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# Use of Gypsum as an Ameliorant of Brackish Ground Water

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## ABSTRACT

Although Pakistan has the largest network of canal system in the world but, still, the river water supplies are insufficient to irrigate the cropped area under canal command. The canal supply, therefore, is supplemented with brackish ground water to fulfill the water requirement of crops. To minimize the harmful effects of brackish ground water, careful water management with suitable amendment is important. To address this problem a long term study was initiated during 1987, where gypsum on the basis of gypsum requirement of water considering the consumptive use of water of crops was applied to soil in maize-berseem-rice-wheat rotation. The quantity of gypsum based on its 50 and 100% requirement for one, two and three years at a time was applied in soil with 10 t $ha^{-1}$ FYM and without FYM to neutralize the sodicity effects of ground water. The pH, $EC_e$ and SAR of the original soil were 7.8, 2.8 dS $m^{-1}$ and 10.9, respectively. The results of first phase of study (upto 1990-91) indicated that the application of gypsum with FYM reduced the SAR of the soil to 5.0 but $EC_e$ increased to 4.2 dS $m^{-1}$. To reduce the $EC_e$ below 4.0 dS $m^{-1}$, a heavy irrigation with canal water was applied to all plots before maize 1991, which reduced the salinity level in soil below 4.0 dS $m^{-1}$. Then 40% leaching fraction was included in the second phase of study to maintain the salinity level in soil below 4.0 dS $m^{-1}$. The application of additional 40% water as leaching fraction was started with berseem 1991-92 and continued upto wheat 1993-94. Unfortunately, the $EC_e$ could not be maintained below 4.0 dS $m^{-1}$ with the addition of 40% an extra water, therefore, it was dropped during 1993-94 and the study was continued in third phase upto 1996-97 without leaching fraction with the same treatments. The average pH, $EC_e$ and SAR values after wheat (1996-97) in control were 8.27, 3.46 and 14.0, respectively; whereas, in 100% gypsum + FYM treatment, these were 8.1, 3.96 and 6.97, respectively. During these three phases of study, recommended doses of fertilizers were applied to each crop. The yield data indicated that during the third phase, the yields of most of the crops were not significantly affected by the use of brackish water with gypsum + FYM. Thus, it is concluded that this type of brackish ground water may be successfully used with gypsum to keep the healthy salt balance in soil without deteriorating the crops yields.

**Key Words:** Gypsum; Brackish water; Rice; Wheat; Maize; Berseem

## INTRODUCTION

Climate of Punjab, being arid to semi-arid, necessitates irrigation to undertake the agricultural pursuits (Bhatti, 1986). The major part of irrigation water (108 MAF) is supplied through canal (GOP, 1998-99). Unfortunately, the canal water supply is not enough to fulfill the entire water requirements of various crops. However, there exist huge reservoirs of sub soil water underlain in the canal command area (Mahmood *et al*., 1999). But, this water contains varying amounts of salts which may adversely affect the soil health and crops yields (Hussain, 1977; Malik *et al*., 1984). The canal water, therefore, is being supplemented with this brackish ground water to meet the water requirements of crops (Thomas *et al.*, 1981) in a cropping intensity approaching to 200% (Saleem *et al*., 1993). The indiscriminate use of this poor quality ground water is creating salinity/sodicity problem in the country (Girdhar, 1988; Sharma & Machanda, 1989; Khan *et al*., 1991; Prunty *et al*., 1991; Hussain *et al*., 1993). However, the ill effects of brackish water on soil health may be minimized with the use of certain amendments (Alvi *et al*., 1980; Goyal & Jain, 1984; Ghafoor *et al*., 1992; Schuman & Meining, 1993).

Keeping in view these facts, a long-term experiment was initiated during 1987-88 to study the effects of brackish ground water with the application of gypsum in soil according to the gypsum requirement of water with and without farmyard manure (FYM).

## MATERIALS AND METHODS

The project was initiated during 1987-88 at research area of Soil Chemistry Section, Ayub Agricultural Research Institute, Faisalabad. Before the start of experiment, representative soil samples from 0-15 and 15-30 cm depth were collected and analysed for their physical and chemical characteristics. Soil was non saline/non sodic with pH, 7.8, $EC_e$ 2.8 dS $m^{-1}$ and SAR 10.9 (0-30 cm). Available phosphorus was 12.4 mg $kg^{-1}$ while available K was 195 mg $kg^{-1}$. Tube well water used for irrigation had EC 2.4 dS $m^{-1}$, SAR 9.2 and RSC 5.7 me $L^{-1}$. The crop rotation followed was berseem-rice-wheat and maize. To ameliorate the ill effects of brackish water, the gypsum requirement of water was calculated by the equation developed by Eaton (1965) which considers two factors:

i. Amount of cations (Ca + Mg and Na) and anions ($CO_3$ and $HCO_3$) present in the brackish water.
ii. Amount of water to be used was based on the consumptive use of water of each crop.

Using this equation, gypsum on the basis of gypsum requirement of water was calculated. Three rates of gypsum i.e. 0, 50 and 100% of its requirement were applied with two rates of FYM i.e. 0 and 10 t $ha^{-1}$ in soil for one, two and three years at a time before sowing the crop. Consumptive use of water for berseem, rice, wheat and maize fodder was 57.5, 150, 42.5 and 32.5 cm, respectively. There were six treatments randomized four times in split plot design. At the end of first phase of study (1990-91), the soil analysis

indicated that the SAR of soil remained within safe limit. It was around 5.0 but $EC_e$ of the soil increased beyond 4.0 dS $m^{-1}$, therefore, it was decided to apply heavy irrigation with canal water to all plots to bring the $EC_e$ of soil below 4.0 dS $m^{-1}$ and then to include 40% leaching fraction to maintain the $EC_e$ of the soil within safe limit (< 4.0 dS $m^{-1}$) in the second phase of study. Thus heavy irrigation with canal water was applied before the sowing of maize (1991). As a result, the $EC_e$ in all the plots reduced to less than 4.0 dS $m^{-1}$. The application of additional 40% water for leaching was started with berseem crop 1991-92 and continued upto the end of second phase i.e. wheat 1993-94.

Unfortunately, the leaching fraction did not work and the $EC_e$ of the soil again increased beyond 4.0 dS $m^{-1}$ upto the end of second phase. Thus, the leaching fraction was dropped from the plan but the study kept continued in the third phase 1994-95 to 1996-97 with the same treatments. The composition of ground water at this stage was little different. The EC was 2.4 dS $m^{-1}$, SAR was 10.6 and RSC was 4.8 me $L^{-1}$. During this period one crop of each maize and berseem and two crops of each rice and wheat were harvested.

## RESULTS AND DISCUSSION

The results of first phase of this study as mentioned earlier, indicated that application of gypsum with brackish water kept the soil non sodic but the salinity level developed beyond 4.0 dS $m^{-1}$ (Saleem *et al*., 1993). The results of second phase of study showed that the application of heavy irrigation with canal water reduced the salinity level in soil below 4.0 dS $m^{-1}$ but the application of additional 40% water as leaching fraction did not work and salinity level in soil again developed beyond 4.0 dS $m^{-1}$ (Rashid *et al*., 1994). The leaching fraction thus, was dropped in the third phase of study and the results of this phase (1994-95 to 1996-97) only are being discussed in this paper.

**Soil Properties**

**Soil salinity.** Since the tubewell water used for irrigation purpose was saline-sodic in nature, therefore salinity level ($EC_e$) in soil increased in all the treatments with continuous use of this water. The salinity level in the original soil was 2.8 dS $m^{-1}$ and after wheat 1994-95 (Table I), the average value was 3.72 in control whereas in 100% gypsum + FYM treatment, the value was 4.31 dS $m^{-1}$. By and large similar was the case in other treatments (Table II). In fact when saline or saline-sodic water is used for irrigation, the salinity level in soil increases because of the accumulation of soluble salts in soil (Bhatti, 1986; Saleem *et al.*, 1993; Rashid *et al*., 1994). Richards (1954) reported that $EC_e$ of the soil will generally be 2-3 times higher than EC of irrigation water. During 1995-96, the yield data of berseem crop, which is comparatively sensitive crop as compared to others, indicated that in control, the berseem fodder yield was far less than in the other treatments. It indicated that salinity level around 4.0 dS $m^{-1}$ negatively affected the yield of berseem crop. It was, therefore, again decided to irrigate all the plots with canal water to reduce the salinity level below 4.0 dS $m^{-1}$. By the application of canal water the $EC_e$ reduced below 4.0 dS $m^{-1}$ (Table II). After that again ground

**Table I. Effect of brackish water and soil treatments on soil properties after wheat 1994-95**

| Soil properties | | Treatments | | | | | |
|---|---|---|---|---|---|---|---|
| | | Control | 0% GYP + 10 t FYM | 50% GYP + 0 t FYM | 50% GYP + 10 t FYM | 100% GYP + 0 t FYM | 100% GYP + 10 t FYM |
| | $Y_1$ | 8.32 | 8.33 | 8.06 | 8.08 | 7.98 | 8.00 |
| $pH_s$ | $Y_2$ | 8.24 | 8.24 | 7.99 | 8.18 | 7.91 | 7.98 |
| | $Y_3$ | 8.24 | 8.14 | 7.96 | 7.99 | 7.90 | 7.95 |
| | $Y_1$ | 3.80 | 3.80 | 3.81 | 3.78 | 4.82 | 3.64 |
| $EC_e$ | $Y_2$ | 3.52 | 3.33 | 3.17 | 3.80 | 3.42 | 4.27 |
| | $Y_3$ | 3.83 | 3.55 | 4.50 | 3.91 | 4.55 | 5.02 |
| | $Y_1$ | 16.36 | 11.88 | 11.19 | 10.47 | 11.40 | 8.88 |
| SAR | $Y_2$ | 13.01 | 13.40 | 11.06 | 10.84 | 7.47 | 7.53 |
| | $Y_3$ | 14.38 | 12.04 | 11.10 | 9.33 | 7.77 | 7.95 |

**Table II. Effect of brackish water on soil properties after berseem 1995-96**

| Soil properties | | Treatments | | | | | |
|---|---|---|---|---|---|---|---|
| | | Control | 0% GYP + 10 t FYM | 50% GYP + 0 t FYM | 50% GYP + 10 t FYM | 100% GYP + 0 t FYM | 100% GYP + 10 t FYM |
| | $Y_1$ | 8.40 | 8.30 | 8.10 | 8.16 | 8.19 | 8.28 |
| $pH_s$ | $Y_2$ | 8.25 | 8.22 | 8.27 | 8.19 | 8.19 | 8.02 |
| | $Y_3$ | 8.35 | 8.33 | 8.12 | 8.13 | 8.04 | 7.99 |
| | $Y_1$ | 2.57 | 2.21 | 2.44 | 2.17 | 2.17 | 1.94 |
| $EC_e$ | $Y_2$ | 2.46 | 2.41 | 2.10 | 2.67 | 2.40 | 2.88 |
| | $Y_3$ | 2.33 | 2.21 | 2.38 | 2.59 | 2.76 | 2.87 |
| | $Y_1$ | 10.92 | 9.74 | 9.58 | 9.26 | 7.89 | 8.22 |
| SAR | $Y_2$ | 9.86 | 9.38 | 9.07 | 8.90 | 5.48 | 6.14 |
| | $Y_3$ | 9.30 | 8.22 | 5.45 | 5.68 | 4.62 | 6.24 |

**Table III. Effect of brackish water and soil treatments on soil properties after wheat 1996-97**

| Soil properties | | Treatments | | | | | |
|---|---|---|---|---|---|---|---|
| | | Control | 0% GYP + 10 t FYM | 50% GYP + 0 t FYM | 50% GYP + 10 t FYM | 100% GYP + 0 t FYM | 100% GYP + 10 t FYM |
| | $Y_1$ | 8.28 | 8.24 | 8.12 | 8.13 | 8.04 | 8.10 |
| $pH_s$ | $Y_2$ | 8.20 | 8.26 | 8.07 | 8.06 | 7.88 | 7.97 |
| | $Y_3$ | 8.33 | 8.25 | 8.21 | 8.13 | 8.17 | 8.13 |
| | $Y_1$ | 3.92 | 3.92 | 3.70 | 3.93 | 3.48 | 3.47 |
| $EC_e$ | $Y_2$ | 3.12 | 3.88 | 3.27 | 3.97 | 3.44 | 4.02 |
| | $Y_3$ | 3.35 | 4.00 | 3.96 | 3.48 | 3.49 | 4.38 |
| | $Y_1$ | 13.43 | 10.87 | 10.23 | 11.06 | 8.47 | 7.39 |
| SAR | $Y_2$ | 14.10 | 13.50 | 13.06 | 8.28 | 7.14 | 7.44 |
| | $Y_3$ | 14.46 | 12.35 | 11.10 | 8.92 | 5.88 | 6.09 |

**Table IV. Effect of brackish water and soil treatments on crops yields (t ha$^{-1}$)**

| Treatments | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | Paddy yield 1994 | Wheat grain yield 1994-95 | Maize fodder 1995 | Berseem 1995-96 | Paddy yield 1996 | Wheat grain yield 1996-97 |
| Control | 2.69 | 3.46 | 11.03 | 23.77 | 3.35 | 4.43 |
| 0% GYP+10 t FYM | 2.80 | 3.88 | 11.11 | 28.71 | 3.14 | 4.68 |
| 50% GYP+0 t FYM | 2.68 | 3.91 | 10.73 | 26.32 | 3.32 | 4.69 |
| 50% GYP+10 t FYM | 2.73 | 3.84 | 11.98 | 28.28 | 3.30 | 4.59 |
| 100% GYP+0 t FYM | 2.98 | 3.92 | 11.36 | 27.35 | 3.48 | 4.37 |
| 100% GYP+10 t FYM | 2.83 | 3.98 | 12.39 | 30.21 | 3.31 | 4.28 |
| | NS | NS | NS | NS | NS | NS |

water was used for irrigation and salinity level in soil again developed and the average $EC_e$ value after wheat 1996-97 in control was 3.46; whereas, in 100% gypsum + FYM, it was 3.96 dS m$^{-1}$.

**Soil sodicity**

**Soil pH.** The data for soil pH during 1994-95 to 1996-97 are presented in Tables II to IV. No appreciable change in soil pH was observed during the period under study. Although there were slight differences in the pH values during all the three years but there was no significant impact of any treatment on this parameter of soil.

**SAR.** The value of SAR in original soil was 10.9. It increased in control with the use of saline-sodic water for irrigation whereas in case of gypsum and gypsum + FYM treatments, it reduced. During 1994-95, the average value of SAR in control treament was 14.0; whereas, in case of 100% gypsum + FYM, it was 8.1. Gypsum application alone on the basis of gypsum requirement of water also proved equally useful because the average SAR value in this treatment was 8.8 (Table I). The sodicity level slightly reduced with the use of canal water for irrigation during 1995-96; whereas, it again increased during 1996-97. The average value of SAR in the case of control during 1996-97 was 14.6 and in 100% gypsum + FYM treatment it was 7.16. It is very clear from these results that soil remained non sodic with the use of gypsum with or without FYM.

**Crops yields.** During the period under study the salinity level in soil remained near permissible limit (4.0 dS m$^{-1}$). SAR level also remained below 15 which indicate that severe saline-sodic conditions did not develop even in control plots. The crops included in the study easily tolerated these levels of salinity/sodicity. The crops yields, therefore, were not significantly affected. Since berseem and maize crops are more sensitive to sodicity, therefore, in control, the yield of berseem was minimum (23.77 t ha$^{-1}$); whereas, in 100% gypsum + FYM treatment, it was maximum (30.21 t ha$^{-1}$). By and large the results of maize crop were also similar. However, the differences in yield because of various treatments were statistically similar in all the cases.

## CONCLUSIONS

1. This type of brackish ground water may be successfully used with gypsum to keep the healthy salt balance in soil without deteriorating the crops yields.
2. Gypsum application controls the sodicity development in soil whereas for controlling the development of salinity in soil, a heavy irrigation with canal water after every 3-4 years is required.

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