

Drip irrigation and crop intensification

on dykes of pond for enhanced land and water productivity

S K Rautaray, S Mohanty, S Pradhan, S Raychaudhuri, R K Mohanty and R Dube, A Mishra

ICAR-Indian Institute of Water Management, Bhubaneswar 23, Odisha

A good amount of money is spent on creating farm pond while the volume of water harvested is limited. The estimated annual cost of pond making results in the cost of harvested water at ₹12.1/m³ for a pond dimension of 15 × 15 × 3 m without polylining. Provision of polylining substantially increases the cost of water harvesting by 43% to ₹17.3/m³. Polylining is required in soils with high seepage percolation loss (exceeding 10 mm/day). Even polylining is desired for soils with moderate seepage percolation loss (5 to 10 mm/day). We experimented using a water harvesting pond (3,894 m² area, 66 × 59 m) excluding dyke area of 1,946 m². Dykes were 7 m at the base and 5 m at top with 1:1 slope. Combined net return from dyke crops (80 papaya plants, 180 banana plants and hybrid napier on dyke slope) was ₹52,057. Net return from the 1.584 ha system area was ₹150,198 (equivalent to ₹94,822/ha). After deducting fixed cost towards pond construction, net return was estimated as ₹70,141/ha. It was higher by 2.3 times as compared to the prevailing practice of rice-fallow. Similarly, water productivity of the system (₹6.94/m³) was higher by 2.1 times as compared to rice-fallow.

Keywords: Drip irrigation, Polythene, Pond, Water harvesting

ONE important way to cope with the rainfall variability under the climate change scenario is to harvest rainwater in farm ponds. Water can be lifted from such ponds to meet the moisture deficit during dryspell(s) in *kharif* and also sometimes to grow a light duty crop in *rabi*. In Eastern India, monsoon is active for a prolonged period (June to October) with a good amount of annual rainfall (1,500 mm). Water used from farm ponds during dry spell in *kharif* is usually refilled from rainfall and surface runoff within the season. Thus, during *kharif*, enough water is available in farm ponds for meeting the water requirement of dyke crops through capillary contribution. Water harvested by November is useful for meeting the irrigation requirement of dyke crops and field crops in *rabi* season.

About ₹ 1 lakh is spent on creating

a water harvesting farm pond of 15 × 15 × 3 m. Another ₹ 0.5 lakh is required if polylining is done using 50 mm polythene. Polylining is must if the seepage percolation rate exceeds 10 mm/day. However, polylining can be provided even under moderate seepage percolation rate (5-10 mm/day), provided the harvested water is used judiciously by micro-irrigation method and for growing high-value crops. Thus, a good amount of money is spent on creating the pond while the amount of water harvested is limited. Estimated annual cost of the pond making for a farm pond of 15 m × 15 m × 3 m dimension results in cost of water at ₹ 12.1/m³ without polylining and ₹ 17.3/m³ with polylining (Table 1). This warrants economic use of water using micro-irrigation, preferably in a nearby area of the pond, so that the conveyance loss is minimized.

Further observation reveals that the cost of water harvesting was reduced enough to ₹ 8.3/m³ when the pond dimension was 20 × 20 × 3 m.

At present, utilisation of water from farm ponds is largely sub-optimal. As an example, in Odisha, about 41,000 farm ponds were constructed during the last 5 years (2014-15 to 2018-19). Maximum number of ponds were constructed by MGNREGA (15,000 nos) followed by Watershed Development (9,700), Agriculture and Horticulture Departments combinely (9,300), and Fishery Department (7,000). These farm ponds provide life-saving irrigation to crops in 5,600 ha, pisciculture in 4,000 ha and integrated farming system (IFS) in mere 560 ha. The state has a target of 5 lakh ponds in the next 5 years. The big size state like Maharashtra has a target of 25 lakh ponds in the

Table 1. Cost of water harvesting in farm ponds with or without polythene lining (2019-20)

Size of farm pond	Cost of pond making MGNREGA rate	Cost of pond making	**Cost of pond making (manual excavation, no cost for sign board etc.)	\$Annual cost for pond making (JCB for excavation)	\$Volume of water harvested	Cost of harvested water (₹/m ³)
10 × 10 × 3	55,200	46,916	38,090	3,428.1	270	12.7
15 × 15 × 3	126,600	112,227	89,102	8,019.2	665	12.1
20 × 20 × 3	163,000	143,395	113,661	10,229.5	1,235	8.3
15 × 15 × 3 (Polylining)	176,600	162,227	139,102	11,519.2	665	17.3

*Indicative cost of the pond making under MGNREGS during 2017 to 2020 as per Directorate of Soil Conservation & Watershed Development, Govt. of Odisha. The cost includes manual excavation and also an additional cost for signboard, supervision charges and drinking water facility/medicine/crèche etc.

** Excavation charge less by 25% due to JCB use, and cost for signboard, supervision charges and drinking water facility/medicine/crèche etc. not included

\$For calculating annual cost, pond life was considered was 25 years with 50% as junk value, 5% interest rate and 2% annual maintenance cost.

\$\$Volume of harvested was estimated at 0.5:1.0 slope as these were small ponds. Also, water harvest in pond was estimated at 0.5 m above the field level in the rainy season.

next 5 years as water is a scarce resource. At the national level, 2.36 M ha of ponds and tanks are suitable for freshwater aquaculture and only 40 % of the area is utilised for such purpose. The area under pond based IFS can easily be enhanced by economic use of harvested water in tanks and ponds. Multiple use of harvested water for pond crops (fish, lotus), dyke crops and field crops may enhance profit level and hence, incentivize for the creating more water harvesting structures. Dyke crops are an important component of pond based IFS requiring irrigation in dry season only as in wet season, rainfall and capillary water can meet the demand. Thus, crop intensification on dykes can be achieved by using suitable crops and drip irrigation in the dry season. We evaluated one such system in a water harvesting structure at the Research Farm of ICAR-Indian Institute of Water Management, Bhubaneswar.

Water harvesting structure and additional surface area created

The dug-out water harvesting structure was developed in an area of 5,840 m² (80 × 73 m). Pond area

was 3,894 m² area (66 × 59 m) and the dyke area was 1,946 m². Dykes were 7 m at base and 5 m at top with 1:1 slope. For each m length of dyke, the surface width was 7.828 m (5 m at top + 2 slanting sides of 1.414 m each). So, additional surface area



Fig. 1. One row of papaya plant between 2 rows of banana plant for high solar energy use

created for each running m due to the land shaping was 0.828 m². For 248 m running perimeter (64 + 60 mx2 sides), additional surface area (slant area) created was 205.34 m². This is about 4.32% increase in surface area with land shaping.

Crop intensification and drip irrigation on dyke

On the dyke top, two rows (5 m apart) of culinary banana were planted with plant to plant spacing of 2.5 m within a row. Between two rows of banana, one row of papaya hybrid 'Red Lady' was planted in diagonal pattern (Fig. 1). At the centre of each square with 4 banana plants, a papaya plant was planted. Spacing between two papaya plants in a row was 2.5 m. A drip irrigation system was installed for irrigating the banana and papaya plants on the embankment of the water harvesting structure (Fig. 2). The system included sand filter, screen filter, fertiliser tank apart from the mainline, sub-mains, laterals and emitters. The system was designed to irrigate 3 rows of plants on each side. Two numbers of emitters with 4 litres per hour (lph) discharge capacity were provided per plant. The hydraulics of the drip system was satisfactory with the average emitter discharge of 3.87 lph, and distribution uniformity of 96.1%. Bottom part (0.6 m height) of the slanting surface was used for hybrid napier grass cultivation. In addition to crops on dyke top, intensive cropping is possible using pineapple, fodder grasses like para grass, hybrid napier and creeping vegetable like pumpkin in the slanting surface of the dyke. Water-loving fodder like para grass can be suitably grown on the slanting area facing the pond.

Yield and return from dyke crops with drip and surface irrigation

The economic cycle of the papaya crop was 2 years for the test variety. The crop yielded 15.5 kg/plant in the



Fig. 2. Papaya at fruiting stage along with banana plant on dyke

first year (2014-15) while 32.8 kg/plant in the second year (2015-16) under drip irrigation (Fig. 2). Banana crop yielded 68.5 and 67.0 fingers/plant for the first and second year, respectively. Papaya was sold at ₹ 12/kg and banana at ₹ 4/finger. Gross income per annum from these two dyke crops (180 banana and 80 papaya plants) was ₹ 72,780. Economic performance of the drip system was compared with the surface irrigation system for the initial 2 years. Gross income from surface irrigation system was ₹ 58,422. Thus, increase in income due to the drip system was ₹ 14,556. The cost of the drip irrigation system was ₹ 60,000 (2014-15). Assuming average life of the drip system as 8 years and 10% as annual depreciation value, the variable cost of the system for the first year worked out as ₹ 6.50. Considering interest on borrowed capital as ₹ 3,000 and maintenance cost of ₹ 1,200, total cost for drip for the first year was ₹ 10,950. Thus, net benefit due to the drip system was ₹ 3,606 with B:C ratio of 1.33.

The economics for the second cycle (third (2016-17) and fourth year (2017-18)) was calculated. The mean yield for the second cycle was similar to the first cycle (mean papaya yield of 23.1 kg/plant and banana yield of 61.5 fingers per plant under

drip irrigation. Papaya was sold at ₹ 13/kg and banana at ₹ 4.5/finger. Gross income per annum from these two dyke crops (180 banana and 80 papaya plants) was ₹ 73,746. Gross expenditure per annum was ₹ 24,430. The mean economics for the two cropping cycles (4-year study) was calculated. The mean gross return was ₹ 72,856 with gross expenditure of ₹ 235,60 and net return of ₹ 49,296 from the papaya and banana crop grown on dyke (Table 2). Additionally, Hybrid Napier grass was grown on 3 sides of the dyke slope (209 m). Mean fodder yield was 4,166 kg/year with a gross return of ₹ 5,000/year and net return of ₹ 2,761/year. Thus, the dyke provided mean net return of ₹ 52,056/year from 1,946 m².

Yield and return from different components of the IFS

Combined net return from dyke crops was ₹ 52,057. Similarly, net return from fish was ₹ 27,995. Combined net return from fish and lotus was ₹ 33,328. Net return from

field crops was ₹ 64,813, out of which *kharif* rice provided ₹ 30,426 and the remaining amount of ₹ 34,387 was obtained from *rabi* crops. On unit area (1 ha) basis, net return was highest from dyke crops (₹ 267,503) followed by pond crops (₹ 85,588) while lowest with the field crops (Table 3). Regarding land productivity (rice equivalent yield), the highest was obtained from dyke crops (23.02 t/ha) followed by field crops (11.3 t/ha total from *kharif* and *rabi* season) and lowest with the pond crops. Field crops despite second highest productivity had the lowest net return/ha. This was due to the high cost of cultivation associated with the field crops as compared to dyke and pond crops. Among the different dry season field crops, it was highest from vegetables (cabbage and cowpea) followed by groundnut.

Thus, for this farming system model of about 4 acres land in high rainfall rainfed area, land modification included the construction of a pond (1 acre, 9 feet depth) and its dyke (0.5 acre). The remaining 2.5 acre without land modification was used for field crops (rice in *kharif* and light-duty crops like blackgram, groundnut, vegetable cowpea, early cabbage, short-duration maize and *utera* blackgram in *rabi*). In the rainy season, rainfall was sufficient for *kharif* rice. Rainwater was managed well using 20 cm high dykes around the rice fields. In *kharif*, the pond was always full of water (2.6 to 2.8 m) as it was located on a drainage line. This was useful in maintaining a temporary high groundwater table for the rice field. Also, the dyke crops could have benefitted from capillary water in *kharif*. One-acre pond could meet irrigation requirement of 2.5 acres light duty *rabi* crops provided by flexi pipes and 0.5 acre dyke crops provided by drip irrigation with a net return of ₹ 34,387 and ₹ 52,057,

Table 2. Economics of the dyke crops under pond based IFS (Mean per annum)

Component crops on dyke	Yield	Gross Return (₹)	Expenditure (₹)	Net Return (₹)
Papaya (80 plants)	23.6 kg/plant	23,578	6,890	16,688
Banana (180 plants)	64.6 fingers/plant	49,278	16,670	32,608
Hybrid Napier	4,166 kg	5,000	2,239	2,761
Total		77,856	25,799	52,057

Table 3. Economics (mean) of the pond based IFS

Components of the IFS	Area (m ²)	On actual area of components of the IFS		Estimated per ha area of components	
		*Rice equivalent yield (t)	Net Return (₹)	Rice equivalent yield (t/ha)	Net Return (₹/ha)
Pond	3,894	2.27	33,328	5.83	85,588
Dyke	1,946	4.48	52,057	23.02	267,503
Field (<i>Kharif</i> rice)	10,000	4.46	30,426	4.46	30,426
**(<i>Rabi</i> crops)	10,000	6.84	34,387	6.84	34,387
Total	15,840	18.05	150,198	-	-

*Rice equivalent yield (REY) for the dyke crops (4.48 t) was obtained by dividing gross return from the three dyke crops (₹ 52,057) with the average price of paddy grain (₹ 11,620/t). Similarly, mean REY for pond (2.27 t), *kharif* rice (4.46 t), and *rabi* season mean (6.84 t) was calculated.

**Mean net return and rice equivalent yield in *rabi*.

respectively. Also, the farm pond helped in a net return of ₹ 33,328 from pond crops besides raising water table temporarily for the benefit of *kharif* rice.

Water use and productivity of the self-reliant farming system

The catchment area of the dugout pond was 15 acres. The runoff water from the catchment was collected in the farm pond using an inlet structure after sedimentation in a lowland rice plot. The excess water from the farm pond was drained through a 'surplus structure'. In

kharif, the pond was always full of water (2.6 to 2.8 m deep). The volume of water harvested for the first, second and the third year were 9,932, 10,300 and 10,085 m³, respectively (water depth of 2.55, 2.65 and 2.59 m, respectively), with a mean of 10,106 m³. The system area was about 4 acres and the pond area was 1 acre. Thus, the pond could cater the irrigation need of about 3 times crop area. Water productivity in terms of net economic return per unit water volume for the IFS was high (₹ 6.94 m⁻³). The value was arrived after considering the annual cost of

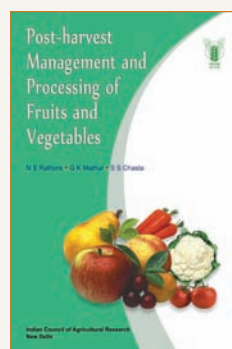
water harvesting farm pond for the experimental site for the year 2014-15. This was due to multiple use of water for fish, lotus, dyke crops and field crops. Water productivity was 2.1 times higher as compared to the prevailing practice of rice-fallow system (₹ 3.35 m⁻³) and 1.7 times higher as compared to the rice-*utera* cropping system using blackgram (¹ 4.07 m⁻³).

SUMMARY

Cost of water harvesting using farm ponds is very high. A large number of water harvesting farm ponds are unutilised due to low volume of harvested water. However, the present study reveals that using drip irrigation for intensively grown dyke crops, pipe conveyance for field crops, and multiple use of water resulted in a net return of ₹ 70,141/ha which was higher by 2.3 times as compared to the prevailing practice of rice-fallow in rainfed areas.

Corresponding authors' email: Sachin Rautaray Kanta, skrautray@rediffmail.com, Sheelabhadra Mohanty, smohanty.wtcer@gmail.com.

Post-harvest Management and Processing of Fruits and Vegetables



Post-harvest management technology offers promising option for increasing production of vegetables and fruits quantity-wise and also in maintaining quality of the products. It involves all the activities that occur after production or harvesting of commodities, including procurement, removal of field heat, sorting, grading, packaging, storage, transportation, primary and secondary processing and marketing of agricultural products from farm-gate to distributors. This book is an effort to document vast available knowledge on the various aspects of post-harvest management and processing, and it will prove worthy for teachers, students and extension workers for understanding post-harvest management and processing of fruits and vegetables. It has 16 chapters covering storage, packaging, advanced preservation technology and value-addition of fruits and vegetables.

TECHNICAL SPECIFICATIONS

Size	: Royal Octavo (16 cm x 24 cm)
No. of pages	: i-viii + 250
Price	: ₹ 350
Postage	: ₹ 50
Binding	: Paper Back
ISBN No.	: 978-81-7161-115-4

For obtaining copies:

Business Manager

Directorate of Knowledge Management in Agriculture
Krishi Anusandhan Bhavan-I, Pusa, New Delhi 110 012
Tel : 011-25843657, Fax 91-11-25841282; e-mail : bmicar@icar.org.in