CONTRIBUTION OF SHALLOW WATER TABLE TO SALINITY / SODICITY DEVELOPMENT UNDER FALLOW AND CROPPED CONDITIONS

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A saline shallow water table can contribute significantly to salinity/sodicity development in the root zone. Field investigation was carried out in saline-sodic soil (EC = 9.7 dS m^{-1}, SAR = 32.4 (mmol $L^{-1})^{1/2}$ and pH = 7.9) to study the effect of fluctuating water table on soil salinization/sodication under fallow and cropped conditions. Wheat and maize were used as cover crops. The water table fluctuation was monitored through piezometer and it ranged from 0.8 to 10 feet during the experimental period. Soil profile salinity /sodicity decreased with lowering of water table and vice versa. Initially at 3.6 feet water-table depth the EC_e of 0-30 cm surface layer was 9.7 dS m^{-1} which decreased to 6.9 & 4.7 dS m^{-1} under fallow and maize crop, respectively when water table lowered to 8 feet. During rabi season further lowering of water table to 10 feet decreased the EC_e to 6.5 & 3.9 dS m^{-1} under fallow and wheat crop. On the other hand EC_e was increased to 11.4 & 10.2 dS m^{-1} during kharif season by rising water water-table to 2.1 feet and to 15 & 11.4 dS m^{-1} during rabi season when water table rose to 0.8 foot. Almost similar trend was found in other soil layers. Likewise SAR was decreased to 25.7 & 21 (mmol $L^{-1})^{1/2}$ under fallow and cropped conditions, respectively at 0-30 cm soil layer by lowering water table to 10 feet. Whereas it increased to 44 & 36.5 (mmol L^{-1} $)^{1/2}$ when water table rose to 0.8 foot. A small change in SAR of other soil layers was found with water table fluctuation. The soil pH did not change much with changing of water table depth. The comparison of fallow cropped plots indicated that decrease in soil salinity/sodicity with lowering water table was greater under crop cover than fallow conditions.
Key words: water table, salinity, sodicity, salt movement.

INTRODUCTION

Land salinization is one of the major desertification processes in Pakistan and about 6.3 million hectares are affected (UNDP, 1997). Ground water depth and water quality play an important role in soil salinization (Ali *et al.*, 2000). Yaseen *et al.* (1995) reported that most of soil salinity in Pakistan is associated with shallow saline ground water. The salts present in the soil are moved with soil moisture through capillary action and become a source of saline soil formation when water table is close to the soil surface and evaporation rate is high (Chaudhry *et al.*, 1996). According to Kavoda (1973) the critical depth of water table in irrigated soil of an arid region is 2 to 2.5 m where the salt content of ground water is 10 to 15 g L^{-1} and 1 to 1.5 where salt content is 1 to 2 g L^{-1}. MacIntyre *et al.* (1982) showed that the rate of lowering of water table from 50 to 75 cm reduced the rate of salt accumulation but water table depth would have to be still deeper in most soils to prevent salt accumulation by capillary rise. The studies carried out by Asghar *et al.* (1962) in lysimeters, at Directorate of Land Reclamation, Lahore, Pakistan have shown that the electrical conductivity of soil varies with water table depth and maximum value (8.5 dS m^{-1}) is found at 3 feet and minimum (2 dS m^{-1}) at 9 feet water table depth.

The process of salinization may be minimized by the presence of plant cover on soil surface as it reduced evaporation. Moreover application of irrigation water to meet crop water requirements may result in leaching of salts below the root zone (Saleh and Troeh, 1982).

The present study is planned with the following objectives;

1. To monitor the effect of fluctuating shallow water table on soil salinization / sodication.
2. To determine the effect of plant cover on soil salinization/sodication under fluctuating water table.

MATERIALS AND METHODS

A field experiment was conducted at Haveli Reclamation Research Station Shorkot Cantt, situated along Trimmu-Sindhi link canal (unlined). The water table fluctuated in accordance with canal discharge and it was monitored through the installation of piezometer in each experimental plot. The experiment was laid out according to randomized complete block design (RCBD) with three replications. After laying out the experiment, composite soil samples were collected from 0-30, 30-60 and 60-90 cm of each experimental plot and were analyzed for its various characteristics following methods described by Richard (1954). The pre-sowing soil analysis was given in the Table 1. The water table depth was recorded at one month interval through piezometers with the help of water meter. There were two treatments; T_1 = Fallow and T_2 = cropped. Maize and wheat crops were used to produce plant cover. Maize crop was sown in the last weak of July, 2003 followed by wheat in second week of November, 2003. Recommended fertilizer and cultural practices were followed. The depth of flood water in each cropped plot was measured with flume and a total of 5 irrigations (each of 3 inch) were applied to each crop. The soil samples were drawn from 0-30, 30-60 and 60-90 cm depths at various water table levels from each plot and analyzed for various characteristics following methods described by Richard (1954).

RESULTS AND DISCUSSION

Water table fluctuation and electrical conductivity of soil

The electrical conductivity of soil profile increased with the rise of water table and vice versa (Fig. 1 & 2). At the beginning of experiment, the EC_e of 0-30 cm soil layer was 9.7 dS m^{-1} which increased to 11.4 & 10.2 dS m^{-1} under fallow and maize crop with the rise of water table from 3.6 to 2.1 feet. This was due to the transportation of soluble salts with water by capillary action which deposited there after evaporation of water. Akram *et al.* (1996) also observed salt accumulation with rising water table. Similarly EC_e was increased by 16% & 4% at 30-60 cm and 11 & 2% at 60-90 cm soil depth under fallow and crop conditions, respectively by rising of water table (Fig. 1). On the other hand when water table lowered to 8 feet EC_e of 0-30 cm soil layer decreased to 6.9 & 4.7 dS m^{-1} under fallow and maize crop respectively. Khan and Akram (1986) reported that rising water table contributed significantly to salinity / sodicity development. Likewise 30% & 41% decrease in EC_e at 30-60 cm and 20% & 27% at 60-90 cm soil depth were found without and with crop cover, respectively. Saleh and Troeh (1982) in a column study also showed that lowering of water table from 50-75 cm reduced the rate of salt accumulation.

During rabi season water table fluctuated from 0.8-10 feet and markedly influenced the rate of salt accumulation. The electrical conductivity was maximum (15 & 11.4 dS m^{-1} at 0-30 cm soil depth under fallow and wheat crop, respectively) when water table was shallowest (0.8 foot) and minimum (6.5 & 3.9 dS m^{-1} at 0-30 cm soil depth under fallow and wheat crop, respectively) when water table was deepest. Almost similar trend was found in other soil layers where 20% & 31% increase in EC_e at 30-60 cm and 6% & 22% at 60-90 cm soil depth, respectively with and without crop cover (wheat) were recorded with the

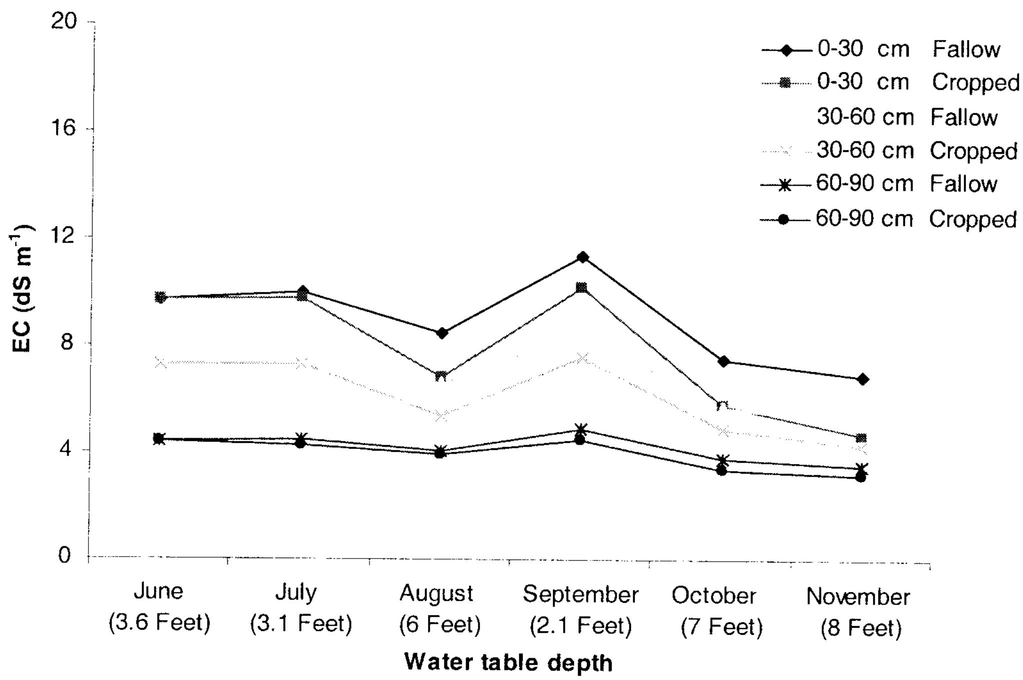

Fig. 1. Effect of water table depth on EC_e under fallow and maize crop

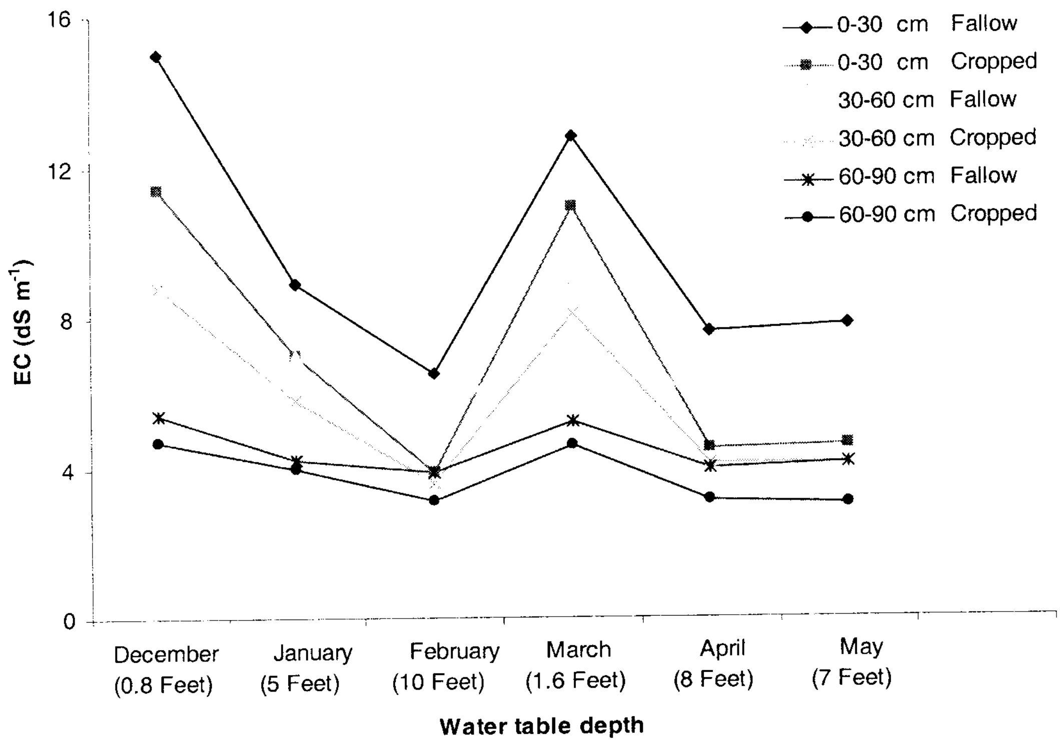

Fig. 2. Effect of water table depth on EC_e under fallow and wheat crop

rise of water table to 0.8 foot. Akram *et al.* (1996) reported that highest water table was observed in winter months resulting in conspicuous salt accumulation through capillary rise and subsequent evaporation. However with lowering of water table to 10 feet 51% & 34% decrease in EC at 30-60 cm soil depth with and without crop cover, respectively were found. The decrease in EC_e with lowering of water table was also reported by Asghar *et al.* (1962). Comparison of the fallow and cropped plots indicated that decrease in EC_e with lowering of water table was greater under cropped conditions than under fallow. This was due the effect of irrigation water being applied to meet crop water requirements which resulted in leaching of salts. On the other hand increase in EC_e with the rise of water table was less under cropped conditions than fallow which was due to the reason that plant cover markedly reduced evaporation and subsequent upward movement of dissolved salts.

Water table fluctuation and sodium adsorption ratio of soil

The sodium adsorption ratio (SAR) almost indicated the same pattern as that of electrical conductivity (Fig. 3 & 4). Originally SAR of 0-30 cm soil layer was 32.4 (mmol L-1)$^{1/2}$ which increased to 37.6 & 33.4 (mmol L^{-1})$^{1/2}$ under fallow and cropped conditions, respectively when water table rose to 2.1 feet. Ali *et al.* (2000) reported that under shallow water table conditions ground water may be a significant source of salts in the development of salt affected soils. Similarly 10% & 4% increase in SAR at 30-60 cm and 4% & 3% at 60-90 cm depth under fallow and cropped conditions (maize crop), respectively were found. These findings were supported by Khan and Akram (1986) who observed shallow and almost stagnant ground water was the main causative factor of salinity and sodicity. When water table lowered to 8 feet SAR of 0-30 cm soil layer reduced to 26.3 & 23.4 (mmol L^{-1})$^{1/2}$ under fallow and maize crop, respectively. Almost similar trend was found in other soil layers (Fig. 3 & 4).

During wheat crop (2003-04) water table fluctuated between 0.8-10 feet and produced marked effect on soil SAR. At 0.8 foot water table depth SAR of 0-30 cm soil layer increased to 44 & 36.5 (mmol L^{-1})$^{1/2}$ under fallow and plant cover, respectively. Similarly 21% & 13% increase (compared to original value) at 30-60 cm and 11% & 5% at 60-90 cm soil depth were found under fallow and cropped conditions, respectively with

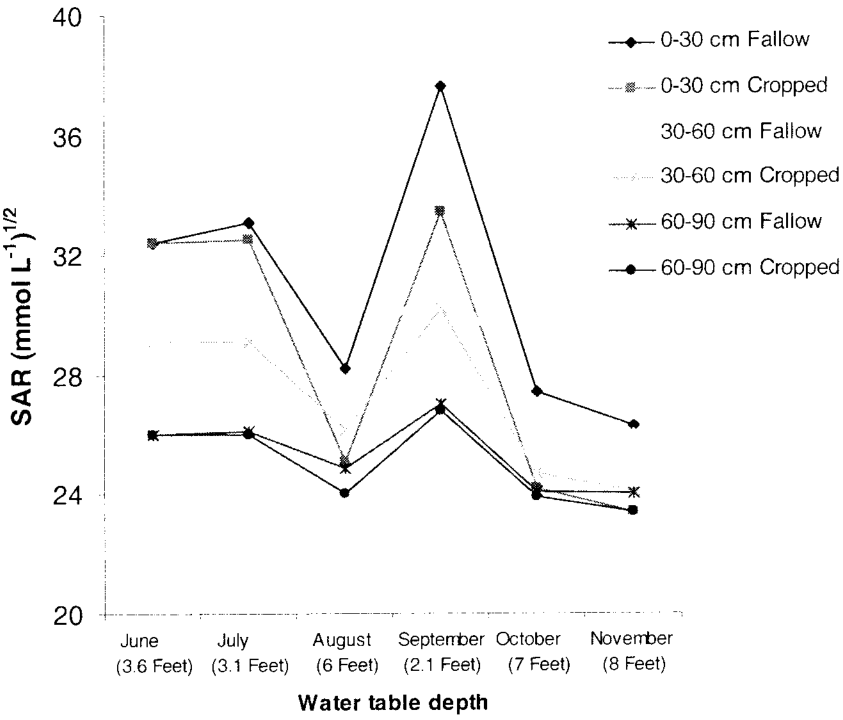

Fig. 3. Effect of water table depth on SAR under fallow and maize crop

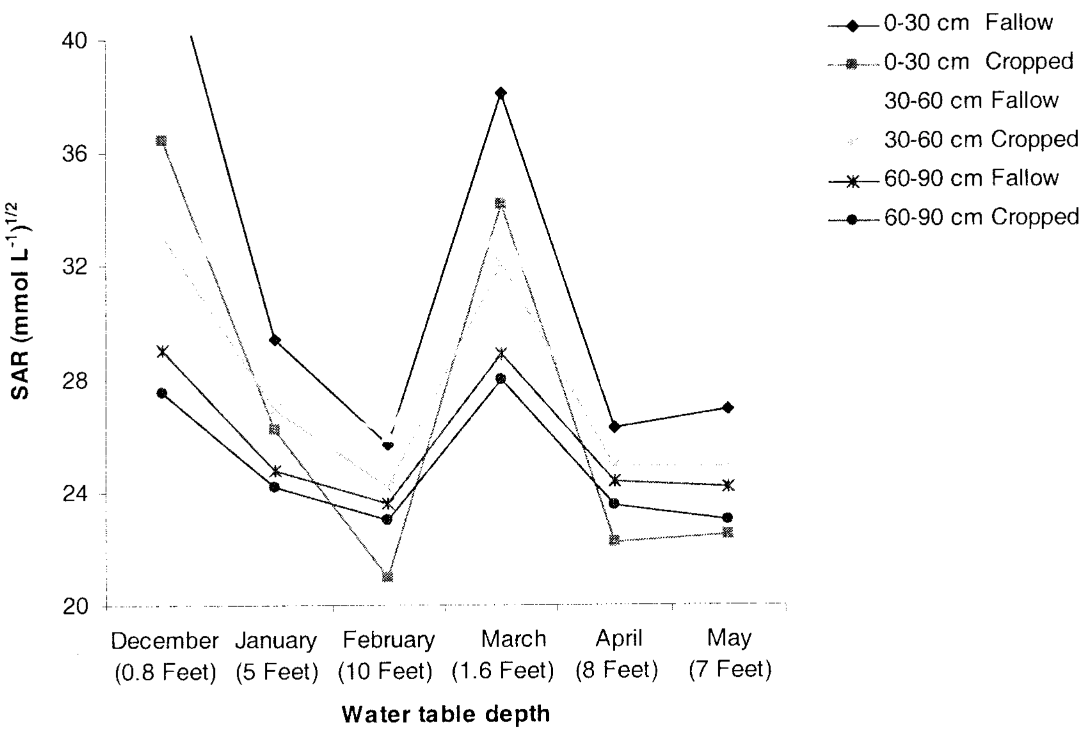

Fig.4. Effect of water table depth on SAR under fallow and wheat crop

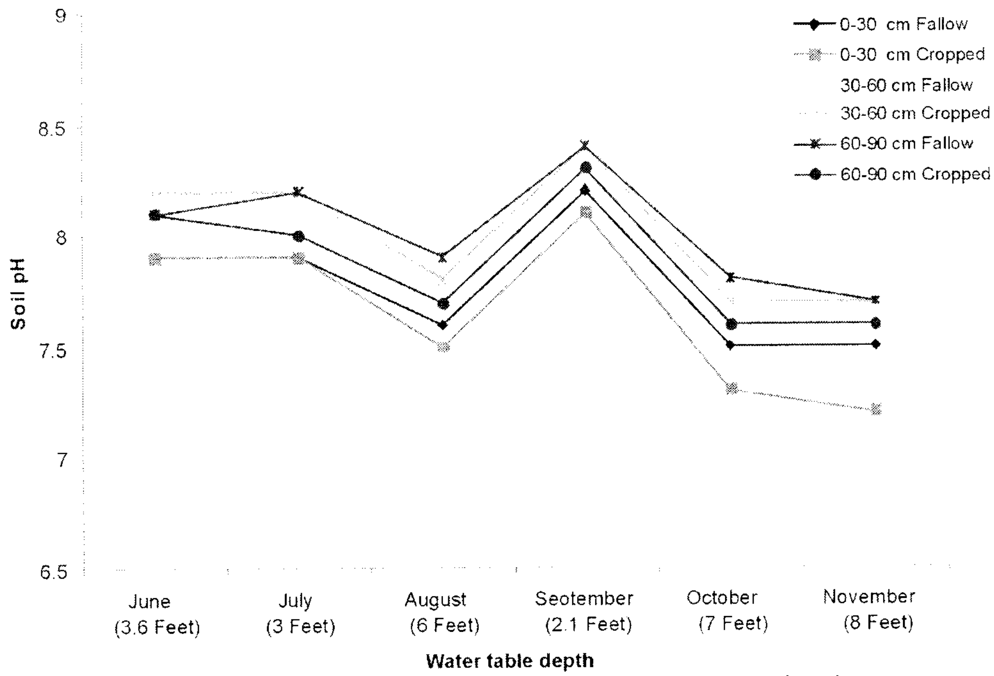

Fig. 5. Effect of water table depth on soil pH under fallow and maize crop

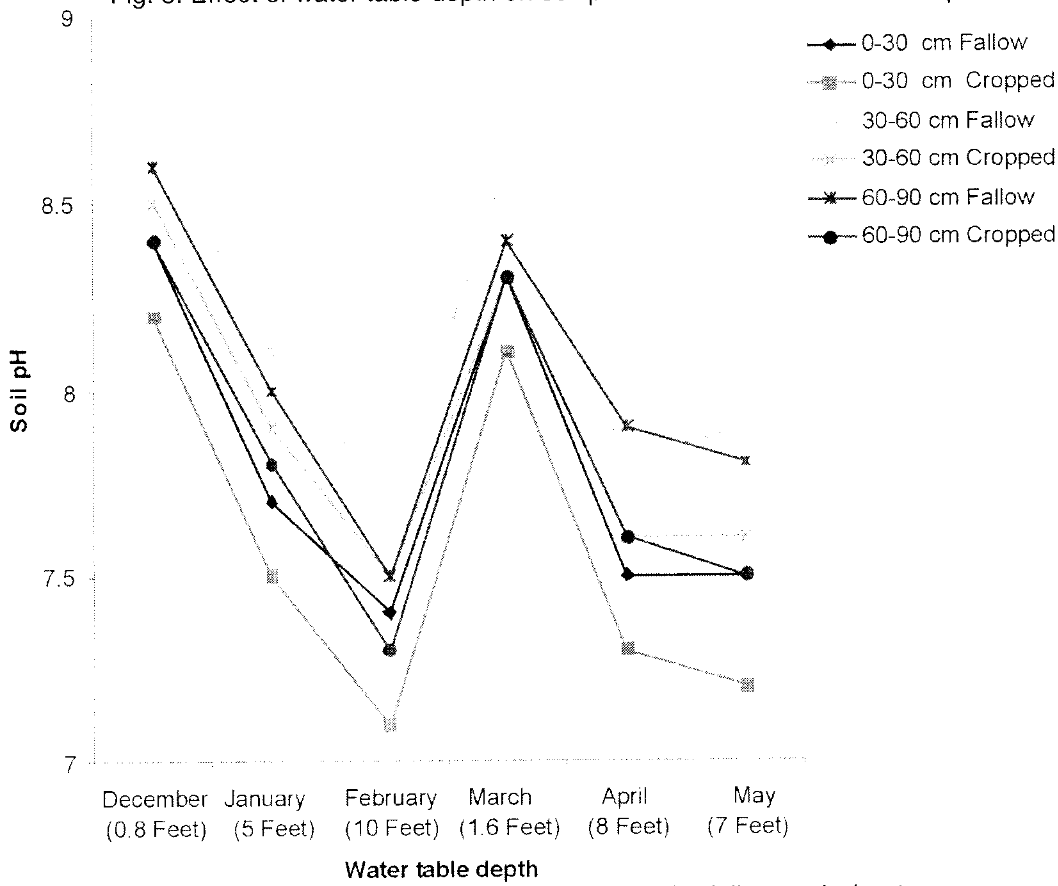

Fig. 6. Effect of water table depth on soil pH under fallow and wheat crop

Table 1. Physical and chemical characteristics of experimental field

Soil depth (cm)	Textural class	Saturation %age	pH	EC (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$
0-30	Loamy	42.4	7.9	9.7	32.4
30-60	Clay loamy	43.2	8.2	7.3	29.1
60-90	Clay loamy	44.6	8.1	4.4	26.0

the rise of water table to 0.8 foot. The mechanism was that when more $Ca(HCO_3)_2$ was released from calcareous material because of water table rise, the SAR of soil would increase owing to precipitation of Ca^{2+} as reported by Bhargave *et al.* (1981). The SAR of all soil layers decreased considerably with lowering of water table and minimum values 25.7 & 21 (mmol $L^{-1})^{1/2}$ under fallow and cropped conditions, respectively in 0-30 cm soil layer were found when water table was 10 feet deep. Likewise 10% & 16% reduction in SAR compared to the original value at 30-60 cm and 9% & 12% at 60-90 cm soil depth under fallow and wheat crop, respectively were recorded when water table rose to 10 feet. Reduction in SAR with lowering of water table depth was also reported by Sommerfeldt and Chang (1980).

Water table fluctuation and soil pH

Water table fluctuation produced a slight effect on soil pH (Fig. 5 & 6). Initially pH_s at 0-30 cm soil layer was 7.9 which increased to 8.2 & 8.1 under fallow and cropped conditions with the rise of water table to 2.1 feet. Almost similar trend was found in other soil layers where 6% & 3% increase in pH_s at 30-60 cm and 3% & 2% at 60-90 cm soil depth under fallow and cropped condition (maize), respectively were found. This increase in pH_s with the rise of water table was due to the reason that $Ca(HCO_3)_2$ was released from calcareous material because of water table rise where Ca^{2+} was precipitated as $CaCO_3$. The continuity of this process resulted in the formation of lime concretion and increased soil reaction in the profile, as also reported by Khan (1993). On the other hand when water table lowered to 8 feet (during maize) pH_s reduced 7.5 & 7.2 and when to 10 feet (during wheat) pH_s further reduced to 7.4 & 7.1 under fallow and cropped conditions, respectively. Similar slight changes in pH_s of other soil layers were found with the fluctuation of ground water table.

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