Control. Results showed that total, commercial yields and of fruits with black bottom varied from 3.8 to 25,3, from 2.1 to 21.6 and from 1.5 to 6.7 ton/ha, respectively. The salinity in the area, that varied from 9.49 to 20.02 dS/m, probably affected the effect of different treatments used.

Material and Methods:

The experiment was carried out in an area with saline problem, without artificial drainage, in the Irrigation Perimeter of Manicoba, in Juazeiro-Ba. It was used for irrigation the water of the São Francisco River with EC of 0.08 dS/m (Table 1). Tables 2 and 3 show the chemical and physical soil characteristics. Soil and water analysis were done according to the methodology of EMBRAPA (1979). It was used the tomato variety IPA 5 which was seeded in trays and transferred to the field after twenty days. It was used a randomized complete bock design with two replicates. There were five variables: V1 - Frequency of irrigation, V2 - Organic matter, V3 - Mulching, V4 - Deep plough, V5 - Sper salt (polimaleic acid, as soil conditioner). Treatments were: T1 - All the variables (1,2,3,4,5); T2 - Variables 1,2,3,4; T3 - Variables 1,2,3,5; T4 - Variables 1,2,4,5; T5 - Variables 1,3,4,5; T6 - Variables 2,3,4,5; T7 - Control. The plot area was 216 m2. The irrigation was applied according to water crop demand with a frequency of days. The soil conditioner was applied based on 8.0 litters per hectare, four litters in the crop establishment and four litters latter. The data collected were total yield, commercial yield and fruits with black bottom, and analyzed by analysis of variance (F test).

Results and Discussion:

Table 2 shows that the soil electrical conductivity (EC) for the experimental area varies from 9.49 to 12.59 and from 9.49 to 20.02 in blocks 1 and 2, respectively, and the EC decreased as the soil depth increased, the soil being considered as saline in the whole profile. There was not significant differences among treatments for all parameters measured (Table 2), probably the high salinity in the soil inhibited treatment effects and the lack of drainage in the area which kept the water table at 0.81 and .088 cm in blocks 1 and 2, respectively. Other parameters, like number of plants at harvest time, total number of fruits, were also analyzed but did not show significant differences either.

The total yield of tomato varies from 3.8 to 25.3 t/ha (Table 2) which is very low compared to the yield obtained in normal soils.

Table 2. Total, Commercial and black bottom fruit yields of tomato for different treatments. EMBRAPA-CPATSA, Petrolina-PE, BRAZIL.

TREATMENT	TOTAL YIELD ton/ha	COMMERCIAL YIELD ton/ha	BLACK BOTTOM FRUIT YIELD ton/ha
T1	7.7	6.2	1.5
T2	22.9	16.2	6.7
T3	15.2	12.4	2.8
T4	8.3	5.9	2.4
T5	25.3	21.6	3.7
T6	3.8	2.1	1.7
T7	16.9	15.2	1.6
F test	0.8ns	0.9ns	0.9ns
C.V.(%)	44.0	46.0	40.0

Conclusions:

In soil with high salt concentration, neither parameter of tomato showed significant difference for either treatment.

In salt affected areas, the lack of artificial drainage has a negative effect on crop yield.

The lack of drainage can strongly contribute for increasing salinity.

3. Effect of Saline Water and Soil Conditioner on Carrot Yield in the Brazilian Semi-Arid

Objective:

Considering the great underground water potential of the crystalline basement in the Brazilian semi-arid and economic importance of carrot for the region, the work has as objective to show alternatives and possibilities for the use of that water, as well as to evaluate the effect of different levels of salinity on irrigation water and the soil conditioner Sper Salt.

Summary:

An experiment was carried out at the experimental Station of Embrapa Semi-Árido, Petroliana-PE, in the first semester of 1997, with the objective of evaluating the effect of different levels of salinity on irrigation water with and without the soil conditioner Sper Salt (polymaleic acid) on the yield of carrot (Dancus carota L.), cv. Early Wonder. The experiment was set up in a randomized complete block design with four replications, and six treatments were tested: water with electrical conductivity of 0.1 (control), 4 and 8 dS/m, and these same levels of electrical conductivity plus Sper Salt. The size of the plot was $2m^2$. The results showed that the yield varied from 20.2 to 65.4 ton/ha, respectively for the treatments with saline water plus Sper Salt and water from the São Francisco River. There was no difference on yield when water salinity levels of 4 and 8 dS/m were used, although productivity at 4 dS/m was superior to 8 dS/m (70.1 vs 33.6 ton/ha). There was no significant difference between the salinity levels of 4 and 8 dS/m, with yields of 29.4 and 26.3 ton/ha, respectively. In the treatments with conditioner Sper Salt, it was found that at the salinity concentration of 4 dS/m the product showed to be more efficient than at the concentration of 8 dS/m.

Material and Methods:

The experiment was carried out at the experimental Station of Embrapa Semi-Árido, Petroliana-PE, in the first semester of 1997. The experimental design was a randomized complete block with four replications and six treatments: 1 - water with electrical conductivity of 0.1 (control), 2 - saline water with 8 dS/m, 3 - saline water with 4 dS/m, 4 - treatment 1 plus Sper Salt, 5 – treatment 2 plus Sper Salt, 6- treatment 6 plus Sper Salt. The water used for irrigation was from the São Francisco River, with salinity of approximately 0.1 dS/m considered as good quality for irrigation, underground water with salinity of approximately 8 dS/m and mixture of these two kind of water that results in approximately saline water of 4 dS/m. The amount of Sper Salt used corresponded to 10 liter per hectare and was applied three times, two at 10 ppm concentration and one as 5 ppm concentration. Plot size was 2.0 m^2. It used a 0.20 x 0.10 m planting space and variety Brasilia sowed strait in the soil.

The amount of irrigation water applied was sufficient to attend crop needs, being calculate based on the water evaporation from class A tank. Commercial yield (root with more than

20 cm length and 2 cm diameter) was evaluated and the results were submitted to analysis of variance (F test) and means were compared by Tukey test, at 5% probability level.

Results and Discussion:

Table 3 shows the commercial yield of carrot for the different treatments. It was observed a variation between 33.1 and 92.3 ton/ha for saline water with 8 dS/m and water with 0.1 dS/m, respectively. However, it was not observed significant difference for salinity levels of 4 and 8 dS/m without Sper Salt, yielding 71.01 and 33.14 ton/ha, respectively, as well as for these salinity levels with Sper Salt with yield of 69.21 and 34.00 ton/ha, respectively, suggesting that carrot can be cropped with high salinity concentration water with reasonable productivity. Even though without significant difference for yield with the use of saline water under levels 4 and 8 dS/m, average productivity for level 4 dS/m (70.1 ton/ha) was higher than for level 8 dS/m (33.57 ton/ha). These results do not agree with Ayres & Westcost (1991) who classify carrot as sensitive to saline water, but agree with Ferreyra et al. (1997), who observed low yield when it was used irrigation saline water with 8 dS/m.

It is important to point out the high yield for the variety Brasilia irrigated with low salt concentration water of 0.1 dS/m (92.30 ton/ha) was similar to yield obtained by Pessoa & Cordeiro (1997) and higher than the yields obtained by Ribeiro et al. (1993), Nicoulaud et al. (1997) and Caetano et al. (1999).

It was observed that using saline water at 8 dS/m with or without soil conditioner, carrot productivity was significant lower compared with treatment at 01. dS/m.

Application of soil conditioner Sper Salt together with the different levels of water salinity did not show significant efficiency on increasing carrot commercial productivity in soil and climatic condition of the Brazilian Semi-arid.

Table 3. Commercial yield of carrot under different salt concentration in irrigation water and the soil conditioner Sper Salt

TREATMENT	COMMERCIAL YIELD (ton/ha)
Water with 0.1 dS/m (control)	92.30 a[1]
Water with 0.1 dS/m + Sper Salt	77.52 a
Water with 4 dS/m	71.01 ab
Water with 4 dS/m + Sper Salt	69.21 ab
Water with 8 dS/m + Sper Salt	34.00 b
Water with 8 dS/m	33.14 b
CV (%)	26.0

[1]Means followed by the same letter do differ for Tukey test at 5% probability level

Actual Research Program

1. Monitoring the Water Table Level Variation in a Quartz Sand Soil Under Irrigation

High water availability and/or farmer low knowledge in some irrigation perimeters of the Brazilian Semi-arid have caused an unreasonable irrigation management characterized by excessive water use that, in a medium or short time, would result in serious salinity problem, even increasing the soil water table to critic level. With the use of irrigation in public irrigation perimeters and in private farms of the São Francisco River Valley, it was expected the increase of the water table level in some places at specific time due to unreasonable irrigation water use, causing unsuitable or disadvantageous condition for growing crops and limiting the productivity, besides the great risk of soil salinization.

To avoid recharges pointed out and the risk of soil salinization in the Brazilian Semi-arid, it is necessary to complement the soil natural drainage capacity by an artificial drainage system, to assure a rapid lowered of the water table to a desirable level in a reasonable short period of time.

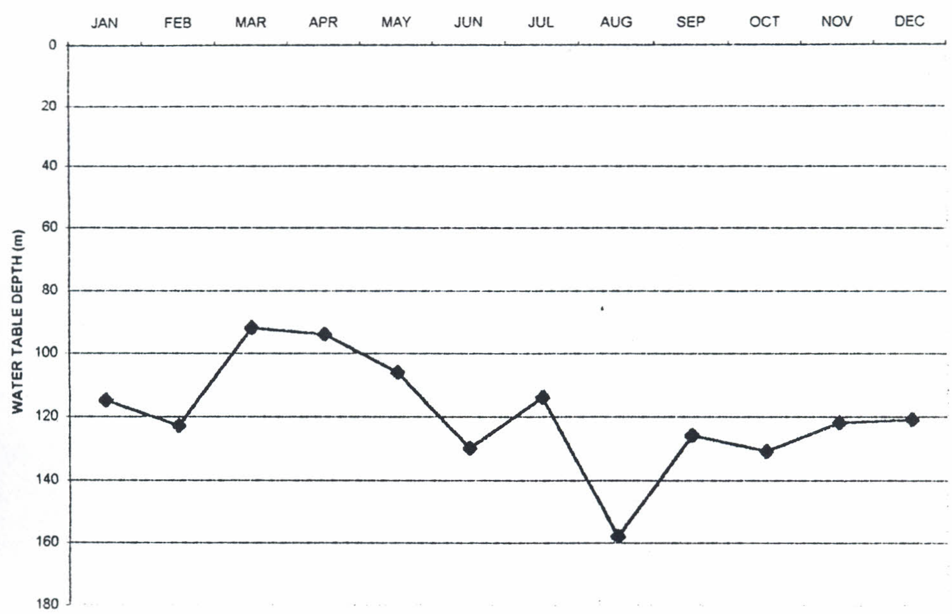
The study has been developed in Boa Esperança Farm, in Petrolina-PE, to get information about the situation and variation of the water table, trying to identify problematic area, its extension and severity, and to determine if it is necessary to establish an artificial drainage system.

The soil of the farm is characterized as quartz sandy and is cropped with mangoes and table grapes under micro sprinkle irrigation for six years.

Forty-six pipes were installed in the area for monitoring water table level regularly at fifteen day intervals.

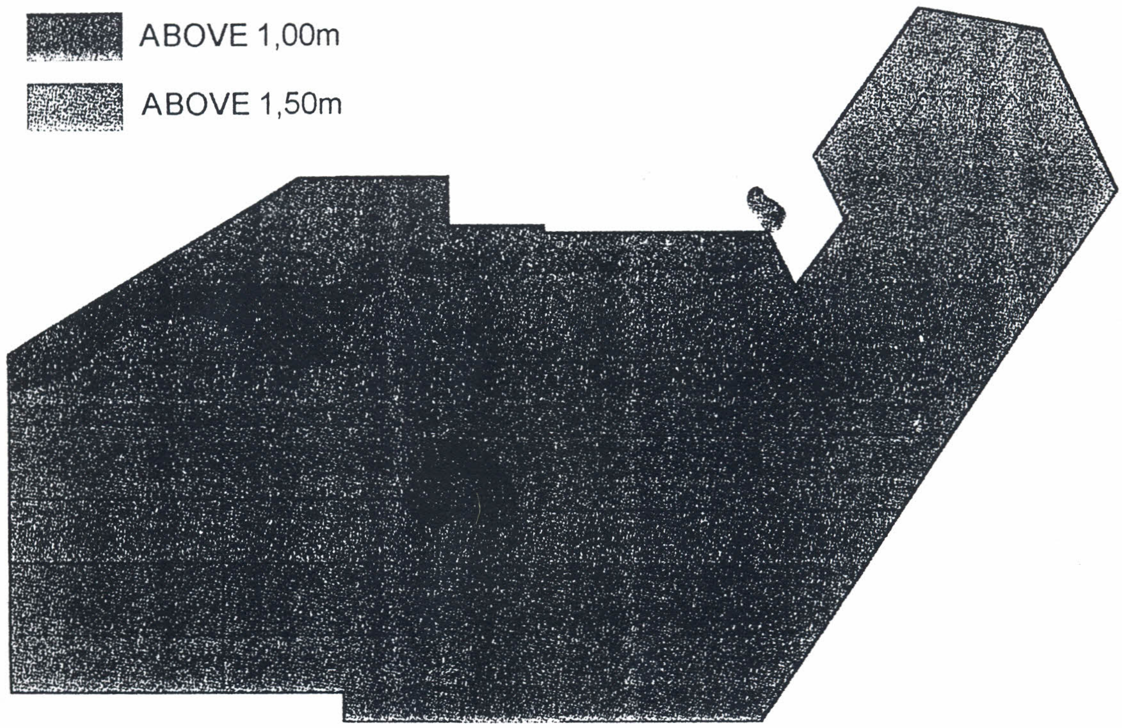
The average depth for monitoring pipes was 1.75 cm, varying from 0.90 m to 1.87 m.

The annual average water table depth in the area, for the period of January to December 1999, was 1.19 m, varying from 1.58 m to 0.92 m (Graphic 1).



Graphic 1. Average water table depth in Boa Esperança Farm

The highest water table level in the studied area was observed in March. This increase happened due to the quantity and the intensity of rainfall that occurred in the region; according to Embrapa meteorological Station it rained 290.2 mm in March; the water table level in the whole area was above 1.50 m, but in a small part of the area it was above 1.00 m (Map 1).



Map 1. Medium depth of water table level in Boa Esperança Farm in March 1999

2. Monitoring the Water Table Level Variation in a Red-yellow Clay Soil Under Irrigation

The study has been developed in Santa Adelaide Farm, in Petrolina-PE, to get information about the situation and variation of the water table, trying to identify problematic area, its extension and severity, and to determine if it is necessary to establish an artificial drainage system.

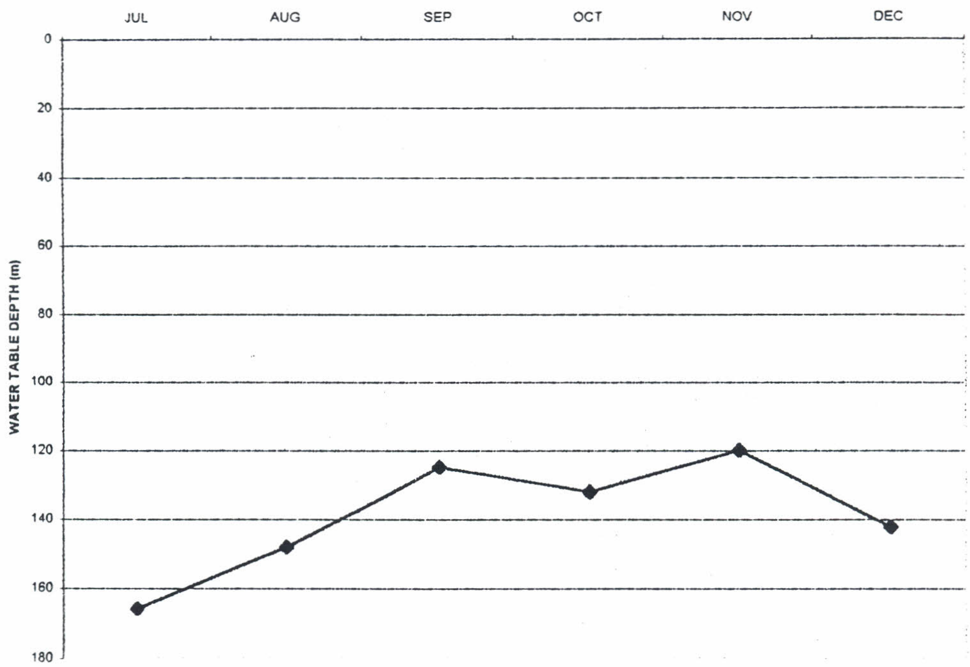
The soil is classified as Red-yellow Podzol, actually classified as Red-yellow clay soil, with variable depth, sand loam/sand loam clay texture, with low electrical conductivity. Table grapes and banana are cropped under micro sprinkle irrigation.

Seventeen pipes were installed in the area for monitoring water table regularly at fifteen day intervals.

This report shows the preliminary results obtained in 1997 and the diagnosis of the problem, mainly related to water table variation. The size of the area is approximately 8.5 ha.

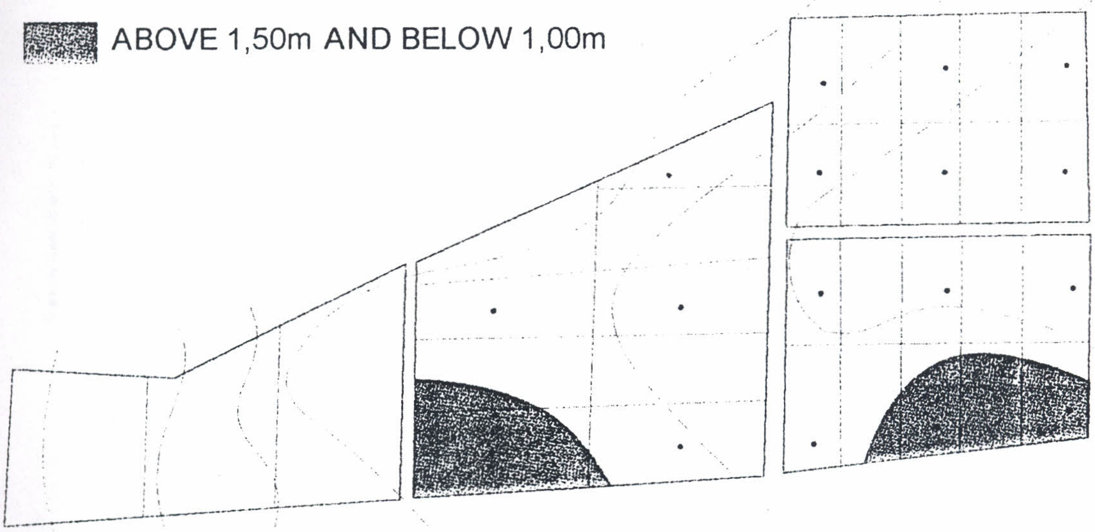
The average depth for monitoring pipes was 1.74 m, varying from 1.43 m to 1.85 m.

The annual average water table depth in the area, for the period of January to December 1997, was 1.39 m, varying from 1.66 m to 1.20 m (Graphic 2).



Graphic 2. Average water table depth in Santa Adelaide Farm

The highest water table level in the studied area was observed in November, being above 1.50 m in a small and low area of the farm. This increase might be caused by the amount of water irrigation applied to the crops, which is very high in that month (Map 2).



Map 2. Average depth of water table level in Santa Adelaide Farm in November 1999

3. Monitoring the Water Table Level Variation in a Dystrophic Yellow Latosol Soil Under Irrigation

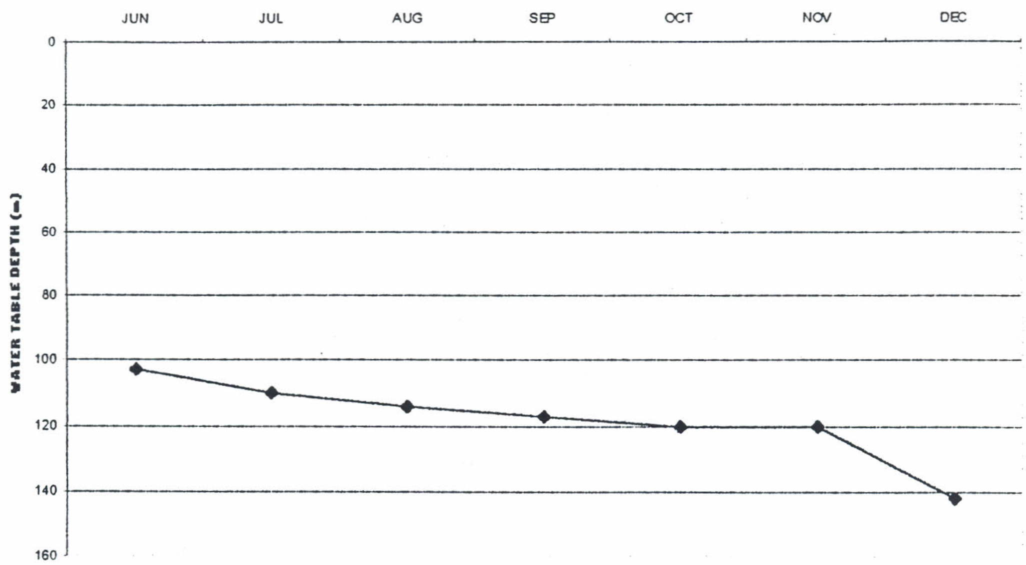
The study has been developed in Fartura Farm, in Petrolina-PE, to get information about the situation and variation of the water table, trying to identify problematic area, its extension and severity, and to determine if it is necessary to establish an artificial drainage system.

The soil is classified as Dystrophic Yellow Latosol with variable depth, sandy texture, well drained, very porous and weakly structured, with low water holding capacity, cation exchange capacity and base saturation. The area is cropped with table grapes under micro sprinkle irrigation.

Six pipes were installed in the area for monitoring water table level regularly at fifteen day intervals.

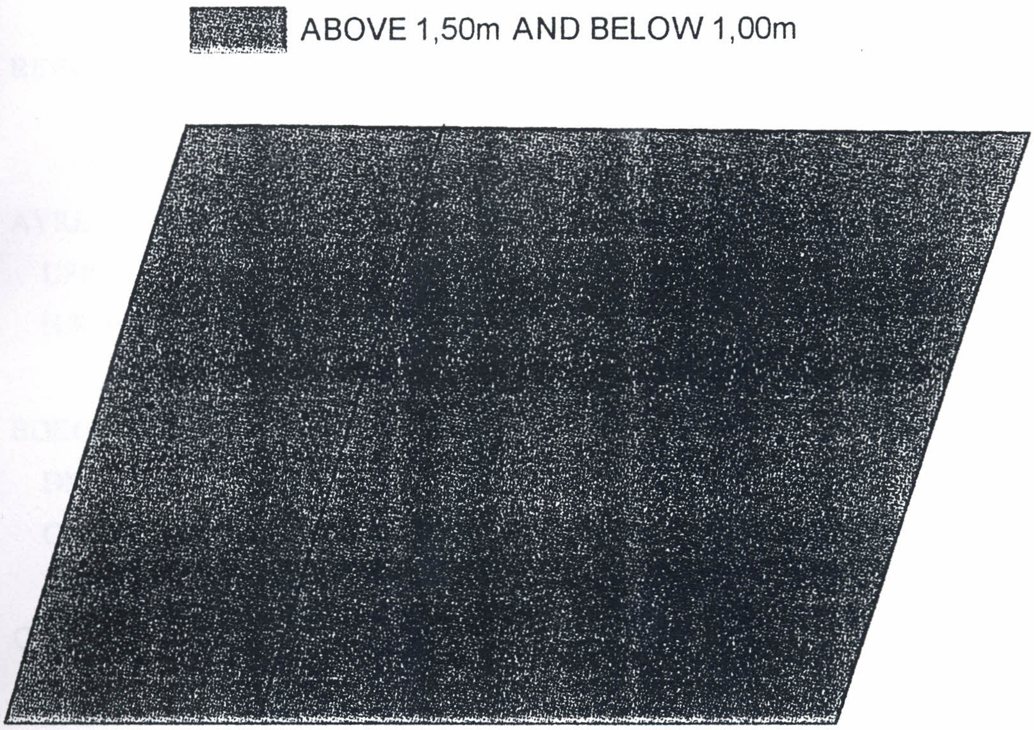
The average depth for monitoring pipes was 1.82 m, varying from 1.76 m to 1.857 m.

The average water table depth in the area, for the period of June to December 1997, was 1.39 m, varying from 1.42 m to 1.03 m (Graphic 3).



Graphic 3. Average water table depth in Fartura Farm

The highest water table level in the studied area was observed in June, being near the soil surface in all the studied area. This increase happened due to the quantity and the intensity of rainfall that occurred in the region; It was registered a rainfall amount of 478.5 mm, from January to May 1997, in the meteorological station of Embrapa near by the studied area. (Map 3).



Map 3. Average depth of water table level in Fartura Farm in July 1997

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