RISING WATER TABLE OF SALINE AND SODIC GROUND WATER IN HARYANA AND MANAGEMENT STRATEGIES - A REVIEW

A.C. Goel and Vijay Kumar
Regional Research Station,
CCS, Haryana Agricultural University, Karnal - 132 001, India

ABSTRACT

The development and execution of canal system in central and south western parts of Haryana brought a large area under irrigation and helped in the introduction of heavy irrigation duty crops. Though the crop production has increased tremendously yet the nonexploitation of the saline ground water and application of heavy irrigation have led to the rising of the water table in central and South-Western part of Haryana. The increase in canal irrigation area from 0.99 to 1.4 million ha in this region has largely contributed to this problem and more than 5 per cent area in this zone is under critical zone (0-3m). The water table has continuously been rising at an average annual rate of 10 to 30 cm for the last twenty five years. The main emphasis in developing the surface irrigation potential and neglecting the drainage of the saline and sodic ground water of the above mentioned zone of the state has created waterlogging condition and soil salinization. Poor water management practices have also aggravated the situation. The serious problem of the rising water table can be tackled by adopting the improved water management practices, introduction of drip irrigation system, bringing more and more area under sprinkler irrigation, using of brackish ground water in conjunction with canal water. Introduction of horizontal drainage i.e. tile drainage system, vertical drainage and reuse of drainage water and farm forestry can be the possible measures to reduce the problem of rising water table.

The development of agricultural potential in Haryana has been remarkable since its inception in 1966. More than 65 per cent area of the state lies in arid and semi-arid region where the rainfall is scarce and erratic in nature. The irrigation facilities were created at a huge cost in early seventies by introducing the canal system particularly in South-Western part of the state and the area irrigated by this system increased from 0.99 to 1.4 million hectare. Since the ground water in most part of this area is brackish, its nonexploitation has posed a serious problem of rising of water table. Therefore the surface irrigation facilities which were developed with tremendous efforts are proving to be a curse rather than a boon. The inadequate planning and execution of surface water resources without anticipating the drainage problem has questioned the sustainability of the present level of agricultural production in the state. The constant rising water table of the brackish and saline ground water have created waterlogging and soil salinization condition in substantial area in the South-Western and central part of state. The problem has been further aggravated by the natural flow of the ground water from North East to South-West and non existence of any natural drainage basin or the out let.

PRESENT SCENARIO

The major area of the South-Western part of the state used to be unirrigated and rainfed before development of the canal system about three decades back. The soils are light textured with very high infiltration rate and poor water holding capacity. Cotton-wheat is most prevalent cropping system in irrigated conditions and Bajra-wheat, gram, mustard crops in unirrigated conditions. The intensive development of the canal system in this region is mainly responsible to sustain the cultivation of the heavy irrigation duty crops. The ground water in this region is brackish and mostly saline in nature. Though the origin of the salinity is not exactly known yet it may be related with the geology of the alluvial basin (Kumar et al., 1993). As a consequence of the nonexploitation of the brackish water the water table has constantly been rising for the last more than two decades (Table 1).
Table 1. Rising of water table in central and South-West Haryana

<table>
<thead>
<tr>
<th>District</th>
<th>Average depth to water table (m)</th>
<th>Rise (m)</th>
<th>Rise per annum (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>June 74</td>
<td>June 97</td>
<td>1974-97</td>
</tr>
<tr>
<td>Rohtak</td>
<td>6.62</td>
<td>3.48</td>
<td>+3.14</td>
</tr>
<tr>
<td>Jind</td>
<td>11.26</td>
<td>6.45</td>
<td>+4.81</td>
</tr>
<tr>
<td>Sirsa</td>
<td>16.01</td>
<td>8.87</td>
<td>+7.14</td>
</tr>
<tr>
<td>Hisar</td>
<td>15.22</td>
<td>8.40</td>
<td>+6.82</td>
</tr>
<tr>
<td>Bhiwani</td>
<td>22.90</td>
<td>16.87</td>
<td>+6.06</td>
</tr>
</tbody>
</table>


It has been estimated that 5 per cent area (about 0.4 m ha) in this region is under critical zone i.e. 0-3 m. The evaporation of the fresh water and deposition of salt in the top layer of the soil results into soil salinization. The waterlogging condition is prevailing in areas where the water table is within 3 meter. The areas where the water table is deeper than 3 meter, the soils are affected due to sub surface inflow from adjoining areas and result into salinization of soils.

The majority of the saline ground water in Haryana has EC between 4 and 8 dS/m.

It has been found that water at shallow depth is comparatively of better quality (EC of water ranges from 1-2 dS/m). Even this water which can safely be used for irrigating crops like wheat, barley and mustard, is also being pumped out negligibly.

Good crop yield under shallow water table condition could also be achieved by using saline water of 4 dS/m. EC or less (Kumar et al., 1996). Before the introduction of the canal system in this region some farmers used to have open well where the water salinity was less at shallow depth but with the availability of canal water in plenty, these open wells were abandoned, thus reducing the pumping to zero level practically.

In some parts of Kaithal district the waterlogging condition does exist in the irrigated areas and the ground water is sodic in nature. It contains high proportion of sodium bicarbonates and this increases the exchangeable sodium in the soil. The increased exchangeable sodium results into deflocculation of soil, decreases soil permeability, soil aeration and ultimately the crop growth.

CONTRIBUTING FACTORS

The introduction of canal irrigation and nonexploitation of saline ground water resulted in water logging and soil salinity problems. Besides this the following are the additional factors which also contribute to the shallow ground water condition.

1. The inadequate and faulty planning for regulating the canals. The excessive release of water creates flooding condition at the down stream side and at the time of normal release there is drought like condition at the tail end because of pilferage of water by the farmers. There is excessive seepage from the sides in unlined canals, which cause water logging conditions in the neighbouring areas.

2. The lack of awareness and non-adoption of improved water management practices such as improved methods of irrigation non-execution of proper field levelling, non-lining of field channels and water courses. The farmers also lack in adopting the soil moisture conservation measures, which may facilitate the application of lesser irrigation water.

3. The switching over to heavy irrigation duty cropping pattern has aggravated the problem of rising of water table of the saline ground water. The total dependence
on canal water and abandoning of the pumping from open wells has also been responsible for enhancing the problem.

4. The uncontrolled spills from drains cause the inundation due to their insufficient capacity.

5. The practice of over irrigating the crop such as cotton and wheat among the farmers is common due to availability of canal water in abundance. Such a practice has added to this serious problem.

6. Soil with relative deeper water table depth (more than 3m) and no irrigation will on long term become saline due to subsurface inflow from neighbouring irrigated areas. Due to the difference in the heads, water flows from the irrigated soils to the non-irrigated soils, where it moves upward through capillary. The evaporation of fresh water and deposition of salts in the top layer of the soil results in salinization (Kumar et al., 1993).

MANAGEMENT STRATEGIES

It is imperative to evolve management strategies to tackle the menace of rising of water table for saline and sodic water separately.

Saline Water: In South-Western region the ground water is mostly saline (EC between 4 and 8 dS/m) and there is dire need of bringing down the water table of saline water in order to protect the soils from salinization. The following steps should possible be taken to check the problem.

1. There is urgent need to review the existing canal system in the region and careful planning on the part of state government for regulating the canals. The farmers should be encouraged to go for the installation of tube-well in the areas where the ground water is having less salinity, by giving incentives. Saline water with higher (EC 8 dS/m) can be used on light textured soils by growing salt tolerant crops. There are reports that saline water of EC 8 dS/m in wheat pearl-millet sequence on sandy loam to loam soil was successful provided pre-sowing irrigation was given with canal water (Poonia et al., 1974 and Nath et al., 1979).

2. The water of higher salinity i.e more than 8 dS/m EC can be pumped and mixed with canal water so that resultant electrical conductivity remains within permissible limit (0.75 dS/m) for safe irrigation of the crops. Nath et al. (1982) have shown that mix use of saline water (EC 6.6 dS/m) and canal water (1:1) increase the wheat yield from 30 q/ha to 38.7 q/ha and Bajra yield from 22.6 q/ha to 25.3 q/ha.

3. The shift in cropping pattern is very important to overcome the problem. Crops which require less amount of water and tolerant to salt should be practiced (Table 2). The different range of salinity tolerant by different crops are given by Gupta, 1990.

4. The maintenance of the canals should be done on regular basis. The eroded and damaged embankments should be repaired during the lean period to avoid overflow, which ultimately causes flooding in the neighbouring areas. All the unlined canals should be lined in a phased program and desilting work should also be executed periodically to maintain the carrying capacity of all the canals.

5. Improved water management practices such as proper levelling of field channels and water courses, conservation of soil moisture, improved and modern methods of irrigation such as drip and sprinkler irrigation should be adopted by the farmers.

Sprinkler Irrigation: The sprinkler system of irrigation can successfully be adopted in the areas where the EC of saline water is up to 6 dS/m and canal water is also available for pre sowing irrigation. The study conducted at
Table 2. The different range of salinity tolerant by different crops

<table>
<thead>
<tr>
<th>Highly tolerant</th>
<th>Tolerant</th>
<th>Semi-tolerant</th>
<th>Sensitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecw 10 dS/m</td>
<td>5-10 dS/m</td>
<td>3-5 dS/m</td>
<td>1.5-3 dS/m</td>
</tr>
</tbody>
</table>

Barley
Sugar Beet
Wheat
Oats
Pearl-millet
Sorghum
Mustard
Safflower
Cotton
Rice
Finger Millet
Maize
Cluster bean
Pigeon Pea
Cowpea
Groundnut
Sugarcane
Black gram
Bengal gram
Green gram
Lentil

Table 3. Average crop yield (q/ha) under different water quality applied by sprinkler irrigation

<table>
<thead>
<tr>
<th>Crop</th>
<th>Canal water</th>
<th>EC (dS/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Wheat</td>
<td>36.90</td>
<td>37.10</td>
</tr>
<tr>
<td>Cotton</td>
<td>22.79</td>
<td>16.33</td>
</tr>
<tr>
<td>Bajra</td>
<td>25.40</td>
<td>21.63</td>
</tr>
</tbody>
</table>

Singh and Agrawal (1993).

Haryana Agricultural University, Hisar on different methods of irrigation, has indicated that with the sprinkler system of irrigation wheat yield was not affected with application of saline water of EC even up to 12 dS/m. For Bajra and cotton crops there was some reduction with application of saline water of EC 6 dS/m by sprinkler irrigation (Table 3).

Drip Irrigation: This method is becoming increasingly popular in areas with water scarcity and salty water. This method is specially suited to semi arid regions characterized by saline soil and saline ground water with high evaporation rate. Under drip irrigation system soil remained quite moist due to frequent irrigation and the salt in the soil remain diluted. Sixty percent less water requirement than the surface irrigation keeps the salt concentration below the harmful level. With the result plant can with stand higher EC of water with out much loss in yield (Meisheri et al., 1993 and Taley and Dalvi, 1993). Agrawal and Khanna 1983 brought out that saline water of 6.5 dS/m produced 15.7 t/ha radish under drip method and only 9.9 q/ha under furrow method. In case of potato saline water of 4.0 dS/m produced 30.5 t/ha under drip method and only 19.2 t/ha under furrow method. The water use-efficiency in both these vegetable crops were almost double in drip method as compare to the furrow method of irrigation.

6. It is well establish fact that irrigation and drainage must go hand in hand for maintaining the hydrological equilibrium. The lack of planning for drainage has contributed significantly in present problem of rising water table in South Western region in Haryana.

Subsurface drainage system is quite effective in lowering the water table of saline ground water. However there are two main problems associated with the operation of this system

a) There is no natural outlet in the state to take the drainage effluent
b) The water salinity rise with the depth and fresh to marginal water is overlying the saline water.

In view of the above situations the water at the lower depth should be drained or pumped by the sub surface drainage so that
salt load of the drainage effluent is minimized. This can be achieved by having horizontal drainage or vertical drainage.

**Horizontal drainage system:** This system is also referred as tile drainage system and is installed in situation where the ground water salinity is high and hydrological condition does not permit installation of tube-well. The horizontal drainage system consist of laterals, sub collectors and collectors. These pipe are of concrete, stone wares, clay tiles and corrugated PVC pipes with perforations. The use of PVC pipes is quite advantageous as it takes care of the silting in pipes and corrosion due to saline water and easy to shift. The central Soil Salinity Research Institute Karnal installed the tile drainage system in 1983 with various drain spacing at Sampla (Haryana). This system not only lowered the water table but also removed the salt from soil profile and obtained satisfactory crop yield (Table 4).

<table>
<thead>
<tr>
<th>Drain Spacing (m)</th>
<th>Mustard (t/ha)</th>
<th>Barley (t/ha)</th>
<th>Wheat (t/ha)</th>
<th>Cotton (t/ha)</th>
<th>Salt removed (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>2.45</td>
<td>4.20</td>
<td>4.94</td>
<td>1.80</td>
<td>32.08</td>
</tr>
<tr>
<td>50</td>
<td>2.07</td>
<td>2.96</td>
<td>4.08</td>
<td>1.64</td>
<td>35.50</td>
</tr>
<tr>
<td>75</td>
<td>0.93</td>
<td>2.09</td>
<td>2.50</td>
<td>1.60</td>
<td>29.08</td>
</tr>
</tbody>
</table>

Rao et al. (1986).

The data showed drain spacing of 25 m was the most effective at Sampla. However this drain spacing may not hold good in areas like Hisar and Bhiwani where the hydrological balance is different.

The research farm of Haryana Agricultural University has been badly affected by water logging and salinity problem. An area of few hundred hectares land is being reclaimed by installing the tile drainage system and the execution work is still going on.

**Vertical Drainage:** In vertical drainage the water is pumped from the shallow wells/tube wells with the help of a pumping unit. The pumping is done from a individual well/tube well or inter connected wells so that the average water table is maintained at a particular levels. This system should be planned in such a way that the fresh or brackish upper part of ground water is skimmed off where as the saline water remain below the well bottom. The prerequisite for installing this system of drainage is that a good thickness of fresh water layer and aquifer should be available. In case of low transmissivity and storativity the conventional type of tube well do not yield sufficient quantity of water. In that case large diameter well may provide the solution of the drainage problem. Adequate discharge can be achieved by connecting a number of well through underground collector and pumping at a central point.

7. The saline water which is available as a result of horizontal or vertical drainage can be re-used for various purpose.

It is easy to drain out saline or the saline sodic water but difficult to dispose it off, as generally the disposal outlets are not available. This water in bulk can be mixed with canal water. Apart from this it can also be used for fish culture. The species of fish like Common crap perform well with considerable high salinity of water i.e. > 10 dS/m.

**Water Table Control by Afforestation:** Though the subsurface drainage is quite effective to bring down the water table in the
problematic areas yet it is very expensive. To substantiate the solution of this problem the drainage of excess water through biological process has been developed. In this process the species of tree are selected which absorb the subsurface water through their roots and this water is release in the atmosphere by evapo-transpiration. So the rising of water table is checked and ultimately the salinization is control. Chhabra, 1998 reported that the eucalyptus and bamboo are the most effective trees. A single eucalyptus tree has the capacity to absorb 2889, 5499, 5518, 5548 and 5019 mm of water and release in the atmosphere by evapo-transpiration, in first, second, third, fourth and fifth year respectively. Thus eucalyptus trees are capable of lowering down up to 3.56 m water in fifth year. These trees help in checking the water logging problems and salts in the soil are also prevented to come on the surface.

Sodic Water: Sodic Water can be pumped by tube wells and can be used. The adverse effect of sodic water can be neutralized by the use of calcium containing amendments like gypsum, pressmud. For 1 me/lit residual sodium carbonates (RSC) in irrigation water of 7.5 cm depth can be neutralized with application of 36 kg gypsum/acre. The total quantity of gypsum required for one growing season can be calculated depending upon the RSC of irrigation water. There are two ways of application of gypsum for sodic water:

a) Direct application of powdered gypsum in the field.

b) Application of coarse size fragment gypsum as “Gypsum Bed” in irrigation channels.

Punia and Pal (1993) reported that in view of expenses incurred in powdering, bagging and storage, the application of gypsum as “Gypsum Bed” is more promising.

Yadav and associates 1990 found that application of irrigation water of 12 and 16 me/lit RSC after amending with gypsum increase the wheat yield from 22.7 to 34.2 t/ha and 15.7 to 30.4 t/ha. Similarly Yadav and associates observed that addition of gypsum 50% GR of soil irrigated with sodic water (RSC=12 me/L) significantly increased the yield of Pearl-millet, Moong Bean, Urd bean, Cow-pea, Pigeon-pea and Cluster bean.

Similarly Kumar et al 1998 found that full amendment of sodic water irrigation water of RSC 6 and 12 me/L produced 92 and 89 per cent plant sugarcane yield, respectively and 96 and 93 per cent ratoon sugarcane yield as compared to cane yield obtained with good quality of irrigation water RSC 2.8 me/L.

CONCLUSION

The introduction of the canal system in South western part of Haryana is mainly responsible for the existing water logging condition and soil salinization due to rising water table of saline water in major part and sodic part in some areas. Though this problem has assumed a serious proportion yet it is still possible to tackle it with careful planning by reviewing the canal system, execution of drainage system and larger participation of farmers in adopting proper onfarm water management practices like levelling of fields, improved irrigation methods, soil moisture conservation and reuse of the drainage water. Afforestation with the use of saline irrigation water is helpful in lowering the water table by choosing certain plant species which draw more water and tolerate more salinity than agricultural crops. Sodic water can also be used successfully for irrigating the crops after application of suitable amendments.

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