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Recovery of saline soils with the incorporation of calcium sulphate hemihydrate (Ca (SO_4) ½ H_2O) in the community of Yotala

Recuperación de suelos salinos con la incorporación de sulfato de calcio hemidrato (Ca (SO_4) ½ H_2O) en la comunidad de Yotala

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Abstract

The study was carried out in the town of the department of the province of Yotala Oropeza Chuquisaca, having obtained the answers of each experimental unit, the objectives proposed in the investigation are achieved. By interpreting the water analyzes we could classify Yotala irrigation water as average salinity water (C2) that can be used as long as there is a moderate degree of leaching. In almost all cases, and without requiring special salinity control practices, moderately salt tolerant plants can be produced. They also say that the irrigation water is a low sodium (S1) water that can be used for irrigation in most soils with a low probability of dangerous levels of exchangeable sodium. However, sensitive crops, such as certain fruits and avocados can accumulate harmful amounts of sodium. At a pH of 7.5 obtained we can say that our sample slightly basic information, based on the reference values (6.0 to 9.0) is in the common range of water for irrigation. In the interpretation of water that have been made, we can say that the irrigation water used in Yotala is optimal for irrigation and is not causing the accumulation of soluble salts in the soil.

Water soluble salts of salinity, Medical

Resumen

El estudio se realizó en la localidad del departamento de la provincia de Yotala Oropeza Chuquisaca, habiendo obtenido las respuestas de cada unidad experimental, se logran los objetivos propuestos en la investigación. Interpretando los análisis del agua pudimos clasificar el agua de riego de Yotala como agua de salinidad media (C2) que puede ser utilizada siempre y cuando exista un grado moderado de lixiviación. En casi todos los casos, y sin requerir prácticas especiales de control de la salinidad, se pueden producir plantas moderadamente tolerantes a la sal. También dicen que el agua de riego es un agua baja en sodio (S1) que puede utilizarse para el riego en la mayoría de los suelos con una baja probabilidad de niveles peligrosos de sodio intercambiable. Sin embargo, los cultivos sensibles, como ciertas frutas y aguacates, pueden acumular cantidades perjudiciales de sodio. Con un pH de 7,5 obtenido podemos decir que nuestra muestra de información ligeramente básica, basada en los valores de referencia (6,0 a 9,0) está en el rango común del agua para riego. En la interpretación del agua que se ha realizado, podemos decir que el agua de riego utilizada en Yotala es óptima para el riego y no está provocando la acumulación de sales solubles en el suelo.

Sales solubles del agua de salinidad, Médico

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Introduction

Over time, the specifically agricultural areas of the entire Andean region, about the nature of the soil, are being affected in their productive capacity by the accumulation of soluble salts; caused in part by the misuse and inadequate management of the land; Currently it is observed that it is being caused by water pollution and sudden changes in climate.

The salinity problem occurs more frequently in arid and semi-arid regions, due to the lack of rainfall and high evapotranspiration, which tends to easily accumulate salts in the superficial part of the soil, manifesting itself with the presence white crusts.

Nature is so vast that it cannot be controlled to reduce the outcrops of salts in the environment.

In Bolivia, salinity affects the Bolivian highlands and the valleys (Chuquisaca, Cochabamba). The incidence of which is more frequent in areas with low irrigation and poor drainage, such as in the department of Chuquisaca.

In our environment there are huge extensions of valley headwaters with potential for agricultural productivity; but due to the outcrop of salts, it is not possible to take full advantage of the use of these lands because the salts are a limiting factor.

Since the population increases annually, and the food supply is considerably reduced to such an extent that year after year, there has been a gradual regional decrease due to the productive degradation of agricultural soils, particularly in our country.

To improve the productive capacity of saline soils, it is necessary to take precautions in the management or use of land to raise the quality and quantity of the products; on the other hand, Richards (1980) has suggested certain arbitrary relative salinity factors, such as the selection of salinity tolerant crops and sodic soils.

To improve saline soils, Milton (1998) has carried out a study on this type of soil to control the outcrop of salts using calcium sulphate hemi-hydrate treatments (baked plaster), at the end he applied washing to leach cations such as Ca, Mg, Na, K, etc. Among which are ammonia; the author indicates that the reduction was 41.2% of electrical conductivity (CE) with the application of 1 tn/ha of calcium sulphate, in the same way it has decreased with the application of 1mmho/cm for every 0.30 mm of the water sheet added.

To recover the saline soils in this study, it was based on the direct use of four levels of calcium sulphate hemi-hydrate or agricultural gypsum with the provision of methods that allowed measuring the resolution of outcropping of salts.

Background

In Bolivia, salinity affects the highlands, such as the departments of Oruro, Potosí, La Paz, and the valleys such as Chuquisaca, Cochabamba, and Tarija, with which it often occurs in low-irrigation and poor-drainage regions, mainly as in the community of Yotala and Sucre.

On the other hand, it is pointed out that the headwaters of the valleys have potential for agricultural production, due to the climatic characteristics that are favourable. However, due to the flowering of saline soils that affect the fertility capacity of soils, they are not used to the maximum in the affected regions. It can also be mentioned that the population increases annually, and the yield of agricultural products is considerably reduced by the salt factor.

The problem of salinity occurs more frequently in arid and semiarid regions due to low rainfall and high evapotranspiration, in the same way one of the factors that affects the productive capacity of soils is the poor management of agricultural work in the production process, which leads to the degradation of the productive capacity of soils, and low yields in agricultural production in various regions that are affected by this problem.

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For all the above, in the present research work it is proposed to carry out a preliminary study in the community of Yotala, using calcium sulphate hemi-hydrate CaSO4•1/2H2O with different levels per hectare as treatment. To contribute to society and be able to solve the problem of salinity in agricultural soils.

Problem statement

In the community of Yotala it appears frequently salinity in the lands in which it is presented under irrigation, which is a negative factor for agricultural producers, since each year that passes the yield of agricultural products is reduced. Faced with this situation, there is sufficient research on the salinity of agricultural soils to be able to solve the problem that affects all of Bolivia. Importance or justification.

To improve the productive capacity of saline soils in our environment, it is necessary to take precautions in the management of agricultural work to reduce the acceleration of soil salinity and carry out research on salinity; through which the yield can be maintained, or the quality and quantity of agricultural products can be increased. Through this research, training and information can be provided to agricultural producers, mainly small producers with low economic resources, and likewise reduce the acceleration of food insecurity that occurs in our environment and worldwide.

These investigations are supported below:

To improve saline soils, Milton (1998) has carried out a study on this type of soil to control the flowering of salts using calcium sulphate hemi-hydrate treatments (baked gypsum), at the end he applied washing to leach out cations such as Ca, Mg, Na, K etc.

Among which are ammonia; the author indicates that the reduction. the application of 1 tn/ha of calcium sulphate, in the same way, with the application of the treatment, has decreased 1mmho/cm for every 0.30 mm of the layer of water added.

The present research work takes into consideration all the aspects mentioned, for this reason it is proposed to carry out a preliminary study in the community of Yotala and mainly in its agricultural community, using calcium sulphate hemi-hydrate, Ca (SO_4) as treatment ½ H_2O.

To have basic and necessary information to guide in future works framed in this area.

To recover saline soils in this study, it will be based on the use of calcium sulphate hemi-hydrate, Ca (SO_4) ½ H_2O, at four levels with provision of a method that allows measuring the resolution of salt outcrop.

This research in which it is intended to use a treatment with calcium sulphate hemi-hydrate, which is very commercial and has an economically accessible price by 95% compared to the use of chemical fertilizers. This is favourable for small producers in our environment.

Research objectives

General objective

To determine the degree of recovery of saline soils with the incorporation of calcium sulphate hemi-hydrate in the community of Yotala.

Specific objectives

- Carry out and interpret a water and soil analysis before the application of the improver, to identify the initial value of the variables involved in the improvement process, such as pH, electrical conductivity, number of dissolved salts, etc.

- Apply the improver to the ground in three different amounts, leaving witnesses to compare the effects caused by the improver.

- Through the interpretation of a soil analysis, determine the effects of doses of calcium sulphate hemi-hydrate according to the level of reduction of both soluble salts in saline soils and soil pH.

Hypothesis

The application of different doses of $CaSO_4 \cdot 2H_2O$ to saline soils influences the recovery of its productive capacity.

In saline soils, its productive capacity is improved with the incorporation of calcium sulphate hemi-hydrate, due to the effect of the amendment, agricultural yield will be increased.

Operationalization of variables

Our variables will be:

- Amount of gypsum used for the treatment. The degree of recovery of saline and sodic soils will depend on this variable.

- pH. The classification of the soil as acidic or basic/alkaline will depend on this variable.

- Irrigation water. This variable will allow us to know if the accumulation of soluble salts is caused by irrigation water.

- Crop production. With this variable we can determine the degree of soil improvement. Namely, a larger stem diameter, larger size and crop production will be obtained.

Materials and Methodology

In the present investigation, the experimental method will be used to obtain chemical results of soils, for which it is described below:

Description of the study area

Location

The community of Yotala is located northeast of the department of Chuquisaca, 16 kilometres from the city of Sucre, capital of the department. It limits to the north with the municipality of Sucre, to the east with the province of Yamparaez and to the south-west with the department of Potosí. The municipality is in the first municipal section of the Oropeza province.

With the respective geographic coordinates 19°9'45”S 65°15'55”W. at a height of 2,254 meters, max: 2,867 meters above sea level. It is a passing town, since it is located a few meters from the interdepartmental highway that connects the cities of Sucre and Potosí.

Weather

The study area is considered as the head of the valley because the climate varies between 8ºC to 25ºC, with a relative humidity of 77%; wind speed 9.66km/h, with approximate rainfall of 60 to 1200 mm per year.

Floors

The soils of the region are characterized by the presence of soil with considerable salinity, with a loamy-clay texture, with low permeability. the presence of soluble salts such as Ca, Mg, K and Na in less quantity of sulfates and bicarbonates of calcium and magnesium. With a pH that is presumed between 7.8. to 8.9 (Acid).

Materials

In the present investigation, agricultural field material and flexo, scale, camera, GPS, wood or venestas for parcel signs, paint, nylon bags, and stationery will be used. (Letter and legal-size bond paper, markers, envelopes, etc.)

Treatment material

In the present research work, calcium sulfate hemi-hydrate will be used as a treatment material for saline soils, it is an element that reduces soluble salts and through which it will be possible to improve the productive capacity of soils and improve fertility.

Methodology

Diagnosis of the Yotala community

For the present investigation, a diagnosis will be made in the study area or the community to verify the soluble salts in the arable plots in the same way as they will perform and interviews to the pessimal producers and the zone for get specific information.

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As is known, each year that passes, the soils produce with lower agricultural yields, a high percentage of pest attacks on plants and the soil texture becomes clayey, due to salinity. In the same way using faith utilizers the texture of the earth becomes more clayey. water sampling.

In the present investigation, water sampling will be carried out for laboratory analysis according to established laboratory standards.

For the titration of cations, anions, and pH.

Soil sampling

The sample will be carried out according to the TRUORG or Olsen (CIAT) method, in a zigzag pattern at a depth of 60 to 90 cm. Once the sub-samples have been obtained, a quartering will be carried out to obtain a kilo of sample. Then the respective interpretation will be made from the data obtained in the laboratory.

Treatment dose

The doses will be used at four levels per hectare and a control, in this investigation the table is presented:

Dosis por hectárea	Dosis en tratamiento 50m^2
1300 kg /ha de Sulfato de calcio	14Kg/50m^2
1500 kg /ha de Sulfato de calcio	20Kg/50m^2
1700 kg /ha de Sulfato de calcio	24Kg/50m^2
	Testigo o sin tratamiento

Table 1 Treatment application

Treatment application

The incorporation of the treatment will be applied once the plot has been irrigated, the soil will be broken up with a yoke, and then the calcium sulphate will be applied in a broadcast application. Once it is applied, the soil will be stirred again and then irrigated after a week to keep the soil moist and to achieve the chemical reaction.

A sketch of the plot is shown below:

I	II	III	IV	V
T1	T3	T2	T1	T3
T0	T0	T0	T0	T2
T3	T2	T0	T0	T1

Reference:

Treatments: T1, T2, T3
Controls: T0
Total plot area: 200m^2
Plot unit: 50m^2

Contextual framework

This study was carried out in the locality of Yotala. In the Oropeza Province of the Department of Chuquisaca, on the premises of the University Experimental Farm -Villa Carmen", in the second orchard, belonging to the Faculty of Agricultural Sciences of the U.M.R.P.S.X.CH. Geographically, it is located between the parallels 65° 15'25" West longitude and 19° 09'28" South latitude, at an altitude of 2515 m.a.s.l., 15 km from the city of Sucre on the road that connects with the department of Potosí.

Theoretical framework

Origin of the nature of saline/sodic soils

Origin of salinity

According to Richards (1983), saline soils are found in arid and semi-arid climates where evapotranspiration is higher than precipitation. In practice, saline soils do not exist in humid climates, the salinity problem is of greater economic influence due to the consequence of soil irrigation, even a non-saline soil could become saline due to the deposition of salt in the soil and irrigation water, salinity can originate from several causes:

a) Natural causes

They are due to natural weathering of rocks and minerals, volcanic activity, movement of salts by the wind, the proximity of the sea which contains salts in large quantities, results of biological phenomena, arid climates with high evapotranspiration.

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b) Human causes

These are due to the action of man in the environment and can be: the generation of salts because of industrial waste, waste from industries from industrial waste, irrigation with very saline solutions or water of poor quality and in continuous form, in regions of high salinity. water, in arid regions where the lack of rainfall prevents the washing of soils and salts tend to accumulate in the soil. and salts tend to accumulate forming white crusts on the surface of the soil.

On the other hand, Eduard, (2000) mentions that in the headwater areas of valleys, salts originate more frequently because of the salts originate more frequently due to the application of irrigation with salty water, which causes the salts to evaporate to the superficial part of the soil. the soluble salts evaporate to the surface of the soil, which is why the soil is covered with a white mantle (white crusts) in these areas. (white crusts) in these soils the inones are present in chemical substances, and with the course of time they accumulate In the course of time, they accumulate in large quantities, so the soil has a susceptibility to become saline.

Susceptibility to become saline or sodic, and the soluble salts are harmful to agricultural producers. In extreme cases, in saline soils, the electrical conductivity is higher than 4.0 millimhos/cm3/year. 4.0 millimhos/cm and the percentage of sodium absorption is 13 to 18.

According to Storie (1970), the interpretation of the minerals, with the course of time are transported to the lower soil layers, the minerals are therefore detained in soils that are under irrigation, and seawater, river deltas in the headwaters of valleys are susceptible to salinity, which is most often observed in arid and semi-arid regions, due to low rainfall and high temperatures. Sometimes soluble salts move below the subsoil, but surface water acts as a solvent of salts, so irrigated land is exposed to flooding by torrential water carrying minerals.

Cepeda (1991), indicated that in arid regions, where there is little rainfall and high temperatures, there is always an accumulation of soluble salts such as Ca+, Mg+, K+, Na+ and other cations, but during the rainy season, these salts are infiltrated into the soil towards the soil, These salts are infiltrated into the lower layers of the soil, after the rainy season the salts return to the surface of the soil, therefore white crusts are observed, due to the intensive evapotranspiration, the groundwater generally contains soluble salts, therefore this type of soil is only suitable for resistant crops. Therefore, only saline-resistant crops thrive in this soil type.

The same author mentions that the upwelling of salts is due to the weathering of minerals that release atmospheric carbon dioxide (CO_2), also calcium hydrates, magnesium and potassium are released in the same way, this is due to the incorrect drainage system, magnesium and potassium are also released in the same way, this is due to an inadequate drainage system, This is due to the inadequate drainage system, which is insufficient for the evacuation of rainwater (torrential), when these waters stagnate in the lower When this water stagnates in the lower parts, it evaporates in large quantities and leaves the soil with white crusts on the surface. The irrigation water also plays a role, e.g. the application of water with a high concentration of salts that water with a high concentration of salts, which raises the underground water table, i.e. in the event of flash floods, the salts are salts are concentrated in the root zones of the plants, which leads to the translocation of nutrients and the translocation of nutrients and water uptake.

The Food and Agriculture Organisation of the United Nations (FAO), (1986), (1986) confirms that saline soils are most frequently observed in arid and semi-arid regions, where rainfall is low and temperatures are high, the fundamental cause being low rainfall and intense evapotranspiration.

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The fundamental cause is low rainfall and intense evapotranspiration, which causes salts to build up in the surface part of the soil, so that the plant does not the plant cannot thrive in these soils, and this is linked to topographical features, flooding of the this is linked to topographical features, flooding from torrential waters that are stagnant in the lower part of the working lands. This tends to degrade the productive capacity of the soils. This occurs more frequently at the headwaters of valleys where the land is under irrigation.

According to Bukman and Brady, (1993), when drainage is insufficient in agricultural land, there is a tendency to accumulate more water in the soil. soil, salts tend to accumulate more easily in the horizons of the soil profile. in arid areas due to unfavourable climatic conditions.

Factors influencing saline/sodic soils Richards, (1993), points out that salt-laden waters are the result of the weathering of minerals. The salts accumulate in the crusts in two ways: underground and in depressions; this causes saline groundwater tables, on the soil surface there are puddles of water, lagoons, etc. This is due to the deficiency of natural drainage, in the same way the mineralisation of saline soils is due to the main causes which are climatic factors, therefore the soil structure is unstable because the organic matter content is poor, due to this they are not suitable for general agricultural use because the salts cause serious problems.

In this respect, Idea Books, (1999), mentions that salts dissolved in water hinder the absorption of nutrients and water by plants, on the other hand, salts produce phytotoxicity in the germination phase of seeds, as well as in the first phases of seedling development, which can cause their death.

Bukman and Brady, (1980), point out that saline-alkaline soils are due to the precipitation of cations such as Ca, Mg, K, Na, as well as lower proportions of chlorides and sulphates and even bicarbonates, due to which the salinity of the soil increases over time, so that the pH varies between 7.5 and 8.5, so that the concentration of salts is high.

Research carried out by Colacelli reveals that the factors that influence alkaline soils are those that have a high salt concentration. alkaline soils are those that have a significant amount of sodium ions with undesirable properties, with low permeability, and with a low undesirable property, low permeability, unstable aeration, so it is necessary to correct the soil structure to increase aeration. correct the soil structure to increase productivity.

Characteristics of saline soils FAO (1986), defines that the electrical conductivity of the base saturation extract in saline soils is higher than 4 mmhos/cm at 25C, the value of the sodium adsorption rate is lower than 15 and the soil pH ranges from 7.5 to 8.5, but it is possible to recognise with the naked eye when the soil is covered by a white (greyish) mantle, also the excessive concentration of salt, hinders the normal development of plants, especially by the deficiency of water and nutrient adsorption, because the permeability is very low, the structure and texture are unstable. The permeability is very low, the structure and texture are unstable.

Cepeda (1991) indicates that saline soils usually contain more than 0.2% of soluble salts. soluble salts, which increases the osmotic pressure of the plant, thus hindering the adsorption of nutrients and water to the plant. adsorption of nutrients and water to the plants, on the other hand, the pH rises between 7.5 and 8.5 because the salts are displaced in water, this This happens during the rainy season because the salts are concentrated in the lower part of the soil. in the lower part of the soil.

Bohn, (1993), classifies saline soils on the basis of electrical conductivity (E.C.), which has established a limit of 4dsm-1, which is why the Soil of Science Society of America has recommended lowering the standards for saline soils. recommended lowering the standards for saline soils to 2dsm-1, so that the base saturation extract is detrimental to plant development, even the characteristics could be observed with the deformation of the leaves, bluish-green colour, stunted size.

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According to Richards (1993), this type of soil is formed as a result of the combined process of salinity and sodium accumulation, moreover, soils were classified with respect to the conductivity of the aqueous saturation extract in five classes:

a) Non-saline soil, those with conductivity values of 2 mmhos/cm or less and according to the effect of plant development, (low salinity degree).

b) Non-saline soil, the E.C. values between 2 and 4 mmhos/cm, with a slight effect on plant growth, (low salinity degree). plant growth, (low salinity).

c) Saline soil with an E.C. value of 4 to 8 mmhos/cm, where the yield of the crop is reduced (degree of salinity mild). (High degree of salinity).

d) Soil with 8 to 16 mmhos/cm of E.C., in which there are few crops that can withstand these conditions, (high salinity degree). these conditions, (very high degree of salinity).

e) Soil with values higher than 16 mmhos/cm of E.C., the restrictions for cultivation are greater than the previous one, (extremely high degree of salinity). Saline soils tend to have a high concentration of salts, but little exchangeable sodium (Na+).

In this respect, Idea Books (1999), defines the characteristic of salinity, indicating that it is due to poor drainage, especially in arid and semi-arid regions, in these areas rainfall is low and evapotranspiration high, this tends to have an abundance of salts, sulphates, chlorides of Na, Ca, Mg and K, these elements are concentrated in the "A" horizon, this prevents the adsorption of nutrients and water to the plant.

According to the soil recovery analysis (2000), it is recommended to wash the soils with abundant water, taking into account the drainage to avoid water stagnation, always taking into account the solubility of salts, which decreases at low temperatures, because in winter evaporation is high and may require several washes. The electrical conductivity of the saturation extracts of these soils is less than 4 mmhos/cm, but the percentage of exchangeable sodium is less than 15.

Research carried out by Bohn, (1993), reports that saline soils are also caused by human activity, in that salts are transported by irrigation, where they run off on the surface with the application of water, thus increasing salinity in headwater valley soils, the main cause being high temperatures, evaporation and transpiration.
transpiration.

With reference to this problem, Idea Books, (1999), indicates that saline soils have a high content of soluble salts, this concentration prevents the plant from adsorbing nutrients due to the difference in osmotic potential, when its conductivity exceeds 4 mmhos/cm the soil characteristics are modified, where it is most concentrated is in the superficial part of the -A‖ horizon, based on these aspects the author classifies the soils as shown in the table:

Grupo de suelo	Conductividad especifica del estrato de saturación a 25°C en mmhos/cm C.E.S.	Saturación de sodio de la capacidad de intercambio catiónico
Salinos no sódicos	>4	<15
Salinos sódicos	>4	<15
Sódicos no salinos	<4	>15
No sódico, no salino normal	<4	<15

Table 2 Classification of soils with salinity problems according to their chemical priorities

Characteristics of sodic soils

Studies carried out by Historie (1983), reveal that sodic soils are those with an excess of sodium, with a pH greater than 8.5 to 10, the dissolution of organic matter is dark in colour with the name of -black alkali‖ with flocculated clay subsoil and with a high content of absorbed sodium.

On the other hand FAO (1986), mentions that sodium adsorption is higher than 15, even can reach 100; with an electrical conductivity of saturation extract of 4mmhos/cm at 25ºC, a pH higher than 8. 5, therefore the management of these soils is difficult and their productivity is low, because the salt is dominant, as sodium carbonate causes the cation exchange complex, in turn also causes the dispersion and translocation of the particles of soil colloid, all this causes a deterioration in the physical conditions of the topsoil.

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This causes a deterioration in the physical conditions of the surface layer of the soil, causing it to crack in dry periods, and can even raise the clods, but in the rainy seasons they become waterlogged because the level of organic matter is very poor, such as calcium, nitrogen and the level of phosphorus is medium, and potassium can be high.

According to Medina (1997), in soils affected by the problem of alkalinity, ions predominate. According to Medina (1997), in soils affected by alkalinity, ions such as Ca+ carbonate, Mg+, K+, Na+, Cl+, HCO3 and CO3 predominate, and in some cases NO3 may be present, and different salts may be formed between these cations and anions, causing difficulties for plant development. The same author describes the compounds that can cause soil salinity as follows:

(a) Chlorides

According to Medina (1997), the derived salts react with some base, such as hydrochloric acid, which are more abundant and more soluble, toxic for crops, the most important being sodium chloride (NaCl), potassium chloride (KCl), (CaCl), (MgCl), all these chlorides become locally important. all of these chlorides become locally important; at the same time they are described in detail:

Sodium chloride: This salt is the main component of soils, in most of them its abundance is due to its great solubility around its abundance is due to its high solubility of about 317 g/l at 20ºC. On the other hand, sodium and chlorine are quite toxic for several crops, in most of them. toxic to various crops, in some cases extremely tolerant plants can develop at a concentration of 0.1% NaCl. of NaCl extremely tolerant plants can develop in some cases.

Potassium chloride - This salt is similar to sodium chloride, with a solubility of 30g/l at 20ºC with a high toxicity to crops due to the Cl ion, however, it is rarely found in large quantities in the soil, because it is in large quantities in the soil, because potassium is a nutrient element consumed by plants and organisms living in the soil. plants and plant-dwelling organisms.

Calcium chloride: It is a salt with a high solubility of 427 g/l at 20ºC, however it is rarely found in abundance, as it generally reacts with the Cl ion in the soil. However, it is rarely found in abundance, as it generally reacts with calcium sulphates and sodium carbonate.

Magnesium chloride - This salt only occurs under extreme salinity conditions; it has a solubility of 410 g/l at 20ºC. solubility of 410 g/l at 20ºC and is a toxic ion for most crops.

b) Sulphates

The same author mentions that sulphates are derivatives of sulphuric acid and occur in saline-sodic soils as sulphates. sodium-saline soils, such as magnesium sulphate MgSO4, sodium sulphate, calcium sulphate and potassium sulphate. potassium sulphate, as follows.

Magnesium sulphate: This ion has a solubility of 262 g/l at 20ºC, this salt is very toxic for crops. This salt is very toxic for the crops.

Sodium sulphate - This is one of the common ions found in saline alkaline soils and can also be found in groundwater. It can also be found in groundwater, its influence is of high toxicity, but in comparison to magnesium it is lower. its solubility varies according to temperature, as shown in the table. as shown in the table.

Temperatura ºC	Solubilidad gr/l
0	45
10	90
20	185
30	375
40	430

Table 3 Effect of temperature on the solubility of sodium sulphate

Calcium sulphate: This salt is physiologically toxic for the plant and has a low solubility of 1.9 g/l at 20ºC, so CaSO4 is precipitated. between 1.9 g/l at 20ºC, so CaSO4 is precipitated, and therefore does not intervene in the salinity problem. the salinity problem.

Potassium sulphate - This salt has similar properties to sodium sulphate; its toxicity is lower and it rarely accumulates in the water. It rarely accumulates in large quantities in the soil, and its solubility is 180 g/l at 20ºC, although it also varies according to the soil temperature. although it also varies according to temperature.

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c) Carbonates and bicarbonates

Studies carried out by Medina (1997), show that these salts are derived from the carbonic acid of (H_2CO_3). $(H_2CO_3)_2$, large quantities could be found in saline-sodic soils, the most important ones are $(Na_2CO_3)_2$ and $(Na_2CO_3)_2$. $(Na_2CO_3)_2$, $(CaCO_3)_2$, $(MgCO_3)_2$, $(K_2CO_3)_2$, all of which are found in smaller quantities in saline soils. in smaller quantities in saline soils.

Sodium carbonate: This salt is very common in alkaline soils and irrigation water, it is highly soluble between 178 g/l at 20°C. soluble at 178 g/l at 20°C, it is extremely toxic to most plants, therefore its presence increases the exchangeable sodium in the soil. its presence increases the exchangeable sodium, resulting in a reduction of soil fertility.

Potassium carbonate - This salt has a low solubility of 0.013 g/l but increases its solubility to 0.014 g/l for its transformation to calcium bicarbonate, its toxicity is not harmful to most plants.

Magnesium carbonate - This salt is soluble at 0.106 g/l but increases in solubility to 0.014 g/l for its transformation into calcium bicarbonates, its toxicity is not harmful to most plants, due to the formation of carbonate by the adsorption of magnesium and clay, it could even be present in arid regions, where it is in arid regions, dolomites such as Ca Mg $(CO_3)_2$.

The researcher Colacelli, (2000), states that alkaline soils are those that above 8.2 pH, where they have a significant amount of sodium ion, this type of soil has a higher concentration of sodium ion. This type of soil has a higher concentration of sulphates and chlorides, even the presence of sodium bicarbonates could be found, then due to these the physical and chemical properties of the soil are unstable, with low permeability, with problems of aeration, then the sodic soils are necessarily correctable to increase their productive capacity, with the incorporation of amendments of chemical and organic substances.

On the other hand, Black, (1975), determines that in alkaline soils, plants do not thrive easily, because high alkaline levels plants do not thrive easily in alkaline soils, because the high concentrations of hydroxide ions have direct detrimental effects on plants. These effects occur between a pH of 8.5 and 8.5, as Jones found in 1961, because the toxicity of hydroxide ions to plants 1961, because the toxicity of aluminium to cultivated plants is strong. In sodic and non-saline soils saline soils, there are differences in elements such as phosphorus, iron, zinc, which have a low solubility in alkaline conditions. solubility in alkaline conditions, the difference is combated to lower the pH and reduce the presence of salts. presence of salts.

Likewise, the author Pizarro (1987) considers that soils containing sufficient proportions of absorbed sodium and high PSI values cause the dispersion of colloids, the consequence of which is the loss of soil structure, whereas the salt content in sodic soils is low and the electrical conductivity (EC) is less than 2 mmhos/cm and the reaction of this soil varies according to the amount of exchangeable sodium (PSI), and also due to the presence of CO_3 or CO_3HO the pH ranges between 8 and 9. Dissolved salts in soils are found in small quantities, such as chloride, sulphates, bicarbonates, although there may be small concentrations of sodium and bicarbonates. This author classifies soils according to the percentage of exchangeable sodium (Na) as shown in the table.

Categoria	Porcentaje de sodio intercambiable (PSI)
Ligeramente sódico	7 - 15
Medianamente sódico	15 - 20
Fuertemente sódico	20 - 30
Extremadamente sódico	>30

Table 4 Classification of Sodic Soils

The author Aidarov (1985) mentions that sodic soils (solonetz) are characterised by their exchangeable sodium content. characterised by their exchangeable sodium content, the soil horizons are affected by the alkaline reaction, such as sodium, calcium, potassium and magnesium carbonates. alkaline reaction, such as sodium, calcium, potassium and magnesium carbonates. presence of salts, the soil's capacity is degraded, but it occurs more frequently in arid regions.

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Regions, at the same time it becomes compacted and therefore has a low permeability and a poor moisture reserve for the plants. for the plants.

Effect of saline soils on plants

The researcher Gaetz (1997) points out that the influence of salinity causes various problems in plant development, the most important of which are:

a) Problems in adsorption: at high concentrations of soluble salts, the plant makes a greater effort in the suction of nutrients and water.

b) The toxicity problem it causes in plants is in the metabolic pathway, thus altering the development of the crop. It alters the development of the crop; plants that are sensitive to salinity may even die.

c) The problem of the physical structure of the soil is caused by the dispersion of organic matter and clay adsorption, which causes low permeability, so that white crusts form on the surface of the soil.

d) The same author mentions that the controversy between the effects caused by low soil fertility, stunted plants, which is due to low fertility and salinity, the symptoms are not so easy to detect because the characteristics are similar, perhaps it could be differentiated by the following: the stunted size, the dark green leaves, this is due to an increase in chlorophyll content, these symptoms can be clearly observed in the leaves, to determine the effect of soluble salts, therefore a series of analytical determinations must be carried out, such as chemical analysis of the plant in the laboratory.

Regarding resistance to salinity, Medina (1997) indicates that not all species are resistant to high concentrations of salts, in many cases influencing plant characteristics such as colour, size and yield, therefore the concentration of organic matter is poor, whereas the assimilation of phosphorus helps in the adsorption of nutrients to the plant.

The authors Bonh, (1993) also point out that the main effect of soluble salts is to prevent the use of nutrients and water, because the roots have a semi-permeable (weak) membrane and the osmotic function of the plant is hindered when salts are extracted, In the case of salinity-sensitive plants, this can lead to serious problems. In this way, crops can be selected according to their resistance to saline-sodic soils, as shown in the table below.

Altamente tolerante	Moderadamente tolerante	Poco tolerante
- Cebada	- Higuera	- Limonero
- Remolacha	- Olivo	- Manzano
- Algodón	- Trigo	- Peral
- Remolacha azucarera	- Sorgo	- Albaricoque
	- Arroz	- Durazno
	- Alfalfa	- Almendra
	- Tomate	- Rábano
	- Col	- Apio
	- Zanahoria	- Frijol
	- Cebolla	- Trébol blanco
	- Lechuga	- Poroto
	- Maíz	- Haba(leguminosa)
	- Patata	
	- Repollo	
	-	

Table 5 Classification of crops tolerant to saline-sodic soils

FAO (1986) also points out that most plants are sensitive to salinity, which causes serious problems in the first few weeks of growth. causes serious problems in the first few weeks of seedling development, whereby the leaves appear leaves are dusty because the soluble salts are pushed through the leaves. However, in saline soils there is a greater difficulty, as the physical, chemical and biological properties of the soil are extremely are extremely exalted, so the pH is greater than 8.5 and with low permeability with alkali black crusts, making it almost impossible to manage sodic soils.

Reclamation of saline alkaline soils

According to Colacelli (2000), the recovery of saline or alkaline soils will be carried out with the aim of recovering the productive capacity; the incorporation of mechanical actions, chemical, biological and hydrotechnical improvers, is according to the chemical and physical analysis of the soil, the substances that can be used as correctors in saline soils and alkalinity are shown in the table.

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Tomando el azufre como unidad base	
Mejoradores de suelos	Equivalente en 1tn de azufre
Azufre	1tn
Yeso Agrícola	5.35 tn
Caliza molida	3.13 tn
Acido Sulfúrico	3.06 tn
Sulfato Ferroso	8.69 tn
Sulfato de Aluminio	6.94 tn
Puli sulfuro de calcio	4.17 tn

Table 6 Substances to be used as correctors for soils affected by saline soils

Organic improvers that are also available in any region, such as ground seaweed, sugar foam and organic matter, are also highlighted. such as ground seaweed, sugar cane foam, organic matter.

Based on the above-mentioned premises, the following recovery methods are indicated.

a) Recovery by the physical method

Colacelli (2000) mentions several sets of well-differentiated mechanical measures, the most common of which are soil texture profile conditioning, which can be aided by deep tillage or fallow and artificial waterproofing, which aids soil aeration and decomposition.

b) Recovery by chemical method

The same author points out that the addition of chemical soil improvers provides calcium in soluble form to soils with sodium problems and lowers the pH, where NaCO3 action occurs, which removes sodium from the soil. NaCO3 reaction occurs, which replaces the sodium absorbed in the colloidal fraction particles. various chemical and inorganic ameliorators are now used to improve the physical condition of salt-affected soils. soils affected by salts.

On the other hand, research carried out in Guadalajara and Jalisco (2000), found that in alkaline soils there are alkaline soils abound with carbonates of sodium, magnesium, potassium, etc., which are intended to be with calcium sulphate (gypsum) and elemental sulphur, but always taking into account the chemical and physical chemical and physical conditions of the soil, as there is a risk that the calcium will precipitate.

According to producers in Mexico, calcium sulphate should be applied to soils that are affected by salts to improve their fertility and to improve crop yields; calcium sulphate improves the physical conditions of the soil and on the other hand neutralises the cation and anion elements that are abundant in alkaline-saline soils while reducing the pH.

In the same way, Zerega Adams (Fonalap- Estación Experimental Yaracuy y Yaritagua Venezuela 2001) states that the reclamation of saline and alkaline soils, generally tends to be uneconomical when the better soils are used. uneconomical when chemical improvers such as sulphuric acid, aluminium sulphate, ferrous sulphate, etc., are used. sulphate, ferrous sulphate, etc., but when organic amendments such as green manure are used, sugar cane molasses, manure or organic material are not as economical as the chemical ones, but you could say that they are economical, but it could be said that they are very slow reacting compared to chemicals.

c) Recovery by the hydrobiological method

With reference to this aspect, Colacelli (2000) mentions that there are crops that improve saline and alkaline soils, which help to improve the physical conditions of the soil, such as root crops and fodder, like atriplex, which helps to extract soluble salts, as well as favouring the absorption of organic matter and water infiltration.

On the other hand, the biology of the plant must be evaluated to be able to observe the chemical reactions caused by the amendments or improvers such as sulphur, it can be observed by means of the behaviour of the plant, for example the colour of the plant, size, etc., and perhaps a chemical analysis of the leaves can be carried out to determine the toxicity of the plant.

d) Recovery by hydro-technical method

References cited by FAO (1986), indicate that reclamation of saline soils can be done by washing or flooding with water that favours leaching of salts, but the quality of water must be taken into account, otherwise the efficient physical properties of the soil may be affected; in case it may have a higher concentration of soluble salts, it would worsen rather than improve instead of an improvement.

In alkaline soils it is recommended to use amendments before applying water, because the high concentration of sodium can precipitate in the soil, so in this case it is necessary to displace the salts, after which they can be leached out.

According to Cepeda Dovala (1991), the following aspects should be considered when applying water or flooding to improve the physical conditions of the soil.

- Water quality.

- Salt distribution.

- Groundwater level.

- Soil drainage conditions.

All these aspects must be taken into consideration in order not to have conflicts of worsening physical and chemical conditions of the soil, which are affected by salts. the physical and chemical conditions of the soil, which are affected by salts; moreover, when it comes to research, many precautions must be taken. research, many precautions have to be taken.

Chemical and biological reaction of sodic saline soils

According to Bohn. (1993), soils affected by salts can be improved in their physical properties with improvers such as gypsum ($CaSO_4*2H_2O$) with several kg/ha, e.g., at a rate of 1000 kg/ha. these soils require an increase in calcium, to replace the exchangeable sodium; among these, gypsum is also considered as a soil improver. is also considered as the elemental sulphur improver, of course, this element reacts to form sulphuric acid. reacts to form sulphuric acid by means of oxidation by soil microorganisms; for reference, an evaluation should be carried out each year to reference, an evaluation should be carried out every 2 to 3 years to know if another application of improvers is necessary. application of improvers is necessary; in this respect, the following reactions are explained:

$$2S + 3O_2 + 2H_2O \rightarrow 2H_2SO_4 \quad (1)$$

$$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2 \quad (2)$$

$$2NaX + CaSO_4 \rightarrow CaX + Na_2SO_4 \quad (3)$$

According to Medina (1993), the correction of alkaline soils that can be carried out with elemental sulphur to reduce the pH from 8 to 7.5, acidifying products must be used, the most economical of which is gypsum (SO_2SO_4). the most economical being gypsum (SO_4Ca), then water must be applied (washing) to leach the sodium from the soil. to leach the exchangeable sodium, for each calcium ion (Ca+) supplied, which is demonstrated in the following way as follows: SO_4Ca (contributed) + 2Na + complex → SO_4Na_2 (leached) + Ca + (passes to the complex).

Na_2SO_4 is then removed by leaching, thus gradually decreasing the sodium (Na+). sodium (Na+) in the soil progressively decreases, while calcium increases due to the reduction of alkalinity-salinity and therefore the pH of the soil decreases.

Wihttig and Janitzky (1968), carried out an investigation on the recovery of soils affected by salts with the use of chemical improvers, observed the microbial activity or chemical reaction of the bicarbonates of calcium, magnesium, etc., which are precipitated in the soil, indicating that calcium is provided to replace the exchangeable sodium by means of the following reactions.

Saline-sodic soil

Solution Na^{++} > Ca + Mg; SO_4 > Cl > HCO_3
High exchangeable Na^{++}, precipitated carbonate of $Ca^{++}$and Mg^{++}

Organic amendment (RC or OH) (microbial activity, CO_2 production) $2CO_2 + 2H_2O + CaCO_3 + MgCO_3 \rightarrow Ca (HCO_3)^2 + Mg (HCO_3)2$ Exchangeable Na^{++} Ca $(HCO_3)^2$ + Mg $(HCO_3)^2 \rightarrow Ca^{++}$ Exchangeable Mg^{++} $Mg^{++} + 4NaH_3$

Collision of good drainage leachate (removal of $NaHCO_3$ and Na_2SO_4 in drainage water).

Normal soil

Table 7

However, water must be added to remove $NaHCO_3$ in order to avoid capillary access to the soil surface.

Capillary access to the soil surface, so with the practice of amendments it is possible to improve the physical properties affected by salts. physical properties affected by salts.

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Results and discussion

Results obtained

PH

The data in the table show the favourable response according to the needs of the plant. Needs of the plant. The pH obtained with the treatments are optimal for the species grown in the area.

pH-H2O			
testigo	1300 kg/ha	1500 kg/ha	1700 kg/ha
8.4	7.5	7.42	7.31

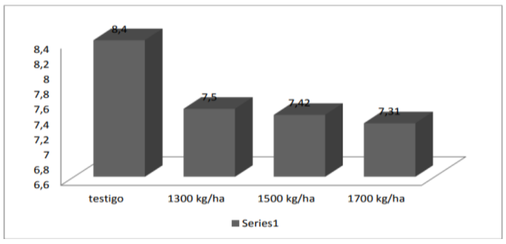

Table 8

Electrical conductivity

The values obtained with the applied amendments result in a decrease in conductivity, this parameter is clearly a function of the soluble salts present in the soil.

conductividad dS/m					
testigo	1300 kg/ha	testigo	1500 kg/ha	testigo	1700 kg/ha
1.042	0.83	1.042	0.58	1.042	0.96

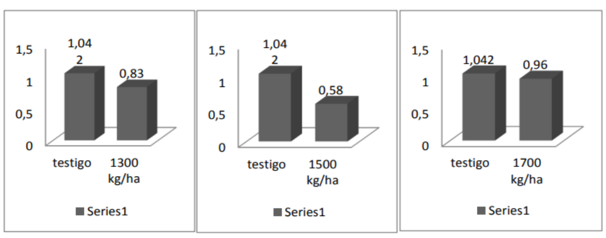

Table 9

Total Nitrogen

Nitrogen as an organic form is used by plants. Nitrogen is part of the soil organic matter and as such contributes favourable nutrients to the soil.

Nitrogeno Total %					
testigo	1300 kg/ha	testigo	1500 kg/ha	testigo	1700 kg/ha
0.151	0.12	0.151	0.12	0.151	0.14

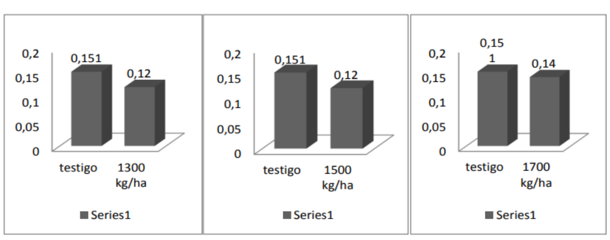

Table 10

Assimilable phosphorus

The substantial increase in phosphorus, a parameter that helps the roots and the plant to develop faster, improving water use efficiency and accelerating ripening.

Fosforo Asimilable mg P/kg					
testigo	1300 kg/ha	testigo	1500 kg/ha	testigo	1700 kg/ha
1.83	4.49	1.83	1.41	1.83	7.14

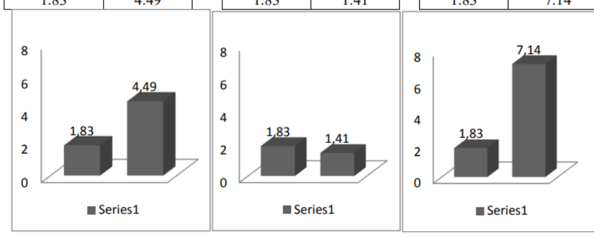

Table 11

Calcium

The calcium surplus obtained from the treatment is very favourable for a fertile soil because the plants will have more ionic Ca^{++} to absorb. The main source of calcium is the main source of ionic calcium.

calcio meq/100g					
testigo	1300 kg/ha	testigo	1500 kg/ha	testigo	1700 kg/ha
9.06	25.3	9.06	19.8	9.06	23.8

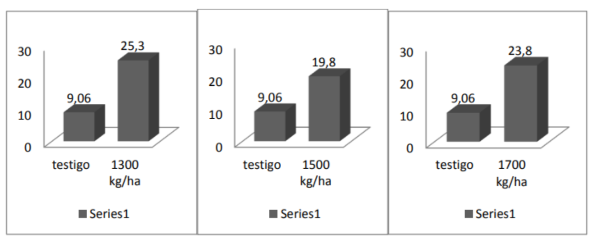

Table 12

Magnesium

The absence of this element is more common than that of calcium. Ionic magnesium is absorbed by plants, but magnesium is generally present as a compound that cannot be.

magnesio meq/100g					
testigo	1300 kg/ha	testigo	1500 kg/ha	testigo	1700 kg/ha
2.97	3.74	2.97	3.71	2.97	3.74

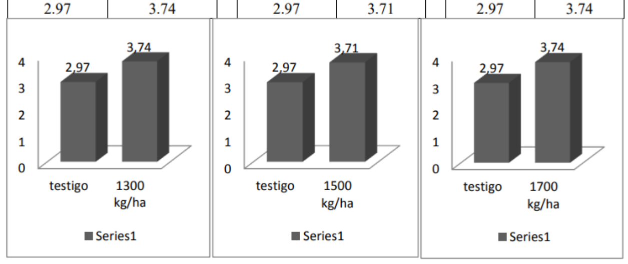

Table 13

Sodium

The decrease of sodium indicates the reduction of salinity in the soil since it is the precursor element of salinity. Due to the presence of calcium and sulphur, sodium ions are difficult for the plant to assimilate.

sodio meq/100g					
testigo	1300 kg/ha	testigo	1500 kg/ha	testigo	1700 kg/ha
0.3	0.25	0.3	0.22	0.3	0.16

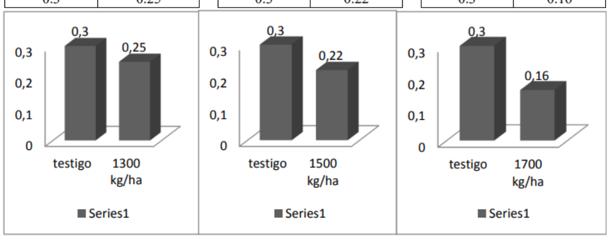

Table 14

Potassium

Potassium as an ion is an element that contributes physiologically and nutritionally to the plant. Available potassium remained moderately constant, since potassium was present as feldspars and potassium ions were produced with the application of the treatment.

Textura					
Arcilla%					
testigo	1300 kg/ha	testigo	1500 kg/ha	testigo	1700 kg/ha
20.6	14	20.6	17	20.6	13

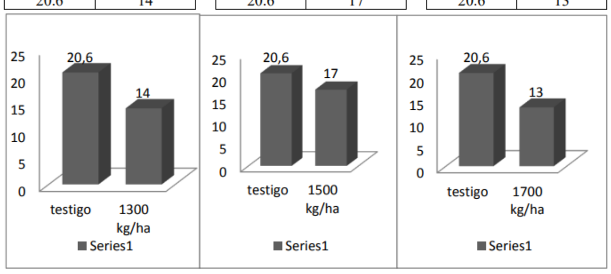

Table 15

Texture

A soil with greater availability to the plants was obtained in parameters such as porosity, saturation that the soil could have, thus obtaining greater soil moisture retention.

Arena%					
testigo	1300 kg/ha	testigo	1500 kg/ha	testigo	1700 kg/ha
38.1	40	38.1	39	38.1	42

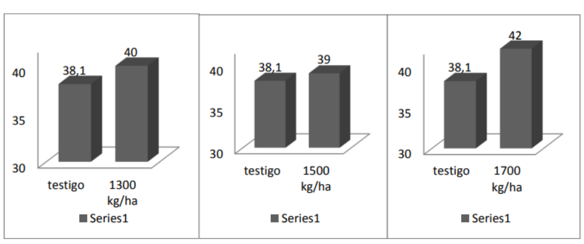

Table 16

Limo%					
testigo	1300 kg/ha	testigo	1500 kg/ha	testigo	1700 kg/ha
41.3	46	41.3	44	41.3	44.9

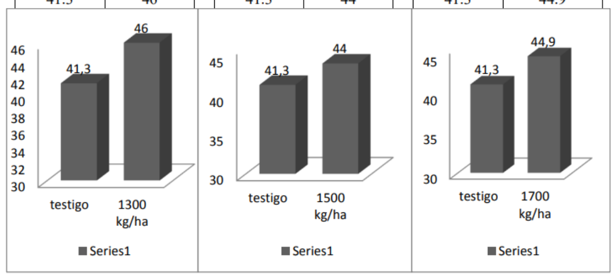

Table 17

Discussion

The results of the variation of the exchangeable bases in the soil by the effect of the application of calcium sulphate to a saline soil with a pH of 8.4 showed a decrease in pH to 7.31, 7.42 and 7.5 in its three levels; the repercussion is shown in the increase in some parameters and the decrease in others.

In the case of calcium, this increased to 131% with the application of 1700 kg/ha of calcium sulphate, 109% with the 1500 kg/ha treatment and 139% with 1300 kg/ha.

As Almaraz (1998) points out, this phenomenon was since thanks to the application of calcium sulphate in the soil, the calcium sulphate in the soil increased and so did the calcium radicals, which are the ones that displace the sodium that causes salinity.

As for magnesium, it was determined that before the application the amount of magnesium was 2.97 meq/100g. 2.97 meq/100g of soil, increasing from 62% in the 1500 kg/ha treatment to 63% with 1700 kg/ha. to 63% at 1700 kg/ha.

According to Cochrane (1971), this increase is due to the increase of calcium in the soil; while the amount of magnesium increases, the ions are not fixed to the soil colloids; but when calcium is present in quantities greater than magnesium, as occurred in this research, it causes this element to be absorbed by the clays and assimilated by the plants.

Although before the application of the soil amendment, the potassium content was 0.30 meq/100g of potassium, the effect of the treatments decreased from 76% with the 1300 kg/ha treatment to 90% with 1700 kg/ha.
with 1700 kg/ha.

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The explanation for this behaviour was due to the fact that the potassium, which was in the form of feldspar that is poorly assimilated for adsorption by the roots, reacted with the sulfuric acid, releasing a greater amount of potassium ions that are easily used by the roots (Bohn, 1993), which would lead one to think that the observed decrease was due to the fact that this element was consumed by the plant and leached by water. Phosphorus records showed a controversial behaviour, increasing from 145% to 290% in the three levels.

Almaraz (1998), points out that phosphorus is found in the soil in the form of a very poorly soluble compound, forming phosphates that are difficult for the plant to access; the incorporation of organic or mineral amendments such as calcium sulfate makes the reaction with the sulfuric acid formed by the calcium sulfate more soluble and helps the roots and the plant to develop more rapidly. In addition, phosphorus in its new state improves water use efficiency, accelerates ripening and is vital in seed formation.

The sodium element, considered as the precursor element of salinity, underwent a decrease from 0.3 meq/100g to 0.25 meq/100g with 1300 kg/ha, 0.22 meq/100g with a 1500 kg/ha treatment and 0.16 meq/100g with 1700 kg/ha. This decrease has made elements necessary for plant growth more available to plants because, according to Richards (1980), high concentrations of sodium in the soil hinder the adsorption of calcium, magnesium and potassium to the plants, thus atrophying soil physics.

Because of all these reactions and variations, a reduction in soil salinity was manifested, favoring soil nutrients. of soil salinity, favoring soil nutrients; the reduction of sodium manifested a greater growth of established plants (Bohn 1993; Buckman and Grady, 1993; Black 1975). growth of established plants (Bohn 1993; Buckman and Grady, 1993; Black 1975).

As a result of the decrease in sodium and potassium in the soil, in addition to the increase in calcium, magnesium and phosphorus, the effective cation exchange capacity also underwent a variation, being lower because of the three treatments compared to the initial soil values.

An economic analysis showed that an optimum application for alkali soil improver is 1300 kg/ha.

Conclusions

Having obtained positive responses from each experimental unit, the proposed objectives of the research were achieved, thus leading to the following conclusions:

- Through the interpretation of the water analyses we were able to classify the irrigation water, from Yotala, as water of medium salinity (C_2) which can be used as long as there is a moderate degree of washing. In almost all cases and without the need for special salinity control practices, moderately salt tolerant plants can be produced.

- Also, irrigation water is a low sodium (S1) water which can be used for irrigation in most soils with little likelihood of reaching dangerous levels of exchangeable sodium. However, sensitive crops, such as some fruit and avocado trees, can accumulate harmful amounts of sodium. By obtaining a pH of 7.5 we can say that our sample has a slightly basic character, although based on the reference values (6.0-9.0) it is in the common range for irrigation water. Having performed the interpretation of the water, we can say that the irrigation water used in Yotala is optimal for irrigation and that it does not cause the accumulation of soluble salts in the soil.

- The application of calcium sulphate to the soil resulted in a reduction of toxic elements for plants such as sodium and potassium; however, other elements such as phosphorus and calcium, which are beneficial as nutrients, increased. Due to the application of the treatment, a reduction in the number of soluble salts in the soil was obtained. In addition, the pH was reduced from 8.4 (strongly alkaline) to 7.4 (weakly alkaline).

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- The cost of the improver (gypsum), is much lower compared to the price of other improvers such as urea, sulfur, sulfuric acid, ferrous sulfate, aluminum sulfate or limestone, therefore, it becomes much more economically therefore becomes much more economically profitable, even more so when we are talking about an area populated by retail farmers who do not area populated with retail farmers who do not have the necessary resources to apply high-priced improvers. high priced improvers.

References

Almaraz, J. 1998. Manual para la interpretación y análisis de suelos. Ed. Tokio.

Beltrán, L. 1970. Análisis químico de suelos. Ed. Omega S.A. Casanova 662 p.

Black, C.A. 1975. Relaciones suelo y planta. Ed. Hemisferio Sur. 717 p.

Bohn, H. et al. 1993. Química del suelo. Ed. Limusa S.A. 363 p.

Boletín FAO. 1986. Guía de fertilizantes y nutrición vegetal. Ed. FAO/FIAT PANIS 107 p.

Bonifacio et al. 1995 Edafología. Universidad Autónoma Chapingo, México. Departamento de suelos. 246

Buckman Y Brady. 1993. Naturaleza y propiedades de los suelos. Ed. Limusa S.A. 4ta ed. 567 p.

Castañón, G, et al. Ingeniería del riego, utilización del agua. Ed. Teresa Gómez – Mascaraque Pérez. Pp 192 – 163.

Cepeda, D 1991. Química de suelos. 2da. Ed. Ed. Trillas, México D.F. 151 p.

Cochrane, 1971. Guía para la interpretación de datos analíticos de los análisis rutinarios de los suelos afectados en laboratorio. Ed. Ministerio de agricultura Pp. 1 -17.

Colacelli, M. 2000. Uso del suelo. Editorial de la facultad de Agronomía y Zootecnia. U.N.T. Pp. 1– 24.

Craetz, H. 1997. Suelos y fertilizantes. 6ta. Ed. Ed. Trillas. Pp. 45 – 46.

Dimanche P. 1999. Análisis de suelo y material vegetativo, bases para la productividad agroforestal. 4ta. Ed. Pp. 60.

Freidich, T. 1996. Servicios de ingeniería agrícola de sistemas de abono. Pp. 18.

Gisbert, C. et al. Océano Central / Enciclopedia práctica de la agricultura y la Ganadería. Ed. Océano S.A.

Idea books. Biblioteca en la agricultura, suelo, abono y material orgánico. 4ta Ed. Pp. 56 – 115.

Richards, 1980. Diagnóstico y rehabilitación de suelos salinos y sódicos. 4ed. Ed Limusa. México. 270p

Storie R. 1970. Manual de evaluación de suelos. Ed. Hispanoamericana. 26-28p

James,N. 1968. Drenaje de tierras agrícolas (teoría y aplicación). Ed. Limusa S.A. pp560-570.

Kremmer. P. 1975. Relaciones Hídricas de suelo y planta. Ed. Edutex S.A. 2da Ed. Pp 242-290.

Medina. J. 1997. El suelo, abono y fertilización de los cultivos. 4ta Ed. Ed. Mundi Prensa. Pp. 167-181.

Porras. M. et al 1975. Aguas subterráneas (problemas de la contaminación) 3ra Ed. Ed. CIFCA. Pp 43-65.

Remmer. F. 1992. Manual del agua, su naturaleza, tratamiento y aplicación. Ed. Miembro de la cámara nacional de la industria 3ra Ed. Pp 42.

Zerega. L.; ADAMS.M. (SA). Efecto cachaza y azufre en los suelo salinos. Whittic.j. 1968. Instituto de Edafología, Facultad de Agronomía. Maracay, Venezuela.

www.drdoreronlbas.com/metodos/analisis-d-agua/intepretacion-analisis-de-agusi.html

www.ciad.mx/boletin/mayjunnoz/suelo.pdt

www.ceniap-gob.ve/brdigital/caral0902./texto/efecto.htm-48k

www.informador.com.mx/lartes/2012/agosto/08pr08a.htm

www.un/med.edu.co/~djaramal/INTERCAMBIO-IONICO.pds

www.drderenonlabs.com/metodos/analisis-de-agua/interpretacionanalisis-de-aguas.htp

www.drealderonlabs.com/metodos/indice-de-metodos.htp

www.economia_cgm.gob.mx/proporcion/doctos/perfiles/yeso.htm.

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