MICRO IRRIGATION TECHNOLOGIES FOR ENHANCED CROP AND WATER PRODUCTIVITY-EXPERIENCES OF ANDHRA PRADESH, INDIA

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ABSTRACT

The agriculture sector is the predominant consumer of water. Almost 70% of all available freshwater is used for agriculture across the world. In India, more than 80 % of the renewable water resources are used for agriculture alone. Many of the world's most important grain lands are consuming groundwater at unsustainable rates. As we have stepped into the twenty first century, the new frontier is boosting water productivity, getting more from every liter of water devoted to crop production.
Government of Andhra Pradesh has launched the Andhra Pradesh Micro Irrigation Project (APMIP) in 2003 to promote micro irrigation in large scale for sustainable development of agriculture. The major thrust was on putting the 3 million electrified pump sets in the state of Andhra Pradesh into micro irrigation. The project has so far covered more than 0.783 m ha area under micro irrigation systems in 7 years period with capital investment of Rs 24,000 million (US $ 533 million), benefiting 0.5 million farmers.
The project has helped in improving the crop productivity, saving in water and energy and creating employment opportunities. The project is contributing to an additional productivity of worth Rs 11,745 million (US $ 261 million) per annum. On annual basis, the project is helping in saving of 144 TMC of water (1 TMC = 2700 ha m), 388 million kwh of energy. On annual basis every rupee invested in micro irrigation pays Rs 2.4 through additional productivity. The attractive payback period of less than 2 years has influenced the bankers to provide loans to farmers to procure micro irrigation systems. The success of APMIP has lead to the extension of micro irrigation into canal commands under major lift irrigation projects in Andhra Pradesh.
A study has been conducted to develop a micro irrigation system suitable to small land holdings in sandy tracts of coastal Andhra Pradesh powered by SPV pumping unit. SPV array having 24 panels with 900W rated capacity, a monoblock centrifugal pump of 1.1 hp, laterals with inline emitters, online emitters and micro sprinklers. The hydraulic performance of 4 models of micro sprinklers was studied with the operating pressure varying from 0.51 to 0.61 kg/cm^2. The diameter of spread was found in the range of 3.7 to 5.0 m and the uniformity coefficient in the range of 40 % to 64%. At an operating pressure of 0.42 kg/cm^2 the droplet size of micro sprinkler was in the range of 0.56 to 0.78 mm. Trickle irrigation design layout is made to suit to SPV pumping system to irrigate banana crop in an area of 7200 sq m.

Key words**:** Water Scarcity, Virtual Water, Sustainable Development, Micro Irrigation, SPV Pumping System

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INTRODUCTION

Although water is the most widely occurring substance on Earth, only 2.53% (35 million km^3) of it is fresh water. The remaining 97.47% (1,365 million km^3) is saltwater. Of the small amount of freshwater, only one third is easily available for human consumption, the large majority being locked up in glaciers and snow cover.

Imbalances between availability and demand, the degradation of groundwater and surface water quality, intersectoral competition, interregional and international conflicts, all bring water issues to the fore. Most countries in the Near East and North Africa suffer from acute water scarcity, as do countries such as Mexico, Pakistan, South Africa, and large parts of China and India. Irrigated agriculture, which represents the bulk of the demand for water in these countries, is also usually the first sector affected by water shortage and increased scarcity, resulting in a decreased capacity to maintain per capita food production while meeting water needs for domestic, industrial and environmental purposes. In order to sustain their needs, these countries need to focus on the efficient use of all water sources (groundwater, surface water and rainfall) and on water allocation strategies that maximize the economic and social returns to limited water resources, and at the same time enhance the water productivity of all sectors. Importing of virtual water (via food or industrial products) can be a valuable solution to water scarcity, especially for arid countries that depend on irrigation to grow low-value food with high water needs.

WATER FOR AGRICULTURE

Almost 70% of all available freshwater is used for agriculture (Table 1). Over pumping of groundwater by the world's farmers exceeds natural replenishment by at least 160 billion cubic meters a year. It takes an enormous amount of water to produce crops: three cubic meters to yield just one kilo of rice, and 1,000 tons of water to produce just one ton of grain. Land in agricultural use has increased by 12% since the 1960s to about 1.5 billion hectares. Current global water withdrawals for irrigation are estimated at about 2,000 to 2,555 km^3 per year.

Table 1. Comparison of water usage in different sectors

Usage in (%)	World	Europe	Africa	India
Agriculture	69	33	88	82
Industry	23	54	5	12
Domestic use	8	13	7	6

Agriculture is responsible for most of the depletion of groundwater, along with up to 70% of the pollution. For the last half-century, agriculture’s principal challenge has been raising land productivity- getting more crops out of each hectare of land. As we have stepped into the twenty first century, the new frontier is boosting water productivity **getting more from every liter of water devoted to crop production.** There is long and growing list of measures that can increase agricultural water productivity.

MICRO IRRIGATION

Micro irrigation ranks near the top of measures with substantial untapped potential. In contrast to a flooded field, which allows a large share of water to evaporate without benefiting a crop, drip irrigation results in negligible evaporation losses. When combined with soil moisture monitoring or other ways of assessing crop's water needs accurately, drip irrigation can achieve efficiencies as high as 95 percent, compared with 50-70 percent for more conventional flood or furrow irrigation. In Micro irrigation water is carried through small tubing and delivered to the plant near its stem to meet its water requirement. .

A National Task Force Committee, appointed by the Govt of Inida in 2003, has recommended that 69 million ha area is suitable for micro irrigation in India. A target of 14 M ha has been suggested for the 11th five-year plan. In view of the various advantages the technology offers, today the Govt of India and number of state governments are keenly focused in promoting micro irrigation in large scale.

AP Micro irrigation Project

Realizing the importance for economic use of precious ground water for irrigation, Government of Andhra Pradesh has launched the Andhra Pradesh Micro irrigation Project (APMIP), first of its kind in the world on 3rd November 2003. The project was aimed at bringing 2.50 lakh ha area under micro irrigation systems in 22 districts of AP, with financial outlay of Rs. 11763 million.

Initiatives of the Government

Govt of AP has taken up number of measures for promoting micro irrigation, like i) 70% subsidy of the system cost, ii) Creation of separate project cells in the districts iii) Positioning of qualified technical persons, iv) organizing exposure visits and capacity building training programs, v) guarantee of the MI equipment against manufacturing defects, vi) Quality check of equipment through CIPET, vii) Monitoring and Evaluation through third party agencies and viii) Providing agronomic and extension services. These measures have helped in confidence building and lead to greater demand for microiriirgation in the state.

Progress of APMIP

The project has created national record during last four successive years by bringing highest area under micro irrigation in the country as shown in the table 2.

Table 2. Coverage of MI systems since inception of APMIP

Year	Area covered under micro irrigation, ha		
	Sprinkler	Drip	Total
2003-04	20,770	3,780	24,550
2004-05	40,020	24,905	64,925
2005-06	25,000	51,811	76,811
2006-07	23,750	66,258	90,008
2007-08	30,000	90,000	1,20,000
2008-09	37,000	94,000	1,31,000
2009-10	37,500	1,09,341	1,46,841
2010-11	38,340	91,345	1,29,685
Total	2,52,380	5,31,440	7,83,820

MICRO IRRIGATION PAYS

Implementation of APMIP has created great awareness among the farmers in the state about micro irrigation. Large number of farmers have realized the benefits of micro irrigation in terms of improvement in yields, water saving and reduction of labor requirement. In order to assess the impact of the project more than 500 case studies of various crops have been collected from the districts across the state.

Effect of MI in sugarcane

A sample analysis carried out on 12 cases of sugarcane has revealed that additional income of about Rs 47,000 per ha was obtained due to higher cane yield. By considering average cost of MI system as Rs 65,000 per ha the bay back period comes to 1.4. APMIP has covered 15,545 ha of sugarcane crop under drip systems till March 2009. Based on the inputs received from the field studies, the projected benefits are worked out and presented in Table 4. With certain assumptions the energy requirement for pumping is estimated that 2,525 kwh and 1,160 kwh of electricity is required for irrigating one ha area under surface and drip methods respectively. This indicates that for every hectare of sugarcane crop with drip system there would be a saving of 1.2 ha m of precious ground water and 1,365 kwh energy in comparison to surface method of irrigation.

Table 3. Additional monetary benefits due to drip irrigation for sugarcane in 15,545 ha

Item	Surface method	Drip method	Saving /Increase	Unit value	Amount, Rs. million
Water	34,200 ha-m	15,545 ha-m	18,655 ha-m	Rs. 2000 /-per ha-m	37.31
Energy	39.25 million kwh	18.03 million kwh	21.22 million kwh	Rs. 2/-per kwh	42.44
Yield	1.2747 million ton	2.0364 million ton	0.7617 million ton	Rs. 1,000 /-per ton	761.70
Total					841.45

The projected benefits due to micro irrigation in sugarcane crop in15,545 ha indicates that there would be a saving of 18,655 ha m of precious ground water, and 21.22

million units of electricity every year apart from 0.762 million tons of additional cane. These additional benefits converted into monetary terms are equivalent to Rs. 841.45 million.
Additional income generated through drip for sugarcane divided by the annual cost gives the net benefit derived per every rupee investment in sugarcane. It shows, that every rupee spent on drip system for sugarcane results in additional benefit of Rs. 4.05

Overall impact of APMIP

The overall impact of APMIP has been summarized to present impact of implementation as detailed below.

I. Total Area Covered : 0.783 M ha
- a) Drip : 0.531 M ha
- b) Sprinkler : 0.252 M ha

II. MI system cost
- a) Total : Rs 24,000 Million
- b) Farmers contribution : Rs 8,400 Million

III. Annual cost (CRF 0.2055) based on
- a) Total cost : Rs 4,930 Million
- b) Farmers contribution : Rs 1,725 Million

IV. Additional yield
- @Rs 15,000/ha minimum : Rs 11,745 million

V. Payback period based (II/IV)
- a) Total cost : 2.0 years
- b) Farmers contribution : 0.7 years

VI. Every rupee on MI yields (IV/III)
- a) Total annual cost : Rs 2.4
- b) Farmers annual cost : Rs 6.9

In addition to the direct benefit of yield increase, the project also helped in a) water saving of 120.12 TMC (1 TMC = 2700 ha m), b) Energy saving of 324 million kwh, c) large labour saving and d) employment generation.

Design of Trickle Layout

A suitable micro irrigation layout is designed to suit SPV pumping system based on the preliminary studies conducted.
Design of microirrigation layout for wide spaced crop with the following assumptions

1. Name of the crop : Banana
2. Spacing
   - a) Row to row spacing (r) : 2.0 m
   - b) Plant to plant spacing(p) : 2.0 m
3. Peak irrigation requirement : 16 l/day/plant
4. SPV pump discharge (Q) (dependable flow): 3,600 l/h
5. SPV pump working period : 8 h/day
6. Emitter discharge rate : 4 lph
7. Type of emitter : Online emitter

Based on the above assumptions the proposed design made is as follows

1. SPV pump discharge per day: 3,600 x 8 =28,800 l
2. Number of plants that can be irrigated per day, N

$$N = \frac{volume\ of\ \ water\ pumped\ per\ day}{water\ requirement\ per\ plant\ per\ day}$$

$$\therefore N = \frac{28{,}800}{16} = 1{,}800$$

3. Area covered by each plant, a

$$a = r \times p = 2 \times 2 = 4\ m^2$$

4. Total area that can be irrigated per day, A

$$A = a \times N = 4 \times 1{,}800 = 7200\ m^2$$

5. Number of plants in a subunit, n_p

$$n_p = \frac{N}{number\ of\ subunits} = \frac{1{,}800}{4} = 450$$

6. Number of laterals in a subunit, n_l

$$n_l = \frac{width\ of\ subunit}{spacing\ of\ lateral} = \frac{40\,m}{2\,m} = 20$$

7. Discharge of each lateral, q_l

$$q_l = \frac{Q}{n_l} = \frac{3{,}600}{20} = 180\ \text{l/h}$$

8. Size of the lateral pipe

The size of the lateral pipe should be such that the head variation in the pipe should be within 20 percent, the inlet operating pressure is about 1 kg /cm^2. In the present study the average operating pressure was assumed to be about 0.6 kg/cm^2. Keeping these as the basis the hydraulic calculator of T System International was used for designing the diameter of the lateral pipe.

i) Flow	: 180 lph
ii) Length	: 40 m
iii) Inlet pressure	: 0.6 kg/cm^2
iii) Pressure drop	0.12 kg/cm^2

The design diameter of the lateral pipe: 12.045 mm, say 12.00 mm

9. Design of the submain and main pipe

Total discharge in to the submain, and length of the submain, inlet pressure head, and allowable pressure drop were considered in designing the size of the submain

a. Flow	: 3600 lph
b. Length of submain	: 40 m

Same amount of inlet pressure and allowable pressure drops are considered for submain also.

The design diameter of the submain pipe: 36. 32 mm, say 40.00 mm

Same size of the main pipe is required as to supply water to the submain, since only one subunit is irrigated at one time.

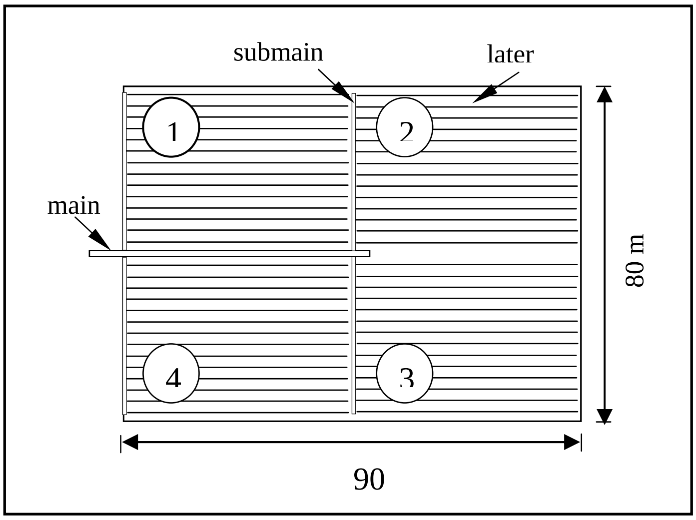

Figure 1. Trickle irrigation layout for Banana crop

Based on the above calculations and layout of the field shown in Fig.1. The estimates of the pipelines for each subunit are made as follows.

Table 3. Estimates of the equipment required for the banana crop layout

S.No	Item	Diameter, mm	Length, m	Number in a subunit	Number of subunits	Total
1	Lateral	12	45	20	4	3600 m
2	Submain	40	40	1	4	160 m
3	Main	40	47			47 m
4	Flow control valves			1	4	4

Application potential

Development of Solar Powered Trickle Irrigation System will lead to optimum utilization of limited fresh water available in the shallow layers by using non-conventional energy source. The outcome of the research has got very good application potential based on the fact that there is an immediate need for development of an efficient irrigation system suitable for sandy tracts of coastal AP.

Future needs

Based on the experiences in APMIP, the following are the areas to be considered seriously to attain sustainability in micro irrigation.

a) Creation of Micro irrigation Department at sate level
b) Bankers participation to fund the farmers share of cost of MI systems
c) Qualified and trained manpower is required for both the industry and the projects.
d) Standardization of imported MI equipment is needed

e) Promotion and adoption of fertigation to reap true benefits of micro irrigation.
f) Introduction of automation in micro irrigation
g) Processing, value addition and marketing of fruits and vegetables to get better price
h) Promotion of micro irrigation in canal commands

SUMMARY AND CONCLUSIONS

The world and more importantly the developing countries are heading towards water stress and scarcity. They are left with no alternative but to adopt modern irrigation technologies, which save water, double the area under irrigation, improve yields and quality as well as save on labour, energy and crop production costs. In India more than 82% of the total water is used for agriculture with very low irrigation efficiencies. It is expected that in the next 7-8 years, there will be cut of about 10% irrigation water for meeting ever-increasing demand from domestic, industrial and other sectors. Hence, there is necessity to undertake large-scale micro irrigation projects like Andhra Pradesh Micro Irrigation Project (APMIP) to bring more areas under drip irrigation systems improving water use efficiencies to as high as 95%. The following conclusions can be drawn

1. The beneficiaries have realized the benefits of micro irrigation in terms of water saving, higher yields and reduction in labor requirement.
2. Many state governments are showing interest to implement such projects in their states. Gujarat government is one, which has got benefited from the experience of APMIP and has already implementing a project on micro irrigation on similar lines of APMIP.
3. Large-scale implementation of such projects will lead to saving of precious water resources, saving energy and improving the productivity.
4. The average pay back period comes to 2.0 years with overall system cost as the basis and by considering only the farmers contribution it comes to 0.7 years.
5. Every rupee invested in micro irrigation on annual basis yields additional income of Rs 2.4 due to additional crop yield.

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