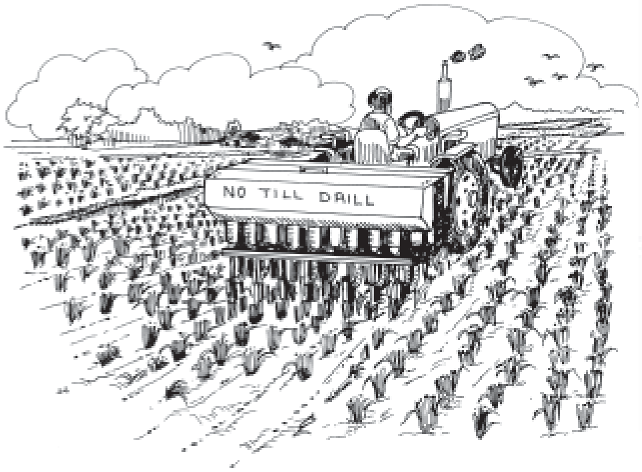
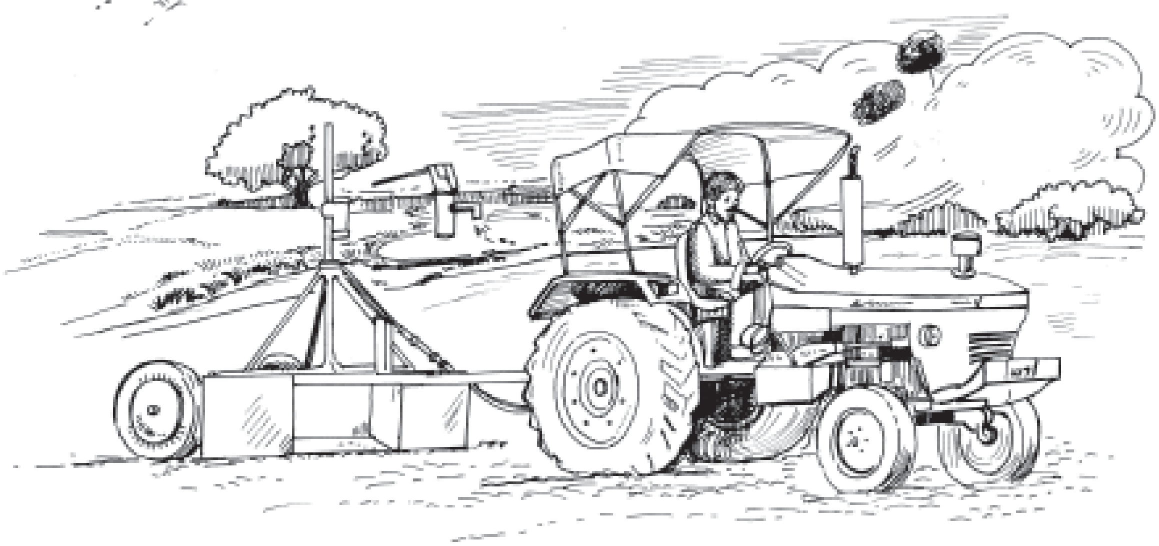
New Opportunities for Saving on Water: Role of Resource Conserving Technologies





Agricultural policy in South Asia during the 1960-70s focused on food security production through increased coverage of high-yielding varieties, expansion of irrigation and increased use of external inputs. This enabled rice-wheat (RW) to emerge as a major cropping system in the Indo-Gangetic Plains (IGP), ushering in “Green Revolution” (GR). It has been reported that nearly 85% of RW systems of South Asia are located in the IGP and evidence is now appearing that RW systems have fatigued the natural resource base. The major challenge for the countries under the Rice-Wheat Consortium (RWC), such as India, Pakistan, Bangladesh and Nepal, is to develop RW systems that produce more at less costs and improve profitability and sustainability. This suggests that agriculture in these countries will be in need of an infusion of new technologies that are able to tap new sources of productivity growth and are more sustainable and the IGP has continental monsoonal climate.

In the northwest Trans-Gangetic Plains, the average annual precipitation ranges from 400-750 mm per year and increases towards the Bay of Bengal, where the annual rainfall is as high as 1800mm per year. Nearly 85% of the total precipitation is received during the monsoon season between June and September. There are wide variations in soil types, generally coarser in the Trans-Gangetic Plains and becoming finer with the run of the river systems. Soils are primarily calcareous micaceous alluviums with sandy loam to loam in the upper reaches becoming finer textured in the distal plains. A significant observation is the greater reliance of farmers on tubewell irrigation in the northwestern parts of the IGP and in Bangladesh. Excessive groundwater development in freshwater aquifer zones has led to recession in water table, while in areas under laid with low quality aquifers having problems of residual alkalinity, high sodium adsorption ratio, and excess salts, canal irrigation had led to a rise in the water table. Low quality waters are interspersed with good quality aquifers in many areas of northwest IGP and are being used successfully in crop production by the farmers.

Some Water-Saving Options

Early Transplanting

In the eastern IGP, delayed onset of rains and the near lack of groundwater development during the monsoon season delays rice nursery and transplanting operations to set in a vicious cycle of late planting of crops. Long-term analysis of the rainfall data for this region clearly indicates that there are three distinct periods of moisture availability. The early moist period, wherein the evaporation exceeds rainfall, extends over the first 12-18 days. This is followed by 93-139 days of humid moist period wherein precipitation exceeds potential evapotranspiration. In the terminal moist period of 17-22 days once again rainfall is less than evapotranspiration. If the rice seedlings can be raised and transplanted with groundwater irrigation, and established early in the first moist period, the rice crop can benefit from the monsoon rain and grow without the need for irrigation during the humid period.

Timely transplanting of rice also results in earlier harvests and early vacating of the main field. This allows timely planting of the wheat crop that follows it. The results of farmer participatory field trials show that the strategy of timely transplanting of rice improves wheat yields. RW system productivity is nearly 12-13 tons per hectare when rice is transplanted before 28th June. This is reduced to about half when fields are planted after 15th August (to 6-7 tons/ha). This strategy has been tested in a few hundred hectares of farmer's fields in Bihar and has paid rich dividends. There are other options also to be more water-wise.

No Puddling

A lot of research is being conducted in the region to look at the possibility of establishing rice without puddling. The major hurdle has been paucity of knowledge regarding good weed management, as most of the rice herbicides available in the region have been developed for transplanted rice and these are not as effective in dry seeded rice. Experiments conducted at Pantnagar (India) and Bhairahawa (Nepal) on total RW system productivity show that tillage and puddling do not have much influence on rice yields. Wheat yields are, however, significantly better when rice soils are not puddled.

Dry Sowing with Zero-tillage

Direct dry sowing using zero-till seed drill, and use of permanent beds for planting can reduce the time lost, and irrigation water used in land preparation for the crop. Along with possibility of groundwater availability for protective irrigation, this can enable early planting.

Suitable Varieties

Given the prospect of early sowing, the question is whether certain cultivars of rice and wheat are especially suited for such practices. It is observed that two cultivars of wheat favored for timely (early) sowing, WH 542 and PBW 343, have a longer vegetative phase and shorter grain-filling phase than older varieties such as HD 2009 and HD 2329 (Mehla *et al.,* 2000).

In Situ Retention of Rainwater

Studies have indicated that raising of peripheral bunds to a height of 18-20cm around fields could store nearly 90% of total rainwater *in situ* for improved rice production and reduce the need for irrigation water.

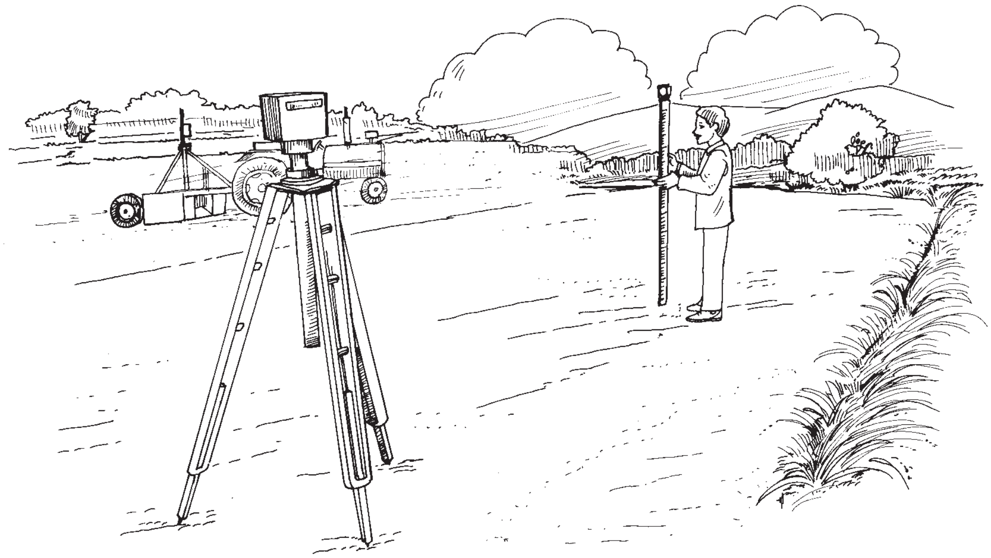
Intermittent Submergence

Whenever the rainwater does not meet the water requirement of rice and the soil develops hairline cracks, irrigation water is supplied to fulfill the demand of water. It is observed that a three-day drainage period is generally suitable and can easily effect more than 40% saving in water without compromising on rice yields (see table below).

Effect of Intermittent Irrigation on Rice Yield and Irrigation Water Requirement at Various Locations in the IGP

Location	Soil type	Yield in t/ha (WR in cm)				Saving in irrigation water*** %
		Continuous submergence	Irrigation after drainage period * of			
			One day	3 days	5 days	
Pusa (Bihar)	Sandy loam	3.6(81)	3.5(60)	3.3 (46)	2.9 (35)	43
Madhepura (Bihar)**	Sandy loam	4.0 (35)	-	4.0 (16)	4.0 (11)	54
Faizabad (UP)	Silt loam	3.8 (65)	2.9 (42)	-	-	-
Pantnagar (UP)**	Silt clay loam	8.1 (121)	7.6 (112)	7.4 (90)	6.9 (60)	44
Ludhiana (Punjab)	Sandy loam	5.5 (190)	5.4 (145)	5.1 (113)	5.2 (96)	40
Hissar (Haryana)	Sandy loam	5.7 (220)	5.2 (196)	4.7 (126)	-	43
Kota (Rajasthan)	Clay loam	5.4 (145)	5.3 (86)	5.1 (68)	-	53

Source: Chaudhary, T.N. 1997. Water Management In Rice for Efficient Production. DWMR Patna India.
Figures in paranthesis show irrigation water requirement (cm)
* Drainage period in days after disappearance of ponded water
** High watertable condition
*** With three-day drainage vs. continuous submergence



Precision Land Levelling

One of the reasons for over-irrigation is poor land levelling. Unevenness in the soil surface adversely affects even distribution of irrigation water in the fields and leads to poor crop stand. Levelling can help eliminate this inefficiency and reduce water requirement through transmission losses and uniformity in moisture distribution to ensure uniform crop establishment and growth through the season. On-farm trials in Cambodia using the same variety and fertilizer inputs showed that land levelling yielded 24% more grain. Part of this increase is due to more efficient weed control in level fields. Levelling enables increase in the plot size and increases the available planting area by 5%-7%. It also reduces operating time for farm machinery (Rickman, 2002).

Laser Levelling

Laser levelling requires conventional farm equipment and laser equipment to efficiently shift soil from the higher levels to the lower levels in a cost effective way. The physical levelling should always be preceeded by a topograhic survey of the land proposed to be levelled.

Saving on irrigation water can easily be obtained by precision land levelling. This is being promoted as a means to improve water efficiency and crop yields through improved nutrient-water interactions. When land levelling is combined with zero-tillage, bed planting and non-puddled rice culture, the plant stands are better, growth is more uniform and yields higher. In Pakistan's Punjab, average water saving with laser levelling, zero-tillage and bed planting over the traditional method was 715, 689, and 1329 m^3/ha for the year 1999-2000.

Save Water in Rice Season

Under the All India Coordinated Research Project on Water Management, the total water requirement for wheat is estimated to range from 238 mm in Bihar to 400 mm in Punjab. It is generally observed that farmers make provision for irrigation water for the wheat crop. It is for this reason that irrigated area is much higher for wheat than for rice. Similarly, the total water requirement of rice is estimated to vary from 1144 mm in Bihar plains to 1560 mm in Haryana. The variations are due primarily to the different rates of deep percolation losses in clay loam and sandy loam soils. A total of 1382 mm to 1838 mm water is required for RW system at different locations in the IGP, with the rice crop accounting for more than 80% of the water use. To save on water, saving must be effected during rice growing season, the major user in RW system.

Irrigation Requirement of Rice and Components of Water Loss (mm) Under Continuous Submergence in Texturally Variant Soils

Particulars	Clay loam	Silt clay loam	Loam	Sandy loam
Irrigation requirement (mm)	1125	1200	1500	1777
Effective rainfall (mm)	358	402	495	485
Total WR (mm)	1566	1657	1955	2262
Percolation as % of total WR	57.0	52.5	60.0	66.9
ET as percent of WR	44.0	44.2	41.3	32.9

Source: Tripathi, R.P. 1996. Water Requirement in Rice-Wheat System. Rice-Wheat Workshop, Modipuram, UP, Oct. 15-16 (recasted table).

Benefits of the RCTs in Terms of Water Use

Farmers are adopting the new RCTs quickly. Nearly 300,000 ha of wheat were grown using this mechanism and this is expected to increase to a million hectares in the next few years. Farmers' feedback on water savings with these new technologies essentially indicates that they save water.

Wheat Yield with Zero-tillage Technologies in Farmer Participatory Trials

Parameter	Paired planting@	Controlled traffic**	ZT	FP-CT
Water saving, %	26.2	30.8	35.4	#
Yield (q/ha)	65	58	57.8	51.9

Compared with conventional tilled wheat planted a week later
** One row behind each tractor tyre not sown
@ Spacing between set-rows (14 cm); and between paired sets (25 cm)

Zero-tillage

Farmers report about 20%-30% water savings with zero-tillage. This comes in several ways. First, wheat sowing with zero-tillage is possible just after rice harvest and residual moisture is available for wheat germination. In many instances where wheat planting is delayed after rice harvest, farmers have to pre-irrigate their fields before planting. Zero-tillage saves this irrigation. Savings in water also comes from the fact that irrigation water advances faster in untilled soil than in a tilled soil. That means farmers can apply irrigation much faster. Because zero-till wheat takes immediate advantage of residual moisture from the previous rice-crop, as well as cutting down on subsequent irrigation, water use is reduced by about 10cm-hectare, or approximately 1 million liters per hectare. One additional benefit is less waterlogging and yellowing of the wheat plants after the first irrigation that is a common occurrence in conventionally-planted wheat. In zero-tillage, less water is applied on the first irrigation and thus yellowing is not seen.

Crop Residue Management

Management of crop residues and plant into loose residues is a key issue not only to avoid burning and environmental pollution but also for addressing issues of organic matter decline and nutrient depletion/mining in the IGP and promoting groundwater recharge. Strategy of incorporating the silica-rich rice residues seems inevitable in acidic soils of Eastern Gangetic Plains to address the liming problems. Liming of these soils reportedly improved the yields of wheat and other upland crops. Incorporation of silica-rich rice residues into isoelectric soils manipulates the charge characteristics in a manner that improves the net negative charge, base saturation on the exchange complex and reduces fixation of applied P. Although incorporation of silica-rich organics is widely practiced in the hills, it needs more rigorous testing for its effects on physico-chemical properties of acidic soils, commonly found in sub-humid and humid Eastern Gangetic Plains.

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