بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِيْمِ

EFFECT OF BICARBONATE PER SE VERSUS EQUIVALENT SAR LEVELS IN IRRIGATION WATERS ON SOIL PROPERTIES AND PLANT GROWTH

BY

Muhammad Yasin

M, Sc. (Hons) Agri,

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

IN

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FACULTY OF AGRICULTURE,

UNIVERSITY OF AGRICULTURE, FAISALABAD.

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INTRODUCTION


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Pakistan has abundant land resources but the supply of surface irrigation water is much less than required for exploiting the soil potentials adequately. Being situated in arid and semi-arid regions, the rainfall is not sufficient to meet the requirements of arable crops. All-out efforts are being made not only to attain self sufficiency in food grains and other agricultural products but also to have exportable surplus. This can either be done by increasing per acre yield of crops or by bringing more area under the plough. Both these approaches require increased water supply. The present supply of canal water is limited to the annual flow of rivers, a significant proportion of which is lost during conveyance, which further aggravates the situation. The solution obviously lies in exploiting the ample groundwater resources.

In order to solve the problems of salt-affected and water-logged soils and to augment irrigation water supplies, about two (lac) public and private tubewells have been installed in various regions of the country, but a large part of the pumped water is not suitable for irrigation without proper soil and water management. The water is mostly saline/sodic containing variable amounts of bicarbonate ions. Moreover as a result of the evapotranspiration process, salt concentration of soil solution becomes much higher than that of irrigation water itself. Further, the precipitation of

calcium and magnesium ions as calcium carbonate and possibly magnesium silicate increases the proportion of Na in soil solution and on the exchange complex. Therefore, by using such waters for irrigation, deterioration of soil structure and decreased soil permeability are ~~the~~ common phenomena that usually occur ~~in soil~~.

While judging the quality of water, the primary consideration is paid to salinity and sodicity hazards involved in their use. The electrical conductivity (EC) is a good index of salinity while the sodium adsorption ratio(SAR) and residual sodium carbonate (RSC) indicate the sodicity hazard of irrigation water. More recently, however, the adjusted SAR has been introduced which incorporates the parameters of SAR and RSC together. In addition to its chemical composition, the suitability of water also depends upon the specific conditions of its use such as the crop grown, various soil properties, climate, leaching fraction, frequency of irrigation ~~water~~ and cultural practices.

The basic approach to evaluate the suitability of waters for irrigation is to predict the quality of soil waters in the crop root zone as influenced by leaching fraction and also to assess the soil and crop problems associated with such waters. In order to study the plant responses to various soil conditions, soil scientists have generally used a uniform root medium as ~~practicable~~ the method of choice. However, under field conditions, uniformity of the root zone throughout its depth is an exception rather than the rule. Therefore, the adoption of appropriate irrigation management practices requires an adequate knowledge of crop responses

to non-uniform soil salinity/sodicity. The objectives of the present study were:

(i) to evaluate the effects on plant growth of non-uniform salinity/sodicity distribution with depth and to relate it to various soil indices of salinity and sodicity,

(ii) to assess the hazard of salinity and sodicity ~~of~~ from irrigation waters of different chemical compositions ~~on~~ with regard to soil properties and plant growth,

(iii) to effectively utilize saline-sodic waters by using different leaching fractions (LF) for ~~achieving~~ control of salts and exchangeable sodium control in the root zone, and

(iv) to evaluate salinity and sodicity tolerance of some crops to non-uniform distribution of salinity/sodicity in the soil profile.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The principal criteria of quality of irrigation waters are salinity, sodicity and toxicity as determined by EC, SAR and specific ion concentrations, respectively. However, the effects of a given water on crops are not determined solely by these water properties. Even non-hazardous waters may cause problems under adverse conditions of use. Water quality parameters should, therefore, be considered in relation to the specific conditions under which the water is to be used.

Wilcox (1948) proposed a water quality evaluation scheme and equated effective salinity with the electrical conductivity of the irrigation water. He pointed out that Ca and HCO_3 would precipitate as $CaCO_3$ in the soil as the irrigation water was concentrated by evapotranspiration, but made no attempt to quantify the effects of $CaCO_3$ precipitation on the accumulation of exchangeable sodium in soil. Later Eaton (1950) showed that the precipitation of Ca and Mg as carbonates may be nearly complete when the sum of CO_3 and HCO_3 concentrations exceeded that of divalent cations. He proposed the concept of residual sodium carbonate (RSC) for evaluating the sodicity hazard of irrigation waters. Wilcox et al. (1954) tested this concept and concluded that waters containing more than 2.5 me/l of RSC were not suitable for irrigation, and those containing between 1.25-2.5 me/l were marginal and those containing