Proceedings WAMIP-2010
M. S. Rao, et al. (eds)
N.I.H., 2010

V-4

Water Scarcity: Causes and Management in Punjab

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Abstract : Punjab, the food basket of India, is currently facing water crisis. The total availability of water from different sources is 3.13 mham/y which is less than total demand (4.33 mham/y). Ground water is being used at a rate of 3.12 mham/y which is more than its recharge (2.14 mham/y). Due to this excessive drafting ground water table is falling down and is threatening the irrigated agriculture of the state. Agriculture is a major consumer (83%) of fresh water, therefore, it is necessary to save water in this sector so that food security of the India is not jeopardized. Many technologies are available which are helpful for saving water in agriculture, like laser leveling (saves upto 26%), control of water loss during conveyance (10-20%), proper selection of crops and their varieties, proper size of plot for planting crops (27%), planting methods (30%), zero tillage (30%), proper scheduling of irrigation (35%) and drip/sprinkler systems of irrigation can save upto 50 per cent of water.

Key words: Punjab, water, scarcity, causes, management

INTRODUCTION

Indian Punjab is considered as food basket of India, because it contributed 31-45 per cent rice and 50-73 per cent wheat to the central pool, during the last three decades, as it has largest surplus of food grains compared to other states of India. Punjab is the home of 24 million people which is about 0.2 per cent of Indian and 0.035 per cent of the world population. Among this, rural population comprises about 66 per cent which mainly depends upon agriculture. Some of the facts, regarding the importance of Punjab in Indian and world agriculture are shown in table 1. The farmers of Punjab had responded quickly towards the adoption of the technologies developed by agricultural scientists during green and post green revolution period, resulting in a tremendous increase in agricultural production (table 2). But, this production has been due to intensive use of inputs and natural resources like soil and water. Presently, a major concern of the state is the rapid decline of water-table. About 77 per cent area of the state is facing the problem of falling water table (Hira *et al.*, 2004). To produce more and more food the demand for irrigation water is increasing and it far exceeds its supply from different sources, resulting in water scarcity in the state. The excessive demand for irrigation water is met through over-exploitation of groundwater, which caused a decline in the ground water table.

Therefore, an efficient use of production resources, especially water, is of utmost importance to sustain agricultural production, national food security and income of farmers in the state.

WATER SCARCITY IN PUNJAB

Water scarcity in Punjab can be understood by studying the water resources, their conditions and water requirement of the state.

Rainfall

The annual rainfall in Punjab ranges from over 300 mm in 21 rainy days in the Western part to over 1100 mm in 48 rainy days in the North and North Eastern part. Almost 80 per cent of the

Table 1. Sharel of Punjab in Indian and world agriculture las in 2007-08 (www.indiastat.com and www.fao.org).

	Punjab	Percentage of	
		India	World
Geographical area	5.03 million ha	1.69	0.0387
Net cultivated area	4.25 million ha	2.68	
Irrigated area	4.04 million ha	6.62	0.29
Cropping intensity	188.1%	136.2	-
Total production (million tonnes)			
Food grain	27.33	11.66	-
Rice	15.67	10.84	2.38
Wheat	15.72	20.73	2.57
Cotton	0.40	9.10	1.5

Table 2. Decadal change in agricultural production in Indian, Punjab. (www.indiastat.com)

Agricultural products	Total production in years (m tonnes)						
	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01	2005-06
Cereals	1.43	2.45	6.99	11.71	19.11	25.28	25.16
Pulses	-	-	0.31	0.20	0.11	0.04	0.03
Oilseed	0.06	0.12	0.23	0.19	0.11	0.09	0.09
Food grain	1.99	3.16	7.31	11.92	19.22	25.32	25.18
Milk	-	-	-	3.22	5.14	7.77	8.91

rainfall comes in the monsoon period (June to September) and about 57 per cent is received in the months of July and August. The total annual rainfall over the cropped area of the Punjab was worked out to 1.57 mham by taking 580 mm as average annual rainfall by Mavi *et al.* (1994).

Surface water

Total annual surface water available from the canal networks in the state 1.45 million hectare meter per year (mham/y) (Singh, 2008).

Groundwater

Total annual replenishable groundwater resource of Punjab is 2.38 mham, and natural discharge during non-monsoon period is 0.23 mham/y, resulting in net ground water availability of 2.14 mham/y. On the other hand total annual ground water withdrawal is 3.12 mham/y, which is being over drafted by 0.99 mham/y (mowr, 2010). There are about 1.23 million electric and diesel pump sets in the state for pumping groundwater for irrigation (Anonymous, 2007), which has led to over-exploitation of groundwater resulting in rapid decline of water table in the entire fresh water zone of the state. In the central Punjab, area having water table depth below 10 meters increased from 3.7 per cent in 1973 to 84.6 per cent in 2004, as shown in the figure 1, while the corresponding values for whole of the Punjab are 17.2 and 55.8 per cent respectively.

Water requirement and availability in Punjab

It has been estimated by Hira (2009) that annual water requirement of Punjab is 4.33 mham and availability from different sources is only 3.13 mham, resulting in a net deficient of 1.20 mham.

CAUSES FOR OVER DRAFTING OF GROUND WATER

The level of the groundwater table in any region depends upon the balance between the amount of groundwater recharge through seepage/percolation and withdrawal of groundwater. This balance is negative in case of Punjab and following are the main reasons for it.

Early transplantation of rice

Early transplanting of rice which was a common practice among farmers, is considered the main cause for fall in ground water table. If rice is transplanted in the hot and dry month of May, the evaporative demand of the atmosphere is very high and which is met through irrigation. This fact is supported by the findings of Hira (1996) who reported that the evapotranspiration of rice transplanted on May 20 is 76 cm, on June 10 is 60 cm, and on June 30 is 52 cm.

Less canal irrigation in the central Punjab

In the central zone of the Punjab (worst effected) only 14 per cent area is canal irrigated (Annonymous, 2008), hence, there is less seepage and hence less recharge of ground water.

Shift in cropping pattern and increase in area under rice

Assured tubewell irrigation and assured procurement has led to an increase in area under crops requiring more water, which is also a reason for water scarcity in Punjab. The area under rice has increased 10 times since 1960 (Table 3) and presently it is cultivated on about 65 per cent area of Punjab (85 per cent area in central Punjab). Moreover water requirement of rice is very high (Table 4) (Hira *et al.*, 2004). Thus increase in area under rice may be regarded as a cause of fall in water table in Punjab.

SECTOR WISE WATER USE IN PUNJAB

Agricultural sector is a major consumer of water as in India it accounts for 83 per cent of the total water used and in Punjab, out of the total ground water used 97.37 per cent is used for irrigation (Cgwb, 2010).

On the one hand agricultural sector is under pressure to produce more for growing populations but on the other hand sustainability of irrigated agriculture is at stake due to decreasing water availability. Therefore, the need is to develop technologies which could help in saving water in agriculture, while enhancing or maintaining the yield levels.

WATER SAVING TECHNOLOGIES IN AGRICULTURE

A brief description of the scientifically proven water saving technologies which can be adopted by the farmers of the region are given here.

Control of water loss during conveyance

During conveyance of water from the source to the fields, considerable amount of it is lost through deep percolation and evaporation. The amount lost depends mainly upon the distance between the source and the field. Kaushal *et al.*

Table 3. Area under various crops in Punjab (Statistical Abstracts of Punjab, Govt of Punjab, 2008).

Crop	Area(000 ha) in the year					
	1960-61	1970-71	1980-81	1990-91	2000-01	2007-08
Rice	227	390	1183	2015	2612	2610
Wheat	1400	2299	2812	3273	3408	3488
Cotton	447	397	649	701	474	604
Maize	327	555	382	188	165	153
Chickpea(Gram)	838	358	258	60	8	3
Other pulses	65	56	83	83	46	23
Total oilseeds	185	295	238	104	86	59

Table 4 : Seasonal ET and drainage loss (mm) in different crops

Crop	ET	Drainage
Rice	620	1330
Maize	480	270
Cotton	650	140
Soybean	600	300
Wheat	380	90
Winter maize	510	90
Chickpea (gram)	320	40
Sugarcane	1400	20
Sunflower	600	20
Brassica juncia	280	40

(2008) observed that brick lining of earthen water channels can save 10-20 percent water. Application of irrigation water through pipes results in higher conveyance efficiency of 997 per cent (Wang *et al.,* 2002), the amount of water saved by the use of pipes in comparison to earth canals is 50 per cent, stone lined canals 15 per cent and concrete lined canals 7 per cent. Underground system of pipes for distribution of water is very effective in controlling water loss and it also increases the area under the crop equal to the product of length and width of the water channel and their maintenance cost is almost nil.

Proper leveling of land

Unleveled fields require more irrigation water and are responsible for low crop yield. A difference of 1 cm in elevation of a field may require 100,000 l/ha more water just to cover the elevated spot with water if we assume the plot size of one hectare. Jat *et al.* (2009) found improvement in rice-wheat system productivity by 7.4 per cent along with irrigation water saving of 12-14 per cent in rice and 10-13 per cent in wheat by laser-assisted precision land leveling as compared to traditional land leveling.

Selection of crops and cropping systems

It is clear from the table 4 that water requirement for rice is very high as compared to other crops (Singh, 2008). Rice is a major crop of the state and is cultivated on about 65 per cent of net cultivated area during summer season, considerable amount of water can be saved (Table 5) if rice is replaced with maize and other crops (Anonymous, 2002). Kukal and Sidhu, (2008) reported that even cultivation of short duration variety of rice (PAU 201) causes less fall in level of groundwater as compared to long duration variety Pusa 44, whereas both varieties have almost equal yield potential.

Proper plot size

Size of plot is very important factor affecting yield and water used for crop production. Singh and Sandhu (2008) has reported that smaller plots of 29x7 m^2 gave a saving of irrigation water (27 %) as compared to plots of 60x14 m^2 in wheat without affecting its productivity.

Planting/transplanting time

Shifting the planting/transplanting time of crops from high to low evaporative demand

Table 5 : Saving of water by crop diversification and proper management

Current crop	Proposed alternative	Area proposed (M.ha)	ET of current crop (mm)	ET of proposed crop (mm)	Saving in water (M.ham)
Rice			730		
	Groundnut	0.05		515	0.01
	Maize	0.2		460	0.05
	Basmati	0.1		516	0.02
	Timely transplanting	1.3		460	0.35

periods is likely to reduce irrigation water requirement of crops. Chahal *et al.* (2007) found that evapotranspiration loss of water from paddy decreases with delay in transplanting from 1st May to 1st July with a corresponding increase in yield. Keeping, timely sowing of wheat in view, transplanting paddy between 15-30 June is the optimum time for saving of water and higher productivity of rice-wheat system.

Planting techniques for saving water

Many planting techniques have been developed which help in saving irrigation water. Work done on these techniques are briefly reviewed here to get an idea about water saving and effect on yield.

Bed planting

In bed planting systems, crops are planted on ridges with flat top or on the slope (as in bed transplanted rice) of the ridge and irrigations are applied in the furrows. Wang *et al.* (2007) observed several advantages of bed planting in wheat with furrow irrigation firstly, it saves irrigation water up to 30 per cent and then improves the nitrogen use efficiency by 10 per cent secondly, it eliminates the soil crusting and improves soil physical properties; thirdly, it changes the micro-climate of the field due to the arrangements of the wheat plants in rows on the beds, which can reduce crop lodging and suppress wheat diseases. These advantages can improve the quality of wheat and increase the grain yield by more than 10 per cent.

In, rice Kumar *et al.* (2005) observed at Ludhiana (Punjab) that transplanting of rice on fresh beds does not statistically affects the grain yield as compared to puddle transplanted (conventional method) rice but beds resulted in a 30 per cent saving in water.

Similarly, advantage of bed planting in terms of yield and water saving had been reported by Idnani and Gautam (2008) in summer moong (*Phaseolus mungo*) and Kumar (2008) in wheat and Indian mustard (*Brassica juncea*).

Zero tillage

Planting crop without preparatory tillage is called zero tillage. It has several advantages like saving of diesel, less emission of harmful gasses due to less burning of fuel, timely sowing, irrigation water saving, healthy crop and prevents soil erosion. The findings of survey in Haryana indicated that zero tillage resulted in statistically higher grain yield of wheat (4%) along with 7.1 per cent saving of water Erenstein *et al,* (2008).

Planting in furrows

Planting of crop in furrow saves water without any adverse effect on yield of crop. Aujla *et al.* (1991) and Singh *et al.* (1995) observed a saving of 100-150 mm and 100-170 mm of water, respectively, in cotton planted in furrows as compared to flat planting with flood irrigation, without any yield loss.

Puddling

Puddling is ploughing the field in the presence of standing water. It is practiced for transplanted rice. Arora (2006) observed that increase in number of runs of a tined cultivator in ponded water (puddling) from one and two to four resulted in saving of irrigation water upto 31 and 10 per cent respectively, along with slight increase in yield. Sarkar (2006) reported a saving of 17 per cent of irrigation water when puddling was done with a power-tiller rotavator with 9-cm depth of puddling as compared to puddling with tractor-drawn cultivator with cage wheels where the puddling depth was 15 cm. Use of rotavator also improved yield of rice as compared to rest of the treatments.

Irrigation scheduling

Proper scheduling of irrigation is must to save water and get good yields. In rice, Sandhu *et* *al.* (1980) found that similar grain yield along with 34 per cent saving of irrigation water when irrigation was applied two days after drainage of applied water as compared to continuous submergence. Hira *et al.* (2002) observed that scheduling irrigations to rice based on soil water tension of 1600 + 200 mm resulted in higher WUE as compared to 2 day drainage interval.

Irrigation methods

Irrigation water requirement in field crops can be reduced by using improved irrigation methods that minimize deep drainage and soil water evaporation losses.

Drip and sprinkler irrigation for saving water

Sprinkler and drip irrigation methods apply water without much loss. These methods can be adopted in areas having excessively coarse textured as well as slowly permeable soils, undulating lands having high cost of leveling and in area of high water table more so with poor quality water. Drip irrigation in sugarcane, groundnut, cotton, grapes and brinjal resulted in water saving of 65, 40, 60, 48 and 35 per cent as compared to flood irrigation and an increase in of yield 33, 65, 27, 23 and 18 per cent, respectively as reported by Narayanmoorthy (2004) and Mahajan *et al.* (2007a).

Sprinkler irrigation resulted in water saving of 56, 56 and 50 per cent as compared to flood irrigation along with yield advantage of 24, 51 and 12 per cent, in wheat, gram and groundnut, respectively, (Narayanmoorthy, 2004).

Alternate row irrigation for saving water

Water can also be saved by applying the water in alternate rows. Ghadage *et al.* (2005) obtained similar yield of cotton by applying water in alternate rows along with saving of 2 cm of water as compared to irrigation in each row. In maize, alternate furrow irrigation maintained similar grain yield with up to 50 per cent reduction in irrigation amount, as compared to fixed furrow irrigation and conventional furrow irrigation in maize (Kang *et al.*, 2000).

Mulching

Mulches increases WUE of crops by influencing hydro-thermal regime of soils, which may enhance crop growth. Mulches of organic material and that of plastic can be used. Ghadage *et al.* (2005) reported that plastic and organic mulches produced 32.6 and 22.3 per cent higher yield as compared to non mulched treatment and along with saving of irrigation water by 7 and 3 cm respectively, in cotton. Mahajan *et al.* (2007b) found that in baby corn plastic mulch increased its yield by 18.9 and 77.5 per cent over rice straw and non mulched treatment, respectively and resulted in 30.6 per cent of water saving as compared to non mulched treatment

CONCLUSION

It can be concluded that Punjab, the food basket of India, is currently facing water scarcity. There is an urgent need to save water in agriculture so that irrigated agriculture can keep on fulfilling the ever increasing demand for food, feed and fiber. Many scientifically proven technologies are available which are helpful for saving water in agriculture, like laser leveling, control of water loss during conveyance, selection of crops, proper size of plot, planting methods, zero tillage, proper scheduling of irrigation, drip and sprinkler systems of irrigation, if these technologies are adopted properly only than we can make agriculture evergreen.

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