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Water Conservation and Management in Crop Production

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Abstract: The present paper focuses attention on the problems of water use in agriculture and the available technologies that can be practiced for improving the irrigation water management and enhancing the efficiency of use of irrigation water with particular reference to the state of Punjab. The viable technologies are suggested through both supply management and demand management. The supply augmentation and management lays emphasis on efficient water conveyance, application and distribution systems; desilting and management of village ponds, artificial recharge of ground water, and conjunctive use of water. The demand management concentrates on improved irrigation practices including sprinkler and drip with fertigation; improved farming technologies such as Sustainable Rice Intensification (SRI) technology; precision land leveling, mulching, crop diversification and use of soil moisture measurements in irrigation scheduling.

INTRODUCTION

India shares 17% of the global population with only 2.4% of land and 4% of the water resources (GOI, 2007). Agriculture sector is the largest consumer of water that accounts for about 84% of the total water withdrawals in the country. However, the poor water use efficiency in irrigation, which is presently estimated to be only 38 to 40% for canal irrigation and about 60% for ground water irrigation schemes (FAO, 1989), is a matter of concern. The share of irrigation water in the total demand is bound to decrease from the present 84% to 74% due to more pressing and competing demands from other sectors by 2025 AD (Swaminathan Sub-Committee, 2006). As such, the question of improving the present level of water use efficiency in irrigation assumes a great significance in perspective water resource planning. It is estimated that 10% increase in the present level of water use efficiency in irrigation projects can bring an additional 14 million ha area under irrigation from the existing irrigation capacities and it would involve a very moderate investment as compared to the investment that would be required for creating equivalent potential through new schemes (Swaminathan Sub-Committee, 2006). The annual food grain requirement of India is projected at 450 m tonnes for a population of 1.6 to 1.7 billion by the year 2050. In view of the limited land and water resources, the pathway for achieving the target of 450 m tonnes of food grain production has to be higher productivity per units of arable land and water. With the advent of green revolution during 20th century, the development of water resources for crop production has resulted in various water management problems both in surface and ground water systems and the state of Punjab is no exception in this regard. The present paper aims at discussing the problems of water use in agriculture and the available technologies that can be practiced for improving the irrigation water management and enhancing the efficiency of use of irrigation water with a focus on Punjab state.

STATUS OF IRRIGATION AND PROBLEMS OF WATER USE IN AGRICULTURE IN PUNJAB

Punjab is one of the smallest states of India with its total geographical area of 5.036 m ha. It has experienced a phenomenal increase in agricultural production during the last three decades, mainly due to extensive adoption of rice-wheat cropping system with assured irrigation facilities. Presently, nearly 86% of the total area is covered under agriculture with a cropping intensity of about 189%. The irrigated area constitutes about 97% of the cropped area. With the area irrigated by canals and tube wells as 27% and 72% respectively, nearly 80% of the water resources of Punjab are used by agriculture sector (Nidhi, URL: *http://dswcpunjab.gov.in/contents/data_folder/Nidhi_Batta_Paper.ht.*). Table 1 shows the area irrigated through different sources and extent of ground water development in Punjab. Green Revolution has changed the overall scenario of Agriculture in Punjab. As a result of this, the state's contribution in rice, wheat and cotton production both nationally and internationally is remarkable.

With the advent of Green Revolution the state has developed its water resources effectively and a mesh of irrigation canals has been laid all over. Most of the existing canal irrigation systems in Punjab are located in south-western districts such as Bathinda, Ferozepur, Mansa, Faridkot, Muktsar, etc. The number of tube wells in the state has increased from 0.19 million in 1971 to 1.17 millions in 2005 (Jain and Kumar, 2007). Almost entire area in central and north-eastern districts is irrigated by groundwater. In the south-western districts, the use of canal water is more than the ground water. This development resulted in water table increase in south-western districts causing waterlogging and salinity problems and its decline in central districts. During the last decade the average fall of water table in the central Punjab was 0.55m/year (Hira et. al 2004). At some places the ground water level declined at the rate of even 0.75 to 1 m/year.

Table 1: Area irrigated by various sources and extent of ground water development in Punjab

S. No.	Districts	% Area irrigated		Extent of ground water development (%)
		Canal	Tube well	
1.	Amritsar	54	46	152
2.	Bathinda	78	22	93
3.	Faridkot	88	12	106
4.	Fatehgarh Sahib	-	100	161
5.	Ferozepur	37	63	105
6.	Gurdaspur	11	88	107
7.	Hoshiarpur	9	90	85
8.	Jalandhar	1	99	254
9.	Kapurthala	1	99	204
10.	Ludhiana	3	97	144
11.	Mansa	24	74	175
12.	Moga	4	96	178
13.	Muktsar	93	7	62
14.	Nawan Shahr	4	96	175
15.	Patiala	2	97	165
16.	Rupnagar	2	98	93
17.	Sangrur	7	93	183

The annual water resources of the state are estimated at 1.45 m ham of canal water available at the outlets and 1.68 m ham of ground water. The total water supply of 3.13 m ham falls short by 1.27 m ham of the total water demand of 4.40 m ham (Jain and Kumar, 2007). The dominance of rice-wheat system has caused reduction in area under low water requiring crops, which led to over exploitation of groundwater resource, as the surface water is not adequate to meet the irrigation needs of the state. The quality of ground water has become vulnerable in a number of areas of Punjab due to intensive use of pesticides and fertilizers in agriculture, increased urbanization and industrialization. The southwest part of Punjab faces severe groundwater quality problems that prevent its withdrawal. In this region, the poor quality of groundwater is due to salinity, alkalinity or both. Presence of salt impregnated strata below these soils is responsible for the poor quality of underground water in these areas. The inadequate drainage, seepage from unlined canals and over watering of the fields has raised the underlying water table giving rise to waterlogging in several areas in Punjab and especially in the south-western part. Therefore, a long term strategy is required that incorporates suitable practices to overcome the existing and potential problems and promotes the sustainable water management in agriculture.

VIABLE TECHNOLOGIES FOR SUSTAINABLE WATER MANAGEMENT IN AGRICULTURE

A number of interventions through both supply augmentation and demand management are suggested for improving the efficiency of use of irrigation water and for promotion of sustainable water management. These are briefly discussed below.

Supply Augmentation and Management

Improvement Of Water Control Measures And Canal Operation Management

The water use efficiency in the canal irrigation systems is about 40% due to poor water control and management. Uncertainty of water supply (in terms of time and quantity) is the major concern in many projects. Hence, the focus should be contemplated on how best we can improve upon the existing surface irrigation techniques. Hydraulically efficient water conveyance, application and distribution systems coupled with geometrically efficient irrigation layouts will complement to the premise of more crop per drop. Priority should be given for lining of the canals and maintenance of control structures so that water control could be ensured.

During a last few decades, a sea change has taken place in Punjab in the cropping pattern, cropping intensity, ground water development, and ground water quality. The low water consuming crops like pulses and oilseeds have been replaced with high yielding varieties having greater demand for irrigation such as paddy and wheat. The number of tube well has increased manifold. It is therefore quite imperative that the canal water operational schedule must be planned keeping in view the prevailing irrigation needs, availability of water resources etc. for making an optimal utilization of water resources.

Renovation of Village Ponds for Irrigation

Chawla *et al* (2001) have reported the feasibility of renovating the village ponds for providing irrigation. The renovation of these ponds for irrigation will be of great importance especially in central districts of state with declining water table and in north-eastern districts having deep water table. The additional water available from these ponds will help reduce the declining water table.

Artificial Recharge of Ground Water

Artificial recharge of ground water is a promising strategy to arrest the declining water table. The roof top rain water can be diverted to the existing open wells or to the percolation pits, recharge trench or recharge wells depending on the conditions. Secondly, the recharge from village ponds can also be promoted by increasing the seepage rate from these ponds through desilting. Collection of harvested rainwater in check dams would also be helpful in augmenting the water supply and recharge through percolation.

Conjunctive Use of Water

The excessive withdrawal of ground water which led to declining water table in central districts of Punjab can be arrested by increased use of canal water in conjunction with groundwater. On the other hand in the south-western districts the use of canal water is more because the ground water is not good. The use of poor quality ground water in conjunction with canal water in appropriate proportions would help in checking the rising water table.

Demand Management

Improved irrigation practices including micro-irrigation and improved farming technologies should receive priority attention for demand management of irrigation water. Some of the technologies for improved agricultural production per drop of water are discussed below.

System of Rice Intensification

System of Rice Intensification (SRI) technology involves the use of certain management practices, which together provides better growing conditions for rice plants, particularly in the root zone, than those plants grown under traditional practices (Swaminathan Sub-Committee, 2006). Four components of SRI include early planting (12 days old single seedlings, wider spacing), limited irrigation (2-3 cm depth after appearance of hairline cracks), weeding and application of more compost and building soil organic matter content. The multiple benefits of SRI approach includes saving of irrigation water (about 600 to 700 mm through intermittent irrigation as against 1200–1500 mm in conventional method), less seed rate, less nursery area, better soil aeration, enhanced yield and control of malaria. SRI is being practiced in states like Tamil Nadu, Andhra Pradesh, Karnataka in South India and sporadically followed in few Eastern states like Tripura and Assam. Up scaling this innovative approach throughout the country alone could sustain the irrigated rice cultivation in future.

The major reason for the low adoption rate of this management-oriented technology is the landscape and poor drainage facility existing in the rice growing regions especially in the deltaic situation. Crop establishment with young seedlings, nutrient use efficiency, soil aeration and crop growth are primarily depending on the drainage facility. A number of measures that are required to improve the drainage facilities include (i) cleaning of the canals for easy drainage, (ii) construction of water harvesting structures to store draining water at appropriate place, (iii) restructuring field bunds to have proper inlet and outlet for easy drainage, and (iv) farmers' participatory research cum demo on improved water management techniques. Besides above, a training and demonstration programme for farmers on production of healthy and robust rice seedlings through development of community nursery for larger scale distribution, proper land leveling for successful crop establishment, and demonstrations to illustrate the significance of the cono rotary weeder operation in soil and water management are some of the suggested action plans for promoting large-scale adoption of the SRI method of rice cultivation

Micro irrigation with fertigation and sprinkler systems

The conventional methods of water conveyance and irrigation being highly inefficient have led not only to wastage of water but also to several ecological problems like waterlogging, salinization and soil degradation. The use of modern irrigation methods viz. drip and sprinkler irrigation is the only alternative for efficient use of surface as well as ground water resources. The water use efficiency in these systems is much higher than the flooding method of irrigation. Studies have revealed that drip irrigation results in water saving ranging between 25 to 50% and yield increase as high as 100% in some crops under specific locations (Sivanappan, 2000; URL: *http://www.usaid.gov)* as compared with surface irrigation method. The rain gun irrigation system has to be appreciated in light of the current irrigation practices. Rain gun is a powerful mega sprinkler that throws a large amount of water (up to 500 liters per minute) to a good distance (radius of 90 feet and even more) as artificial rain.

Fertilizers applied under traditional method of irrigation are not efficiently utilized by the crops. Once investment on micro irrigation is made, it is very easy to achieve the full benefits through the next ultimate step called as fertigation. Fertigation is a coined term to irrigate and give fertilizers along via micro irrigation systems.

Precision land leveling

Precision land leveling will be of great use for improving conveyance, application and distribution efficiency in central districts where mostly ground water is being used for irrigation. Unevenness in the soil surface adversely affects the uniform distribution of water in the fields. Precision land leveling results in reduction in time and quantity of water required to irrigate the field, and more uniform distribution of water and soil moisture in the field for better crop growth.

Mulching

Application of straw mulch improves the water use efficiency. It reduces the evaporation losses from the soil surface. Mulching keeps the weed down and improves the soil structure and eventually increases the crop yield.

Crop diversification

In central Punjab, large scale adoption of rice-wheat system has been a major factor in over exploitation of ground water. Therefore, efforts should be made to divert area under paddy to alternate less water requiring crops.

Monitoring of soil moisture

The application of precise quantities of irrigation water at the right time not only ensures a high efficiency of water use by the crops, but also reduces nutrient losses through leaching, results in better aeration of the soil, and significantly improves crop yields and farm productivity. Competition for water, high pumping costs, and concerns for the environment are making good water management more important. A tendency to over- or under-irrigate the cropped fields results due to the absence of information about the soil moisture status down the soil profile. Therefore, irrigation water Management requires a combination of a method of soil moisture measurement and some method of irrigation scheduling. Measuring soil moisture detects if there is a water shortage that can reduce yields, or if there is excessive water application that can result in water logging, wastage of water and nutrients below the root zone through deep percolation and surface runoff of tail water. Soil moisture readings are useful to determine how much water is available for the crop, when to start irrigating, and how much water to apply. Though a variety of methods are available for measuring soil moisture, the use of soil moisture sensors or tensiometers which provide soil potential are quite handy and easy for use by farmers. The irrigation scheduling can be done for different type of soils based on the readings of soil potential.

CONCLUSIONS

The share of irrigation water in the total demand is bound to decrease in future due to more pressing and competing demands from other sectors and as such, the question of improving the present level of water use efficiency in general and for irrigation in particular assumes a great significance in perspective water management planning. Technological improvements in irrigation and farming systems have increased opportunities for water management in agriculture. Modern irrigation technologies, particularly sprinkler and drip irrigation, increase water use efficiency. This technology has also enabled regions facing limited water supplies to shift from low-value crops with high water requirements (e.g. cereal) to high value crops with lower water requirements such as fruits, vegetables and oil seeds. Renovation and desilting of village ponds, construction of check dams and similar small storage structures to store harvested rain water are the promising strategies for artificial recharge of ground water to arrest the declining water table. There is considerable scope for preventing and alleviating drainage problems by more integrated planning and water management. This can include integrated use of canal and groundwater for water table control, adapting land use to the natural drainage conditions, canal lining and land leveling etc. Soil moisture monitoring coupled irrigation scheduling can play a vital role in saving irrigation water.

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