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DRAINAGE MANAGEMENT TO CONTROL SALINITY AND ALKALINITY FOR BETTER CROP PRODUCTION

BY

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ABSTRACT

An impermeable salt-affect land was made cropable with gypsum treatment to meet the requirement of its 15 cm depth. Four successive irrigation, of 10cm depth each, were applied for its surface flushing. The effluent was disposed off with the help of a Gravitation Drainage Tubewell. (GDT). The new technique was used further, to keep intact a water logged land and to reclaim the salinity patches in cropped fields with success.

INTRODUCTION

The lands in the arid and semi-arid regions of the world, are of low rainfall. The moisture movement trend in them is upward. The salts inherently present in them have the tendency to accumulate in their upper layers. Consequently these lands are salt affected. Almost all of the salt-affected lands are of saline solid type.

The salts they contain are mostly sodium chloride (NaCl) and sodium sulphate ($Na_2SO_3.XH_2O$). They are highly soluble in water.

The canal irrigated lands of Pakistan are a part of this situation. The magnitude of the problem in the country has been assessed by the Water and Power Development Authority (WAPDA) in 35.5 million acres.; 14.2 million hectares of the culturable commanded area (CCA) covered by different canal systems. According to them, 38% of this area is salt-affected to various degrees.

Only irrigated Agriculture, on these lands, is possible. To ensure sustainable irrigation supply, the biggest contiguous canal system of the world has been developed in the country to take about 106 million acre feet (maf) of water from the Rivers: Chenab, Jehlum and Indus, to the cultivated fields for growing crops. The whole canal system is built with earth.

About 50 percent of the water flowing in this canal system is lost on the way. The major part of this goes deep into the earth to join the groundwater. In the absence of any under ground drainage system the groundwater has been showing rise in the earth mass. At present, in the province of Punjab, with 20.1 million acres of cca, the ground water depth exists within three meters from the natural soil surface in 42% of this area. In the Province of Sind, with cca of 9 million acres, this water table depth is found in 90% of the area.

In all these lands the groundwater is influenced by evaporation from the soil surface. The evaporating water leaves the salts in its upper layers (Fig.1) to aggravate the problem of soil salinity further.

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The salt affected lands are to be reclaimed to make them cropable. To achieve this objective gypsum is mixed with the earth mass to meet the requirement of 15cm depth of the soil. Thus a saline sodic soil is converted into a gypseferous saline sodic soil which behaves as a saline soil.

Methods exist for the reclamation of salt affected permeable lands. A fraction of these lands is impermeable. The surface flushing technique was developed for their reclamation. The benefit of this technique was also taken to keep intact a waterlogged land and to reclaim the salt affect patches in cropped fields. The result achieved, there from, are reported in this paper.

REVIEW OF LITERATURE

Kelly (1951) applied gypsum to an alkali soil at the rate of 10 to 12 tons per acre. The plots were flooded continuously for three weeks. He found that the exchangeable sodium was effectively removed to the depth of 5 feet and practically a highly sodic land was converted into a highly productive land.

R.C. Renord and C.A. Bower (1960) used sea water for reclaiming a sodic soil. The sea water contained 11.6 meq/l of Ca + Mg. They pointed out that with the use of only 4 feet of sea water, in conjunction with 6 feet of Colorado river water, reduced the initial exchangeable sodium percentage from 39 to 5 and reduced the time of reclamations from 120 to 12 days.

Hussain Mohammad (1968) reported that it takes 6 to 8 years for reclaiming a saline sodic soil by rice culture and that application of gypsum accelerates the replacement of exchangeable sodium.

B.K. Khosla and I.P. Abrol (1972) studied the effect of gypsum of varying fineness on the composition of saturation extract of a saline sodic soil. The reported that much of the gypsum is utilised in precipitating the soluble carbonates to form relatively insoluble calcium carbonate,. Gypsum of a slightly finer than 0.59 mesh would be more effective than of the coarse grades. The amount of gypsum needed to neutralise the soluble carbonate is known to be indicative of the minimum amount of amendments required to start the reclamation of a saline sodic soil high in carbonates.

G.R. Dutt Terkeltoul and Road Shkool R.S. (1972) pointed out that the amount of water and gypsum required, for the reclamation of the soil, were highly dependent upon quality of water used for leaching.

Altaf and Asghar (1985) found that with the application of gypsum, even through it is applied to the extent of 1/2 or 1/4th of the total requirements of the soil, the reclamation of a saline sodic soil is accelerated and can be achieved within a limited period of time. The increase in infiltration rate of the soil is almost equal with 1/2 and 1/4th of the gypsum requirement applications.

Altaf (1985-86) reported that the reclamation of saline/sodic calcareous lands can be achieved within a short period of time, when the chemical amendments are used for this purpose. Sulphuric acid and gypsum are equally effective to increase the infiltration rate of the soil.

Altaf (1986) pointed out that 1/2 and 1/4th gypsum applications are almost equally useful to facilitate the leaching process of a saline sodic soil.

Altaf (1987) achieved successful reclamation of a saline sodic soil at the field level with the use of gypsum and brackish water.

Altaf and Nazir (1990) reclaimed a highly saline sodic soil with surface flushing, within the period of a week, in the month of December and raised the Berseem Crop (Egyptian Clover) which competed with the crop sown in the months of October & November.

Altaf and Zahid (1990) reclaimed an impermeable saline sodic soil, by its surface flushing, within the period of a fortnight and got flourishing first rice crop.

MATERIAL & METHODS

The work was carried out at the field level at different sites. In each case the Chemical Analysis of the soil was conducted to ascertain its salinity and sodicity status.

The study on surface flushing/drainage of impermeable lands was carried out at the Pakistan Agricultural Research Council's Reclamation site, Sadoki, in the Gujranwala District. An area of 5 hectares was selected for the experiment. Each field covered 0.5 hectares. Thus these were 10 fields in all.

The water courses were kept along the distal ends of the fields and a drainage channel was made to run in between the two rows of the fields to remove the drainage effluent. Fig.IV. It was disposed of with the help of a G.D.T.

The experiment to flush the water logged saline sodic lands was carried out at the Havali Reclamation Research Station, Shorkat in the Multan District. The water table depth, at this site, varied from 0.30 meter to 0.45 meter. The Ec x 10^6 of the groundwater varied from 5600 to 6500, table-2c.

4 fields of 0.4 hector-size each, were selected for the study. The water courses were kept along their distal ends and a drainage channel of 0.3 meter width and 15cm depth was made in between the two rows of the fields, Fig-IV.

The surface flushing technique was applied on four fields, whereas, the 5th field was kept as control.

The wheat crop remained under study. The crop was irrigated, whenever, it needed watering. The water applied was removed through the drainage channel. It carried with it the salts left on the soil surface with the evaporating groundwater. The effluent was lifted into the Trimu-Sihnai (T.S.) link.

The study of flushing of saline soil patches, in the cultivated fields, was carried out at various reclamation research stations and in farmers fields, Fig-III.

During the growth period of different crops; Rice, Wheat and fodders, while irrigating the crops in the field, the irrigation water was passed through the salt affected patches to irrigate the rest of the field.

RESULTS AND DISCUSSION

At the Sadoki reclamation Research Station the soil analysis result show Table 1-A, that it was of Clay Loam Texture. The soil saturation extract analysis results indicate that it was of highly saline sodic type and of impermeable nature, table 1-B,C,D&E. After flushing the soil it was fit to grow crops, table 1F.

The yield results of the first rice crop indicate that they were 3650 Kgs per hector of Irri.-6 and Basmati 385 varieties respectively, table 1-H.

There was no deep percolation losses of the irrigation water applied to the crop. After 105 days of the crop stay in the field, the soil beyond 15cm depth, was almost dry.

For the waterlogged lands the experimental results of the soil, table 2-A, before sowing and after harvesting the wheat crop show that originally the soil was suitable for growing this crop. After the crop, in the fields 1 to 4, the salts left on the soil surface with the groundwater evaporation, were removed with the surface flushing and there was no change in its salinity status, table 2-B. The wheat crop in these fields followed its normal course of life cycle. The wheat grain yield in them ranged from 860 to 880 v Kgs per hector. In the 5th field, where the surface flushing was not practised, the EC x 10^3 of the soil saturation extract, after the wheat crop, was increased to 32.52 and the crop yield in this field was reduced to 250 Kgs per hector, table 2-E.

In case of patchy saline sodic lands, where the salt affected patches were present in the cultivated fields (Fig-IV), the application of 3 to 4 irrigations through the patch/patches during the stay of any crop reclaimed the soil, table 3. The next crop was uniform in the whole field in all the cases.

CONCLUSIONS

Reclamation of salt affected lands is shifting of salts, from the root zone of crops in them by drainage and the replacement of exchangeable sodium, by calcium ions. The easily available source of calcium ion, in nature, is gypsum.

Leaching and surface flushing of soils are the means of their drainage. The effluent, in case of surface flushing, is disposed off in a source of water or deep into the earth with the use of a G.D.T. The reclaimed lands ensure the successful growth of crops.

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Table-1A

Machenical Composition of the Soil

Percentage of each;

Sand	Silt	Clay	CaCo	Texture
15.60	52.00	30.40	5.40	Clay Loam

Table-1B

Soil Saturation Extract Analysis

SP	PH	Ec x 10^3	SAR
32.00	9.20	9.00	9.30

Infiltration rate of the soil after making it calcium saturated 0.14 mm/hour

Table-1C

PH, 1:5 soil water suspension **10.0**

Percentage of salts, (1:15 soil water suspension) **0.70**

Table-1D

Gypsum Requirements of the soil tons/0.3 meter	CEC/100 Grams	Exchangeable Sodium/100 gm	Exchangeable Sodium Percentage
11.0	16.0	6.4	40.0

Table-1E

Penetration of Water in the soil (pots):

1	2	3
-	-	The water soked the soil but later on its penetration through the soil was stuck up completely.

1. The original soil treated with canal water.
2. Calcium saturated soil treated with canal water
3. Original soil treated with saline water.

Table-1F

Analysis Results of the Soil Saturation Extract After Flushing the Soil at Sadoki

Sr.No.	Treatment	SP	PH	Ecx10^3	SAR
1.	Gypsum 0-15 cm depth	30	8.4	1.4	12.0

The analysis results were identical in all the fields. Hence they are given here only one of them.

Table-1G

AVERAGE YIELD RESULTS OF RICE PADY IN KGMS PER HECTOR IN THE FIELDS OF 0.5 HECTOR AREA

1.	Irri-6	3650
2.	Basmati 385	2550

Table 2-A: Analysis results of soil Saturation Extract
Before sowing wheat crop

Field No.	pH	Ecx10³	SAR
1	8.3	5.5	29.5
2	8.4	5.0	26.7
3	8.3	4.5	40.3
4	8.4	5.0	27.7
5	8.3	5.0	28.6

Table 2-B: Analysis results of soil : After Harvesting the Wheat Crop

Field No.	pH	Ecx10³	SAR
1	8.3	6.0	30.5
2	8.5	5.4	28.3
3	8.4	6.0	41.5
4	8.3	5.0	28.3
5	8.1	32.5	161.0

Table 2-C: The Groundwater Analysis Results

Field No.	pH	Ecx10³	SAR
1	7.9	5600	28.0
2	7.6	5560	27.5
3	7.7	6000	29.3
4	7.8	58000	30.0
5	7.6	65000	332.5

Table 2-D Analysis Resultsof the Water used for Irrigation (Canal Water)

pH	Ecx10^6	RSC	SAR
7.6	220	-	0.1

Table 2-E Yield of Wheat in Kilograms/hector:

1	2	3	4	5
2200	2100	2150	2100	250

Table 3 The Condition of the Soil in the Salt Affected Patches (0-15 cm depth)

Site	Before Flushing the Soil			After Flushing the Soil		
	pH	Ecx10^3	SAR	pH	Ecx10^3	SAR
1.	9.8	8.5	75.0	7.8	3.2	12.0
2.	10.0	3.8	55.0	8.0	2.8	9.5
3.	8.8	9.0	45.0	8.2	3.4	10.6

The canal water was used for irrigation.

FIG. I

MOVEMENT OF SALTS
IN
THE SOIL
UNDER FALLOWING AND CROPPING CONDITIONS

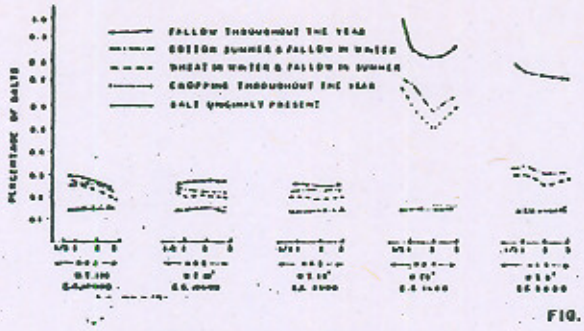

FIG. II

GRAVITATIONAL DRAINAGE TUBEWELL

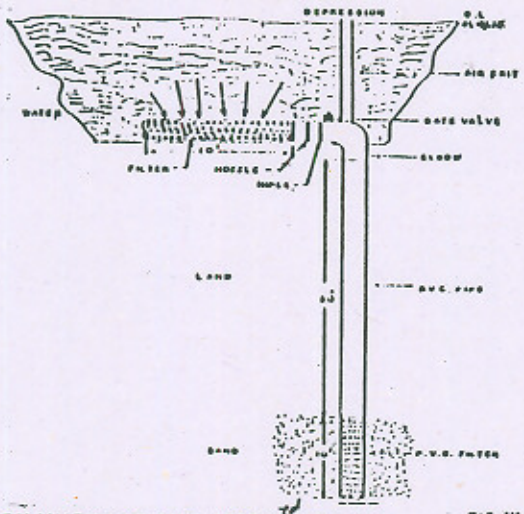

FIG. III

RECLAMATION OF SALT AFFECT PATCHES
IN IRRIGATED FIELDS

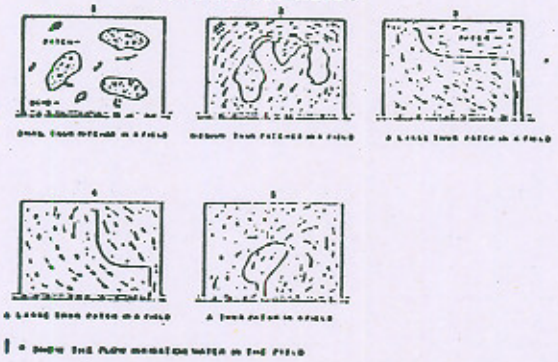

FIG. IV

EXPERIMENTAL PLAN

