SUMMARY

The studies reported in this thesis were started with the object of finding out the effect of waters of different quality on the crop and soil, so that critical appraisal of the standards for judging the quality of irrigation water could be made. With the above object in view the following experiments were conducted:

A. Effect of salt concentration and sodium-adsorption-ratio of irrigation water on soil and crop.

B. Effect of ratios of anions in irrigation water on the soil and crop.

C. Effect of ratios of cations in irrigation water on soil and crop.

D. Effect of carbonate and bicarbonate concentration in irrigation water on soil and crop.

E. Effect of leaching the soil with water containing different levels of sodium bicarbonate on the soil.

Experiments from A to C were conducted in pots using two types of soil, one heavy (clay loam) and the other light (sandy loam). In experiments D and E, the heavier textured soil was replaced with medium textured soil (loam). Maize and wheat were used as the test crops representing semi-tolerant and tolerant crops. The three crops were taken in succession, two of maize and one of wheat.

The salt concentration in irrigation water used in experiment A were 7.5, 22.5, 50 and 200 me./l. Only two cations were used viz. Na and Ca, so as to have SAR value of 4, 8, 16 and 26. The anions used were chloride and sulphate in equivalent amounts. But in no case sulphate was added in quantities large enough to precipitate calcium sulphate.

In experiment B the concentration of salts was kept 22.5 me./l. and the anionic ratios were as follows:
Water Cations expressed as percentage of the total cations number (concentration in me./l.)

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<th>Water number</th>
<th>Cations expressed as percentage of the total cations</th>
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<tbody>
<tr>
<td></td>
<td>CO$_3$</td>
</tr>
<tr>
<td>17</td>
<td>1</td>
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<tr>
<td>18</td>
<td>1</td>
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<tr>
<td>19</td>
<td>1</td>
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<tr>
<td>20</td>
<td>1</td>
</tr>
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<td>21</td>
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In experiment C, the total concentration was again kept at 22.5 me./l., but the ratio of cations were so varied as to have predominant Ca, Na, Ca, Na, K or Mg.

In experiment D, the salt concentration used was 12 me./l. and the residual sodium carbonate varied from 0 to 5. Studies were also made to compare the effect of carbonate and bicarbonate ions. The total quantity of water used in experiments A, B and C was 90 inches and in D was 65 inches. The results of the different experiments are summarised as below:

A. Effect of salt concentration and sodium-adsorption-ratio of irrigation water on soil and crop.

Neither wheat nor maize germinated when the concentration of salts in irrigation water was 200 me./l. The yield of both the crops progressively decreased with the increase in salt concentration, but the differences were non-significant in case of wheat until salt concentration of 22.5 me./l. 50 percent decrease in yield was observed in case of maize with only water having salt concentration 50 me./l, but in case of wheat, even this concentration did not reduce the yield to 50 percent. The sodium, calcium, magnesium, potassium, nitrogen and phosphorus were increased in the plants with the increase of salt concentration in irrigation water.

The conductivity of the saturation extract increased from 0.52 millimhos/cm to 1.83, 4.63, and 8.05 millimhos/cm, by the application of 90 inches of irrigation waters containing 7.5, 22.5 and 50 me./l, salt concentration.
ESP increased with the increase in salt concentration. The ESP was higher in upper layer than in the lower layer of the soil. The tolerance of high salts was more in heavy soil than in the light soil in both the crops.

Though the yield of crops decreased with the increase of SAR in irrigation water, yet the differences were not significant between SAR 8, 16 and 26 in case of maize and SAR 16 and 26 in case of wheat. Similarly, though in maize, water with SAR 4 gave significantly higher yield than water of SAR 8, but in case of wheat the differences were not significant. 50 percent decrease in yield was not observed in any case.

The increase of SAR in irrigation water increased Na, and decreased Ca in all the crops. The increase in SAR of irrigation water also decreased Mg, and K and slightly increased N and P contents in the second crop of maize fodder.

The increase in SAR of irrigation water increased electrical conductivity SAR and Na and decreased Ca content of the saturation extract of the soils. The increase in SAR of the irrigation water also resulted in an increase in ESP, pH, dispersion coefficient and decreased hydraulic conductivity of soils. The increase in SAR of irrigation water resulted higher ESP in light soil than heavy soil.

A significant adverse effect of interaction of salinity and alkalinity has been found by the use of C3S3 and C3S4 (C3 = 50 mL.; S3 = SAR 16; S4 = SAR 26) irrigation waters.

B. Effect of ratios of anions in irrigation water on the soil and crop.

The results of the experiment reveal that in case of both the crops of maize and wheat at equal concentration, sulphate was less harmful than chloride. The differences between the two were significant. Addition of small amount of carbonate to chloride rich water did not prove worse than the water when only...
chloride was used. The water in which bicarbonate was added to constitute 44 percent of the total anions, was significantly better than chloride rich water, but the difference between bicarbonate and sulphate rich water was not found to be significant. Though the sulphate rich water gave more yield of the crops than the chloride rich waters, but there was lesser uptake of Ca and more uptake of Na in the former than the latter. Similar effect was observed in bicarbonate rich water. Use of chloride rich waters resulted in high content of N and P in the plants.

The electrical conductivity of the saturation extract was less when bicarbonate rich water was used than when chloride and sulphate rich waters were used. The chloride and sulphate rich waters increased chloride and sulphate respectively in the soil, but the bicarbonate rich water did not increase bicarbonate.

There was a progressive increase in exchangeable Na and decrease in exchangeable Ca+Mg with the continuous use of various irrigation waters. The highest increase in exchangeable Na was produced by the bicarbonate rich water closely followed by the sulphate rich water.

The analysis of the soil revealed that the upper layer of soil had more electrical conductivity of the saturation extract of the soil and more exchangeable Na and less exchangeable Ca+Mg than the lower layer.

C. Effect of ratios of cations in irrigation water on the soil and crop.

The variations in ratios of cations in irrigation water did not affect the yield of first crop of maize fodder on both the soils, but in case of second crop the increase in Na content in irrigation water decreased the yield of the crop. The adverse effect of these waters varied in the following order irrespective of the texture of the soil:

Na\textsuperscript{7} Na+Ca\textsuperscript{7} K\textsuperscript{7} Mg\textsuperscript{7} Ca

The water rich in Na had also the most marked adverse effect on wheat.
and significantly decreased its yield. In case of heavy soil, the Mg rich water proved the best and Na rich water the worst.

Na rich water and Na+Ca rich water increased Na content in plants and Ca and Mg rich waters increased Ca content, while K rich water increased K content of both the crops of maize and wheat.

Ca, Na, Mg and K contents of the saturation extract of the soils were increased in accordance with the amount of these elements in the irrigation water. The exchangeable cations content of the soil varied with the amount of respective cations in irrigation water. The increase in Na content of irrigation water increased the pH of the soil and maximum pH was found in waters rich in sodium and minimum in the soil treated with water rich in Ca.

D. Effect of carbonate and bicarbonate concentration in irrigation water on soil and crop.

The yield of first two crops of maize was not affected by the increase of ESC in irrigation water, but the yield of third crop of wheat was reduced considerably irrespective of the texture of the soil and source of ESC. Irrigation water with 2.50 me./l. ESC produced significantly lower yield than the water without ESC. The higher level of ESC (5.00 me./l.), though depressed the yield still further. The increase in ESC in irrigation water increased Na and decreased Ca contents in both the soils. The results also indicated that the high amount of ESC increased the Na content of wheat and maize both and decreased K content of maize.

The continuous irrigation with water containing no ESC increased the electrical conductivity more than the water containing ESC. The increase in ESC in irrigation water decreased water soluble Ca and Mg and increased Na in the saturation extract of soils.

The increase in ESC in irrigation water also resulted an increase in exchangeable Na and dispersion coefficient, but decreased hydraulic conductivity.
of soils. The dispersion was more in light soil than in heavy soil. The electrical conductivity of saturation extract, exchangeable sodium percentage and pH was increased more in case of irrigation water containing ESC in the form of carbonate than in the form of bicarbonate. Hydraulic conductivity was also decreased more when the source of ESC was carbonate. The results show that for determining the quality of irrigation water, it is not enough to know the ESC, but the nature of anion, whether it is carbonate or bicarbonate, is also important. The carbonate waters are more harmful than the bicarbonate waters.

E. Effect of leaching the soil with high sodium bicarbonate water on some characteristics of the soil.

Leaching of the soil with 21 inch irrigation water containing bicarbonate increased electrical conductivity of the soil in proportion to the concentration of bicarbonate of irrigation water. The increase in bicarbonate content increased CO$_3^-$+HCO$_3^-$ and Na and decreased Ca+Mg content of the saturation extract. The increase in bicarbonate content also resulted in increase in exchangeable sodium, dispersion coefficient and decrease in hydraulic conductivity of soils.

These studies have indicated that for the determination of suitability of an irrigation water besides the electrical conductivity and SAR, the nature of the soil and crop also should be taken into consideration. At a given level of salinity the residual sodium carbonate derived from carbonate is more harmful than the one derived from bicarbonate. Chloride ions seems to be more harmful than sulphate ions.