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EFFICIENCY OF GYPSUM GRADES AND QUALITY OF LEACHING WATER FOR RECLAIMING A SALINE-SODIC SOIL.I. AMOUNT AND SALUTE CONCENTRATION OF EFFLUENTS

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Gypsum particles (5-16, 16-25, 25-60, 60-100 and finer than 100 mesh) @ 100% GR of 0-15 cm soil columns and four synthetic waters (EC 0.6 + SAR 6, EC 1.0 SAR 12, EC 2.0 + SAR 18 and EC 4.0 + SAR 30), in all possible combinations, were used for reclaiming a loamy clay saline-sodic soil in a laboratory experiment. The results indicated that the time to start leaching decreased with increasing fineness of gypsum particles and/or brackishness of synthetic waters. Under continuous submergence at 26±2°C total volume of water leached through 30 cm soil columns (BD = 1.33 g cc) increased as the gypsum particle size decreased and/or as brackishness of water increased. The removal of soluble salts (me treatment^{-1}), mg of soluble Na and Ca increased with increasing the fineness of gypsum. Rate of removal of the solutes in leachate was much higher for the gypsum treatments than the control but decreased with time.

INTRODUCTION

The water intake rate may be very low, and even negligible, of the dispersed sodic and saline-sodic soils particularly during initial stage of reclamation. The amelioration of such soils involves application of amendments containing soluble Ca or those which release calcium from $CaCO_3$ in calcareous soil. The reaction of calcium with the soil exchange complex releases sodium which has to be removed from the site of reaction in order to maintain a favourable reaction rate.

In some situations use of saline or even saline-sodic water may be useful for leaching such alkali salts because this will ensure reasonable soil permeability for timely reclamation. Under dense sodic soil conditions, even the use of gypsum may not increase soil permeability due to its low dissolution rate (Rhoades, 1982), especially when coarser grades are used with view to lower the cost of soil reclamation.

Most of the ground waters in the Punjab (75% of the discharge of existing wells) are saline, saline sodic or sodic in nature (Malik et al., 1984) according to the criteria of U.S. Salinity Lab. Staff (1954). For using such waters during soil reclamation, the knowledge of the pattern and rate of sodium/calcium removal in leachate is necessary because rapid removal of Na will expedite the reclamation while that of calcium will be a wastage. Such information will be helpful to provide an insight about the calcium threshold concentration in soil solution for optimum soil reclamation. For similar reasons, the present experiment was designed to monitor the rate of leaching and solute removal in leachate during reclamation of a saline-sodic soil using differnt gypsum grades and waters.

MATERIALS AND METHODS

A bulk sample from surface 30 cm layer of the Gandhra soil series (Loamy clay in texture, EC_e=14 dSm^{-1}, SAR=59, pH_s=9.1) was collected, sun dried, ground and passed through a 2 mm sieve. A 30 cm high column with 2400 g soil was prepared in each of the 72 PVC pipes (45x8.75 cm) with almost a uniform bulk density of 1.33 g cc^{-1}. Gypsum powder @ 100% GR was mixed with the surface 15 cm soil layer before packing the soil uniformly. Uniform bulk density was achieved by dropping the pipes four times vertically from a height of

5 cm. The pipes were leached with 90 cm of synthetic waters under continuous submergence at 26±2°C. The time for leaching initiation, amount of leachate collected after every 10th day, and the analyses of each leachate were performed according to the methods described by the U.S.Salinity Lab. Staff (1954). The pipes were arranged in completely randomised design with three replications and at a uniform height from the floor.

Gypsum particle size

G_0 = No gypsum, G_1 = 5 - 16 mesh,

G_2 = 16 - 25 mesh, G_3 = 25 - 60 mesh,

G_4 = 60 -100 mesh, G_5 = - 100 mesh,

Synthetic waters

W_1 = EC 0.6 dS m^{-1} & SAR 6, W_2 = EC 1.0 dS m^{-1}& SAR 12

W_3 = EC 2.0 " " " " 18, W_4 = EC 4.0 " " " 30.

Solubility of gypsum

A known weight (5g) of each gypsum particle size was mechanically shaken with 100 ml of each synthetic water for half an hour at a temperature of 26 °C. The filtrate was titrated against standard EDTA for soluble Ca + Mg using NH_4OH + NH_4Cl buffer solution and eriochrome black T indicator.

Preparation of synthetic waters

The salts to develop desired EC+SAR levels in distilled water were calculated with the help of quadratic equation. For example a water has an EC = 1.0 dS m^{-1} with SAR = 12 where Ca:Mg was 4:1 and Cl:SO_4 was 1:1 . These ratios are to be maintained with Na_2SO_4, $CaCl_2.2H_2O$, NaCl and $MgSO_4.7H_2O$ salts.

Here TSS = 10 me l^{-1}. Suppose Ca+Mg = X me l^{-1}, then Na = 10-X me l^{-1}.

We know that $SAR = Na/\sqrt{Ca+Mg/2}$, where conc. units are me $l.^{-1}$ By putting the values : $SAR = 10-X/\sqrt{X/2}$. After taking square of both sides and rearranging $2X-184x200 = 0$. From this quadratic equation, the value of X can be computed as:

$$X = \frac{-b\pm\sqrt{b^2-4ac}}{2a} = \frac{184\pm\sqrt{(-184)^2-4x2x200}}{2x2} = 1.1025 \text{ me } l.^{-1}$$

So Ca+Mg = 1.1025, Ca = 0.8820, Mg = 0.2205 and Na = 8.8975 $mel.^{-1}$ Then by multiplying the me l^{-1} with equivalent weight of a salt, mg l^{-1} were obtained.

RESULTS AND DISCUSSION

i. Dissolution of gypsum in synthetic saline-sodic waters

The data contained in Table 1 indicate that solubility of gypsum decreased significantly with each increment in EC+SAR of water as well as with an increase in gypsum particle size. The decrease (<1.0me Ca+Mg l^{-1}) with increasing brackishness of waters may be due to the common ion effects of Ca,SO_4 or due to low solubility product constant ($2.4x10^{-5}$ at 25°C) of gypsum (Bresler et al., 1982). The higher solubility of finer gypsum particles (<1.0 me l^{-1}) may be through the increased contact area between solute and solvent.

ii. Time for initiation of leaching

The increasing fineness of gypsum powder and brackishness of leaching water generally decreased the time to pass through and start dripping at the bottom of soil columns (Fig.1). The effect of water quality on time of initiation of leaching remained much more pronounced for the control and treatments receiving gypsum coarser than G_3 (25-60 mesh), while the grades finer than 60 mesh took almost similar time for the initiation of leaching. The less time to start leaching with the respective treatments appears to be the result of increased solute concentration either due to gypsum application or due to solutes of the leaching waters. Similar results were reported by Keren and Shainberg (1981).

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Table 1. *Dissolution of gypsum grades in synthetic waters (me l^{-1} Ca + Mg).*

Gypsum grade (mesh)	EC SAR	0.6 6.0	1.0 12.0	2.0 18.0	4.0 30.0	Mean
5-16		26.13	26.00	25.88	25.76	25.94 e
16-25		26.25	26.13	26.02	25.95	26.09 d
25-60		26.37	26.25	26.15	26.07	26.21 c
60-100		26.58	26.43	26.28	26.15	26.36 b
-100		26.82	26.55	26.43	26.37	26.54 a
Mean		26.43 a	26.47 b	26.15 c	26.06 d	

Means (column or row) followed by the same letters (s) are not statistically different at P= 5%.

SE: Waters = 0.024^{**}, Gypsum grades = 0.026^{**}, W X G = 0.053^{NS}

iii. Amount of leachate

The leachate was collected and measured every 10th day after the start of leaching(data not reported). With W_1 & W_2, the pattern and rate of leaching remained almost similar throughout the study period for all the gypsum grades. The use of W_3 & W_4 produced almost similar results for all the gypsum grades. The differences between the gypsum treatments and the control pertaining to the volume of leachate were more conspicuous with W_3andW_4 than those with W_1 and W_2. It appears that the soil solution concentration later due to gypsum (Keren et al., 1980) or mineral weathering (Rhoades, 1968) along with salinity of applied

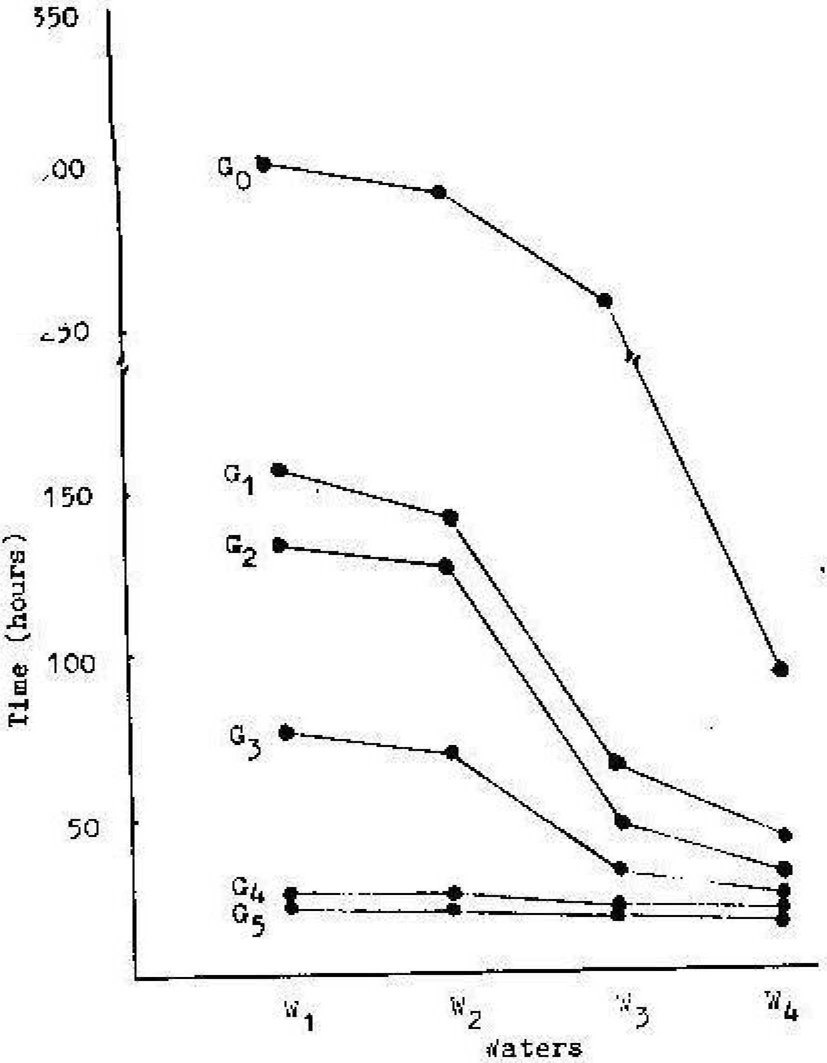

Fig.1. Time required for initiation of leaching in response to application of gypsum particle size and water qual quality.

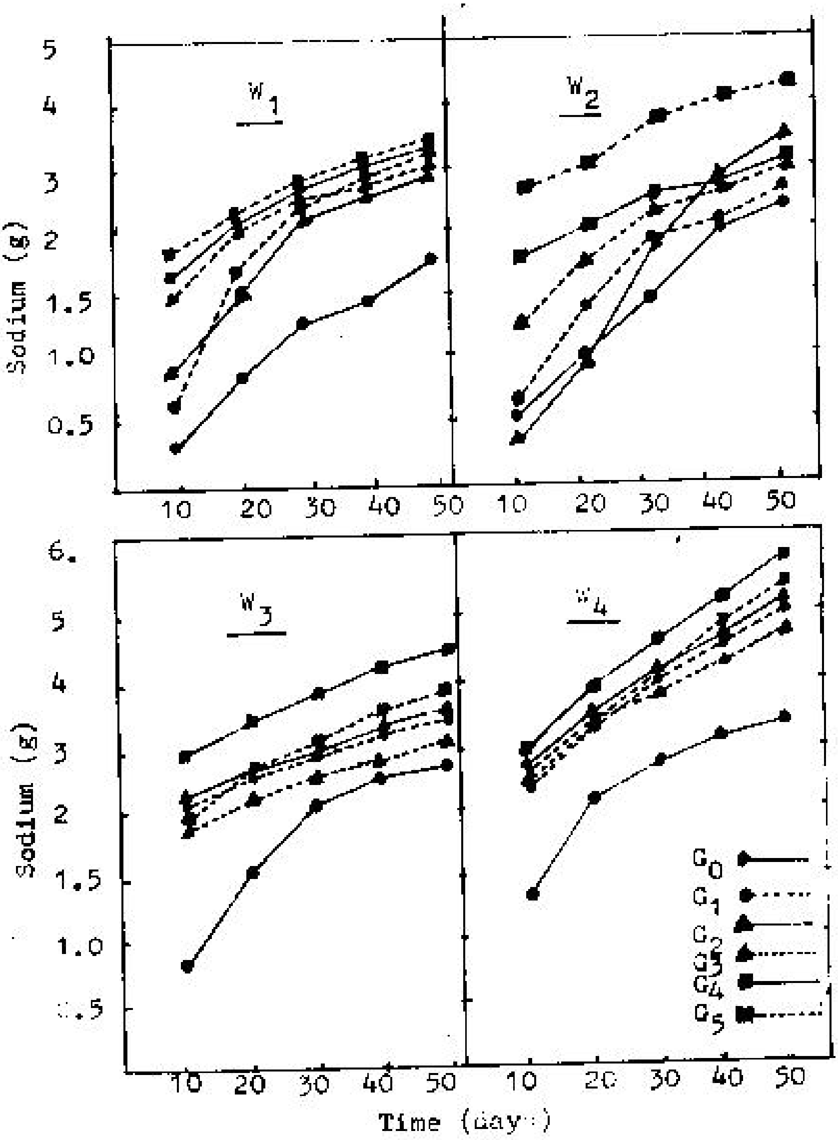

Fig. 2. Cumulative sodium removed as a function of gypsum particle size and water quality.

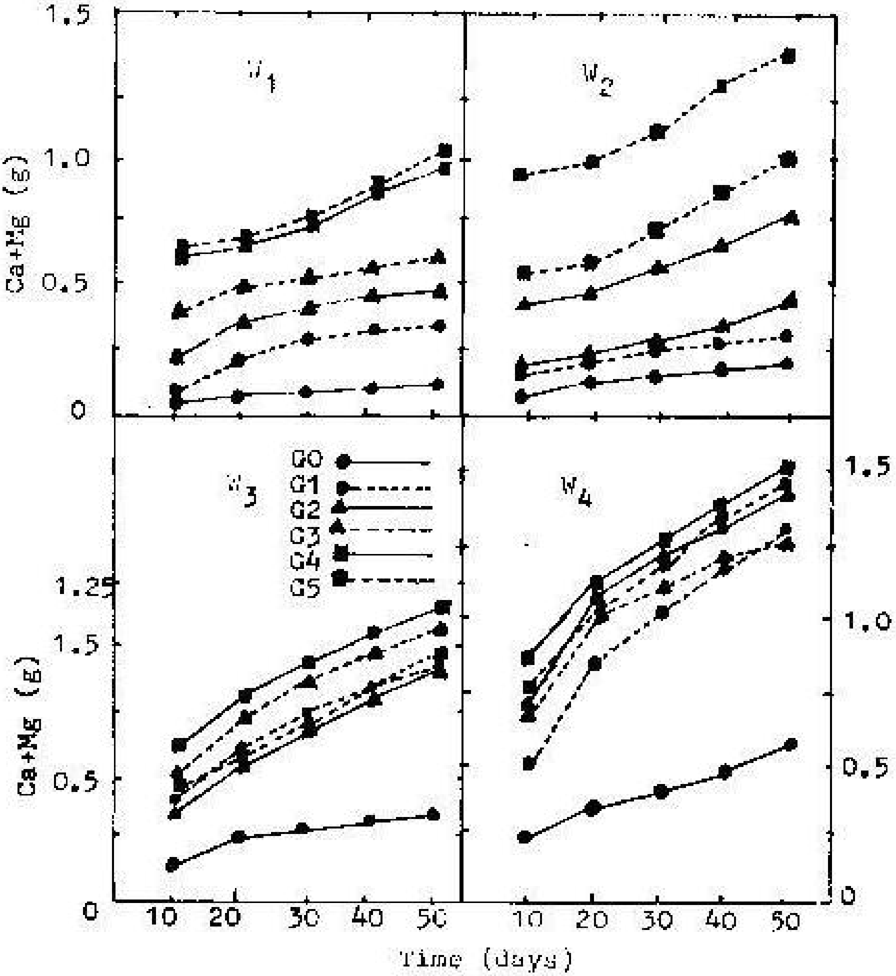

Fig.3. Cumulative calcium + magnesium removed as a function of gypsum particle size and water quality.

water caused these differences. The gypsum dissolution was higher in W_1 and W_2 than in W_3 and W_4 and the increasing fineness promoted the solution concentration (Table 1). Thus the increased dissolution of gypsum released higher amounts of [illegible] which, through augmenting flocculation, increased the rate of leaching and hence the volume of leachate.

iv. *Chemical composition of leachate*

a. Total salts: All the gypsum sizes removed more salts from the soil than the control (data not presented). Most probably this was due to the higher amounts of leachate with gypsum treatments. However, the difference in salt removal decreased as the brackishness (EC+SAR) of leaching solution increased. Moreover, the solute concentration was much higher in the initial leachate which decreased with time for all the treatments. Similar results were reported by Chaudhry (1984).

b. Sodium: The removal of sodium in leachate (Fig.2) was less for the control than that for the gypsum treatments with all the waters used. This was probably due to lower amount of leachate from the control columns. However, the differences in Na removal decreased as the brackishness of water increased.

The surface area of gypsum particles that comes in contact with soil-water system, increases as the particle size decreases. Consequently, the dissolution of gypsum may increase with decrease in particle size. As a result of higher soil solution concentration, the improved hydraulic conductivity will lead to more removal of salts including sodium. The Na- Ca exchange will produce a sink for soluble Ca. Hence the Ca-depleted soil solution will help gypsum dissolution because of the decreased common ion effect. As a result of integrated effect, the removal of sodium from the soil columns will increase which, in turn, will help timely soil reclamation.

C. Calcium+magnesium: The calcium plus magnesium removed in leachate from the control soil columns was lower than that in leachates from the gypsum treated soil columns with all the waters (Fig.3). Under local soil conditions, this seems natural because of the dominance of hydrus mica in the clay fraction (McNeal, 1966) which has a low rate of cation exchange partialy due to its low CEC and the non-expanding nature (Bear, 1964). Thus all the soluble calcium released from the applied gypsum might have not been utilized to react with exchangeable Na and hence was leached out of the soil.

As the water concentration (EC + SAR) increased, the leaching losses of Ca increased for G_2 to G_3 treatments and values were very close among themselves with W_3 and W_4. To overcome these Ca+Mg losses, grades of gypsum even coarser than G_3 may be suitable for soil reclamation where saline-sodic waters, like W_4, are available, but the reclamation time may slightly increase. However, under field conditions, the soil profiles are deep enough to utilize this Ca + Mg in draining water.

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