RIP IRRIGATION IN INDIA

इनसिड
INCID

भारतीय राष्ट्रीय सिंचाई एवं जल निकास समिति

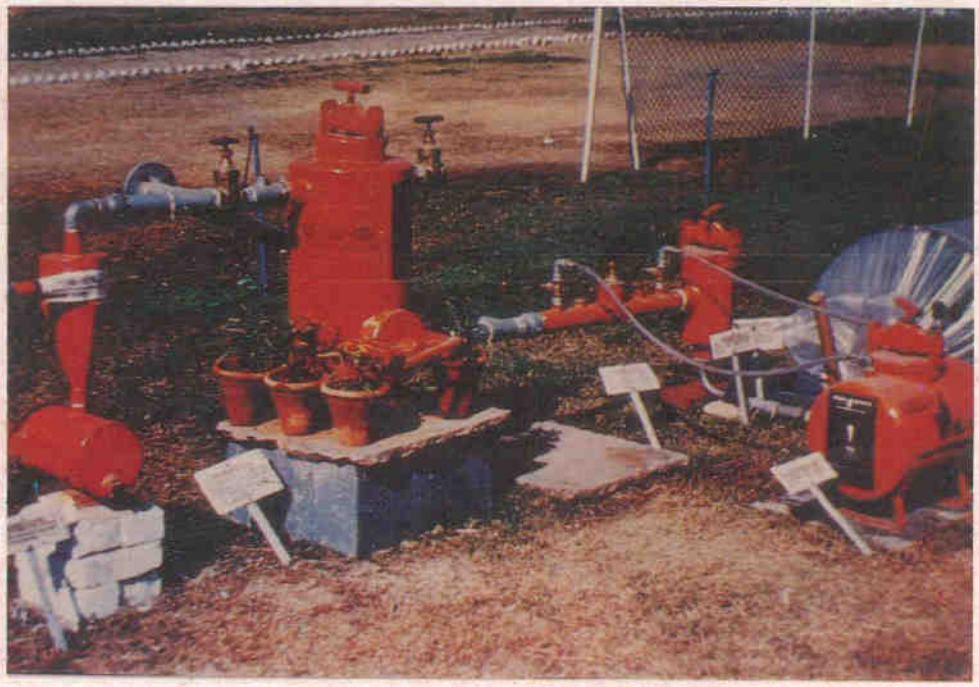
(जल संसाधन मंत्रालय भारत सरकार द्वारा गठित)

INDIAN NATIONAL COMMITTEE ON IRRIGATION AND DRAINAGE

(Constituted by Ministry of Water Resources, Govt. of India)

NEW DELHI
JULY, 1994

DRIP CONTROL ASSEMBLY WITH FERTILIZER TANK,
SAND & SCREEN FILTER (Courtesy : WTC, IARI, New Delhi)



ANOTHER DRIP CONTROL ASSEMBLY WITH FERTILIZER UNIT,
SAND & SCREEN FILTER (Courtesy : WTC, IARI, New Delhi)

Front Cover : DRIP IRRIGATION FOR PAPAYA
(Courtesy : Jain Irrigation)

DRIP IRRIGATION IN INDIA

इनसिड
INCID

भारतीय राष्ट्रीय सिंचाई एवं जल निकास समिति

(जल संसाधन मंत्रालय भारत सरकार द्वारा गठित)

INDIAN NATIONAL COMMITTEE ON IRRIGATION AND DRAINAGE

(Constituted by Ministry of Water Resources, Govt. of India)

NEW DELHI
JULY, 1994

Published by :
A.S. RAO
Member - Secretary, INCID &
Chief Consulting Engineer,
WAPCOS (INDIA) LIMITED,
301 & 303, Ansal Chambers - II,
6, Bhikaiji Cama Place,
New Delhi - 110 066.

Compiled by :
DR. R.K. SIVANAPPAN,
Former Dean,
Tamil Nadu Agri. University,
14, Bharathi Park, 4th Cross Road,
COIMBATORE - 641 043, TAMIL NADU.

Modified, Updated and Edited by:
A.S. RAO,
Member - Secretary, INCID &
Chief Consulting Engineer,
WAPCOS (INDIA) LIMITED
&
N.K. DIKSHIT
Consultant, INCID &
WAPCOS (INDIA) LIMITED

Cover Design Conceived by:
INCID SECRETARIAT.

July, 1994

Printed at **Jolly Reprographics**, New Delhi - 110 008
Phone No.: 5740443, 5744989

Inner Page : DRIP IRRIGATION FOR BANANA
(Courtesy : WTC, IARI, New Delhi)

सत्यमेव जयते

AGRICULTURE MINISTER,
GOVERNMENT OF INDIA,
NEW DELHI - 110 001.

June 29, 1994.

FOREWORD

I am glad to learn that the Indian National Committee on Irrigation and Drainage (INCID) of Ministry of Water Resources, Government of India is bringing out a comprehensive publication on "Drip Irrigation in India" for wide circulation in the country and to all the National Committees of ICID globally.

2. Drip Irrigation is a technological innovation for stepping up production with limited water supply. It increases yield by 25-35% and saves water to the extent of 30-40%. It can be adopted for a wide range of crops particularly for horticultural crops, flowers, vegetables etc. It may also be useful in the oilseeds, plantation crops, spices and sugarcane. Realising the importance of Drip Irrigation, Ministry of Agriculture is administering a scheme to promote its use with a provision of Rs. 2,000 million as subsidy to be spent on drip installation and demonstrations. This is likely to bring an additional area of 1.25 lakh hectares under this technology during the VIII Plan.

3. The INCID publication besides tracing the historical development of drip irrigation, also deals with Drip Irrigation Research, Experiences, Cost Benefit Analysis, its Potential and Prospects. Policy related issues have also been highlighted. It is hoped that this document would provide the much needed impetus for rapid expansion of drip irrigation in our Country by serving as a handbook for planners, designers, drip manufacturers, implementation authorities, research organisations and above all the farmers who are the end users. I appreciate the Ministry of Water Resources and the Indian National Committee on Irrigation and Drainage for bringing out such a valuable publication of national importance.

(BAL RAM JAKHAR)

KERALA AGRICULTURAL UNIVERSITY

Dr. A.M. MICHAEL
VICE-CHANCELLOR

PREFACE

The utilisable water resources in India are not enough to irrigate the entire cultivable area and hence concerted efforts are needed to maximise existing water use which is of paramount importance. Drip Irrigation is an advanced method of irrigation to achieve considerable saving of water through high water-use efficiency compared to surface irrigation methods where irrigation efficiency is low due to losses in the water distribution system and on the field. Research in drip irrigation conducted so far in India and abroad has shown that this method leads not only to appreciable saving of water but also results in achieving higher crop yields as compared to surface irrigation methods. Drip System is well suited for water scarcity areas and undulating topography where surface irrigation proves costly for land shaping and levelling.

Drip Irrigation was introduced in India in early seventies in the Agricultural Universities and Research Institutions. The growth has gained momentum in the last few years. From a mere 1500 ha in 1985, the area under drip irrigation has gone up to over 70,000 ha as at present. Amongst the States, the area coverage is highest at 32,924 ha in Maharashtra, followed by Andhra Pradesh with 11,585 ha and Karnataka with 11,412 ha. This has been possible due to encouragement given by Central and State Governments through a subsidy scheme started in the year 1982-83 which continued upto the end of Seventh Plan (1989-90) and also during the two Annual Plans 1990-91 and 1991-92. Under this scheme, 50% subsidy was provided by the Centre and balance by the State Governments. In the Eighth Five Year Plan, however, Ministry of Agriculture, Government of India has launched a promotion scheme with an outlay of Rs 250 crores for bringing an additional area of 1.25 lakh ha under drip irrigation. I am sure that the scheme will provide great impetus for rapid development of drip irrigation in the coming years.

It is timely that the Indian National Committee on Irrigation and Drainage (INCID) is bringing out a Status Report on the subject and I highly commend the efforts of INCID and its Special Committee on Micro and Mechanized Irrigation in this regard. It is hoped that all those engaged in the development of drip irrigation will find this document as a very useful hand-book.

A.M. Michael

THRISSUR,

Ist June, 1994.

(Dr. A.M. MICHAEL)
VICE-CHANCELLOR
Kerala Agricultural University

PREAMBLE

Drip Irrigation is one of the advanced methods of Irrigation, by which water can be supplied directly into the root zone of the soil. This technology is being practised by over 60 countries, both developed and developing throughout the world. The ICID Working Group on Micro Irrigation through their world-wide survey conducted for the leading Countries and the World in 1991 arrived at a figure of 1784,846 ha as the area under micro irrigation in which India occupied 7th position with 70,859 ha.

Drip Irrigation is fast picking up in India. From a mere one thousand and odd hectares in 1985, the area under drip irrigation is now over seventy thousand hectares with additional areas being added year after year. Although this growth is phenomenal, the coverage works out less than 0.1 percent of the total irrigated area of 82 M ha. All out efforts will have to be made even to achieve a coverage of one percent of the gross irrigated area by the turn of the century, which may be of the order of one million hectares by then.

Following the subsidy scheme operated by the Union Ministry of Water Resources (Minor Irrigation Division), during the 6th and 7th Plan periods, the Ministry of Agriculture, Government of India has launched a fresh subsidy Scheme of Rs 2.5 billion during the Eighth Plan period of 1992-97 for drip installation, drip demonstration, mulching, green houses, training etc. This is indeed a massive effort aimed at propagating the drip irrigation with a view to encourage second green revolution.

The Indian National Committee on Irrigation and Drainage (INCID) with the assistance of its Working Group on Micro Irrigation, later constituted as Special Committee on Micro and Mechanized Irrigation has brought out an excellent Report on Drip Irrigation in India. Dr. S.D. Khepar, Chairman, Shri A. Shekhar, Convenor and other members of the Working Group prepared a first draft of the Report. This first draft was referred to Dr. R.K. Sivanappan, former Dean of Tamil Nadu Agricultural University, Coimbatore and an expert in drip Irrigation who provided a comprehensive draft covering among others research findings of various research institutes, development experiences, benefit cost and economics, potentials, policy issues etc. This draft was discussed in a mini workshop in August, 1992 attended by the Chairman, INCID & CWC, INCID Members, Working Group Members, Some Manufacturers, Officers of the National Committee for Use of Plastics in Agriculture (NCPA) and other State and Central Officers etc. and amended on the basis of the suggestions and recommendations of the workshop. The amended draft was later extensively modified, updated and edited in INCID Secretariat. Apart from restructuring the Chapters, additional information on several items such as 'Design of Drip Irrigation Systems', 'Research through Centrally sponsored Research Programme under Ministry of Water Resources, Government of India', 'Agro-Climatic Zones demarcated in the Country and feasibility of Drip Irrigation in various zones, 'Subsidy Scheme operated by MoWR during 6th and 7th Plan Periods and the fresh subsidy Scheme of the Ministry of Agriculture, Government of India during the 8th Plan period' etc. have been incorporated while updating the amended draft. Although the advantages of drip irrigation are manifold, the farmers are having some doubts in their inquisitive minds, whether such huge investment is justified, what will be the pay-back period, how much water could be saved, whether any improvement

in water use efficiency could be achieved and whether at all there will be any increase in yield etc. etc. Attempts were made to answer these questions adequately in this report.

The area under drip irrigation in the country reported as 24,000 ha in the amended draft appeared to be an under-reported figure. With a view to arrive at the correct coverage of drip irrigation in the country, INCID Secretariat approached all the drip system manufacturers for details of installations made by them in different states and for different crops. On the basis of the responses received by them, the area under drip irrigation was arrived at 70,859 ha which may be firmed up by the State Governments by collecting information from public and private agencies.

Dr. S.D. Khepar, Shri A. Shekhar, Dr. Ashwani Kumar and other members of the Working Group have made significant contributions in preparing the first draft of the Report and later participated effectively in the Workshop. Dr. R.K. Sivanappan's contribution in preparing the comprehensive draft and later providing the amended draft is indeed commendable and praiseworthy. The manufacturers who have furnished the much needed information deserve to be complimented. Shri A.S. Rao, Member-Secretary, INCID and Chief Consulting Engineer, WAPCOS and his colleagues in INCID Secretariat including Shri N.K. Dikshit, Consultant have done a commendable job in modifying, updating and editing the text and in bringing out this document. Shri Vimal Kumar Gaur, Computer Operator who diligently typed the entire report single handed and Shri S. Srinivasa Rao, Consultant who besides assisting in the report preparation, patiently did the proof reading for faultless final typescript, deserve to be complimented. Special thanks are due to Shri R. Rajappa, Chairman and Managing Director, WAPCOS (India) Ltd. for his keen interest and intellectual support besides providing all the infrastructure facilities to the INCID Secretariat in publishing this document.

It is hoped that this document would serve as a useful handbook to Administrators, planners, designers, drip manufacturers, implementation authorities, research institutes and lastly the farming community and facilitate promotion of drip irrigation in the country.

Place : New Delhi

Date : 22.06.1994

(A.B. JOSHI)
Chairman, INCID &
Central Water Commission

THOTA SHANKER REDDY
Grape Cultivator

H.No.2-9-71, Buttanguda
Macha Bollarum, Rangareddy Distt.
SECUNDERABAD - 500 010. A. P.

MY IMPRESSIONS ON DRIP IRRIGATION.

I have started grape cultivation in an area of 1.2 ha in Ranga Reddy District of Andhra Pradesh in the year 1990, initially with flow irrigation but switched over to drip irrigation after six months, due to shortage of water. The lay-out and design for drip Irrigation was provided by M/s ELGI Equipments Ltd; Coimbatore-641018, Tamil Nadu who have also installed the system at a cost of Rs 14,000/-.

Subsequently, in the year 1992, I had extended grape cultivation to an area of 3.24 ha incurring an expenditure of Rs 49,400/- per ha for which a generous subsidy of Rs 15,450/- per ha was given by the Government of Andhra Pradesh. This subsidy amount was fixed by the State Government prior to the year 1990 when the system cost prevailed at that time was around Rs 30,900/- per ha.

I would like to share my fruitful experiences about drip irrigation which are given below:

i. There was an appreciable saving of water, nearly 45-50% compared to flood irrigation due to which additional area could be brought under cultivation.

ii. There was considerable saving in labour upto an extent of 40-50% in relation to water application.

iii. The reduced labour force could also attend to the general upkeep of the crop and other vital operations such as weeding, spraying, topping, pruning, nozzle cleaning etc. throughout the year.

iv. Substantial reduction in weed growth was noticed due to the change over to drip irrigation which in turn has resulted in significant saving (40-50%) in the labour engaged for weeding operations.

v. There was also a saving (25 to 30%) in the cost of organic manures and chemical fertilizers due to drip irrigation as there was absolutely no wastage in their application.

vi. Instead of running the LD pipes in the field all along, the same were tied to the wires ensuring trickling of water drops at the root zone. This was felt necessary because the LD pipes would otherwise interfere with the intercultivation operations and also could be damaged by rodents, dogs etc. The life span of LD pipes and drippers would be enhanced by adopting this method.

vii. Another significant advantage in the adoption of drip irrigation is that the excessive vegetative growth was reduced and the maturity of grape bunches was uniform.

viii. Although record yields could not be obtained, but certainly there was an improvement in the quality of fruits harvested at considerably reduced costs of inputs per acre.

In general, the water and fertilizer use efficiencies were observed to be higher in drip irrigation as compared to flood irrigation.

However, few problems noticed are as under:

1. Salt accumulation near and around the drip resulted in clogging despite treatment with diluted Hydrochloric acid mixed with bleaching powder once in a year.

2. High initial cost of the drip equipment, which unfortunately, is not within the easy reach of small and marginal farmers.

To sum up, I would like to state that on the whole, the drip irrigation is definitely advantageous to the fruit crops in general and grapevines in particular. I am of the firm view that Drip Irrigation needs to be popularized further amongst small and marginal farmers by providing necessary incentives. The subsidy amount should be maintained atleast at 50% of the total cost incurred for the installation of the Drip Irrigation System.

Secunderabad - 500010

31st May, 1994.

(THOTA SHANKER REDDY)

INCID WORKING GROUP ON MICRO IRRIGATION.
(From January, 1991 to August, 1993)

1. **DR. S.D. KHEPAR,** **Chairman**
Dean,
College of Agricultural Engg.,
Punjab Agricultural University,
LUDHIANA - 141 004. PUNJAB.

2. **DR. R.K. SIVANAPPAN,** **Co-Chairman**
Former Dean,
Tamil Nadu Agril.University,&
Present Chairman,
Centre of Agricultural Rural
Dev. & Environmental Studies,
14, Bharathi Park, 4th Cross Road,
COIMBATORE-641 043 Tamil Nadu.

3. **THE CHIEF ENGINEER** **Member**
Minor Irrigation,
Ministry of Water Resources,
Krishi Bhawan, **NEW DELHI-110001**

4. **SHRI V.D. KETKAR,** **Member**
Superintending Engineer & Director,
Irrigation Research & Development,
8, Moledina Road, PUNE - 411001
MAHARASHTRA

5. **DR. S. K. TRIPATHI,** **Member**
Reader, WRDTC
University of Roorkee,
ROORKEE - 247 667. UTTAR PRADESH

6. **SHRI B. R. MADHOK,** **Member**
Superintending Engineer &
T.A.(Works) to Chief Engineer
Irrigation, **JAIPUR - 302 005.**
RAJASTHAN.

7. **SHRI M. JAYA KUMAR,** **Member**
Head,
Education & Extension Divn.,
CWRDM, Kunnamangalam, Kozhikode
CALICUT- 673 571. KERALA.

8. **SHRI K. K. SAXENA,** **Member**
Additional Chief Engineer,
WAPCOS (INDIA) Ltd.,
B-3, Community Centre,
B-1 Block, Janakpuri,
NEW DELHI - 110 058.

9. **DR. ASHWANI KUMAR,** **Member**
Sr.Scientist, WTC,
IARI, Pusa Campus,
NEW DELHI - 110 012.

10. **SHRI D. G. HOLSAMBRE,** **Member**
Professor,
Water & Land Management Instt.,
WALMI Campus, Kanchanwadi,
P.O.Box No.304, **AURANGABAD-431005.**
MAHARASHTRA

11. **DR. T.N. CHAUDHARY** **Member**
Asstt. Director General (IWM),
Indian Council for Agril.Research,
Room No.220, Krishi Bhawan,
NEW DELHI - 110 001

12. **DR. G. S. RAJPUT,** **Member**
Professor (Agricultural Engg.)
WALMI, Right Bank of Kaliasote Dam,
New WALMI Campus, **BHOPAL - 462 010**
MADHYA PRADESH

13. **DR. N.K. TYAGI** **Member**
Principal Scientist,
Central Soil Salinity
Research Institute,
KARNAL - 132 001. HARYANA

14. **DR. MANJIT SINGH** **Member**
College of Agricultural Engg.
Punjab Agricultural University,
LUDHIANA - 141 004. PUNJAB

15. **SHRI D.T. SHETE,** **Member**
Reader,
Water Resources Engineering &
Management Institute,
Samiala Centre, Samiala - 391410,
Distt.BARODA, GUJARAT.

16. **SHRI R.N. GOSWAMI,** **Member**
Addl Chief Engineer,(Zone 4),
Irrigation Department,
DIPHU, KARBIANGLONG-782460 ASSAM

17. **DR. P. KANDASWAMY** **Member**
Prof. & Head, (Deptt. of SS&AC)
Tamil Nadu Agricultural University,
COIMBATORE-641003. TAMIL NADU.

18. **PROF. P.S. PAMPATTIWAR, Member**
Head,
Deptt of Irrigation & Drg.Engg.,
College of Agril. Engineering,
M.P.Krishi Vishwa Vidyalaya,
RAHURI-413722 DISTT.AHMEDNAGAR
MAHARASHTRA

19. **DR. R. S. MALIK, Member**
Asstt. Soil Scientist,
Deptt. of Horticulture,
College of Agriculture,
Haryana Agricultural University,
HISSAR - 125 004 HARYANA

20. **DR. R.R. NAIR, Member**
Associate Director,
Regional Agril. Research Station,
KUMARAKON-686563, KOTTAYAM DISTT.,
KERALA.

21. **PROF. V.B. DALVI Member**
Associate Professor,
Deptt. of Soil & Water Mangt.
Punjabrao Krishi Vidyapeeth,
AKOLA-444104 MAHARASHTRA

22. **SHRI N.K. SONETHA, Member**
Superintending Engineer (C&PS),
Central Design Organisation,
2nd Floor, Block No.9,
Dr.Jivraj Mehta Bhawan,
GANDHINAGAR-382010.GUJARAT.

23. **SHRI A. SHEKHAR, Convenor**
Director (PA),
Central Water Commission,
Room No.418, Sewa Bhawan,
R.K. Puram, NEW DELHI-110066

INCID SPECIAL COMMITTEE ON MECHANIZED AND MICRO IRRIGATION.
(From August, 1993 onwards)

1. **DR. S.D. KHEPAR,** **Chairman**
   Dean,
   College of Agricultural Engg.,
   Punjab Agricultural University,
   LUDHIANA - 141 004. PUNJAB.

2. **SHRI A.H. NAVKAL** **Co-Chairman**
   Chief Engineer & Jt.Secretary,
   Irrigation Department,
   Mantralaya, BOMBAY-400034
   MAHARASHTRA

3. **DR. G. S. RAJPUT,** **Member**
   Director,
   WALMI, Right Bank of
   Kallasote Dam, New WALMI Campus,
   BHOPAL-462010 MADHYA PRADESH

4. **DR.ASHWANI KUMAR,** **Member**
   Sr.Scientist, WTC,
   IARI, PUSA CAMPUS,
   NEW DELHI - 110 012.

5. **SHRI D.G. HOLSAMBRE,** **Member**
   Professor,
   Water & Land Man.Institute,
   WALMI Campus, Kanchanwadi,
   P.Box No.304,AURANGABAD-431005
   MAHARASHTRA

6. **SHRI O.T. GULATI,** **Member**
   Professor,
   Water & Land Management Instt.,
   Vadod Road, ANAND,
   Distt. KHEDA-388001. GUJARAT

7. **DR. R.K. SIVANAPPAN** **Member**
   Former Dean,
   Tamil Nadu Agril.University &
   Present Chairman,
   Centre of Agricultural Rural
   Development & Environ.Studies,
   14, Bharathi Park, 4th Cross Rd.,
   COIMBATORE - 641 043 TAMIL NADU

8. **DR. N.K. TYAGI** **Member**
   Principal Scientist,
   Central Soil Salinity Res.Instt.
   KARNAL-132001. HARYANA

9. **SHRI D.T. SHETE,** **Member**
   Reader,
   Water Resources Engineering &
   Management Institute,
   Samiala Centre, SAMIALA-391410,
   Distt. BARODA, GUJARAT.

10. **PROF. P.S. PAMPATTIWAR,** **Member**
    Head,
    Deptt of Irrign.& Drg.Engg.
    College of Agril.Engineering,
    M.P. Krishi Vishwa Vidyalaya
    RAHURI-413722, Distt.AHMEDNAGAR
    MAHARASHTRA

11. **PROF. V.B. DALVI,** **Member**
    Associate Professor,
    Deptt. of Soil & Water Mangt.
    Punjabrao Krishi Vidyapeeth,
    AKOLA - 444104 MAHARASHTRA

12. **SHRI N.K. SONETHA,** **Member**
    Superintending Engineer (C&PS),
    Central Design Organisation,
    2nd Floor, Block No.9,
    Dr.Jivraj Mehta Bhawan,
    GANDHINAGAR-382010. GUJARAT.

13. **SHRI S.K. DUA** **Member**
    Director (Monitoring)
    Haryana Irrigation Deptt.,
    Dhillon Complex, Mani Majra,
    CHANDIGARH

14. **SHRI S.R. NARAYANAN,** **Member**
    Additional Chief Engineer,
    WAPCOS (India) Ltd.
    B-3 & B-4, Community Centre,
    B-1 Block, Janakpuri,
    NEW DELHI - 110 058.

15. **SHRI A. SHEKHAR,** **Convenor**
    Director (PA),
    Central Water Commission,
    Room No.418, Sewa Bhawan,
    R.K. Puram, NEW DELHI-110066

PARTICIPANTS IN THE MINI WORKSHOP ON DRIP IRRIGATION HELD AT NEW DELHI ON 07.08.1992.

1. **Shri M.S. Reddy,**
   Chairman, INCID & CWC &
   Member (WP),
   Central Water Commission,
   Sewa Bhawan, R.K. Puram,
   New Delhi-110066

2. **Dr. S. D. Khepar**
   Dean,
   College of Agricultural Engg.,
   Punjab Agricultural University,
   Ludhiana-141004 PUNJAB

3. **Dr. T.K. Sarkar**
   Project Director,
   WTC, IARI, Pusa Campus,
   New Delhi-110012

4. **Dr. M.S. Ahluwalia**
   Research Engineer,
   College of Agricultural Engg.,
   Punjab Agricultural University,
   Ludhiana-141004. Punjab

5. **Shri P.A. Viswanathan**
   Superintending Engineer
   Agricultural Engineering Deptt.,
   Madras, Tamil Nadu

6. **Shri J.C. Deka**
   Additional Chief Engineer (M&E),
   Irrigation Department,
   GUWAHATI-781003 Assam

7. **Dr. G.S. Rajput**
   Professor,
   Water & Land Management Institute,
   BHOPAL-462010 Madhya Pradesh

8. **Shri V.B. Dalvi,**
   Reader,
   College of Agril.Engg.& Technology,
   Punjab Rao Krishi Vishwa Vidyapeeth,
   Krishinagar, Akola-444104 Maharashtra

9. **Shri R.G. Sulibhavi,**
   Consultant,
   World Bank & ADB
   55, Lodi Estate, P.O.Box 416,
   New Delhi-110003

10. **Shri A. Shekhar**
    Director (PA-North)
    Central Water Commission,
    Sewa Bhawan, R.K. Puram,
    New Delhi-110066

11. **Shri D.T. Shete**
    Reader,
    Water Resources Engineering &
    Management Institute (WREMI),
    M.S. University of Baroda,
    Samiala Centre, SAMIALA-391410
    Distt.BARODA Gujarat

12. **Shri G.K. Jha**
    National Committee for the
    use of Plastics in Agriculture
    Himalaya House, New Delhi-110001

13. **Shri N. Modi**
    National Committee for the
    use of Plastics in Agriculture,
    Himalaya House, New Delhi-110001.

14. **Dr Ashwani Kumar,**
    Sr. Scientist,
    Water Technology Centre,
    IARI, Pusa Campus,

15. **Dr. R.K. Sivanappan**
    Consultant,
    14 Bharati Park, 4th Cross Road
    Coimbatore-641043 Tamil Nadu

16. **Shri H.S. Chadda**
    Jain Irrigation System Ltd.
    Jain Industrial Complex,
    Jain Pipenagar, P.O.Box 20,
    Jalgaon-425001 Maharashtra.

17. **Shri B. Hoon**
    Jain Irrigation System Ltd.
    (Address same as Sl. No. 16)

18. **Shri R. Gupta**
    Jain Irrigation System Ltd.
    (Address same as Sl. No. 16)

19. **Shri J.S. Patil**
    Jain Irrigation System Ltd.
    (Address same as Sl. No. 16)

20. Shri A.D. Mohile
Chief Engineer (IP),
Central Water Commission,
New Delhi-110066

21. Shri H.P.S. Iyer
Director (Monitoring - West)
Central Water Commission,
R.K. Puram, New Delhi-110066

22. Shri B. Pyda Raju
Chief Engineer,
Central Water Commission,
R.K. Puram, New Delhi-110066.

23. Shri D. Chakrapani
Deputy Secretary to CM,
Government of Andhra Pradesh
Hyderabad-500022
Andhra Pradesh.

24. Shri Sanjay Sinha
Proprietor
Raindrop Irrigation
D-66, Naraina Vihar
New Delhi-110028

25. Dr. Satish K. Dua
Director (Irrigation)
Government of Haryana
Irrigation Department,
95, Sector 14,
Faridabad-121007 Haryana

26. Dr. N.K. Tyagi
Principal Scientist,
Central Soil Salinity Research Instt.
Karnal-132001, Haryana

27. Shri S.K. Gupta
Head,
Division of Drainage & Water Mangt.
Central Soil Salinity Research Instt
Karnal - 132001 Haryana

28. Shri A.S. Rao,
Member-Secretary, INCID &
Chief Consulting Engineer,
Water and Power Consultancy
Services (India) Limited,
B-4, Community Centre, B-1 Block,
Janakpuri, New Delhi-110058

29. Shri N.K. Dikshit
Consultant, INCID &
Water and Power Consultancy
Services (India) Limited,
B-4, Community Centre, B-1 Block,
Janakpuri, New Delhi-110058

30. Shri S.R. Agrawal
Engineer, INCID &
Water and Power Consultancy
Services (India) Limited,
B-4, Community Centre, B-1 Block,
Janakpuri, New Delhi-110058

Officers and Staff of INCID Secretariat in WAPCOS (India) Limited who contributed to the Preparation of Status Report on Drip Irrigation in India.

PROJECT TEAM

1. **SHRI A.S. RAO**
   Member-Secretary, INCID &
   Chief Consulting Engineer
2. **SHRI N.K. DIKSHIT**
   Consultant
3. **SHRI A. NARAYANA RAO**
   Consultant
4. **SHRI S. SRINIVASA RAO**
   Consultant
5. **SHRI S.R. AGRAWAL**
   Engineer
6. **SHRI D.P. TALWAR**
   Draftsman
7. **SHRI VIMAL KUMAR GAUR**
   Computer Operator

SUPPORT TEAM

8. **SMT. ANJANA CHHABRA**
   Personal Secretary
9. **SHRI R.K. TULI**
   Technical Assistant
10. **SMT. BALWINDER KAUR**
    Junior Assistant
11. **SHRI JAICHAND**
    Messenger
12. **SHRI ASHOK KUMAR**
    Messenger

ABBREVIATIONS

B.C.Ratio	Benefit Cost Ratio.
BIS	Bureau of Indian Standards.
CAZRI	Central Arid Zone Research Institute.
CBI&P	Central Board of Irrigation & Power.
CGWB	Central Ground Water Board.
CTAE	College of Technology and Agricultural Engineering.
CWC	Central Water Commission.
DIS	Drip Irrigation System.
FRP	Fibre Reinforced Plastic.
GBPU&AT	Govind Ballabh Pant University of Agriculture & Technology.
GCIWRA	Geographical Committee of International Water Resources Association
GNP	Gross National Product.
GOI	Government of India.
HDPE	High Density Polyethylene.
IARI	Indian Agricultural Research Institute.
ICAR	Indian Council of Agricultural Research.
ICID	International Commission on Irrigation and Drainage.
INCID	Indian National Committee on Irrigation and Drainage.
IPCL	Indian Petro-Chemicals Limited.
ISO	International Standards Organisation.
JIL	Jain Group of Industries Limited.
Kg.ha.cm	Kilograms per hectare per centimeter.
LDPE	Low Density Polyethylene.
LLDPE	Linear Low Density Polyethylene.
LPH	Liters per hour.
MCU	Master Control Unit.
M cu m	Million Cubic Metres.
MFI	Melt Flow Index.
M ha	Million hectares.
M ha m	Million hectare metres.
mm	millimeters.
MOWR	Ministry of Water Resources.
MPKV	Mahatma Phule Krishi Vidyapeeth.
Mt ha	Metric tonnes per hectare.
NABARD	National Bank for Agriculture and Rural Development.
NCPA	National Committee on the Use of Plastics in Agriculture
NGOs	Non-Governmental Organisations.
NLBC	Narmada Left Bank Canal.
NRBC	Narmada Right Bank Canal.
O&M Costs	Operation and Maintenance Costs.
PAU	Punjab Agricultural University.
PDC	Plasticulture Development Centre.
SAUs	State Agricultural Universities.
SIS	Sprinkler Irrigation Systems.
SGWO	State Ground Water Organisation.

Th ha m	Thousand hectare metres.
TNAU	Tamil Nadu Agricultural University.
UNCED	United Nations Conference on Environment and Development.
USAID	United States Agency for International Development.
UV	Ultra Violet.
WALMI	Water Land Management Institute.
WAPCOS	Water and Power Consultancy Services (India) Limited.
WTC	Water Technology Centre.
WUE	Water Use Efficiency.

STATUS REPORT ON DRIP IRRIGATION IN INDIA

CONTENTS

STATUS REPORT ON DRIP IRRIGATION IN INDIA

EXECUTIVE SUMMARY

1.1 Nature has endowed us with abundant water resources. However, due to limitations of topography, geology, physiology, dependability, quality and the present state of technology, only a part of available water resources can be utilised. The utilisable water for irrigation is further limited considering other competing demands for domestic, industrial uses etc. It is a matter of concern that this is happening at a time when there is an increased demand for various agricultural commodities due to phenomenal growth in the population. The need of the hour is, therefore, to maximise the production per unit of water, besides effecting utmost economy in water use for agriculture.

1.2 Technological innovations are to be exploited to achieve the twin objectives of higher productivity and optimum use of water under irrigation. Drip irrigation has revolutionized agriculture in many countries of the world. India has embarked on a massive programme for further popularising this method. Though the economic and social advantages are substantial, the expected coverage of drip system could not be achieved so far due to institutional, socio-economic, financial and technical problems. The area under drip irrigation in India was around 71000 ha, of which an area of 33000 ha was located in Maharashtra State alone as on 1992.

1.3 Though irrigation is as old as the civilization, it is considered as a modern science - the Science of Survival. Many changes have taken place in all walks of life, but the age old practice of flood irrigation is still practised in many parts of the country. Although some steps have been taken to improve water management in surface irrigation, the water use efficiency is not to the desired extent which has resulted in waterlogging and salinity in some areas. In view of the urgent need to maximise use of the available resources, it is imperative to effect utmost economy in water use by adopting advanced methods of irrigation like drip, sprinkler and piped systems. By introducing these advanced methods, more and more cultivated areas in the Country can be brought under irrigation resulting in increased agriculture production. Incidentally, the utilisable water resources available in India are not enough to irrigate the entire cultivable area and hence concerted efforts have to be made to maximise existing water use which is of paramount importance.

2. Drip irrigation is an advanced method of irrigation accepted even in the developing countries. The farmers are convinced about the usefulness of the system, but the adoption is rather slow due to the high investment cost of the system with recurring O&M costs which include energy charges as well. Even

Drip irrigation reduces labour and energy costs.

though research and demonstration of the system have been in progress since 1970 onwards, large scale adoption of this system is accomplished only in the last few years. The Government of India has constituted a National Committee on the Use of Plastics in Agriculture (NCPA) which helped greatly in popularising the system through incentives by the Government by way of subsidies to the farmers. There are numerous successful drip irrigation farmers although a few instances of failures were also not uncommon, due to the inbuilt defects in design and other related factors, as also the poor quality of water in some cases.

3.1 Historical development of drip irrigation in the world dates back to experiments in Germany in 1860s, followed by studies of U.S.A. in 1913, of Germany in 1920, of Israel in 1940, of United Kingdom in 1948 and of Israel again in 1960 and later in 1969. The area under drip irrigation has increased from a mere 40 ha in 1960 to 1,784,846 ha in 1991, India occupying seventh position with 70,859 ha. The area coverage is highest in Maharashtra with 32,924 ha, followed by Andhra Pradesh with 11,585 ha and Karnataka with 11,412 ha.

3.2 Drip system essentially consists of a main, sub-main, laterals, drippers and few other accessories to deliver the required quantity of water at the root zone of the crop. Biwall system is used for closely spaced crops like sugarcane, vegetables, cotton etc. Micro sprinkler and Micro sprayers are also available to sprinkle the water around the root zone of the tree crops to maintain optimum moisture level. There are many other types like Typhoon, T-tape, Twin Wall etc. The main accessories are filters and fertilizer tanks/venturi. Filters are necessary to prevent clogging of the drippers. Fertilizers can be applied through venturi/fertilizer tanks to avoid wastage of this costly input.

3.3 The relative advantages and disadvantages of the drip system are as under :

Advantages

i. Water saving.
ii. Enhanced plant growth and yield.
iii. Saving in labour and energy.
iv. Most suitable to poor soils.
v. Controls weed growth.
vi. Economy in cultural practices and easy operations.
vii. Possible to use saline water.
viii. Improves efficiency of fertilizer.
ix. Flexible to operate.
x. No soil erosion.
xi. Installation is easy.
xii. Land preparation is not required.
xiii. Diseases and pest problems are minimum.

Disadvantages/Limitations

i. Saline hazards.
ii. Economic and technical limitations.
iii. Requires high skill in design, installation and subsequent operation.

4.1 Research work on drip irrigation is in progress since 1970 onwards in various Agricultural Universities, Research Institutions, Manufacturing Firms and also by the Farmers. TNAU, Coimbatore; IARI, New Delhi; University of Agriculture, Jobner and Udaipur; Choudhary Charan Singh Agricultural University, Hisar; CAZRI, Jodhpur; UAS, Bangalore and Dharwad; MPKV,Rahuri; Agricultural University, Kalyani; CWRDM, Kozhikode; ICAR Complex for North Eastern Hill Region, Shillong; IIHR,Bangalore; PKV,Akola; Vasantdada Sugar Institute, Manjari; Jyothi Farm, Vadodara; Directorate of Irrigation Research and Development, Pune; IPCL,Vadodara etc. are some of the Institutes where research is being conducted.

4.2 The studies conducted by various institutions have revealed that the water saving by drip irrigation is significant, ranging from 40 to 70% over surface irrigation with a yield increase as high as 100% for some crops in specific locations. In addition, the saline water could, also be used in this system and the salt is accumulated only at the surface of the periphery of wetting zone and hence does not affect the growth of the crop. Therefore, the potential of this system is considerably high in the country.

5.1 The development of the system was rather slow and that too confined to some areas in the South and North Western States with water scarcity conditions where the drip system came as a ready answer to maintain sustainable agriculture. The experiences of numerous farmers in the new method are of interesting nature. The old coconut Plantations could not be irrigated as the ground water fast depleted. Numerous farmers in Coimbatore District had adopted drip irrigation for their coconut plantations which proved quite successful for them. The development of drip irrigation is very spectacular in Maharashtra after 1987. This was due to the encouragement given by the State Government and the sustained efforts of publicity given by the manufacturers to educate the farmers. The farmers, were compelled to take up drip since water had become a scarce commodity in Nasik, Jalgaon and other districts. In Nasik, the grapevine farmers irrigated their grapevines through drip system by buying tanker loads of water during summer (April-June). More than 50% of grapevines are generally irrigated by drip method. Though the cost of the system is about Rs.25,000 per ha., the cost benefit ratio is very high (11 to 32). Similarly, many farmers are using drip irrigation for Banana, Pomegranate, Orange, Tomato, Sugarcane and various other crops.

Drip irrigation is the right choice for preventing salinity and waterlogging.

5.2 In Kerala, the coconut and other plantation crops needed water during January to May, and the farmers had introduced drip method, due to shortage of water. The experiences in Karnataka, Andhra Pradesh are also most encouraging, especially for grape, coconut and other fruit crops. It is slowly catching up in Gujarat, Rajasthan and Madhya Pradesh. This system is not yet adopted in Northern and North Eastern States, may be due to abundance of water resources in these States. However, this method is very well suited to the undulated terrain and for commercial and plantation crops to get more yield and thereby higher income to the growers. Therefore, the farmers should be educated to adopt this improved system to get more income and to save fertilizer and labour expenses.

5.3 The Country adopted the agro-climatic regional planning for which 15 zones have been identified. During the Eighth Plan (1992-97) emphasis is on formulation of integrated development plans for sustainable development. Such a plan for water resources sector should aim at development possibilities for drip irrigation. Details of 15 agro-climatic zones are given in Chapter - 5.

5.4 If a farmer in USA is asked as to why he is practising drip irrigation, his answer unhesitatingly would be :

1st : more yield,
2nd : less labour oriented, and
3rd : less inputs (fertilizers/pesticides) and then the last but not least would be saving of water.

The Indian farmer though yet to reach the level of his American counterpart, is certainly convinced that drip system is highly beneficial and useful to get more income for sustained agriculture, especially where water is a very scarce commodity i.e. in South and North Western States of India.

6.1 Drip Irrigation is commonly believed to be an expensive proposition. The experimental results have supported drip irrigation and its technical feasibility has also been established beyond doubt. It has found ready acceptance with the progressive farmers and the social acceptability is an undisputed fact in most of the States. Then the question of economic viability arises which is most crucial for large scale adoption of drip system. The cost of the system depends on the type of crops grown, spacing adopted, water requirements, location of water source etc. It varies from Rs 15,000 per ha for coconut/mango - wide spaced crops to Rs 40,000 per ha for sugarcane, vegetables, cotton - closely spaced row crops.

6.2 The B.C. ratio for drip system was worked out by interviewing the farmers in Maharashtra and Tamil Nadu. The ratio excluding the proportion of water saving

is found to range from 1.31 to 2.60 for various crops excluding grapes. In case of grapes, it is about 13.35. If water saving is also taken into account, the ratio goes up from 2.78 to 11.05 for various crops and 30.00 for grapes. This accounts for the economic logic of entrepreneurial grape farmers to go in for the drip system on an extensive scale.

6.3 To encourage use of water saving devices like sprinklers, drip systems, solar pumps, wind mills, hydrams, water turbines, man or animal operated pumps, Ministry of Water Resources (Minor Irrigation Division), Government of India had sanctioned a centrally sponsored subsidy scheme in the year 1982-83 of the VI Five Year Plan. Centre provided a subsidy of 50% to the farmers with a matching contribution of 50% from State Governments for installation of the devices. Of the total subsidy, 75% was meant for small and marginal farmers with the balance 25% for other farmers.

During the 7th plan period also, the above subsidy scheme was continued with the following modifications :

The subsidy rates for different categories of farmers and the upper limits for each are shown in Table 6.5 of Chapter 6.

i. The non-conventional energy devices like solar pumps and wind mills were excluded from this subsidy scheme as the same were included in the scheme operated by the Department of Non-Conventional Sources of Energy.

ii. The subsidy was limited to the small and marginal farmers only, excluding other farmers from the scope of the scheme.

iii. The percentage of subsidy eligible under the scheme was on par with Integrated Rural Development Programme.

iv. Farmers growing horticultural crops like grapes, papaya, Banana, Arecanut and coconut were also eligible for subsidy.

v. Scheduled Caste and Scheduled Tribe farmers belonging to small and marginal categories and co-operative/community schemes of small and marginal farmers were provided with 50% subsidy under the scheme.

The Central assistance released to the State Governments under centrally sponsored scheme for encouraging use of drip systems, sprinklers and other devices during the 3 years of the VI Plan from 1982-83, VII Plan and the two Annual Plans 1990-91 and 1991-92 was Rs.1194.46 lakhs for the scheme as a whole and the specific component of Central assistance for drip irrigation

Install drip irrigation and avail Government subsidy.

alone is not readily available. The VIII Plan Working Group on Minor Irrigation Programme (MOWR July, 1989) mentioned that the subsidy scheme for drip irrigation did not get good response as the same was limited to small and marginal farmers who could not afford these systems even at subsidised costs.

6.4 During the Eighth Plan (1992-97), the Government of India has launched a new subsidy scheme with a view to encourage second green revolution through the use of drip system with an investment of Rs. 2.5 billion in the plan period for encouraging the use of plastics in agriculture. The components of the scheme and the investment together with physical targets proposed are as given below :

	Component	Investment (Rs. lakhs)	Area ha.
A.	Drip Irrigation	18,810	139,185
	Drip Demonstration	900	12,000
	Mulching	1,400	28,000
	Green Houses	2,200	247
	Total 'A'	**23,310**	**179,432**
B.	New Plasticulture application	500	
	Training	590	
	NCPA	600	
	Total 'B'	**1690**	
	Grand Total (A+B)	**25,000**	

Under this scheme, a subsidy of 50% is being offered to farmers upto 1994-95 (limited to a maximum of Rs. 15,000) for installation of drip system subject to a ceiling of one hectare. For 1995-96 and 1996-97 the subsidy is 40% from the Centre and 10% from the States.

7.1 As stated earlier, the drip method is technically feasible, economically viable and socially acceptable. Therefore this method can be adopted in the following areas :

.. Well irrigated areas which constitute about 35% of the irrigated area in the country.

Drip irrigation transforms arid and semi-arid lands into profitable plantations.

.. It is ideally suited to all row crops especially coconut, fruit trees, vegetables, flowers, commercial crops, plantation crops etc. which alone constitute more than 18 M ha. in the Country..

.. Cultivable Waste lands by planting trees that include fruit trees. More than 25 M ha is available under this category.

.. Hills and semi-arid zones.

.. Coastal sandy belts.

.. Water scarcity areas.

.. Command areas of the Community Wells.

7.2 Regarding the prospects of development of drip irrigation, it may be highlighted that the method is most suitable for fruit and plantation crops in view of the high returns expected. The gross cropped area in 1989-90 under fruit and vegetable crops (inclusive of cotton, plantation crops and tobacco) was 20 M ha. The area irrigated under these crops by drip method is only 45000 ha at present which represents a very small percentage of the gross cropped area. This reflects that large potential is available for expanding drip under these crops. Drip can advantageously be developed in waste land areas, hills and semi-arid areas, coastal sandy areas besides water scarcity areas. Further development can tap this large potential by overcoming constraints in development.

8.1 The following are the constraints experienced in bringing large areas under drip method:

.. High initial costs.

.. Quality of the drip material - clogging of drippers and cracking of lateral pipes.

.. Lack of awareness among the farmers.

.. Inadequate technical inputs.

.. Damage due to rodents.

.. High costs involved in spares and accessories.

Future of horticulture/sericulture rests on drip irrigation.

.. Difficulty in getting subsidy.

.. Insufficient extension and promotional activities.

8.2 For tapping the full potential of this system, the constraints are to be removed by appropriate policy changes, financial support and technical guidance. This calls for an integrated approach and endeavour on the part of both the Central and State Governments, implementing agencies, manufacturing companies and end users of the system i.e. farmers. The technology is to be perfected and hence more field oriented research is to be undertaken by the Universities and Research Institutions. Training should be imparted to the officials and farmers to learn about the system and its maintenance etc. Seminars and workshops can be organised in the block, district, State and Central levels for better appraisal of the system, its problems and other relevant details. The steps to be taken to popularise the method are :

.. The main policy should be so as to encourage and to motivate all categories of farmers, since the critical issue is saving of water and augmentation of productivity.

.. The cost of the system should be brought down; otherwise, the subsidy component can be increased to all the farmers.

.. There should be a separate Department entrusted with the responsibility for popularising the system in the State Governments and to avoid multiplicity of agencies.

.. The manufacturing companies should commit themselves for the supply of standard material and equipment conforming to BIS standards. Also the firms have to provide prompt customer services for ensuring proper maintenance with supply of adequate spares.

.. Farmers should develop conviction and confidence in the system.

.. The research institutions should integrate their activities with R&D units of the manufacturing companies.

8.3 The Agricultural Plastic Development Centres should embark on undertaking field based research studies for all problems in Drip Irrigation to find satisfactory solutions.

8.4 The State Governments should prepare action plans for the VIII and subsequent plans. Although the land and water resources are constant, it is possible to increase the gross cultivated area by two to three times of net area by raising

2-3 crops in a year through judicious use of available water resources. Drip Irrigation can contribute effectively to achieve this objective. Drip Irrigation would also solve many problems in the country including unemployment and earn foreign exchange by way of exportable surplus vegetables, fruits, flowers in the coming years.

The State Governments should also formulate perspective Plans for 15 years for different agro-climatic zones and work out the requirement of funds for implementation and also develop necessary infrastructure as suggested in this report. Before preparing such plans, the concerned State Departments may have a quick survey carried out in respect of the areas where the drip method can be advantageously introduced. The plans should also indicate the requirement of men, materials and training needs, besides infrastructural development to create the required manufacturing capacity in the Country. The nodal Ministries at the Centre viz. Ministry of Water Resources, Ministry of Agriculture and ICAR should have a Steering Committee to propagate the use of drip irrigation in the country.

The perspective plans for drip irrigation for the next 5-7 years can aim at a coverage of 1% of the total irrigated area i.e. about 1 M ha. by the turn of the century. The cost involved to bring 1 M ha under drip is estimated to be about Rs.2500 crores. The financial requirement is justifiable on the basis of the long term benefits accruing by way of increased area under irrigation and higher production. It will also generate employment opportunities to a large extent. Farmers have to be motivated to invest part of the capital expenditure from their own resources and the balance may be supported by loans and subsidies from Government.

Drip irrigation system is a great boon to farmers.

DRIP IRRIGATION FOR POMEGRANATE
(Courtesy : Jain Irrigation)

DRIP IRRIGATION FOR ORANGE
(Courtesy : Jain Irrigation)

CHAPTER - 1

INTRODUCTION

Land and water are the two basic needs for agricultural development and economic advancement of any country. With the per capita availability of land and water being much less than many other countries in the world, the demand for these two resources is continuously escalating in India. Experts have assessed that water will be the major resource constraint in future for economic development. Though the land area is constant like water, there is scope for utilising the same in an intensified manner in project commands and rainfed areas to increase the production. Further, this can also be achieved by reclaiming the fallow, barren and uncultivable wastelands. All this would need water and hence optimum use of the available water is very crucial.

1.1 WATER AVAILABILITY.

a. Surface Water.

The country's average rainfall is about 1170 mm, which falls over the geographical area of 329 M ha yielding a run-off of 400 M ha m. The total surface flow is assessed as 187 M ha m. as shown in Table 1.1. However, owing to the limitations of physiographic conditions and topography, geology, dependability, the present state of technology and other constraints, only 37% of the total run-off amounting to 69 M ha m only can be utilised.

b. Ground Water.

There are several estimates of the ground water potential by various agencies. There are also wide inter-State variations in utilisation of this resource ranging from over-exploitation upto 90% in Haryana and underutilisation of a mere 10% in Kerala. The approximate potential of utilisable ground water is about 45.2 M ha m. (Central Ground Water Board, 1989).

Table 1.1

Basin-wise Average Annual Surface Water Run-off.

Sl No	River Basin	Average Annual Run-off(M cum)
1	Indus	73,305
2	Ganga-Brahmaputra-Meghna	
	(a) Ganga	525,023
	(b) Brahmaputra	537,240
	(c) Barak & Others	48,357

Drip irrigation system has made a significant breakthrough in modern agriculture.

Sl No	River Basin	Average Annual Run-off(M cum)
3	Godavari	110,540
4	Krishna	78,124
5	Cauvery	21,358
6	Subernarekha	12,368
7	Brahmani-Baitarani	28,477
8	Mahanadi	66,879
9	Pennar	6,316
10	Mahi	11,020
11	Sabarmati	3,809
12	Narmada	45,639
13	Tapi	14,879
14	West flowing rivers from Tapi & Tadri	87,411
15	West flowing rivers from Tadri to Kanyakumari	113,532
16	East flowing rivers between Mahanadi & Pennar	22,520
17	East flowing rivers between Pennar & Kanyakumari	16,458
18	West flowing rivers of Kutch & Saurashtra including Luni	15,098
19	Area of inland Drainage in Rajasthan Desert	Negl.
20	Minor rivers draining into Myanmar (Burma) & Bangladesh	31,000
	Total	**1,869,348**
	Say	**187 M ha m**

Source : *Reassessment of Water Resources Potential of India - A Central Water Commission Publication, March, 1993.*

The total utilisable quantum of both surface and ground water adds upto 114 M ha m and even with full exploitation of this potential, nearly half of the cultivated area will always remain rainfed.

1.2 IRRIGATION NEEDS.

The total geographical area of India is 329 M ha, of which the net sown area is 142 M ha (43%) and the gross sown area is 180 M ha in 1988-89. The net sown area, intensity of cropping, the gross sown area and gross irrigated area in the years 1970 and 1989 with projections for the years 2000/2025 A.D. are given in Table 1.2.

Drip irrigation transforms deserts into goldmines.

Table 1.2
Cropped Area, Intensity of Cropping and Irrigated Area.

Year	Net area sown Mha	Intensity of cropping %	Gross area sown Mha	Gross Irrigated area Mha	% of gross irrigated to gross sown area
1970	140.4	118	165.1	38.5	23.0
1989*	141.7	127	180.1	59.3	32.9
2000	150.0	133	200.0	84.0	42.0
2025	155.0	136	210.0	110.0	52.0

Source : *(i) Report of National Commission on Agriculture (1976)*
*(ii) *Agricultural Statistics at a Glance by Ministry of Agriculture, (May, 1992).*

It has been estimated that food grains of about 245 million tonnes would be needed by the turn of the century to feed India's growing population which may touch a staggering figure of 1000 million by then. The expansion of area under irrigation is essential for obtaining this increased agricultural production. This can be achieved only by additional development, conservation and efficient management of the available water resources. While some States have harnessed the available water resources to a large extent, others have yet to develop their resources fully. The constraint in the future for increased production is going to be the water. Agriculture draws more than 90% of the total water used. It is estimated that the allocation of water to agriculture will be reduced to 75-80% in the next 10 years, since the demand of water for industries and municipal purposes is expected to increase as can be seen from the following two tables.

Table 1.3
Water Utilisation in India in 2000 A.D.

Activity	% Use	Water Use requirement M ha m.	Consumptive Use : M ha m.	Water Resource reused (return flows) M ha m.
Irrigation	77	86.0	77.4	8.6
Livestock	1	0.9	0.9	--
Power	13	15.0	0.5	14.5
Industries	3	3.5	1.0	2.5
Municipal and Rural Water	6	6.2	3.1	3.1
Total	100	111.6	82.9	28.7

Source : *Dr.K.L.Rao (1974). India's Water Resources - Its Assessment, Uses and Projections*

Drip irrigation is an efficient irrigation technique.

Table 1.4
Latest estimates of Water Needs (M ha m.)

ACTIVITY	YEARS		
	1990	2000	2025
Irrigation	46.0	63.0	77.0
Drinking & Livestock	2.5	3.3	5.2
Industrial	1.5	3.0	12.0
Energy	1.9	2.7	7.1
Others	3.3	3.0	3.7
Total	**55.2**	**75.0**	**105.0**

Source : *Water Resources Development in 21st Century Policy options for India by Shri M.S. Reddy (September, 1992).*

1.3 NEED FOR ECONOMIC USE OF WATER.

It has been recognised that among the basic factors of agricultural productivity, adequate and timely supply of irrigation water is a crucial one. The development of irrigation is given top priority in the Indian economy as agriculture contributes about 50% to the Gross National Product (GNP). The irrigation also assumes importance due to the fact that over 80% of people live in rural areas, of which more than 70% are directly dependent on agriculture for their livelihood.

Table 1.5
Development of Irrigation in India - Irrigation Potential-Gross Area (M ha.)

S No	Plan Period	Major and Medium	Minor Irrigation			Total Irrigation (Cumulative)
			Ground	Surface	Total	
1	Pre-Plan (1950-51)	9.70	6.50	6.40	12.90	22.60
2	First Plan(1951-56)	12.19	7.63	6.43	14.06	26.25
3	Second Plan(1956-61)	14.33	8.30	6.45	14.75	29.08
4	Third Plan(1961-66)	16.57	10.52	6.48	17.00	33.57
5	Annual Plans(1966-69)	18.10	12.50	6.50	19.00	37.10
6	Fourth Plan(1969-74)	20.71	16.50	7.00	23.50	44.21
7	Fifth Plan(1974-78)	24.72	19.80	7.50	27.30	52.02
8	Annual Plans(1978-80)	26.61	22.00	8.00	30.00	56.61
9	Sixth Plan(1980-85)	30.01	27.80	9.72	37.52	67.53
10	Seventh Plan(1985-90)	31.52	35.62	10.99	46.61	78.13
11	Annual Plans(1990-92)	32.80	38.89	11.46	50.35	83.15
12	Ultimate	58.50	40.00 *	15.00	55.00 *	113.50 *

Source : *Eighth Five Year Plan, Planning Commission (1992)*
* *Under revision.*

Drip irrigation is a modern scientific technology.

Table 1.6

Plan-wise average investment of Irrigation Projects.

S. No.	Plan	Investment per ha at current price (Rs)	
		Major & Medium Irrigation	Minor Irrigation
1.	First (1951-56)	1061	550
2.	Second (1956-61)	3619	2556
3.	Third (1961-66)	1734	1952
4.	Annual (1966-69)	10585	2777
5.	Fourth (1969-74)	4739	2597
6.	Fifth (1974-78)	6378	3753
7.	Annual (1978-80)	11167	3656
8.	Sixth (1980-85)	23848	4309
9.	Seventh(1985-90)	42721	6938

Source : *Shri B. N. Navalawala : Economic Aspects of Irrigation and Pricing of Water 1992.*

The investment per hectare at current price of projects has risen from about Rs 1,000 during the First Five Year Plan (1951-56) to about Rs 43,000 during the Seventh plan and is likely to increase further in the Eighth Plan (Table 1.6) due to general price rise and other factors. On the other hand, the cost of drip irrigation varies from Rs 15,000 to 40,000 per ha which besides comparing favourably, also results in considerable saving of water and increased productivity. Economic use of water for agriculture would enable bringing more and more areas under irrigation. This could be achieved only by introducing advanced methods of irrigation like drip, sprinkler and other improved water management practices. The overall irrigation efficiency in surface irrigation is only 30-50% which is very low when compared to sprinkler irrigation with 60-75% and drip irrigation with 80-90%.

A farmer can avail subsidy upto Rs. 15,000/- for drip irrigation.

DRIP IRRIGATION FOR AMLA
(Courtesy : Jain Irrigation)

DRIP IRRIGATION FOR CAPSICUM
(Courtesy : NCPA, New Delhi)

CHAPTER - 2

IRRIGATION METHODS

Irrigation is an ancient art, as old as civilization but for the modern world, it is a science - the science for survival. The pressure of survival and the need for additional food are necessitating a rapid expansion of irrigation in India, but in many parts water is becoming a scarce commodity.

Although, many changes had taken place in other spheres, there has not been much change in the field of irrigation and the age old methods are being followed even now.

2.1 PRESENT METHOD.

The dominant method of irrigation practised from times immemorial consists of diverting a stream from the head of a field into furrows or borders and allowing it to flow down-the-grade by gravity. No basic change has taken place in these surface or gravity irrigation methods over the years, though certain refinements or some degree of sophistication did take place. Under the gravity system, water infiltrates the soil while traversing the furrow, border or basin. By subsequent ponding and lateral movement of the water, the soil profile is filled to its water holding capacity to a depth which depends inter-alia on the quantity applied, the duration and rate of stream flow, the gradient, the soil structure and texture. The overall conveyance and application efficiency of irrigation water is the relationship between the quantity of water that has actually wetted the root zone of the crop besides deep percolation and the quantity of water released from the source.

Generally, under open ditch conveyance and surface irrigation methods, less than one half of the water released reaches the plants. The plants actually use only about 50% of the water delivered. In projects which may be assumed to be planned, designed and operated properly, the efficiency ranges from 30-50%. These low efficiencies may be, partly due to conveyance losses resulting from seepage, evaporation and non-beneficial use of phreatophytes. The losses are also partly the result of poor farm distribution of water due to inadequate land preparation, and lack of farmer know-how in the application of water, with consequent excess applications and deep percolation. Moreover, in addition to these low efficiencies, erosion, salination and waterlogging take their toll of land productivity and water quality, degrading these two basic natural resources. Higher efficiencies in gravity irrigation can be obtained under certain conditions, like research stations and projects managed and operated by highly-skilled and trained personnel. These skills include the planning and execution of land-forming operations including levelling and shaping, the introduction of advanced techniques in the determination of irrigation frequencies, quantities, stream size and duration

Wastelands and coastal sandy belts can be made arable with drip irrigation.

of irrigation, the installation of water measurement and regulation systems, lining of canals, the adoptation of surface irrigation delivery to suit the crop water requirements and providing proper drainage system for the removal of excess water.

To sum up, the gravity/surface irrigation has the following disadvantages compared to modern irrigation methods :

i. More water is needed per unit area, and application of small doses of water is almost impossible.

ii. The absence of proper drainage arrangements would result in accumulation of excess water thereby causing waterlogging and salinity.

iii. Continuous care and vigilance are needed for proper water applications and adjustment of head of water.

The advantages in using gravity irrigation are :

Much lower initial capital cost required to serve an irrigated area and also nominal O&M costs as no energy charges are involved like drip and sprinkler. This fact is highly attractive to world bodies for providing financial support to such projects.

2.2 ADVANCED METHODS.

The advanced methods of irrigation which are otherwise known as sprinkler and drip could be introduced for all types of crops depending upon the soil, slope, water source, farmers' capacity etc. It is a known fact that the yields of the crops are better in addition to the saving of water with the above methods. The reasons attributed for increased yields are :

- Water is applied once in 3-6 days period in sprinkler irrigation which in turn reduces the moisture stress to some extent. Further, the water application being controlled, only the needed water can be regulated in this system.

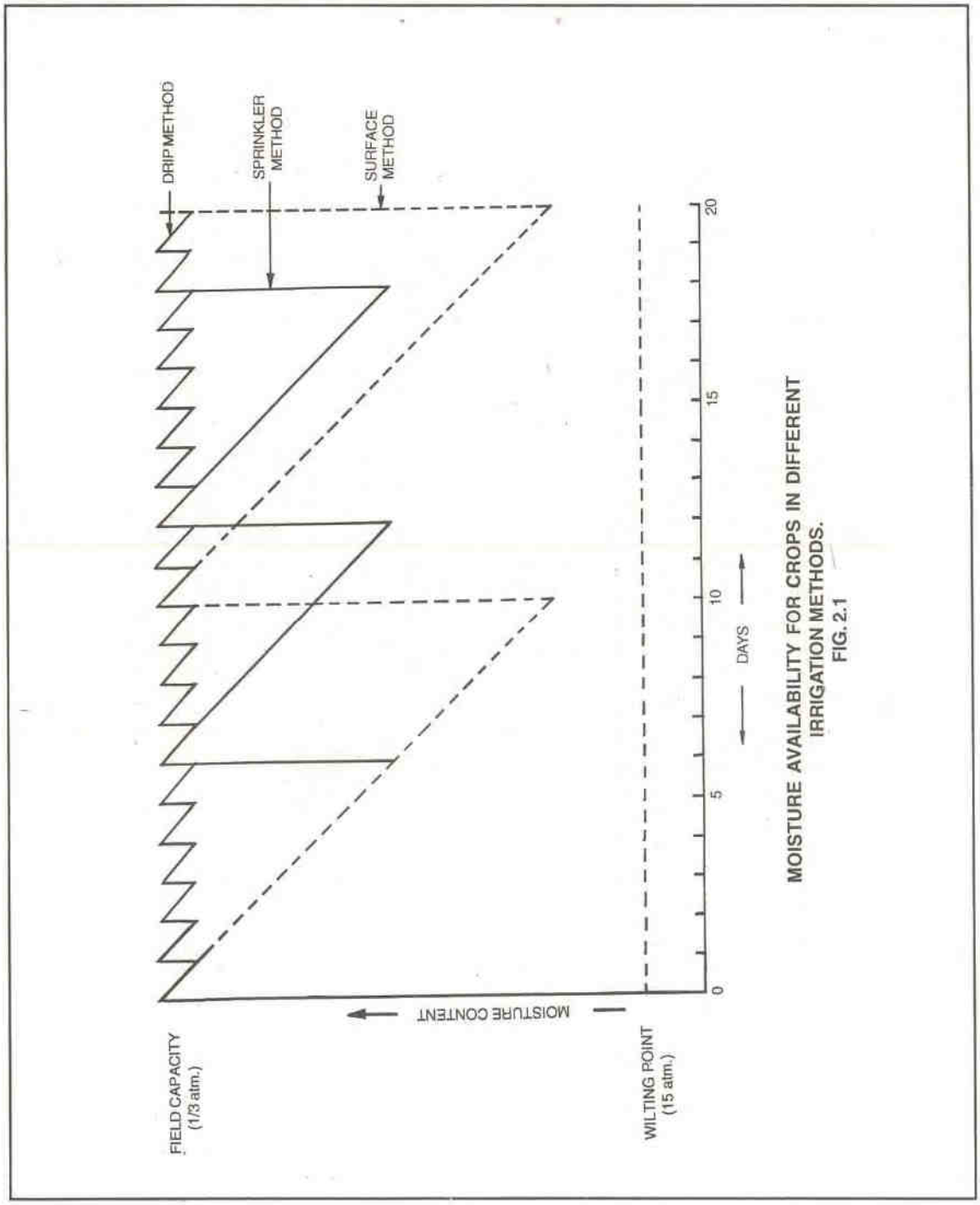
- Water is applied daily in drip irrigation and hence the growth is uniform. As there is no water/moisture stress, the crop growth is not affected at all. Water is also controlled and only the required quantity of water is given to each plant based on the evapo-transpiration requirements.

- See figure 2.1

Drip irrigation can profitably be extended to the command areas of the community wells.

FIGURE 2.1

MOISTURE AVAILABILITY FOR CROPS IN DIFFERENT IRRIGATION METHODS



Unlike in Surface irrigation, drip irrigation supplies water direct to root zone.

2.2.1 Sprinkler Irrigation.

The sprinkler method is replacing the surface/gravity irrigation methods in all developed countries due to higher water use and application efficiency, less labour problems, adaptability to hilly terrain, ability to avoid frost attack, possibility of applying fertiliser in solution. In India, Sprinklers were first adopted in the States of Haryana, Madhya Pradesh, Maharashtra, Rajasthan, Karnataka and North-eastern States. With 3 lakh ha in the year 1985, the gross area under Sprinkler irrigation nearly doubled by 1989 reaching 5.80 lakh ha with total number of sets crossing the figure of 1.14 lakhs. In this method, water is carried through a network of pipes under medium or high pressures and is sprayed like light rain/drizzle. Irrigation is given under controlled conditions and hence it is possible to give the required quantity at the required time. The saving of water is about 30 to 50% and hence by introducing this method for closely spaced crops (high value crops) more than 50% additional area can be brought under irrigation besides increased yields.

2.2.2 Drip Irrigation/Line Source Irrigation. (Biwall/Typhoon/Tee Type/Leakage Pipes)

This method is very well suited for wide spaced high value crops. The required quantity of water is provided to each plant daily at the root zone through a network of piping system. Hence there is no loss of water either in the conveyance or in the distribution. Evaporation loss from the soil surface is also very little since water is given only to the root zone and crop canopy provides shade to prevent evaporation. This new Agro-Technology can be adopted for undulating terrain having shallow and porous soils and in water scarcity areas. Saline/brackish water can also be used to some extent for crop cultivation since water is given daily in this method, and the salt is pushed to the periphery of the moisture zone i.e. away from the root zone of the crop as shown in Figure 2.2. Research studies have indicated that the water saving is about 40-70% and the yield is increased by 10-100% for various crops, if the drip method is used. An area of 70,859 ha is presently under drip irrigation for various crops in India.

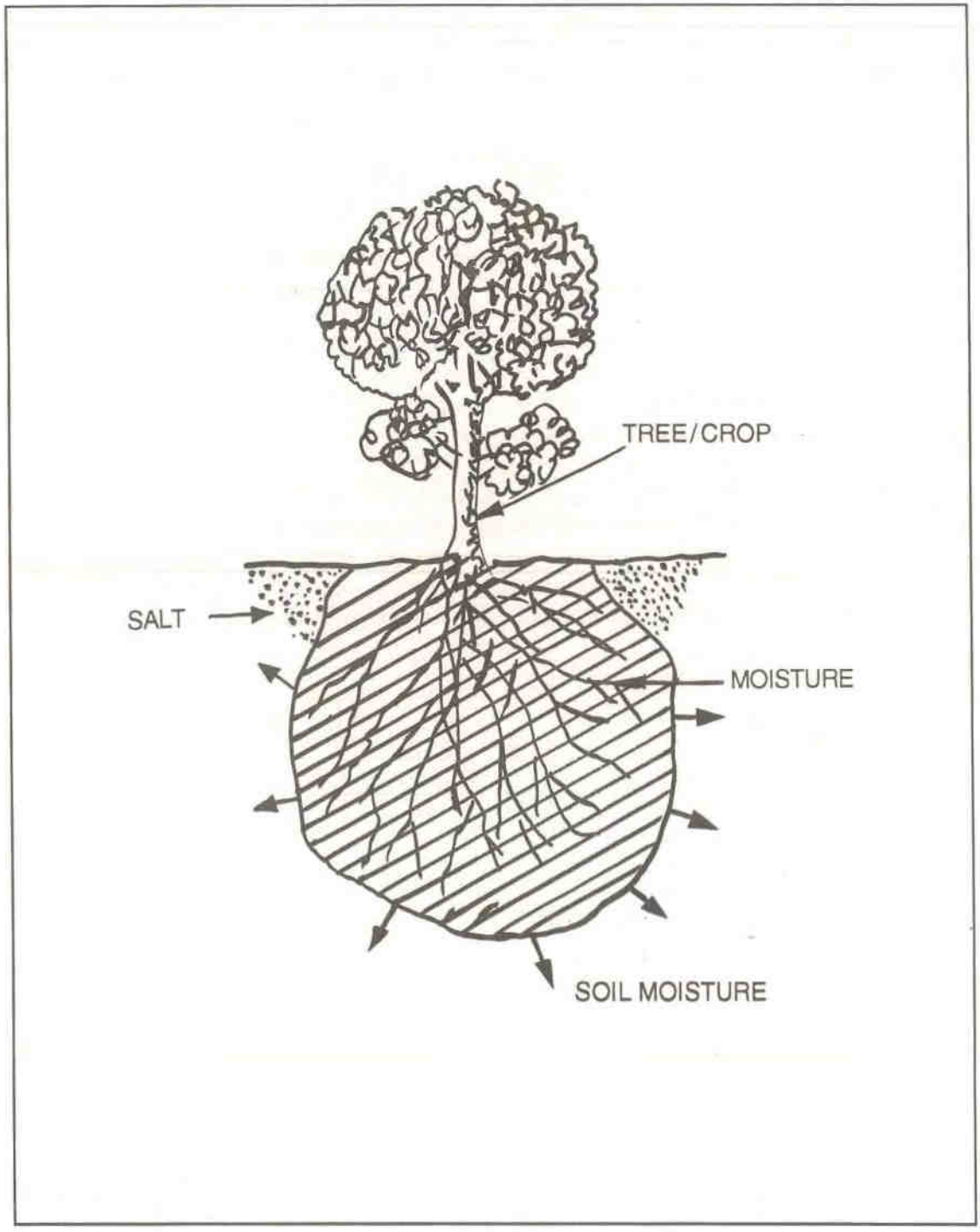
2.2.3 Micro Sprinkler and Micro Sprayer.

This is a combination of sprinkler and drip irrigation. Water is sprinkled or sprayed around the root zone of the trees with a small sprinkler which works under low pressure. This unit is fixed in a network of tubing but can be shifted from place to place around the area. Water is given only to the root zone area as in the case of drip irrigation but not to the entire ground surface as done in case of sprinkler irrigation method. This method is very much suited for tree/orchard crops.

Drip irrigation facilitates maximum out-put per unit of irrigation water.

FIGURE 2.2

POSITION OF SALT ACCUMULATION IN DRIP IRRIGATION

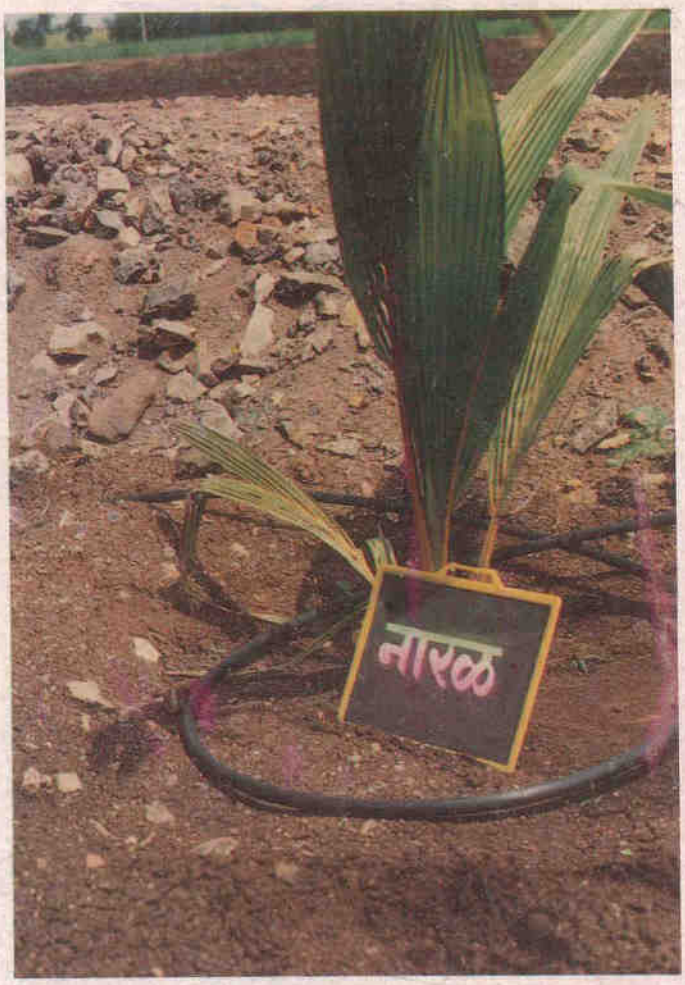


Recurring expenses on inter-cultivation / hoeing are minimised with drip irrigation.

2.2.4 Pipe Distribution System for irrigation.

This System has developed in a rapid way in the last 10 to 15 years in water management especially in conveyance and distribution of water as it will reduce seepage losses and lead to more efficient water utilisation, preventing waterlogging and weed growth. This system will also reduce requirement of land and maintenance costs. Large quantities of water can be conveyed through pipes having bigger diameter which can now be fabricated at the site wherever required. The Australian technology of 'Ribloc', which will prevent completely the seepage and evaporation losses is now being imported. In this technology, large diameter pipes can be fabricated at the site itself and hence the cost of the pipe is reduced. In water application, better water management practices based on soil-water-plant relationship are available for all crops. By introducing pipe conveyance system clubbed with sprinkler and drip irrigation for the crop, it is possible to expand irrigation facilities to at least double the area with the same quantity of water. The conveyance of water through pipes by using pressurised irrigation method is common in USA, Israel, Australia etc. The thinking process in this direction has already started in the States of Gujarat, Maharashtra and Madhya Pradesh. Maharashtra Government has decided to give sanction for many lift irrigation schemes only, if the water is conveyed through pipes and used by drip and sprinkler methods of irrigation. The Gujarat Government is planning to bring large areas under irrigation by introducing drip method in their Narmada Project (Sardar Sarovar Project) and action is being taken in this direction. Madhya Pradesh has also introduced pipe distribution systems in a number of medium and minor projects under USAID assisted programme. These methods have greater scope in irrigation development.

There is no soil erosion in drip irrigation.



DRIP IRRIGATION FOR NEW PLANTATION OF COCONUT
(Courtesy : Jain Irrigation)

DRIP IRRIGATION FOR NEW BANANA PLANTATION WITH MULCHING
(Courtesy : Jain Irrigation)

CHAPTER - 3

DRIP IRRIGATION

In the context of United Nations Conference on Environment and Development (UNCED) Agenda 21, Chapter 18 is of particular relevance to the Indian National Committee on Irrigation and Drainage (INCID), as it provides a framework for sustainable development to enhance the effective use of water and land resources. It also envisages an environmental action plan for both developed and developing countries for extensive implementation throughout the decade and further into the 21st Century. Of the wide variety of measures existing to boost agriculture productivity through economic use of water, drip irrigation is very pertinent. Starting in the late 1960's, drip irrigation techniques began to expand in countries facing water scarcity - the ultimate goal being to increase water use efficiency. In India, however, the system was introduced in 1980's with a small beginning and is presently on the threshold of a widespread expansion with many manufacturing firms entering the market and farmers showing keen interest for installing more and more units and State Governments coming forward with attractive packages of subsidies and loan arrangements. The total drip irrigated area in the world is around 1,785,000 ha, while that in India is 70,859 ha.

3.1 HISTORICAL DEVELOPMENT.

3.1.1 World.

Drip irrigation was developed originally as a sub-irrigation system and this basic idea underlying drip irrigation can be traced back to experiments in Germany in 1860s. The first work in drip irrigation in the United States was a study carried out by House in Colorado in 1913. An important break-through was made in Germany way back in 1920 when perforated pipe drip irrigation was introduced.

During the early 1940s, Symcha Blass, an Israeli Engineer, observed that a big tree near a leaking tap exhibited a more vigorous growth than other trees in the area, which were not reached by water from the tap. This led him to the concept of an irrigation system that would apply water in small quantity literally drop by drop. Around 1948, green house operators in the United Kingdom began to try a similar method with some modifications. The earliest drip irrigation system consisted of plastic capillary tubes of small diameter (one millimeter) attached to large pipes. Friction in the tube restricted the flow of water into the soil from a given discharge of two to ten litres per hour. Initially, the system was installed underground, but because of the primitive filtration techniques of the time and frequent clogging, the system was moved above ground. One of the refinements made by Blass in his original system was coiled emitter.

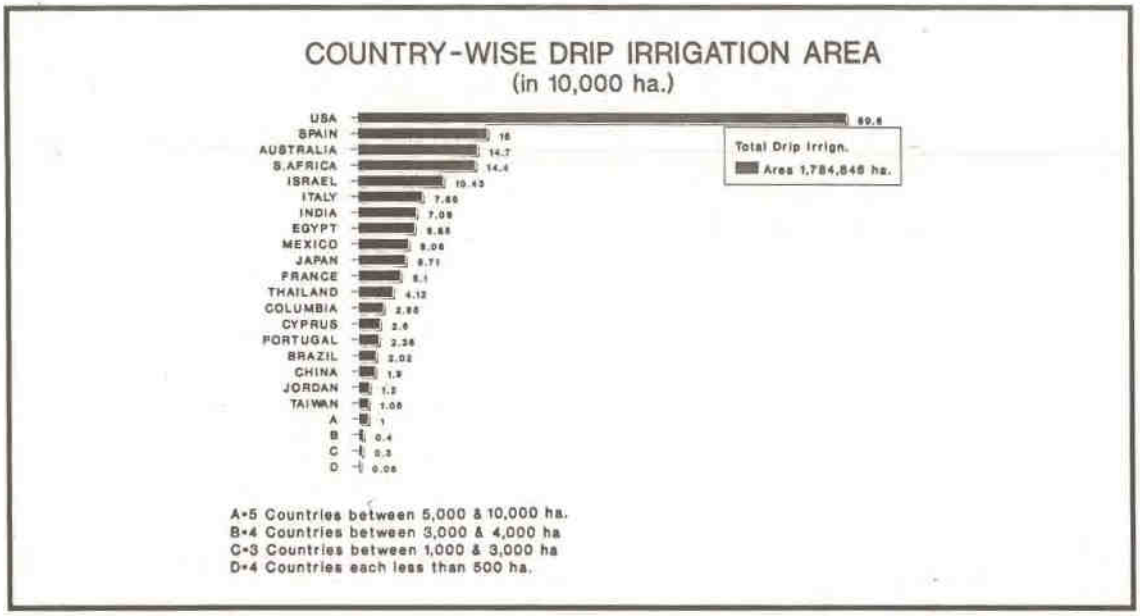
There is less weed growth in drip irrigation.

In the early 1960s, experiments in Israel reported spectacular results when they applied the Blass system in the desert areas of the Negev and Arava.

Drip irrigation pipes began to be sold outside Israel in 1969 on commercial basis. Drip irrigation units in their current diverse forms were installed widely in U.S.A., Australia, Israel, Mexico and to a lesser extent in Canada, Cyprus, France, Iran, New Zealand, United Kingdom, Greece and India. The area under drip irrigation has increased from a mere 40 ha in 1960 to more than 54,600 ha in 1975. In 1981 it reached a figure of 4,12,760 ha. The Worldwide survey conducted by the ICID Working Group on Micro Irrigation in 1991 reveals that drip irrigation is being practised in 35 Countries with the highest figure of 606,000 ha in United States of America and the lowest figure of 20 ha in Ecuador, India occupying seventh position with 70,859 ha. The total area of drip irrigation in the world was 1,784,846 ha, with the country-wise break up as shown below :

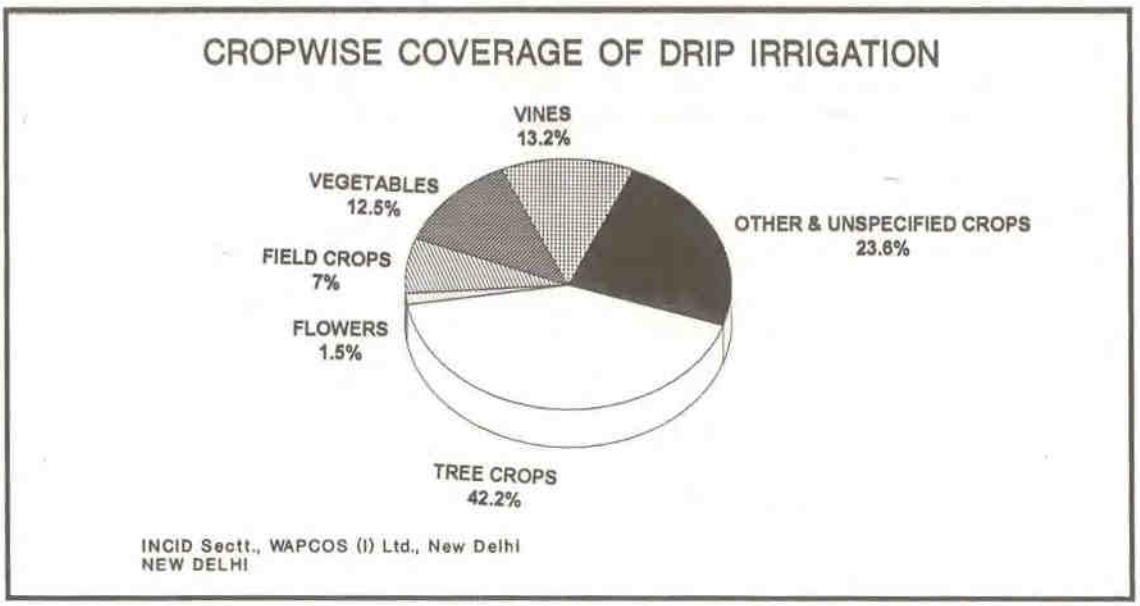
S. No.	Country	Area under drip Irrigation in ha.	S. No.	Country	Area under drip Irrigation in ha.
1	United States	606,000	20	Morocco	9,766
2	Spain	160,000	21	Chile	8,830
3	Australia	147,011	22	Canada	6,149
4	South Africa	144,000	23	U.K.	5,510
5	Israel	104,302	24	Philippines	5,041
6	Italy	78,600	25	Poland	4,000
7	**India**	**70,859**	26	Yugoslavia	3,820
8	Egypt	68,450	27	Hungary	3,709
9	Mexico	60,600	28	Netherlands	3,000
10	Japan	57,098	29	Czechoslovakia	2,310
11	France	50,953	30	Austria	2,000
12	Thailand	41,150	31	Germany	1,850
13	Colombia	29,500	32	Malawi	389
14	Cyprus	25,000	33	Malaysia	177
15	Portugal	23,565	34	Turkey	32
16	Brazil	20,150	35	Ecuador	20
17	China	19,000			
18	Jordan	12,000		**Total**	**1,784,846**
19	Taiwan	10,005			

Drip irrigation saves labour and energy costs unlike lift irrigation.



Drip irrigation is being used on a large scale for various crops such as tree crops - Citrus, Deciduous, Avocado/Mango, Olives/ Nuts, Nurseries and others; Vines - Grapes and others; Vegetables - Field, Greenhouses; Flowers - Nurseries, Greenhouses; Field Crops - Cotton, Sugar, Others; unspecified other Crops. Various types of Drip system, viz. Biwall System, Tee type, Typhoon, Leaky Pipe are available and are used effectively in many parts of the world.

The coverage of different crops in terms of percentage of the total micro irrigated area is shown below in graphical depiction.



Micro-nutrients like Zinc and Iron can be fed easily through drip system.

Due to its importance and the need for introducing such a system, many International Congresses (Seminars) were organised, the first one in 1971 in Israel, the 2nd in 1974 and the 3rd in 1985 both in California (USA) and the fourth one in 1988 in Australia. An International Workshop on Micro Irrigation World wide was held at The Hague, The Netherlands coinciding with the ICID Congress in September, 1993. In all 27 papers were submitted by different National Committees, of which the largest contribution of 12 papers was from the Indian National Committee on Irrigation and Drainage (INCID). The tally of papers by different countries is given below :

Sl.No.	Country	No.of Papers Contributed
1.	**India**	**12**
2.	Poland	4
3.	Czech	2
4.	Japan	2
5.	USA	1
6.	UK	1
7.	Nigeria	1
8.	Hawaii	1
9.	South Africa	1
10.	Israel	1
11.	Romania	1
	Total	**27**

The titles of papers and the names of Indian Authors are mentioned in **Annexure-I.**

5th International Micro-Irrigation Congress, Orlando, Florida, U.S.A. April 2-6, 1995.

The American Society of Agricultural Engineers in co-operation with the Irrigation Association of Florida Irrigation Society are organising the International Micro-Irrigation Congress at Orlando, Florida April 2-6, 1995 on the theme; "Micro-Irrigation for a Changing World : Conserving Resources/Preserving the Environment."

INCID Secretariat has circulated the Bulletin for "CALL FOR PAPERS" for the above Congress to all WALMIs, Universities, Research Institutes, Members of relevant Special Committees etc for sending their papers. A total of 33 abstracts have been contributed by the Indian authors vide list at **Annexure-II.** All the 33 abstracts have been accepted by the Organising Committee some for lecture and others for poster presentations.

Entire Israel is covered by drip irrigation leading to its remarkable progress.

3.1.2 India.

In India drip irrigation was practised through indigenous methods such as perforated earthenware pipes and perforated bamboo pipes and pitcher/porous cup irrigation. In Maharashtra, perforated earthenware pipes were used and their efficiency and benefit cost ratio have been elaborated for popularising them. In Meghalaya, some of the tribal farmers are using bamboo drip irrigation system for betel, pepper and arecanut crops by diverting hill streams in hill slopes. The discharge at the head varies from 15 to 20 litres per minute and is reduced to 10-30 drops per minute at the time of application. Earthenware pitchers and porous cups have also been used for growing vegetable crops in Rajasthan and Haryana. The technique envisages embedding of earthen cups of 500 ml capacity at the site of the seedlings. The cups are filled with water at an interval of 4 to 5 days. These methods can advantageously be used by individual farmers for small plots.

In India drip irrigation was introduced in the early seventies at the Agricultural Universities and other research Institutions. Significant development has taken place only in the eighties. The growth of drip irrigation has really gained momentum in the last five years. From a mere 1500 ha in 1985, the area under drip irrigation has grown to 6000 ha in 1988 and then to 70,859 ha at present. These developments have taken place mainly in areas of acute water scarcity and in commercial/horticultural crops, such as coconut, grapes, banana, fruit trees, sugarcane and plantation crops in the States of Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu and Gujarat.

The scientists of the Tamil Nadu Agricultural University, Coimbatore who are the pioneers in drip irrigation research, have conducted large scale demonstrations in the farmers' fields for various crops such as vegetables, grapes, banana, cotton and sugarcane. Based on farmers' interests and requests, pilot demonstration plots were selected, and drip irrigation using locally available pipes and micro-tubes were installed during 1973-74. The operational research studies were carried out for 2 to 3 years. The farmers were happy as they were able to cultivate more area from the available little water in the wells.

Some progressive farmers in Coimbatore, Madurai, Tirunelveli and Trichy districts of Tamil Nadu took up drip irrigation in their fields since water supply was insufficient to irrigate their land with surface methods. The crops grown in their lands were coconut, lime, sapota, guava, flowers, vegetables etc. The system was installed in their lands in the year 1980 to 1982.

Studies were also taken up in IARI, New Delhi; College of Agricultural Engineering, Udaipur; Haryana Agricultural University, Hisar; Punjab Agricultural University, Ludhiana; University of Agricultural Sciences, Bangalore and Raichur Campus; Central Arid Zone Research Institute(CAZRI),Jodhpur; Agricultural Universities in Maharashtra at Akola and Rahuri; Agricultural University in West Bengal; Centre for Water Resources

Drip irrigation system keeps space in between crop rows dry and weed free.

Development & Management, Kozhikode; Jyothi Farm, Vadodara; Jain Irrigation Farms, Jalgaon; ICAR Complex; Shillong; G.B. Pant University of Agriculture & Technology (GBPUA&T), Pantnagar, various State Departments etc.

In 1981, the Government of India constituted a National Committee on the Use of Plastics in Agriculture (NCPA), with the financial assistance of Indian Petro Chemicals Limited, Vadodara(IPCL). The Agricultural Finance Corporation initiated a techno-economic feasibility report on Drip Irrigation on a Pilot Scheme basis in Tamil Nadu, Karnataka,Gujarat, Rajasthan, Uttar Pradesh and Bihar covering about 3,000 ha in about 400 villages.

There are other numerous farms in India where the drip irrigation has been installed due to water scarcity. The versatality of the system indicates the acceptability of this system with the farming community. There are also some failures due to defects in design, poor quality of material used to produce the system, carelessness of the farmers in maintaining the system and very poor quality of water in some cases.

Drip Irrigation is adopted for a wide range of crops, a list of which is given at **Annexure - III.**

The authentic figures of area under drip irrigation in our country are not readily available. In the absence of any recording system, several guess estimates have been made by different experts and agencies.

Dr.R.K.Sivanappan has mentioned in his draft report of September, 1992 a figure of 24,000 ha as the area under drip irrigation in India. In the National Level Workshop on Sprinkler and Drip Irrigation Systems organised by Central Board of Irrigation and Power (CBI&P), New Delhi, Geographical Committee of International Water Resources Association (GCIWRA)(India) and co-sponsored by NABARD, Bombay; Jain Group of Industries(JIL), Jalgaon; Indian Petro-Chemicals Corporation Ltd.(ICPL), Vadodara held at Jalgaon, Maharashtra in December,1993, the paper on present status of Drip Irrigation in India by Associate Professor Jaspal Singh of the College of Technology & Agricultural Engineering (CTAE), Udaipur gives the areas covered by drip irrigation in different States as follows :

Sl.No.	State	Area (ha.)
1.	Maharashtra	31,363
2.	Tamil Nadu	2,529
3.	Karnataka	2,023
4.	Andhra Pradesh	809
5.	Gujarat	405
6.	Kerala	405

Brackish water (Salt water) can also be used for drip irrigation.

Sl.No.	State	Area (ha.)
7.	Rajasthan	283
8.	Other States	N.A.
Total		**37,817**

The paper on Sprinkler and Drip Irrigation in India by Shri R.S. Saksena while stating about the non-availability of authentic figures under drip irrigation concludes that the only reliable source is loan sanctions made for this system by NABARD and went on to describe the state-wise coverage under NABARD Schemes. The figures arrived thus would also not be authentic as quite a few progressive farmers have installed drip systems without any loan assistance from NABARD.

However, NABARD has independently estimated the present total area under drip irrigation as 55,000 ha with achievements during different years as given below :

Year	Achievement (ha.)
Upto 1990	20,000
1990-91	5,750
1991-92	14,560
1992-93	14,680
Total	**54,990**
Say	**55,000**

Source : *All India Seminar on Sprinkler and Drip Irrigation held on 9th and 10th December, 1993 organised by the Institution of Engineers (India), Andhra Pradesh Centre, Hyderabad : Availability of Credit for Drip Irrigation System in India by Shri P.K. Chatterjee, Dy. General Manager, NABARD.*

The paper on Drip Irrigation : Indian Experience and Growth Strategy by S/Shri Rabi Gayen, Marketing Manager and S. Ravishankar, Sr. Marketing Officer, Indian Petro-Chemicals Corporation Ltd., Vadodara gives the area under Drip Irrigation as follows:

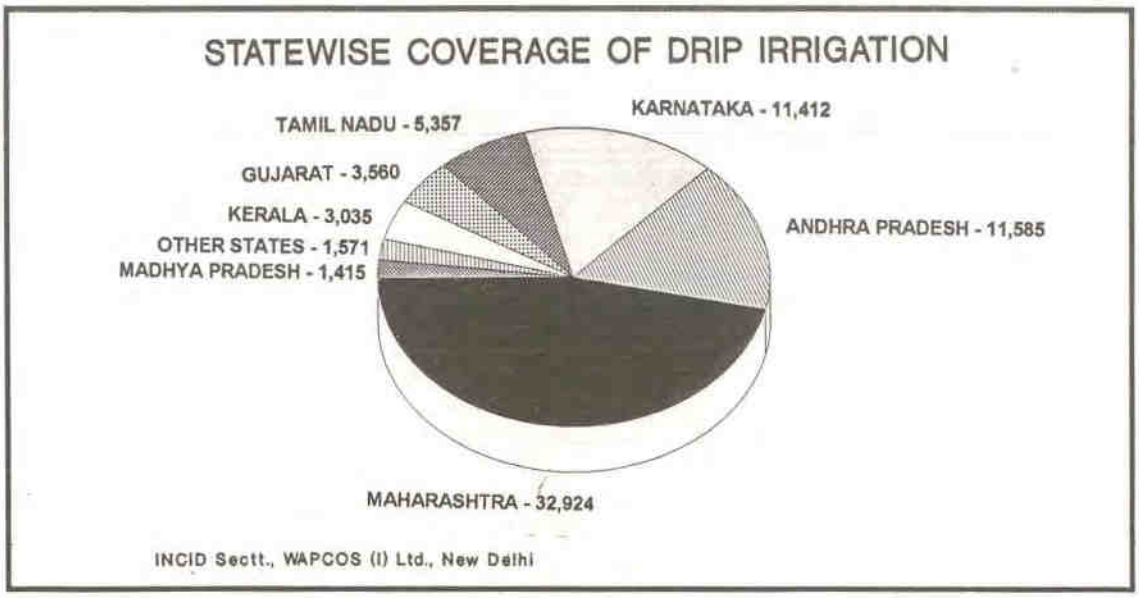
One labourer can easily attend to drip irrigation upto 10 ha.

Sl. No.	State	Area under drip irrigation (ha.)
1.	Maharashtra	38,000
2.	Tamil Nadu	9,000
3.	Karnataka	7,000
4.	Gujarat	6,000
5.	Andhra Pradesh	3,000
6.	Other States	3,000
	Total	**66,000**

With a view to know the exact coverage of area by drip irrigation, INCID Secretariat made concerted efforts to collect the figures from different sources. Letters requesting supply of such information were made out to various State Governments, Drip Equipment Manufacturers and individual experts in the field to furnish the figures of areas under drip irrigation crop-wise, in different States. A large number of Manufacturers have responded and furnished the figures which have been compiled State-wise in **Annexure-IV** and Crop-wise in **Annexure-V** and summarised as follows:

Sl. No.	State	Area under drip irrigation (ha.)
1.	Maharashtra	32,924
2.	Andhra Pradesh	11,585
3.	Karnataka	11,412
4.	Tamil Nadu	5,357
5.	Gujarat	3,560
6.	Kerala	3,035
7.	Madhya Pradesh	1,415
8.	Rajasthan	304
9.	Assam	180
10.	Haryana	120
11.	Uttar Pradesh	111
12.	West Bengal	100
13.	Other States	756
	Total	**70,859**

Land levelling is not necessary for drip irrigation.

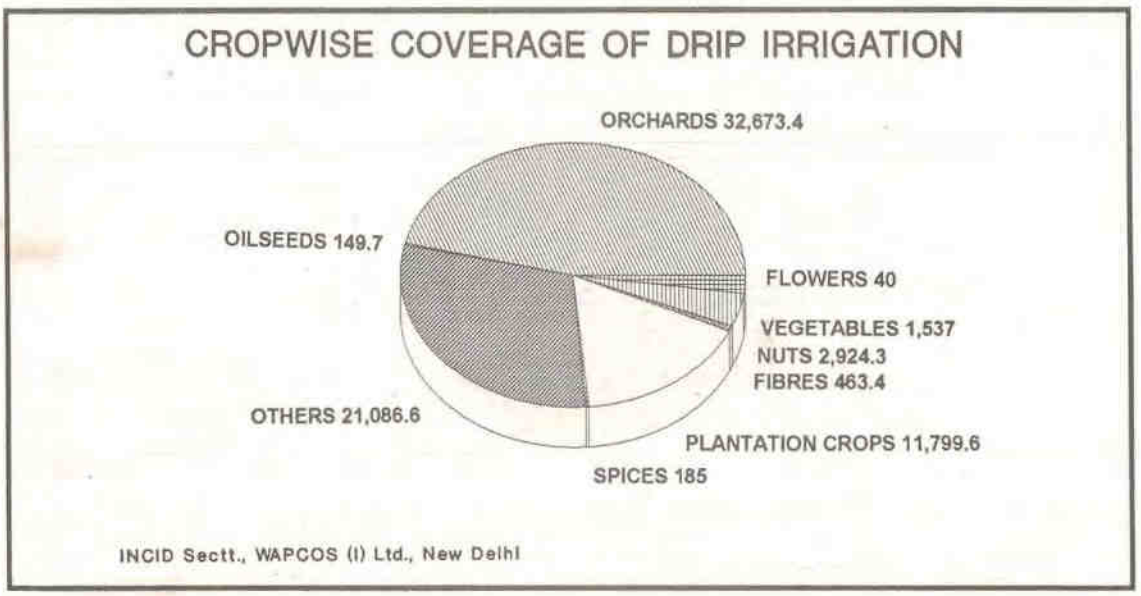


It is possible that there may be some more Manufacturers who might have carried out installations and not responded. These figures also need be collected and incorporated. Nevertheless, the coverage figure arrived at by INCID Secretariat on the basis of information furnished by various manufacturers is quite close to the figure reported by IPCL. However, the State Government/ Agencies will have to look into the matter and update the coverage figures for their States Crop-wise as these would be quite useful for any futuristic planning. It is recommended that the States may systematically collect the data from various sources, viz. Manufacturing Firms; Financial Agencies like NABARD; users etc and publish the data periodically.

The crop-wise coverage in the country on the basis of information furnished by Manufacturers is given below :

Sl. No.	Crop	Area under drip Irrigation in (ha.)
1.	Flowers	40.0
2.	Fibres	463.4
3.	Nuts	2,924.3
4.	Oilseeds	149.7
5.	Orchards	32,673.4
6.	Plantation Crops	11,799.6
7.	Spices	185.0
8.	Vegetables	1,537.0
9.	Others	21,086.6
	Total	**70,859.0**

Drip irrigation is specifically suited for high value crops.



Many institutions and Universities organised and conducted several national and regional seminars on Drip Irrigation from 1982 onwards including numerous training programmes. Under the banner of INCID also, a Mini-Workshop was held in August, 1992 to discuss the draft report on Drip Irrigation in India, prepared by Dr. R.K. Sivanappan. The details of Seminars/Training programmes with their main recommendations are given in **Annexure - VI**.

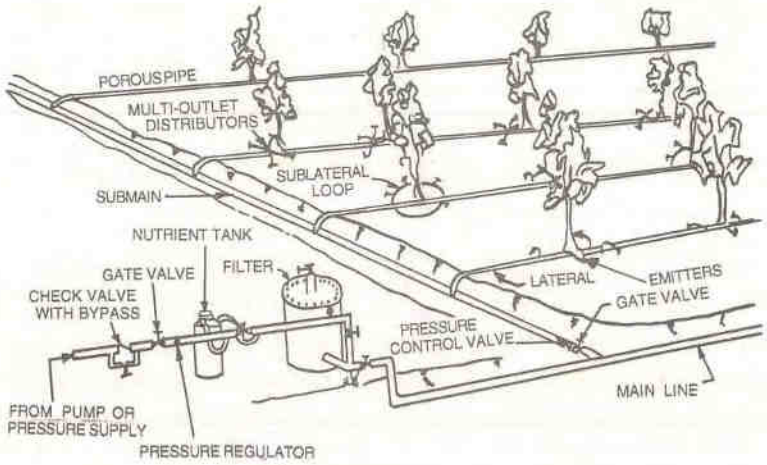
3.2 DIFFERENT TYPES OF DRIP IRRIGATION SYSTEMS IN INDIA.

3.2.1 What Drip System Consists of:

Drip Systems vary according to topography, size and shape of irrigated area, crop type and planting pattern besides the drip equipment itself. However, a drip irrigation system basically consists of main line, sub-main, laterals, valves, drippers or emitters, a riser valve, vaccum breakers, pressure gauges, water meters, filters, fertilizer tanks or venturi pumps, flush valves and pressure regulators, as can be seen from figure 3.1.

From the main, feeder lines are run across the field and laterals are inserted on the same. Low density polyethylene pipes are laid along the plant or tree rows with outlets or drippers inserted at appropriate intervals. These are designed to supply water at the desired rates (1 to 10 litres per hour) directly to the soil. Low pressures ranging from 0.35 to 2 Kg/sq.cm are sufficient to work. Usually 3.75 to 7.00 cm diameter pipes are used for mains, and 2.5 to 3.75 cm for sub-mains. For laterals, pipes of various ranging from 6 mm to 18 mm with a pressure rating of 4 atm are generally used.

Expand cultivated area through drip irrigation.



ATYPICAL DRIP IRRIGATION SYSTEM
FIG. 3.1

3.2.2 Biwall Irrigation.

Biwall is an extruded dual chamber micro-irrigation tubing, manufactured from a Linear Low Density Polyethylene (LLDPE). Holes are drilled by laser beam at regular intervals (50, 75, 100 cm) along the tube to give even and equal amounts of water to plants over long lengths. Water is delivered from the main chamber through a distribution chamber with evenly spaced supply orifices provided by laser beams. It is then slowly released through emission orifices. This system is suitable for all closely spaced row crops like sugarcane, cotton, vegetables, grapes, pineapple, onion, tea etc.

3.2.3 Micro Sprinkler and Micro Sprayer Irrigation.

This is a combination of sprinkler and drip irrigation. Water is sprinkled around the root zone of the trees with a small sprinkler working under low pressure. This unit is fixed in a network of tubing but can be shifted from place to place around the area. Water is given only to the root zone area as in the case of drip irrigation but not to the entire ground surface as done in the case of sprinkler irrigation method.

The other different drip systems are (i) single chamber tube; (ii) dual wall; (iii) twin wall; (iv) T-type; (v) Gal-drip; (vi) tri-wall triple chamber; (vii) Leaky pipe; (viii) Typhoon, etc.

3.3 SYSTEM COMPONENTS.

The components of drip irrigation system can be grouped into two major heads viz.

i) Control head and
ii) Distribution network.

3.3.1 Control head.

The control head of drip irrigation includes the following components :

I. Pump/Overhead Tank.

Pump or an overhead tank is required to provide sufficient pressure in the system. Centrifugal pumps are generally used for low pressure trickle systems. They are easily adjusted to provide constant pressure and have the added safety measure of non-overloading head characteristic. Pumps are generally recommended for larger areas under drip irrigation, undulating topography, closely spaced crops or where water requirement is high comparatively.

Instead of connecting directly to the pump, an overhead tank having a height of about 3 meters can also be used in certain types of drip system. Overhead tank is generally used for small areas of orchard crops with comparatively lesser water requirement.

II. Filters.

The hazard of blocking or clogging necessitates the use of filters for efficient and trouble free operation of the drip system. The different types of filters include;

a) Media filter.

Media filter consists of fine gravel and sand of selected sizes placed in a pressurized tank. It is required to remove organic matter such as algae mass and other vegetative material present in the water. The filters are made up of a circular tank filled with layers of coarse sand and different sizes of gravel with a provision of valves for flushing the filter assembly in case of clogging. The media filters are available in different sizes ranging from 500 to 900 mm diameter with an output of 15 to 50 Cum respectively.

b) Hydro-cyclones or Centrifugal filters or sand separators.

If the irrigation water is having more sand, hydro-cyclone type filters are required to remove the sand; it is also known as vortex sand separator. Hydro-cyclone type filters are produced in various sizes for different discharges and have been found most suitable for removing particles from water before it enters the drip irrigation system. Hydro-cyclones must be followed by a screen filter as a safeguard.

Overall efficiency of drip irrigation system is almost double that of surface irrigation.

c) **Screen Filter.**

The screen filter is fitted in series with the gravel filter in order to further remove the solid impurities like fine sand, dust etc. from the water. In general, the screen filter consists of a single or double perforated cylinders placed in a plastic or metallic container for removing the impurities. Generally 100 to 200 mesh screens are used in this type of filters. It must be cleaned and inspected periodically for satisfactory operation of any drip system.

A different type of filter is the 'Volumetric' filter which instead of screen has concentric grooved rings that are mounted on a longitudinal shaft. When tightened together, the rings form a cylindrical filtering body.

Automatic cleaning of filters either by electronic or hydraulic devices are now-a-days used in drip and micro-sprinkler systems.

iii. **Fertilizer Applicators/Fertigation.**

The direct application of fertilizer through drip irrigation has increased the efficient use of fertilizer along with saving in labour and money.

Application of fertilizer into pressurised irrigation system is done by either a by-pass pressure tank, or by venturi pump or direct injection system.

In by-pass system, by closing main system valve, certain quantity- generally 10% of flow quantity is allowed to by-pass through fertilizer tank. Then the by-passed water along with dissolved fertilizer goes into the system. In the venturi-pump type fertilizer application, some water is passed through the venturi (decreasing the diameter in taper form) where velocity head is created, due to increase in velocity at the place. This will create a suction head and will suck the fertilizer solution in the system.

In direct injection type, pumps of piston type or diaphragm type are used. These pumps operated by the system pressure only, give fixed quantity of fertilizer in the water throughout irrigation.

iv. **Pressure Regulators.**

Pressure regulators are generally used to decrease the higher system pressure to the lower required system pressure. It controls pressures in one way only i.e. high to low. Pressure regulators are required on a large scale design, undulating terrain and slopy land etc. For normal small system, a simple by-pass valve can be used to control pressure in the system.

Drip irrigation offers very high efficiency of water use.

3.3.2. Distribution Network.

The distribution network mainly constitutes main line, submain line, sub-submain line and laterals with dripper and other accessories.

i. Main Line, Submain Line.

Generally Rigid PVC and High density Polyethylene(HDPE) pipes are used as main line. Pipes of 65 mm diameter and above with a pressure rating of 4 to 6 Kg/sq.cm are recommended for main pipes. These pipes laid underground, offer a long life of more than 20 years. For sub-main pipes, Rigid PVC, HDPE or LDPE (Low Density Polyethylene) are recommended. Pipes having an outer diameter ranging from 32 mm to 75 mm with a pressure rating of 2.5 Kg/sq.cm are used as sub-mains. These pipes may be laid above the ground or underground.

ii. Laterals.

The laterals/drip lines are normally manufactured from LDPE (Low Density Polyethylene). These pipes are generally laid above the ground. Recently a better material than the presently used LDPE i.e., Linear Low Density Polyethylene (LLDPE) is being used. The linear low density polyethylene gives more protection against ultra violet rays and longer life of pipe than LDPE.

Generally pipes having 10, 12, 16, and 20 mm internal diameter with wall thickness varying from 1 to 3 mm are used in drip system.

iii. Polytype.

It is made with LLDPE with super speed extrusion for high pressures and stress and crack resistance.

3.3.3 Drippers/Emitters.

Drippers function as energy dissipators, reducing the inlet pressure head (0.5 to 1.5 atmosphere) to zero atmosphere at the outlet. These drippers are generally manufactured from poly-propelene material.

a) Inline Drippers.

The inline drippers are fixed along with the line i.e. the pipe is cut and dripper is fixed in between the cut ends, such that it makes a continuous row after fixing the dripper. The inline drippers have generally a simple thread type or labyrinth type flow path. With the labyrinth type flow path, it is possible to have larger cross section area and turbulent flow of water to prevent clogging of dripper. The inline drippers are available with discharge of 2, 3, 4, 8 litres/hr. at 1 atm. pressure. These drippers can be fixed in 10 to 13 mm internal diameter pipes.

Drip irrigation offers more crop yields.

b) **Online Drippers.**

The online drippers are fixed on the lateral by punching suitable size holes in the pipe. These drippers can be classified into simple or non-pressure compensating type and pressure compensating type.

i. Simple type/Laminar flow.

In simple type dripper, the discharge of dripper is directly proportionate to the pressure. These drippers have either a simple thread type, labyrinth type, zig-zag path, vortex type flow path or have float type arrangement, to dissipate energy. Generally these types of drippers have discharge of 2, 3, 4, 8, 16 litres/hr relating to 1 atm. pressure. Some types of on-line drippers have multiple openings 2, 3, or 4 which can be used for spot irrigation.

ii. Turboy Key Drippers.

These are made from virgin and stabilized polymers and are available in 2, 4 and 8 lph discharge. It is blockage resistant and pressure compensating one.

iii. Pressure Compensating Drippers.

This type of dripper gives fairly uniform discharge at pressure varying from 0.3 to 3.5 atm. Generally the drippers give 2, 3, 4, 8 litres/hr discharge at varying pressure. This type of drippers are provided with a high quality rubber diaphragm to control pressure. The pressure compensating type drippers are most suitable on slopes and difficult topographic terrains.

iv. Built-in Dripper Tube.

In this system, polyethylene drippers are inseparably welded to the inside of the tube during extrusion of polyethylene pipes. The drippers are provided with independent pressure compensating water discharge mechanism and extremely wide water passage to prevent clogging. These types of drip lines are available with 0.6, 0.75 and 1.0 m spacing, with a capacity of 2 to 3.5 lph discharge at 0.5 to 4 atm pressure.

v. Laser Beam.

Perforated polyethylene pipe drip line; In this system instead of dripper a hole is drilled longitudinally at 5°C to horizontal line by a laser beam. Drip lines are available in diameter of 12, 16, 20 mm with standard nominal discharge rate of 4 and 6 litres/hr at working pressure of 1 atm.

Other Accessories.

The other accessories include take out/starter, rubber grommet, end plug, joints, tees, manifolds, etc. All these components are available in 4, 10, 12, 16 and 20 mm sizes. The takeouts are used for taking out laterals/driplines from sub-main.

Drip irrigation requires less tillage.

Simple shut-off valves : The simplest small scale control is the volumetric valve, which shuts-off automatically after pre-determined volume of water has been delivered. Such valve can work sequentially, one valve opening as the previous one shuts-off, enabling the irrigation of large fields without human intervention.

Small Scale electronically controlled Units : The unit can control a limited number of valves in a relatively small area. The units are capable of regulating irrigation on the basis of quantity and/or time detecting and controlling excessive or insufficient flow rate, automatic shut-off when the pressure is too low, starting and terminating irrigation based on sensor reading and control of fertilizer injection into the net-work.

Large Scale Computer based System : A computer based system consists of three main units :

- A Master Control Unit (MCU) which may be located kilometers away from the field. It has a computer and issues instructions to the field units for operation of valve, pump, fertilizer injection etc.

- The field units, which receive the instructions of MCU and transmit information from the field to MCU for processing.

- The communication link, an underground electrical cable, carries the instructions to the field unit and feed back information to the MCU and also supplies if necessary, power to the field units.

A large computerised system can control hundreds of valves and irrigate an extensive area.

A large variety of crops are being grown with drip systems. However, the system is generally most successful for high value crops because of the relatively high initial cost. Crops which have been grown with this system include the following :

i) Orchard crops such as grapes, citrus, apples, pomegranate, pears, delicious fruits (peaches, apricots, plums, etc.), nuts (almonds, pistachios), bananas, dates, olives, mangoes, guavas, etc.

ii) Vegetables - tomato, green pepper, cucumber, lettuce, green pea, cauliflower, etc.

iii) Row and field crops - cotton, sugarcane, sorghum, corn and groundnut.

iv) Others - berries, melons, alfalfa, flowers (carnations, gladioli and roses) and other ornamental plants.

Drip irrigation offers improved plant protection and less diseases.

3.4 DESIGN OF DRIP IRRIGATION SYSTEM.

The design of drip system broadly involves selection of emitters, laterals, submains, mains and pumping units. The steps need to be followed for designing the drip irrigation system are given below:

i. Collection of General Information.
ii. Lay-out of the field.
iii. Cropwater Requirement.
iv. Hydraulic Design of the System.
v. Selection of Components.

STEP - 1 : Collection of General Information.

General information on water source, crops to be grown, topographic conditions, type and texture of soil and climatic data are essential for designing the drip irrigation system.

STEP - 2 : Lay-out of the Field.

The layout of the field by giving the path and lengths of main line, sub-mainline and lateral lines in meters is worked out to connect water source with the existing/planned crop in the area.

STEP - 3 : Crop Water Requirement.

The monthly crop water requirement is estimated with the formula,

$$V = Ep \times Kc \times Kp \times A \times N \text{ litres}$$

Net Volume of water to be applied (Vn) = V - Re x A litres.

Number of Operating hours of System (T) during a month

$$= \frac{Vn \times Wp}{\text{No. of drippers per plant} \times \text{No.of plants} \times \text{dripper discharge}}$$

$$\text{Operating hours per application} = \frac{T}{Nm}$$

Where

V is Volume of Water required in litres.

Drip irrigation offers higher efficiency in fertilizer application.

Ep is Mean pan evporation for the month in mm/day.
Kc is Crop factor
Kp is Pan factor
A is Area to be irrigated (Sq.m.)
N is Number of days in the month.
Re is Effective rainfall in mm.
Wp is Percentage wetting
Nm is Number of applications per month.
T is number of operating hours per month

STEP - 4 : Hydraulic Design of System.

The ideal drip irrigation system is one in which all drippers (or orifices) deliver the same volume of water in a given irrigation time. From the practical point of view, it is almost impossible to achieve this ideal performance. However, the dripper flow variation caused by water pressure can be controlled by hydraulic design.

Flow carried by each lateral line (de)

= discharge of dripper x no.of drippers per lateral line.

. Flow carried by each sub-main line (ds)

= de x no. of lateral lines per sub-main line.

Flow carried by each main line (dm)

= ds x no. of sub-mains

Select the diameter of lateral sub-main and main line.

Calculate the pressure drop due to friction in main, sub-mains and laterals with the help of any commonly used equations such as Blassius equation, Williams and Hazen equation etc.

STEP - 5 : Selection of Components.

The Finalisation of dimensions of main, sub-mains & laterals and selection of pump consists of the following steps :

Total pressure head drop in metres due to friction (Hf)

= friction head loss of mains +

Drip irrigation permits use of poor quality of water.

friction head loss of sub-mains +
friction head loss of laterals.

Operating pressure head required at the dripper = He is metres

Total static head = Hs is metres

Total Pumping Head (H) = Hf + He + Hs

Discharge of main = dm litres/Sec

Efficiency of pump = Mp %

Efficiency of motor = Mm %

$$H.P. = \frac{H \times dm}{75 \times Mp \times Mm}$$

High skill is needed for designing the drip irrigation system. Any improperly designed system will pose numerous problems. It is therefore, suggested that assistance of experienced personnel/agencies only may be availed for the design and proper lay-out of the system. The drip system manufacturers are doing a commendable job, in reaching a wide cross section of farmers and supplying good drip systems. More than 50 drip system manufacturers are operating in our country with requisite expertise in the design and installation of drip systems. Some of them are having tie-ups with international companies and have developed reasonably good net-work to cater to the needs of the farmers.

3.5 RELATIVE ADVANTAGES AND DISADVANTAGES/LIMITATIONS.

Each irrigation method has its own advantages and disadvantages with specific reference to technical, economical and crop production factors. Drip Irrigation System also has advantages and disadvantages to its credit with advantages outweighing the disadvantages, as can be seen below:

3.5.1. Advantages.

i. Water Saving.
Due to partial wetting of the soil volume, reduced surface evaporation, decreased run-off and controlled deep percolation losses, the water use efficiency is as high as 90 to 95 percent compared to only 40 to 50 percent in the conventional furrow or flood irrigation.

ii. Enhanced Plant Growth and Yield.
Slow and frequent watering eliminates wide fluctuations in soil moisture

Drip irrigation offers less weed growth and prevents potential pests.

content resulting in better growth and yield. It has been reported that drip irrigation increases the yield from 10 to 230 percent depending upon soils and crops over conventional methods of irrigation.

iii. **Saving in Labour and Energy.**
There is considerable saving in labour as the well designed system needs labour only to start or stop the system. Because of high irrigation efficiency, much time is not required to supply the desired quantity of water, thus, it also saves energy.

iv. **Most Suitable to Poor Soils.**
Very light soils are difficult to irrigate by conventional methods due to deep percolation of water. Like-wise, very heavy soils with low infiltration rates are difficult to irrigate even by sprinkler method. However Drip irrigation has been found successful in both the types of soils.

v **Control of Weeds.**
Due to partial wetting of soil, weed infestation is very less in comparison to other methods of irrigation.

vi **Economy in Cultural Practices and Easy Operations.**
Besides achieving effective control of weeds, it also increases the efficiency of other operations like spraying, weeding, harvesting etc. thereby reducing the operational costs even upto the extent of 50 percent.

vii. **Possibility of Using Saline Water.**
High soil moisture content due to frequent irrigation and lesser water requirement upto even 60 percent than surface method keeps saline concentration below the detrimental level.

viii. **Improves Efficiency of Fertilizer.**
Because of reduced loss of nutrients through leaching and run-off water and also due to localized placement, the fertilizer use efficiency can be improved considerably.

ix. **Flexibility in Operation.**
This system can be worked at any part of the day when power is available.

x. **No Soil Erosion.**
There is no soil erosion due to drip irrigation.

xi. **Easy Installation.**
This system can be installed with considerable ease and is equally beneficial to both small and big farmers.

Drip irrigation can be used conveniently in hilly terrain and problematic soils.

xii. **No Land Preparation.**
Preparation of levelled bed, bund and channels is not necessary. Only land smoothening will suffice.

xiii. **Minimum diseases and Pest Problems.**
Minimum diseases and Pest Problems are observed because of less atmospheric humidity.

3.5.2 Disadvantages/Limitations.

Despite observed successes, some problems have been encountered in the mechanics of applying water with drip equipment for some soils, water qualities and environmental conditions. Some important limitations are described below :

i. **Persistent Maintenance Requirements :** Emitter clogging is considered the most serious problem in drip irrigation unless preventive measures are taken. It is therefore necessary that water should be filtered properly and this can be expensive. Apart from this, salt and chemical deposits can accumulate plugging the discharge openings. Clogging will adversely affect the rate and uniformity of water application, increased maintenance costs (as it becomes necessary to check, replace or reclaim the clogged emitters), and result in crop damage and decreased yield, if not detected early and corrected timely.

Other maintenance problems include pipe line leaks and cracking of the tubes. Rodents, coyote, rabbits, dogs, etc. can chew and damage drip line; and ants and other insects have occasionally enlarged openings in drip tubings. Drip lines can be cut or dug-up accidentally when weeding, replacing plant material or when replacing or repairing other pipe lines or utilities in nearby areas. Filters, chemical injectors, pressure regulators, water meters and pumps are also subjected to malfunctioning and are liable to theft.

ii. **Salinity Hazards :** Although drip system can be used under saline conditions, they must be managed properly. Otherwise reverse pressure gradients in the soil will cause flow of salts towards plant root with the resulting detrimental effects.

iii. **Economic-Technical Limitations :** Because, equipment require-ments are numerous with drip irrigation, initial investment and annual costs may be high when compared with surface or portable sprinkler irrigation systems. The actual costs will vary considerably depending on the types of crops, grades of pipe lines, filtration equipments, fertilization equipments etc. Generally, drip irrigation is more suited to widely spaced crops.

Drip irrigation offers improved infiltration in soils of low intake.

iv. High skill is required for designing the installation and subsequent operation.

Technical improvements in the designs of emitters, fittings, filters, etc. have been necessary; the development procedures for preventing or correcting emitter clogging and equipment failure have been difficult; and the development of the proper methods for injection of fertilizers and other chemicals has sometimes been a problem. A higher level of design, management and maintenance is required with drip than other irrigation methods.

Drip irrigation system keeps space in between crop rows dry and weed free.

DRIP IRRIGATION FOR POTATO WITH MULCHING
(Courtesy : PDC, CTAE, Udaipur)

POTATO CROP UNDER DRIP IRRIGATION
.(Courtesy : PDC, CTAE, Udaipur)

CHAPTER - 4

DRIP IRRIGATION RESEARCH

4.1 GENERAL.

4.1.1 Drip Irrigation is used extensively in many Countries although it's development in India is small compared to other methods of irrigation. Experiments and farm trials have been going on in India from 1970 onwards. Progressive farmers in the States of Andhra Pradesh, Kamataka, Kerala, Maharashtra and Tamil Nadu have introduced this method in the late seventies, eventhough there was no subsidy or any support from the State Governments at that time.

4.1.2 Research work/studies have been taken-up by various Agricultural Universities, Research Institutions, Manufacturers, farmers etc. The IPCL/NCPA has sponsored many research schemes under the Plasticulture Development Centres (PDC) to the various institutions in the country from 1985 onwards. The results of various research studies undertaken for the last 20 years are described briefly under each institution.

4.2 TAMILNADU AGRICULTURAL UNIVERSITY, COIMBATORE, TAMILNADU.

At the College of Agricultural Engineering, Tamilnadu Agricultural University, Coimbatore, studies on drip irrigation are being carried out from 1970 onwards. A low cost drip irrigation system was designed and fabricated to determine the water use for various vegetable and fruit crops. Extensive experiments were conducted to study the water requirements and yields of various crops, namely, tomato, lady's finger, radish, beetroot, brinjal, sweet potato, chillies, papaya, banana, cotton and sugarcane. The results have indicated that the water required under the drip method was about one-third to one-half of that under surface method and the yield was invariably more in drip system, when compared to the surface method.

4.3 INDIAN AGRICULTURAL RESEARCH INSTITUTE, NEW DELHI.

The drip irrigation equipments used at Indian Agricultural Research Institute, New Delhi are nozzle type buried underground and of self-flushing type. Jacketed nozzles were buried at 20 cm below the alluvial soils at Indian Agricultural Research Institute farm and the pattern of moisture redistribution was noticed at weekly intervals. Extensive field studies were conducted to optimise the spacing of emitters, the water application rate and the duration of irrigation based on the hydraulics of soil moisture front.

Comparing the drip method with conventional basin irrigation for onions and lady's finger, significant increases in yield and water use efficiency in the drip method were

Drip irrigation generally suits any type of crop, soil and climate.

observed. This system ensured the availability of soil moisture at low tensions and reduced surface evaporation. It is also reported that the soil moisture in the wetted zone resulting from a point source of water application manifested itself by a rapid increase in the soil moisture content in the soil layer close to the point of water application. This zone was identified to extend to a depth of about 15 to 20 cm.

In a recent study conducted at IARI on crop response to drip and furrow for tomato, the root spread area at a depth 30-40 cm below the ground surface indicated that it was greater in the plants irrigated by the furrow than those irrigated by the drip method. The yield of the crop has increased more than 50% in drip irrigated field over the furrow irrigation. Nitrogen concentration was maximum at a depth of 30-60 cm minimum at a depth of 60-90 cm below the soil surface under both drip and furrow methods.

4.4 UNIVERSITY OF UDAIPUR, JOBNER, RAJASTHAN.

Under the All India Coordinated Scheme on Water Management, experiments on the drip irrigation were conducted at Jobner. During 1974-75, trickle irrigation was tried for pomegranate and compared with check basin irrigation. It was observed that the water applied by trickle was only 76.5 litres as compared to 110.3 litres in the basin method. When the plants were given irrigation, the same amount of water namely 211.50 litres in both the methods, the plant growth in trickle irrigation was 3.22 times more than that of basin irrigation. Similar results were obtained in the case of eucalyptus plants. Drip irrigation resulted in significant increase in production and water use efficiency of potato.

4.5 UNIVERSITY OF UDAIPUR, UDAIPUR, RAJASTHAN.

At the College of Technology and Agricultural Engineering, University of Udaipur, it was reported that besides the saving in water, the yield of potato tubers was high and the effect of frost was minimum and weed growth was the least during 1970-71. During the year 1972-73, the experiment was repeated with improved design of drippers. Water was given at the rate of 28.35 cm/plant/hour which resulted in a saving of 47 per cent over furrow method and yield was increased by 74.2 per cent.

4.6 HARYANA AGRICULTURAL UNIVERSITY, HISSAR, HARYANA.

Comparative studies of drip versus surface method were conducted in small plots with onion, sugarbeet, potato and radish. It was found that the drip method produced significant higher yields and also resulted in greater water use efficiency (Table 4.1).

In yet another experiment, the size of the onion under surface irrigation was only 6.15 to 7.20 cm as compared to 7.71 cm when irrigated by drip. Similarly, the weight of lady's finger was only 5.47 to 6.24 kg per plant when surface irrigated as compared to 6.88 kg per plant of drip irrigated.

Plants never face water stress with drip irrigation.

Table 4.1
Comparative Studies of Drip and Surface Method - Hissar.

Crop	Total Water in mm	Surface		Drip		Total Water (mm)
		Yield (q/ha)	W.U.E. (q/ha/cm)	Yield (q/ha)	W.U.E. (q/ha/cm)	
Onion	602.00	93.00	1.54	112.00	2.48	451.00
Sugarbeet	495.00	418.40	8.45	489.00	13.17	371.20
Potato	200.00	235.70	11.78	344.20	22.95	150.00
Radish	--	174.93	9.43	268.13	29.78	--

4.7 CENTRAL ARID ZONE RESEARCH INSTITUTE, JODHPUR, RAJASTHAN.

At the Central Arid Zone Research Institute, Jodhpur, Rajasthan higher yield of tomatoes was obtained with only two-third water use as compared to furrow method. Only 50 per cent water applied through drip in comparison to furrow yielded almost same yield and the water use efficiency was doubled.

4.8 UNIVERSITY OF AGRICULTURAL SCIENCES, DHARWAR, KARNATAKA.

Experiments conducted at the University of Agricultural Sciences at Dharwar in Karnataka State on the evaluation of drip and furrow methods of irrigation of cabbage have indicated that (a) 46.25 per cent of water was saved in drip system; (b) 17.65 per cent of increased yield was obtained in drip system; (c) the weed infestation was less by 40.32 per cent in drip and (d) early maturity of crop was noticed in drip irrigation as compared to furrow irrigation. The studies on the effect of drip irrigation, compared to the check basin method for grapes have revealed that the drip method resulted in 88.8 per cent higher yield per unit quantity of water over the control. The net return per hectare per cm of water was 39.68 per cent more under the drip system than the check basin system.

4.9 MAHATMA PHULE KRISHI VIDYAPEETH, RAHURI, MAHARASHTRA.

Studies on drip irrigation were conducted by growing vegetables and cash crops at Rahuri in Maharashtra State. With the optimum pressure of 0.5 Kg/cm in the laterals of the drip system and considering wetted area for the vegetable crop to the extent of 60 percent, it was observed that there was substantial water saving ranging from 30 to 60 per cent in different crops. At the same time, there was substantial increase in the yield (5-24 per cent) in all crops. The overall capital investment alongwith its maintenance cost could be recovered within three crop seasons. The water used and yields obtained for various crops are given in Table 4.2.

Drip irrigation system is ideally suited to vineyards and orchards.

Table 4.2

Water Applied, Yield, W.U.E. As Influenced By Different Methods of Irrigation for Different Crops - **Rahuri**

S. No.	Crop	Water applied in cm		Yield (q/ha)		W.U.E. (Kg/ha/cm)		Water Saving by drip over traditional method (%)	Increase in yield by drip over traditional method (%)
		Tradi-tional method	Drip method	Tradi-tional method	Drip method	Tradi-tional method	Drip method		
1	2	3	4	5	6	7	8	9	10
1.	Cotton	89.53	42.00	22.55	28.46	25.19	67.76	53.0	26.0
2.	Lady's finger	219.86	113.32	189.02	203.41	85.97	179.50	55.0	8.0
3.	Tomato	29.70	20.84	164.00	171.86	552.19	824.66	27.0	5.0
4.	Brinjal	90.00	42.00	28.00	28.00	31.11	66.67	55.8	-
5.	Sugarcane	231.00	162.20	1,220.90	1,464.10	5,285.3	9,026.51	30.0	10.0

4.10 BIDHAN CHANDRA KRISHI VISHWA VIDYALAYA, KALYANI, WEST BENGAL.

Studies were conducted at Bidhan Chandra Krishi Vishwa Vidyalaya, Kalyani, West Bengal on potato crop in the field with three levels of soil moisture tension, four levels of nitrogen and two methods of irrigation namely, furrow and drip. The results have indicated that the measured total evapotranspiration values were significantly higher in furrow irrigation. Compared to the total evapotranspiration values in drip, the corresponding value in furrow irrigation was about 12.26 per cent more. It was also revealed that the yield was always higher under drip irrigation.

4.11 CENTRE FOR WATER RESOURCES DEVELOPMENT AND MANAGEMENT, KOZHIKODE, KERALA.

At the Centre for Water Resources Development and Management, Kozhikode, Kerala, studies were conducted to compare the drip method with the conventional methods such as ring and basin methods for coconut. Under drip method, the quantity of water applied was about 30 lit/day/tree. About 360 lit of water were applied once in six days (60 lit/day/tree) in the case of ring and 600 litres once in six days in the basin method (100 litres/day/tree). No difference in yield was noted among the various treatments. The trials conducted for banana crop has indicated that the treatment involving micro irrigation daily with mulching was superior to other treatments in saving water and crop performance. The quantity of water used for micro irrigation was 4-6 lit/plant against 20 litres in the conventional method.

4.12 ICAR COMPLEX FOR NORTH EASTERN HILL REGION, SHILLONG, MEGHALAYA.

The Scientists of the Indian Council of Agricultural Research Complex for North Eastern Hill Region have studied the techniques of bamboo drip irrigation system used for betel and pepper irrigation planted with arecanut on hills having about 45 to 100 percent slope. Water distribution in bamboo drip irrigation system is done with the use of bamboo channels, water division pipes with thin bamboo strips. The whole system enables distribution of 15 to 20 litres of water per minute entering into the main channel to 10-80 drops per minute at the sites of water application, without leakage at any point. The study revealed that with the help of bamboo drip system, meagre quantity of water available can be well utilised for irrigating betel pepper plantations. By this method, irrigation can be done in steep slopes without causing any erosion.

4.13 INDIAN INSTITUTE OF HORTICULTURAL RESEARCH, BANGALORE, KARNATAKA.

The studies conducted at the Indian Institute of Horticultural Research, Bangalore for banana have indicated improved growth, early flowering, higher productivity, more dry matter accumulation and nutrients with increased water use in drip method compared to basin irrigation. The yield of banana under drip irrigation was markedly higher as compared to basin irrigation largely due to significant differences in bunch weight.

4.14 PUNJABRAO KRISHI VIDYAPEETH, AKOLA, MAHARASHTRA.

Experiments were conducted to compare drip with traditional method of irrigation for vegetable crops such as cauliflower, tomato and brinjal. The research findings summarised and presented in Table 4.3 show 30 to 50% saving in water and substantial increase in crop yield through drip irrigation.

Field experiments on drip irrigation for Orange crop showed that water saving was more than 50% and the wetted area was 10 to 20% of the traditional irrigation system. The soil moisture content in the root zone was within 70-100% of the field capacity of soil in drip and the accumulation of salt was found to be maximum at the periphery of wetted area. The weed infestation was minimum in drip irrigated plots.

Other studies carried out by PKV, Akola were as follows:

a. Effect of length and diameter of micro-tubes and flow rate on head loss was studied and prediction equation was developed for laminar flow condition to determine the head loss due to friction in micro-tube.

b. Soil moisture distribution pattern from point source of application under different discharge rates and different volumes of application in clay and clay loam soils was studied.

Drip irrigation ensures uniform water distribution.

c. Effect of changed planting geometry under drip irrigation was studied for tomato crop 60 cm x 60 cm square planting and 90 cm x 40 cm rectangular planting. In rectangular planting, nearly 10% more yield and 16% saving in the cost of drip system was observed.

d. Research work was done to bring out chemigation schedule for cleaning the sets clogged due to inorganic participants and algae growth and the following recommendations were made :

   i. Monthly treatment of low concentration hydrochloric acid (6pH) is essential, 24 weeks after the installation of new drip sets to prevent inorganic clogging. No hazardous effect of acid on soil was observed.

   ii. When Algae affected water is used for drip irrigation, discharge rates reduced to about 50% in a month. A weekly treatment of 50 ppm sodium hypochloride reclaimed the clogging in four applications which was economical too.

e. A low cost (Rs.200) screen filter was designed, developed and tested which proved very good compared to the costlier ones available in the market.

4.15 VASANTDADA SUGAR INSTITUTE, MANJARI, MAHARASHTRA.

Experiments were conducted at Vasantdada Sugar Institute, Manjari, Pune for sugarcane using surface drip, sub-surface drip with daily and alternate day irrigation and raised rows of planting (Co 7219) and compared with conventional planting and furrow method irrigation for one crop season during 1987-88; and also for comparing micro tube irrigation, sprinkler irrigation and furrow methods were conducted at 3 different locations in Maharashtra State. Compared to furrow irrigation, micro irrigation recorded water saving to the extent of 50-55% and the yield increase from 12-37%, increase in sugar recovery by one unit and 2.5 to 3 fold increase in water use efficiency. Among the micro irrigation, the surface drip with pressure compensating mechanism, with paired row planting and daily irrigation recorded the highest yield per hectare (175 Mt/ha).

4.16 JYOTHI FARM, VADODARA, GUJARAT.

Experiments were conducted from 1975 onwards with drip irrigation for lime plant at Jyothi Farm, Vadodara. The results have showed about 80 per cent saving of water under drip as compared to basin method of irrigation. No significant yield difference was, however, noticed amongst the two methods. Another experiment on the same crop has indicated that over a span of five years an average saving of 53 per cent of water was observed in drip irrigation. After 3.5 years, 50 per cent trees under drip and 30 per cent trees under basin irrigation started bearing fruits and the first year of fruiting

was about 34 per cent more in drip compared to basin. The trials conducted on groundnut have indicated that the yield was 66 percent higher under drip, compared to the border method of irrigation. The water use efficiency under drip method was 2.8 times more than surface method. The experiments conducted on tomato crop using drip irrigation have shown that the water saved was about 50 per cent compared to the furrow method. Though there was not much difference in yield, the production of tomato per hectare cm of water observed as 540 kg and 1040 kg under furrow and drip methods respectively due to water saving.

Table 4.3

Water Applied, Yield and W.U.E. As Influenced By Different Methods of Irrigation for Different Crops, worked out at Punjabrao Krishi Vidyapeeth, Akola

S. No.	Crop	Water applied (cm)		Yield (q/ha)		Water Saving by drip over Conventional method (%)	Increase in yield in drip over Conventional method (%)	W.U.E. (q/ha/cm)	
		Conventional method	Drip method	Conventional method	Drip method			Conventional	Drip
1	2	3	4	5	6	7	8	9	10
1.	Cauliflower	38.88	25.50	83.33	115.93	34.41	39.12	2.14	4.55
2.	Tomato	101.50	69.58	45.04	58.33	31.44	29.50	0.44	0.84
3.	Brinjal	168.00	63.90	91.00	148.20	61.96	62.86	0.54	2.32

4.17 JIVRAJBHAI PATEL AGRO FORESTRY CENTRE, SURENDRABAGH, GUJARAT.

Many farmers in Gujarat had introduced drip irrigation for various tree crops in Saurashtra Region of Gujarat State. It is stated that about 200,000 trees are not only saved, but are brought to a high productivity level by 51 farmers in a short span of 6 months. Many innovative techniques were adopted by the farmers including getting water through tankers and applying drip irrigation to reap a rich harvest. The results in this region for Ber, Lemon, Chickpea, Mango are very much encouraging with increased yield of more than 25% and income raised by 60% (1990).

4.18. DIRECTORATE OF IRRIGATION RESEARCH AND DEVELOPMENT, PUNE, MAHARASHTRA.

The Directorate conducted scientific field studies at 10 Research Farms on drip irrigation in different agro-climatic regions of Maharashtra since 1982 at the following locations :

Drip irrigation promotes economic use of water.

Research Farm	District	Area ha.
a. Phaltan	Satara	1.00
b. Arale	Satara	0.70
c. Mandwa	Sholapur	0.50
d. Kashti	Ahmednagar	1.30
e. Siddheshwar	Parbhani	2.70
f. Ranjangaon	Ahmednagar	1.04
g. Malegaon Colony	Pune	0.35
h. Kedgaon	Pune	1.00
i. Natuwadi	Ratnagiri	1.50
j. Venna	Nagpur	2.30

These Research Farms in irrigation commands like NLBC and NRBC have created greater awareness among the farmers for judicious use of water by considering the weather parametres like temperature, humidity etc and many farmers have installed such systems in the Command areas of the projects.

In Ankalkhop Village of Sangli district an area of 169 ha along Krishna riverside has been totally brought under drip irrigation system by the Co-operative Water Users' Society. Saving in water from drip system is about 60 to 70% and increase in yield is in the range of 20 to 30%.

The results on water saving and increase in yield for four crops are as follows :

Sl.No.	Crop	% of Water Saved	% increase of yield
1.	Grape	65-70	30
2.	Pomegranate	50-55	30
3.	Guava	55-60	25
4.	Custard Apple	50-55	20

4.19 RESEARCH UNDER PLASTICULTURE DEVELOPMENT CENTRES IN VARIOUS STATES.

The National Committee on the Use of Plastics has financed 12 leading agricultural universities and institutions in the country to take up studies on drip irrigation and related activities from 1985 onwards. The summary of the research findings are given below :

Drip irrigation gives bumper yields.

a) **Mahatma Phule Krishi Vidyapeeth (MPKV), Pune, Maharashtra.**
At the Plasticulture Development Centre, Pune, the economical feasibility of the drip irrigation system for tomato crop has been studied. The crop yield was 48 MT/ha which is 50% more than the conventional irrigation. Water saving was 32% in drip system.

Drip in brinjal has shown 65% increase in yield and 55% saving in water.

Chilli under drip has reported 31% increase in yield with 72% water saving.

b) **Indian Agricultural Research Institute, New Delhi.**
Biwall irrigation in lady's finger showed an increase of 16% in yield with 36% water saving.

Mulberry under drip has resulted in 50% water saving.

Onion under biwall could consume only 25% of water as compared to control. Drip irrigation with micro tube in cauliflower has given 70% increase in yield over control. The yield is 28.74 MT/ha in micro tube whereas it is only 17.13 MT/ha in control.

c) **University of Agricultural Sciences, Bangalore, Karnataka.**
Pomegranate under drip has shown an increase of 250% in yield

d) **Rajasthan Agricultural University, Udaipur, Rajasthan.**
It has been concluded that the cost of drip system for tomato could be met from the net extra income of only one season. Drip System resulted 65% increase in yield with 49% water saving.

In summer groundnut, drip has shown 58% increase in yield with 35% water saving.

e) **Gujarat Agricultural University, Navsari, Gujarat.**
Banana under drip, showed 30% water saving with 16% increase in yield.

Potato under drip has shown 54% water saving with 15% increase in yield.

In tomato under drip, 30% increase in yield with 47% water saving has been reported.

4.20 RESEARCH ON USING SALINE WATER.

Bhorgande et.al. (1971) has reported that highly saline water could be used in drip method of irrigation and the salt accumulation at the surface of the periphery of wetting zone would prevent the development of osmatic stress in the root zone. Kumar and Sivanappan (1983) have reported that with regard to salinity, drip irrigation has an

Drip irrigation prevents spread of weeds and diseases.

Table 4.4

Results of drip versus traditional irrigation system on various crops in India.

Research Institute	Crop	Water Saving %	Increase in crop yield %	Water requirement(mm/ha)		Crop Yield (MT/ha)	
				Traditional Irrigation System	Drip Irrigation System	Traditional Irrigation System	Drip Irrigation System
1	2	3	4	5	6	7	8
MPAU, Rahuri	Sugarcane	60	6	1950	785	158.00	167.00
MPAU, Rahuri	Sugarcane	30	20	2310	1620	122.00	146.00
TNAU, Coimbatore	Sugarcane	47	29	1360	921	92.00	119.00
MPAU, Rahuri	Cotton	43	40	895	511	2.25	3.14
TNAU, Coimbatore	Cotton	60	25	856	302	2.60	3.26
TNAU, Coimbatore	Cotton	79	25	700	150	2.60	3.25
TNAU, Coimbatore	Tomato	79	43	498	107	6.18	8.87
MPAU, Rahuri	Tomato	30	5	297	208	1.64	1.72
TNAU, Coimbatore	Lady's Finger	84	13	535	86	10.00	11.31
MPAU, Rahuri	Lady's Finger	49	7	2189	1133	18.90	20.33
MPAU, Rahuri	Brinjal	47	Nil	900	420	28.00	28.00
MPAU, Rahuri	Chilli	62	44	1097	417	4.23	6.09
TNAU, Coimbatore	Radish	77	13	464	108	1.05	1.19
TNAU, Coimbatore	Beet	80	56	857	177	0.57	0.89
TNAU, Coimbatore	Sweet Potato	61	40	631	252	4.24	5.89
HAU, Hissar	Potato	Nil	46	200	200	23.57	34.42
HAU, Hissar	Onion	Nil	31	602	602	9.30	12.20
CAZRI, Jodhpur	Water-melon	Nil	179	800	800	29.47	88.23
TNAU, Coimbatore	Banana	77	–	2430	580	N.A.	N.A.
TNAU, Coimbatore	Papaya	68	77	2285	734	13.00	23.00
Jyoti Ltd.Vadodara	Lemon	81	35	42	8	1.88	2.52
Jyoti Ltd.Vadodara	Groundnut	40	66	500	300	1,713.00	2,841.00
TNAU, Coimbatore	Grapes	48	89	532	278	–	–
TNAU, Coimbatore	Coconut	65	12	–	–	–	–
CAZRI, Jodhpur	Bottlegourd	12	47	840	740	38.01	55.79
CAZRI, Jodhpur	Ashgourd	12	12	840	740	10.84	12.03

advantage as it keeps the soil moisture continuously high atleast in the root zone. Therefore, a low salt concentration level is maintained in the root zone due to daily irrigation which leached away the salts to the outer periphery. Agarwal et.al. (1981) has stated that the saline water can be used for irrigation by drip method to a better advantage in comparison to surface irrigation. Khepar et.al. (1983) reported that the salt when applied with irrigation water moved to a greater depth at faster rate of application than at a lower application rate in an initially dry soil when salt was applied on the surface of the soil. Rama Devi (1981) conducted field studies to determine soil moisture and salt distribution pattern in the root zone of tomato crop by drip using saline water.

4.21 APPLIED RESEARCH BY THE ENTERPRISING FARMERS.

Apart from the above studies, many progressive farmers are doing their own research to work out the water requirements to get the maximum yield, extending the life of the system, prevention of evaporation loss by mulching etc. All these have shown that farmers are very much interested in going in for the system since it is highly economical and viable.

4.22 WATER USE EFFICIENCY.

Irrigation efficiency in drip system is adjudged to be more than 90 percent as compared to about 65 per cent in the case of sprinkler and about 30-50 per cent in the case of lined distribution of conventional method of irrigation (CWC, 1991).

Experimental studies indicate (CWC, 1991) that as compared to conventional methods, the saving of water in the drip irrigation, varies from 27 percent for tomato to 59.8 per cent for sugarcane and similarly increase in crop yield varies from 5 per cent for sugarcane to 27 per cent for cotton (Table 4.5) depending upon the crop.

Table 4.5

Saving of Water and increase in yield in Drip Irrigation as compared to Surface Irrigation (CWC, 1991).

Sl.No.	Crop	% Saving of water	% increase in yield
1.	Cotton	53.0	27.0
2.	Lady's Finger	39.5	16.1
3.	Tomato	27.0	5.0
4.	Brinjal	55.8	17.5
5.	Gourd	52.1	13.5
6.	Ridgegourd	58.9	17.0
7.	Sugarcane	59.8	5.0
8.	Cabbage	59.5	23.4

Adopt drip irrigation and become prosperous.

According to a survey conducted on All India basis (Padhye, 1990), the increase in crop yield as compared to flood irrigation was higher in drip irrigation than sprinkler irrigation (Table 4.6).

Table 4.6

Percentage Increase in Yield Using Sprinkler and Drip Irrigation as compared to Flood Irrigation (Padhye, 1990).

Sl.NO.	Crop	Sprinkler	Drip
1.	Coconut	14	29
2.	Coffee	17	39
3.	Sugarcane	11	20
4.	Vegetables	9 - 30	20 - 80

It was also found (Padhye, 1990) that saving in power, water, labour and annual cost of maintenance was higher in drip irrigation than sprinkler method of irrigation (Table 4.7).

Table 4.7

Saving in power, water, labour and annual cost of maintenance (Value per acre per year) as compared to conventional method of irrigation (Padhye, 1990).

Sl. No.	Saving	Drip Irrigation		Sprinkler Irrigation	
		Metallic	Plastics	Metallic	Plastics
1.	Power (KWH)	286	458	85	150
2.	Water (%)	50	53	19.5	23
3.	Labour (%)	65	65	42	42
4.	Annual Maintenance as % of cost of system	7.5	5	5	2

4.23 NATIONAL COMMITTEE ON THE USE OF PLASTICULTURE IN AGRICULTURE (NCPA).

The Indian Petro Chemicals Limited, Vadodara and the National Committee on the Use of Plastics have done yeoman service for the popularisation of drip irrigation in India. The NCPA was constituted in March, 1981 to promote and develop the use of plastics in agriculture, water management and related fields. Dr. G.V.K. Rao, the then Chairman of the Committee evinced keen interest in introducing drip irrigation in a big way. The IPCL provided funds to the Agricultural Finance Consultants, Bombay to prepare pilot drip irrigation projects to be taken up in Rajasthan, Gujarat, Karnataka, Tamil Nadu,

Drip irrigation is the right choice for preventing salinity and waterlogging.

Bihar and Uttar Pradesh. The NCPA has prepared leaflets about drip irrigation and other information. It organised with the support of IPCL, Xi International Congress on "The Use of Plastics in Agriculture" during 1990 at New Delhi. The NCPA has also conducted many national seminars on Drip Irrigation in 1983, 1987 etc. Due to the concerted efforts of the Chairman, NCPA, Government of India and the State Governments have sponsored subsidy schemes for popularisation of drip irrigation in India.

The development of drip irrigation is very spectacular in the last 2-3 years. Thanks to the various State Governments, Central Government and leading drip manufacturers in promoting drip irrigation. The area under drip irrigation was only about 1200 ha in 1985, which increased to 12,000 Ha in 1989 and it is over 70,000 ha in 1993. Still it is a long way to go to popularise the system as it only represents a fraction of the total area irrigated in India.

4.24 FUTURE NEEDS IN RESEARCH IDENTIFIED.

The Special Committee on Micro and Mechanised Irrigation of INCID has identified the following areas for research in drip irrigation which are to be undertaken by both research organisations and manufacturers. While R&D efforts of manufacturers will be to improve the technology and make it more cost effective, the research organisations will concentrate efforts in evolving best lay-outs, improving efficiency and tackling clogging problems etc.

i) Cost effectiveness.

ii) Water requirement of crops.

iii) Fertigation, Package of Practices.

iv) Improvement of components of a drip system for better performance.

v) Treatment for clogging of drip emitters.

vi) Use of saline water.

vii) Optimisation of layout and design.

viii) Benefit-cost analysis.

Other areas of research could be :

ix) Realistic methods for predicting the temporal and special variation of soil moisture under drip irrigation for different crops, weather and soil conditions.

Drip irrigation offers higher returns and prosperity.

x) Determining the minimal and optimal fraction of the soil volume needed for various crops.

xi) Setting the irrigation rate to account more precisely for the partial canopy cover prevailing in the early stages of each crop.

xii) Assessing and controlling downward seepage and leaching rates from the rooting zone under drip irrigation.

xiii) Reducing the capital cost and maintenance requirements and increasing the reliability and longevity of simplified versions of drip irrigation.

4.25 RESEARCH THROUGH CENTRALLY SPONSORED RESEARCH PROGRAMME UNDER MINISTRY OF WATER RESOURCES (MOWR), GOVT. OF INDIA.

Under the Centrally sponsored research programme for river valley projects and flood control schemes, MOWR provides grants to State and Central Research Organisations for carrying out research on various thrust areas. Indian National Committee on Irrigation and Drainage (INCID) has been assigned the task of co-ordinating the National Research Programme for the 6 thrust areas relating to irrigation and drainage, of which, one thrust area pertains to "Efficient Water Management techniques including better farm application methods of Drip/Sprinkler systems and dynamic regulation of Canal networks". Many Research Institutes and Agricultural Universities are carrying out research under this programme, receiving grants from the Ministry of Water Resources, Government of India. The research schemes concerning drip irrigation sanctioned by MOWR during the last three years are shown in **Annexure-VII**. In all, 10 schemes valued at Rs 52.30 lakhs are under execution by various Institutes.

Details of the Six research Schemes, in brief, sanctioned by MOWR, Government of India during the year 1992-93 are given hereunder :

1. "EFFICIENT WATER MANAGEMENT THROUGH DRIP AND SPRINKLER IRRIGATION SYSTEMS" by Andhra Pradesh Agricultural University (APAU), Rajendranagar, Hyderabad-500030 Andhra Pradesh at an amount of Rs 6 lakhs in a period of 3 years duration.

   The above experiments are envisaged to be conducted on groundnut, Chillies and other vegetables to determine water use efficiency and to arrive at cost benefit ratios in comparison with the conventional methods.

2. "COMPARATIVE EVALUATION AND ECONOMIC APPRAISAL OF DIFFERENT METHODS OF APPLICATION IN DRIP SYSTEMS" by Water Technology Centre, Tamil Nadu Agricultural University (TNAU), Coimbatore - 641003 Tamil Nadu at an estimated cost of Rs 3 lakhs in a period of 3 years.

The project is meant to design and evaluate different schemes of application through Drip Systems for orchards with a selection of few sites for characterising water limited environment. The whole study will be carried out in four phases, the first phase consists of preliminary surveys, selection of sites, designing, preparation of lay-out and collection of literature. In the second phase, designing of the actual execution of different schemes is to be dealt with while observations in hydraulic behaviour of different systems are to be recorded in phase three. In the final and fourth phase, the statistical analysis and interpretation of data to draw meaningful conclusions and development of suitable software are specified.

3. "OPTIMIZATION OF DRIP IRRIGATION SYSTEM, LAY-OUT AND DESIGN FOR ROW CROPS AND ORCHARDS" by Water Resources Engineering & Management Institute, Faculty of Technology & Engineering, M.S. University of Baroda, Samiala Centre, Samiala-391410 Gujarat in a period of 3 years at a sanctioned cost of Rs 6 lakhs.

The main features of the proposed study include selection of suitable farm land of 15 ha in Bhuj District, Gujarat, finalisation of four different lay-outs as per the shape and size of the individual plot and the system design by 8 different methods for each lay-out.

The system is to be operated for different crop periods and thereafter the actual yield has to be determined by crop cutting techniques. For each lay-out and each method of design, the benefit cost ratio is to be calculated. It is intended to find out the optimum lay-out and design that will give the highest benefit cost ratio.

4. "EVALUATION OF DRIP IRRIGATION TECHNOLOGY FOR VARIOUS CROPS" by Water Technology Centre, IARI, Pusa Campus, New Delhi -110 012. at an estimated amount of Rs 4.28 lakhs in a period of 3 years.

The experimental techniques proposed comprise of installation of Drip System such as main line, sub-main component line, emitters and control head (filters etc.). Observations of leaf area index, height, girth of stem etc for various fruit crops are to be recorded besides total water applied through the Drip Irrigation System as compared to traditional method of irrigation. In addition, yield response of the crops will be assessed.

5 "DEVELOPMENT AND EVALUATION OF MICRO IRRIGATION TECHNOLOGY" by Water Technology Centre, IARI, Pusa Campus, New Delhi - 110 012. for Rs 3.74 lakhs in a period of 3 years.

Drip irrigation transforms arid and semi-arid lands into profitable plantations.

In the proposed study, the Drip Irrigation System such as main line, sub-main components line, emitters and control head (filters etc.) will be designed to suit the Indian conditions. The basic criteria for selection of different materials and design will be energy efficiency and uniformity of water application. The designed components will then be developed at the Water Technology Centre Workshop and evaluated at the laboratories established at WTC, IARI, New Delhi. Further, various parameters will also be prescribed for the developed components such as pressure variation co-efficients etc.

6. "PUBLISHING OF STATUS REPORTS ON VARIOUS SUBJECTS CONCERNING IRRIGATION AND DRAINAGE" by the Indian National Committee on Irrigation and Drainage (INCID), NEW DELHI-110066 for which an amount of Rs.4.75 lakhs was sanctioned.

The amount is meant for meeting the expenditure in preparing and printing three publications which include printing of Status Report on Drip Irrigation in India.

Brackish water (Salt water) can also be used for drip irrigation.

DRIP IRRIGATION FOR BANANA.
(Courtesy : NCPA, New Delhi)

DRIP IRRIGATION FOR SUGARCANE
(Courtesy : WTC, IARI, New Delhi)

CHAPTER - 5

EXPERIENCES OF DRIP IRRIGATION DEVELOPMENT

Drip irrigation in India could not make much progress until the year 1987-88, despite large scale experiments and pilot demonstrations conducted by various agencies including research institutions, Government Departments and Private Companies. Drip Irrigation is adopted only in Southern and North Western States of the Country. There is an absolute need to propagate drip irrigation in various agro-climatic zones of the Country (see para 5.6). The experiences of the farmers in different States for different crops are given below in detail.

The rewarding experiences of some of the farmers in the States of Tamil Nadu, Maharashtra, Gujarat, Kerala, Karnataka and Andhra Pradesh are described below :

5.1 EXPERIENCES IN TAMIL NADU.

5.1.1. Pilot/Demonstration Plots.

Large scale experiments and pilot demonstrations were conducted at the Tamil Nadu Agricultural University (TNAU), Coimbatore for various crops like vegetables, grapes, banana, cotton, sugarcane with encouraging results. The farmers who visited the University during "Farmers' Day" and on other occasions were enlightened about the advantages and efficacy of the system. Some of the farmers wanted this system to be installed in their own farms as demonstration units. Encouraged by the keen interest evinced by them, three pilot demonstration plots were selected and drip irrigation systems installed using available local material and micro-tubes, in Thondamuthur and Perivanaichenpalayam Blocks of Coimbatore district during 1975-77. The crops selected were cotton, banana and tomato. The above applied research work was carried out for 2 years. The farmers were very happy with these innovative methods as they were able to save about 60-70% of water and in all cases higher yields more than the normal were achieved compared to the conventional methods. Since the cost of the system was beyond the reach of the small and marginal farmers, the system could not make much headway in the absence of any incentive and patronage either from the Government or from the banks.

5.1.2 Farmers' Experience.

But some progressive farmers in Coimbatore, Madurai, Tirunelveli and Trichy districts of Tamil Nadu have taken up the drip irrigation in their fields since the normal water supply was not sufficient to irrigate more area. The crops grown in their lands are coconut, lime, sapota, guava, flowers, vegetables etc. The systems were installed in their lands during the years 1981 and 1982. The crop growth and performance of the systems was very satisfactory. In one case, the system was designed and fabricated

by the farmer himself after getting details from TamilNadu Agricultural University and other drip manufacturing companies in India and Israel, since he has workshop facilities. This system was working under medium pressure of about 1.5 atmosphere. He has developed gravel filters, fertilizer tank, ordinary drippers (button type), and special pressure compensated drippers to ensure uniform supply of water to all points even in slopes with high gradient and automatic and flush valve. The system is working in 12 acres of land for coconut, lime, banana, mango, sapota and guava. The water given to the crops amounted to 24 litres/day for coconut; 12 litres/day for lime, guava, mango and sapota; 6-7 litres/day for banana; and 2-5 litres/day for vegetables. He followed this schedule even for fully grown coconut trees. Before installing drip system, he got only 20 nuts per tree which increased to 55 nuts/tree in the second year. He was very much convinced about the effectiveness of the system in water saving and higher productivity.

The story of other farmer is different. Although, he has a bore well of 27,000 LPH capacity, he could not get the regular 3 phase electric supply. He therefore went in for a single phase without waiting for a 3 phase connection and installed one HP deep well pump, as the water table is more than 13 m from the ground surface. This pump gave 2700 LPH continuously. He has planted 600 coconut saplings in a 4 ha block and designed and installed the simple drip system with micro tubes in 1981. He gave water amounting to 32-35 litres/day for each plant by operating the pump only for 8 hours. He has divided the entire area into 4 blocks of 1 ha each and allowed water to drip for 2 hours in each block. The quantum of water for the crop was increased upto a maximum of about 70-100 litres/day/plant.

5.1.3. Various Other Farms in Tamilnadu.

a) **Navlok Farm, Ranipet :** The sandy soil with very poor water retention capacity has posed a problem to keep alive the 3000 coconut trees planted at Navlok Farm, Ranipet along the sandy Palar river bed. The Department of Agriculture installed the drip irrigation system in 1978 in a portion of the plot when the plants under drip showed marked growth response compared to the others which were exposed to water stress.

b) **Vandalur Farm :** The 2 ha farm has served as an experimental station for field trials of various drip irrigation components developed in the country. Crops of a wide range - tomato, lady's finger, cluster beans, brinjal, chilli, banana, mango, coconut, lime, sapota have been tried with excellent results. The entire irrigation was done by a meagre discharge capacity from a small wind mill operated pump. Visitors to the farm were thrilled and quite impressed by the luxuriant growth of plants with such a minor water source viz. a windmill operated pump.

Drip irrigation system is a technical marvel brought to your door step.

c) **Subbiah Estate, Kodaikanal :** One farmer introduced thedrip irrigation in his estate at Kodaikanal hills for orange crop. The system was erected in 1981 and within months, new shoots came up all over the trees. The shedding was reduced and fruit size improved uniformly measuring 6.4 Cm in diameter, fetching a better market price.

d) **Coconut Farm in Coimbatore District :** The area under coconut plantation is increasing every year in Coimbatore District. Due to paucity of labour for agricultural operations and also due to scarcity of water, crops like paddy, sugarcane etc. cannot be grown. Shri Marudhachalam has a total area of 28 ha with 3400 trees, which are about 30 years old. Due to water scarcity, he could not irrigate the entire area by surface method and therefore switched over to drip method during 1986 and 1987. The average cost of the system has worked out to Rs.12,500/ha. Drip was given daily @100-200 litres/tree/day. Each tree yielded on an average about 110 nuts/year. According to the farmer, it is more advantageous and economical to go in for the drip system.

e) **Mixed Crop in Coimbatore District :** Another farmer Shri Veluswamy, has 6 ha of land near Sulur in Coimbatore District with a well in one block. Prior to 1985, he was able to cultivate about 1 ha in summer and 2 ha in rainy season. After visiting drip irrigation farms nearby, he was convinced that drip method would solve his problem and accordingly decided to install drip system in his farm. In 1985, he spent about Rs 60,000/- to provide the system in the entire area of 6 ha and he received Rs.15,000/- only as subsidy from the Government. He has changed the crops to mango, orange, mulberry, cotton and coconut and could irrigate the entire area through drip. It is a model farm in the water scarcity area.

Numerous such farmers are available in the water scarcity districts of Coimbatore, Periyar, Salem, Anna, Madurai, Tirunelveli and Changai MGR in Tamil Nadu.

5.2. EXPERIENCES IN MAHARASHTRA.

The development of drip system is quite spectacular in Maharashtra State after 1986, mainly due to theconstant encouragement provided to the farmers by the Government on one hand and the leading drip irrigation manufacturers of the State on the other. With a band of highly dedicated extension staff who canvassed the relative merits of the drip system and the imperative need for adopting such systems in Maharashtra.

The progressive farmers in Nasik, Jalgaon, Ahmednagar, Aurangabad, Pune, Sangli, Sholapur, Kolhapur and other districts in the State switched over to the drip system realising the need of the hour quickly (due to water scarcity for growing their crops) which resulted in increased production, income and employment opportunities. The drip system was used for various crops namely grapes, pomegranate, orange, banana,

Drip irrigation system is a great boon to farmers.

lemon, mango, tomato, other fruit and vegetable crops, sugarcane, cotton, betelvine, etc. In most of the cases, the yield of the crop has increased by 50% with a water saving of 50-70%. Added to these excellent results, the Government of Maharashtra is encouraging very much the drip method of irrigation even in the medium irrigation project areas. Some case studies are highlighted below:

5.2.1 Grape Farmers - Nasik District.

The grape growers have mastered the technique to obtain very good crop by pruning at the appropriate time and giving all inputs in time, but water was the main constraint for them. All the grape growers are cultivating the crops by using ground water and this resulted in depletion of water table year after year in many parts of Maharashtra and especially in Nasik District. Therefore, many farmers have preferred for drip irrigation. With only 20% of the grape area under drip during 1989, the figure has now crossed 50-60%. Many farmers including Shri Om Prakash Patil and Shri Kode of Pimpalgaon, Shri Niwrity Vithoba Rakibe Dhodamba in Nasik district are cultivating grapes using drip irrigation. The cost works out to about Rs.25,000/ha. It was informed that they are able to get about 25-40 T/ha compared to 15-25 T/ha under the traditional surface method. Further, the water saving through drip is about 60-70% according to the farmers. The water used by them is about 6-12 litres/day/plant. The benefit cost ratio worked out to 12:1. Another interesting feature is that in some cases where wells dried up in summer, the farmers even purchased water in tankers costing Rs.300-400 for 30,000 litres and irrigated the crops by drip.

5.2.2. Banana Farmers - Jalgaon.

Banana is grown in about 3 lakh ha with a higher water intake. Due to acute water scarcity and associated low yields, drip irrigation was introduced by Shri S.D. Patel of Bhadgaon Taluk of Jalgaon District. The spacing of the crop is 1.8 m. x 1.2 m. The quantity of water applied varied from 5-20 litres/day/plant depending upon the climate, the stage of the crop etc. The average yields in surface and drip methods were recorded as 12 and 14 kg/plant respectively.

The duration of the crop was also reduced by about 2 months by using drip. Conservative estimate of water saving by drip in this case is about 50%. The benefit cost ratio according to the farmer was 3:1 and cost of the drip was Rs.40,000/ha. The farmer's view was that one dripper per plant is sufficient and he has strongly recommended drip irrigation especially for banana crop.

5.2.3. Micro Irrigation for Sugarcane - Sangli.

235 farmers of Sri Vasantdada Irrigation Society joined together and installed biwall irrigation for their sugarcane crop in Sangli District covering an area of 179.28 ha at a cost of Rs 54 lakhs by obtaining subsidy from the State Government. The sugar company as a surety, extended the credit facility of Rs 20 lakhs. It is indeed praiseworthy to mention that the entire loan of Rs 20 lakhs was promptly repaid within a year though the term of repayment provided was for 5 years. It was possible because

Adopt drip irrigation system and achieve high cost benefit ratio.

the yield was increased by about 20-25 tons/ha over the conventional method of irrigation and the water saving alone was more than 50%. Farmers are happy since the system worked very efficiently.

5.3. EXPERIENCES IN KERALA/KARNATAKA/ANDHRA PRADESH/GUJARAT.

In Kerala, the coconut and other plantation crops need water during January to May as the rains recede in November/December. With no intermittent showers, though the average annual rainfall is more than 3000 mm. Irrigation is needed for most of the perennial crops particularly during the dry spell. Therefore drip irrigation is introduced by farmers for many crops including coconut, and other plantation crops and the coverage is increasing every year.

In Ramakrishna Vidyashala, Mysore large collection of sapota and coconut trees suffered due to water scarcity in 1978. The drip irrigation was introduced here between 1978 and 1980. The response was very good for sapota, coconut, lemon and pomegranate.

Several farmers in Bangalore district have introduced drip system for their grape, pomegranate, coconut, mango crops with very good response.

Drip irrigation is becoming very popular in Andhra Pradesh owing to the following reasons :

* Water is becoming a scarce commodity.
* Increase in yield is consistently uniform and a wide range of crops are grown.
* The crops grown are lime, grapes and pomegranate.

The drip irrigation has also become popular in Saurashtra region of Gujarat and in arid/ semi-arid regions of Rajasthan.

5.4 EXPERIENCE IN PUNJAB.

Drip irrigation studies conducted on Kinnow Plantations at Regional Research Station, Bhatinda in Punjab (PAU, 1983-87) showed that in terms of water economy, the area under Kinnow orchards can be increased by 200 per cent with the same amount of water used in conventional basin irrigation method. The studies further revealed that irrigation application at the rate of 75% of estimated evapotranspiration gave the best results under drip irrigation treatments. The observations were also recorded about growth parameters of Kinnow trees in respect of tree girth, tree spread both under saline water and fresh water conditions using drip irrigation system.

A new liberalised and simplified subsidy scheme for drip irrigation system is currently in operation.

5.5. OTHER STATES.

This system is not adopted in other Northern and North Eastern States mainly due to abundance of water in these States. However, water problem is noticed in some months and water scarcity conditions do exist in some pockets/areas. Further, this method is very well suited to undulated terrain and to orchard and commercial crops including plantation crops to get more production and good quality produce. Therefore, it is time that appropriate action is taken to introduce drip method in these States also to reap good harvests by maximising productivity.

5.6. SOME PROBLEMS IN EXPANSION AND OPERATION OF DRIP SYSTEM IN INDIA.

The constraints in the adoption of drip system are three fold :

i) Lack of Awareness.
ii) Limit on the subsidy.
iii) Field Problems.

5.6.1. Lack of Awareness.

According to a Survey conducted recently, only 16% of the farmers are aware of drip irrigation (Padhye 1990). Those who are aware also, do not have sufficient knowledge about its application, utility, method of operation and maintenance. The only source of information for them about the system was through other farmers and local manufacturers besides extension staff and Bank officials. Proper attention is needed for promotional measures by creating greater awareness of the system. Conducted Farmers Visits to the nearby farms having drip irrigation systems would go a long way in creating awareness amongst the farmers about the imperative need for adopting such modern techniques.

5.6.2. Subsidy.

Ministry of Water Resources was operating a centrally sponsored subsidy scheme since 1982-83 in which Centre and State Governments provided matching subsidy. During the Seventh Plan the subsidy was limited to small and marginal farmers. The farmers taking up horticulture crops like grapes, papaya, banana, arecanut and coconut were also eligible for subsidy. The Government of Maharashtra has made pioneering efforts for the successful adoption of drip irrigation system and to make it cost effective by providing subsidies to small and marginal farmers to the extent of Rs 2282.35 lakhs during the period 1986-93.

The Government of India, taking a serious note on the possibility of having a Second Green Revolution through the use of drip irrigation system, has provided liberal subsidy to different State Governments for adoption of this system at the field level. In this connection, the Government of India has introduced Rs 2.5 billion promotional

Mixed cropping is also possible with drip irrigation.

Scheme in the VIII Plan on the use of plastics in agriculture, having components such as Drip Irrigation, Drip Demonstration, Plastic Mulching, Green Houses, New Plasticulture Application, Training and NCPA.

The physical and financial targets for these components are as follows:

Component	Area in ha	Amount in Rs Lakhs
Drip Installation	139,185	18,810.99
Drip Demonstration	12,000	900.00
Mulching	28,000	1,400.00
Green Houses	247	2,200.00
Total	**179,432**	**23,310.99**

Details of the components and the state-wise break-up of the targets are given in **Annexure - XX.**

Other allocations made in this Scheme (for which State-wise break up is not available are as follows :

New Plasticulture Application	Rs. 500 Lakhs
Training	Rs 590 "
NCPA	Rs 600 "
Total	**Rs 1690 "**

This amount of Rs. 1690 lakhs with the earlier total of Rs 23,311 lakhs for the above four components, add upto Rs 25,000 lakhs (Rs 2.50 billions).

The operation of the Centrally sponsored scheme for subsidy is now within the purview of State Governments. However, NABARD has independently assessed the ground level credit requirement for drip irrigation as Rs.338.8 crores for the five years of 1993-94 to 1997-98 as follows :

Year	Potential (ha)	Credit Requirement (Rs. Crores) @ Rs.30,000 per ha
1993-94	15,160	45.5
1994-95	20,160	60.5
1995-96	21,930	65.8

No evaporation losses in drip irrigation.

Year	Potential (ha)	Credit Requirement (Rs. Crores) @ Rs.30,000 per ha
1996-97	25,900	77.7
1997-98	27,985	89.3
Total	**111,135**	**338.8**

Source: *All India Seminar on Sprinkler and Drip Irrigation held on 9th & 10th December, 1993 organised by the Institution of Engineers (India) Andhra Pradesh Centre, Hyderabad : Availability of Credit for Drip Irrigation System in India by P.K. Chatterjee, Dy.General Manager, NABARD.*

5.6.3. Field Problems.

Emitters clogging is one of the most serious problems in using the drip system. It adversely affects the rate and uniformity of water application, increases maintenance costs and results in crop damage and decrease in yield. This necessitates constant inspection of the equipment throughout the growing season and calls for R&D effort to provide an effective solution to the problem which inhibits the expansion of drip irrigation. Other problems relate to the non-availability of spares, lack of after sale service facilities from manufacturers and faulty design of the system. These problems have to be given proper attention, if the drip system is to be propagated on an extensive scale.

5.7 AGRO-CLIMATIC ZONES DEMARCATED IN THE COUNTRY AND FEASIBILITY OF INTRODUCTION OF DRIP IRRIGATION IN VARIOUS ZONES.

For the purpose of agro-climatic regional planning, the country has been divided in to 15 Agro-climatic Zones. Each Zone has been further sub-divided into Divisions and Sub-divisions.

This approach is adopted for formulating integrated development plans for agriculture and allied sectors for each zone. During the Eighth Plan, emphasis is on development of resources and their optimum utilisation in an integrated and sustainable manner for constituent sub-sectors. Such a plan for water resources sector should aim at development possibilities for drip irrigation which are to be specifically identified in various agro-climatic zones. Some of the possibilities for minor irrigation are mentioned briefly below for different agro-climatic zones.

5.7.1. Western Himalayan Region.

It covers the eight Hilly districts of Uttar Pradesh and whole of Himachal Pradesh and Jammu & Kashmir. The surface water minor irrigation schemes comprise small hill contour channels known as Kuhls in Himachal Pradesh and Jammu & Kashmir. The

There are nearly 50 leading manufacturers of drip irrigation Systems in India today.

availability of Ground Water is limited and confined to Terai Region of Nainital, Valley fall of Dehradun in Uttar Pradesh, hill areas in Jammu & Kashmir and Himachal Pradesh and Srinagar Valley in Jammu & Kashmir. While in Terai region of Nainital district in Uttar Pradesh ground water is fully developed through construction of large number of artesian wells and tubewells, the Ground Water resource development in Jammu & Kashmir & Himachal Pradesh is limited.

5.7.2 Eastern Himalayan Region.

This comprises thewhole of the State of Sikkim, Assam, Arunachal Pradesh, Meghalaya, Mizoram, Nagaland, Manipur, Tripura and the districts of Cooch Bihar, Jalpaiguri and Darjeeling in West Bengal. From the point of view of irrigation, these areas are most underdeveloped except for the Brahmaputra Valley in Assam. The Minor Irrigation is generally through surface water schemes both diversion and lift except for Assam where large number of shallow tubewells have come up. In other States, Ground Water Development is negligible and possibilities are also few, because of sub-surface formations, and difficult terrain. In this region there is a strong need to first carry out necessary surveys and investigations to determine the possibilities of construction of minor irrigation schemes for which necessary infrastructure and organisation is to be created. Thrust should be more on impounding,retention and storage of rain water because of acute shortage of water in the lean months. In Assam, however, greater stress on full development of vast ground water potential should be given.

5.7.3. Lower Gangetic Plain Region.

This region comprises plain districts of West Bengal only. Minor Irrigation schemes mostly are dugwells, shallow tubewells, deep tubewells, tank and lift irrigation schemes. Enormous unutilised ground water potential exists in this zone, which can be developed by construction of a large number of dugwells and shallow tubewells and also deep public tubewells, where shallow tubewells are not possible. In the case of surface water, old tanks will have to be desilted and also new ones constructed. Lift irrigation schemes should be taken up on perennial rivers and streams.

5.7.4. Middle Gangetic Plain Region.

Northern Plain alluvial districts of Bihar (26 in Nos.) and Eastern U.P. plain districts 12 in Nos. are included in this region. The groundwater potential of this region has not been utilised fully. It needs to be developed through construction of shallow tubewells mainly which are cheap compared to dugwells. A boring with PVC or steel pipes costs only Rs 3000 to 4000 only. In Eastern districts of Bihar, very cheap bamboo borings are done. In respect of surface water, village tank, lift schemes for irrigation and small weirs and barrages in Northern Bihar can be taken up.

5.7.5. Upper Gangetic Plain Region.

It comprises 12 districts of Central Uttar Pradesh plains, 10 districts of North Western U.P. plains and 10 districts of South Western U.P. plains. Minor Irrigation is through mainly shallow tubewells with mostly cavity type. Dugwells have gone out of use. Large

scale scope for ground water development is mainly in Central U.P. In North Western and South Western U.P. there is general decline in ground water level which is more pronounced in areas which are out of canal commands. These areas need recharging of groundwater through construction of monsoon canals which should be taken up on priority basis. In South-Western part, there is a problem of large chunks of land having saline water. In the Central and North-Western parts, large patches of barren lands are to be reclaimed through development of ground water. In respect of surface water, existing village tanks will require desilting. At the same time new tanks will have to be constructed.

5.7.6. Trans-gangetic Plain Region.

It includes Delhi, Punjab, Haryana and Ganganagar district of Rajasthan. Ground water is fully developed through construction of shallow tubewells. By the end of VII Plan (1985-90) 84.4% of ground water in Punjab and 77.13% in Haryana had been developed. Further scope is limited unless large scale recharge of aquifer specially in saline zone is taken up through construction of monsoon canals specially in Haryana. In Punjab the gross area irrigated to gross sown area is already 91%. The problem of waterlogging in Punjab and salinity in Haryana needs to be tackled on priority basis. Use of sprinkler irrigation in sandy undulating region of Haryana should be encouraged. The possibilities on the use of saline ground water by mixing the fresh canal water should be examined in detail. Surface water schemes are possible in Kandy areas of Punjab through construction of check Dams which should be encouraged. In Delhi the agricultural land is shrinking due to urbanisation. Minor Irrigation is mainly through private shallow tubewells and there is a general decline of ground water level in these areas. Surface water minor irrigation is only through effluent canals. There is a strong need for development of effluent irrigation and artificial recharge of acquifers through monsoon pumped canal. In Ganganagar district the rising water table in canal commands is leading to waterlogging problem. About 9000 ha. is already waterlogged or prone to waterlogging. Conjunctive use is to be encouraged in canal commands by construction of more shallow tubewells.

5.7.7. Eastern Plateaus & Hill Region.

The Zone includes Chotanagpur plateau division in Bihar, Purulia district of West Bengal, Inland district of Orissa, Eastern hills and Chattisgarh district of Madhya Pradesh and Wainganga Plain and hill division districts of Bhandra, Chandrapur and Gadchiroli of Maharashtra. The topography of the region is undulating and hardly 10% of the area is irrigated. Tanks are major source of irrigation accounting for 51.7% of irrigated area, wells and tubewells is only 4.5%. The existing tanks need desilting, strengthening existing bunds, construction of adequate surplusing arrangement and construction of field channels. An ambitious programme of renovation and modernisation of tanks is needed. In addition, new tanks are to be constructed in large numbers. According to revised assessment of Ground Water Potential done by CGWB, the area has a large unutilised ground water potential. Dugwells, Borewells and

Agriculture / Horticulture would be a profitable venture through drip irrigation.

Tubewells wherever feasible should be taken up in a bigway, Surface lift irrigation schemes are to be encouraged and check dams are also to be constructed in large numbers. The zone requires special attention in respect of minor irrigation development.

5.7.8. Central Plateau and Hills Region.

It includes Banda, Hamirpur, Jalaun, Jhansi & Lalitpur districts of Uttar Pradesh, 25 districts of Madhya Pradesh including plains in the districts of Bhind and Morena. East Rajasthan Plains and hill districts of Rajasthan 12 Nos. and 3 districts of South Rajasthan Plateau and Hill Division viz Banswara and Dungarpur. Udaipur and Surohi are also included. Presently minor irrigation in this region is mostly through tanks and lift irrigation schemes. Ground Water Development is mostly through dugwells. In plain areas shallow tubewells are also constructed. Borewells on small scale have also been taken up. Few hundred deep tubewells also exist. Revised assessment of CGWB of ground water potential in the country has indicated availability of abundant resources in the State of Madhya Pradesh. The areas in Madhya Pradesh can sustain more than 40 lakh dugwells, while present rate of dugwell construction is only 30,000 per annum. This needs to be stepped up to atleast 100,000 per year. In respect of surface water programme, construction of tanks need to be accelerated. Priority should also be given to completion of on-going schemes first by allocating plan funds. Modernisation of tanks is also needed in this zone. In Rajasthan region, **the use of sprinkler and drip irrigation is to be given top priority** because of inadequate resource availability. In Uttar Pradesh also a crash programme for construction of dugwells, tubewells, check dams and tanks should be taken up including desilting and restoration of old tanks.

5.7.9. Western Plateau and Hills Region.

It includes 22 districts of Maharashtra, 11 districts of Malwa region of Madhya Pradesh and Jhalawar district of Rajasthan. The region is characterised with low rainfall and poor irrigation facilities. Large unutilised ground water potential has been assessed by the CGWB but the present rate of development is slow which needs acceleration mainly through construction of dugwells. In respect of surface water, construction of new tanks and modernisation of existing tanks should be given priority. Check Dams, Percolation tanks are also to be constructed in large numbers. Surface water lift irrigation schemes should be taken up on perennial sources or impounding water in deep valleys through check dams.

5.7.10. Southern Plateau and Hills Region.

It includes 10 districts of Telengana, 3 districts of Rayalaseema, which includes Chittor district of Andhra Pradesh, 7 inland districts of Tamilnadu and 14 plateau districts of Karnataka. Tanks and dugwells are prominent source of minor irrigation. However, most of the tanks have silted-up and have no distribution system. Modernisation and renovation of tanks is needed in a big way. It is rather important and needs urgent attention in case of Tamilnadu where practically all the surface water has been

Drip is the most versatile and economic method of irrigation.

developed. In respect of Ground water development in Andhra Pradesh according to CGWB estimates, there is large scope of Ground water development in all districts except Chittor. Dugwells and Borewells programme should be accelerated. In Chittor, percolation tanks should be constructed for artificial recharge. In Tamilnadu State, the position is critical. In Salem, Periyar and Coimbatore, Ground Water development is more than 75%. Artificial Recharge through percolation tanks is urgently needed. In other districts dugwell and borewell programme can be taken up. In Karnataka only Kolar district is critical whose stage of development of ground water is 64%. In remaining districts there is no problem. Dugwell and borewell programme on accelerated rate should be taken up.

5.7.11. East Coast Plains & Hills Region.

It includes 4 coastal districts of Orissa, 5 of Andhra Pradesh, 8 of Tamilnadu and Union Territory of Pondicherry. Minor Irrigation is through tanks and dugwells and filterpoint wells. Number of tanks is more than one lakh. Majority is below 40 ha of ayacut being maintained by Panchayats. Due to neglected maintenance for decades, most of these have silted up. Bunds have also become weak. Proper surplusing arrangements are hardly seen. Foreshore areas have been encroached for cultivation.

Waterways have been blocked bringing even tank beds under cultivation. Some tanks have been allowed for housing of weaker sections. Modernisation of these old tanks have been taken up in Tamilnadu only in a small way. This should be launched as a crash programme at an accelerated way. In case of ground water development there is large scope available except in case of Pondicherry. However, due to problem of salt water ingress, the programme should be taken up with abundant caution very near to coast say within a radius of 3 to 4 km. from the sea shore.

5.7.12. West Coast Plains and Ghat Region.

It includes whole of Kerala State, Kanyakumari and Nilgiri districts of Tamilnadu, Five coastal districts of Karnataka, five of Maharashtra and Goa State. In this region of high rainfall, minor irrigation is mainly through tanks and lift irrigation schemes. Enough Ground Water Development has not taken place. Minor Irrigation Strategy proposed for this region is construction of new tanks and for ground water development dugwells and borewells in upland areas only. Lift Irrigation on perennial water sources should be taken up.

5.7.13. Gujarat Plains & Hill Division.

It includes the whole of Gujarat, Diu and Daman Minor Irrigation Schemes comprise tanks, lifts, dugwells, shallow and deep tubewells. In respect of surface water there is not much scope for further development. However, according to recent reassessment of Ground Water potential of State, the balance potential available can irrigate a gross cropped area of million hectare. In all districts except for Mehsana. Amreli and Rajkot the stage of development is less than 50%. However, on the ground there is

Net extra income due to drip irrigation of tomato with mulch in Maharashtra is Rs 62,660 per ha.

a serious problem of salt water ingress all along the Saurashtra coast. Inland, there is excessive lowering of water table in Mehsana district. In fact, the situation is critical in all North Gujarat districts and Saurashtra area. Artificial Recharge is necessary in the area which may be provided by Narmada Canal System. Strategy for minor irrigation shall be construction of dugwells, shallow tubewells in areas of groundwater availability. In case of surface water, old tanks should be modernised and new ones constructed depending upon feasibility. To conserve water and irrigate more areas, **large scale use of sprinkler and drip system is necessary on all lift irrigation schemes including wells and tubewells.**

5.7.14. Western Dry Region.

It includes the nine dry desert districts of Rajasthan. Net irrigated area is only 6.3% of net sown area. About 90% is irrigated by ground water sources. According to recent assessment made by CGWB, the district-wise availability of Ground water is as follows:

(Thousand ha m)

Name of District	Utilisable G.W. Resource	Net Draft (84-85)	Ground Water Balance	Stage of Development
1. Bikaner	6.24	1.32	4.92	21%
2. Jaisalmer	9.82	0.49	9.32	5%
3. Jodhpur	39.61	13.50	26.12	34%
4. Sikar	43.42	15.17	28.25	35%
5. Nagaur	50.34	12.28	38.06	24%
6. Churu	16.62	1.47	15.15	9%
7. Jhunjhunu	26.30	12.25	14.05	47%
8. Barmer	19.67	8.22	11.45	42%
9. Jalore	52.08	21.50	30.58	41%
Total	264.10	86.20	177.90	29%

This shows large ground water resources exist in the area. With 0.5 m. water from the balance ground water 3 lakh ha gross cropped area can be brought under irrigation. However, present Ground Water Development is very slow in this state. CGWB and SGWO should make all out efforts to utilise the groundwater available effectively. Water being scarce, large scale use of **sprinkler and drip irrigation methods** should be adopted. In respect of groundwater availability indicated by CGWB, it needs a thorough exercise to establish the potential of the groundwater by indicating the area and type of structure feasible, as recharge is less due to low rainfall.

Net extra income due to drip irrigation of watermelon with mulch in Maharashtra is Rs 122,670 per ha.

5.7.15. The Island Region.

It includes Andaman Nicobar and Lakshadweep. In Andaman & Nicobar Islands presently the area under farming is very limited. Irrigation is only needed hardly for 2 to 3 months in a year. It is possible only through the construction of storages and in some cases by diversion. Small dug unit farm ponds are also feasible. Ground water development feasibility also exists. In Lakshdweep, irrigation requirements are not anticipated.

One labourer can easily attend to drip irrigation upto 10 ha

DRIP IRRIGATION FOR TOMATO IN PLASTIC GREEN HOUSE.
(Courtesy : NCPA, New Delhi)

DRIP IRRIGATION FOR CABBAGE
(Courtesy : NCPA, New Delhi)

CHAPTER - 6

BENEFIT COST AND ECONOMICS

Drip Irrigation is generally believed to be an expensive method. The manufacturing companies and others involved in the trade also concede that it is of capital intensive nature, though there had been some reduction arising due to indigenous manufacturing of few items. However, import of some of the raw materials and high duty rate imposed on these items, has a direct bearing on the cost of the individual items as also the system as a whole. Hence, the economic viability only remains as the crucial factor in large scale expansion of the drip system. However, the feed back from experimental trials support unequivocally adoption of drip irrigation even from the view point of economics, with its technical feasibility having already been established adequately.

6.1. COST OF DRIP IRRIGATION SYSTEM.

The cost of drip system depends to a large extent on the type of crop, its spacing, water requirements, proximity to water source, etc. An attempt was made in 1990 to prepare estimates of cost for installing drip/biwall systems for all important crops by contacting farmers having holdings of one ha to 2 ha. The details are presented in Table 6.1. It could be seen that the average cost ranges from Rs 9700 per ha for coconut/mango to Rs 32000 per ha for banana. The relative cost decreases with increase in the area, since certain essential components remain the same irrespective of the area covered. Further, cost per ha also reduces by adopting pair row system. The life of the materials and accessories of the system is about 5-10 years.

In Maharashtra, the cost of drip system estimated by the Government agency for different crops is given in Table 6.2(a). It will be seen that the cost varies from a minimum of Rs 15,625 per ha for Chikoo/Mango to a maximum of Rs 40,000 per ha for tomato/ chilli/brinjal.

The cost of Drip System for different crops in Tamil Nadu is given in Table 6.2(b). It will be seen that the cost varies from a minimum of Rs.20,000/- per ha for Mango/ Sapota to a maximum of Rs.50,000/- to Rs.70,000/- per ha for vegetables.

Further studies/exercises on the economics of drip irrigation in comparison with the conventional system in vogue need to be done. While the cropping pattern in the conventional system is mostly confined to cereal crops, drip is more suitable for orchard, commercial and plantation crops in view of their high returns.

Net extra income due to drip irrigation of banana in Maharashtra is Rs 262,600 per ha.

Table 6.1

Estimated cost of Drip/Biwall Irrigation Systems for various crops with different spacings.

Sl. No.	Crop	Spacing m x m	Estimated Cost (Rupees)			Average Cost/ha
			0.40 ha	1.20 ha	2.00 ha	
1.	Coconut/ Mango	7.62 x 7.62 (25' x 25')	4,475	11,930	18,550	9,710
2.	Banana	1.52 x 1.52 (5' x 5')	13,670	38,740	62,835	32,012
3.	Grapes/Ber & Pomegranate	3.04 x 3.04 (10' x 10')	7,700	20,030	31,880	16,558
	Grapes	2.44 x 2.44 (8' x 8')	9,340	27,020	45,500	22,739
4.	Orange & Citrus Species	4.57 x 4.57 (15' x 15')	8,040	19,980	31,200	16,450
5.	Papaya	2.13 x 2.13 (7' x 7')	9,500	27,840	46,700	23,344
6.	Sugarcane/ Vegetables	Between Biwall (1.83 m)	12,750	34,200	53,750	27,972

N.B. : Water source is assumed to be close to the system. Estimated cost was calculated based on field data collected during the spot interviews/question-answer sessions held with the farmers and suppliers in the year 1990.

Source: Constraints and potentials in popularising drip and sprinkler irrigation systems. Dr. Sivanappan and Associates, 1990.

Table 6.2 (a)

Cost of Drip System for different crops in Maharashtra (1990).

Sl.No.	Crop	Spacing (m x m)	Maximum Cost Rs/ha
1.	Chikoo/Mango	10 x 10	15,625
2.	Coconut	7 x 7	20,000
3.	Jamun/Citrus/Lemon	6 x 6	20,000
4.	Pomegranate/Sitaphal	5 x 5	20,000
5.	Betelvine	3 x 3	25,000
6.	Grapes	3 x 1.6	27,500
7.	Banana	1.5 x 1.5	30,000
8.	Sugarcane	1 x 0.6	31,875
9.	Cotton	1.3 x 1.3	33,750
10.	Tomato/Chilli/Brinjal	1 x 0.5	40,000

Source : Directorate of Irrigation Research & Development, Pune.

Net extra income due to drip irrigation of chilli in Maharashtra is Rs 73,220 per ha.

Table 6.2 (b)

Cost of Drip System for different crops in Tamil Nadu.

Sl.No.	Crop	Spacing (m x m)	Maximum Cost Rs/ha
1.	Coconut	7.5 x 7.5	22,500
2.	Mango & Sapota	10.0 x 10.0	20,000
3.	Guava, Acid Lime & Pomegranate	5.0 x 5.0	30,000
4.	Grapes	3.0 x 2.0	35,000
5.	Banana	2.0 x 2.0	40,000
6.	Jasmine	2.0 x 2.0	40,000
7.	Vegetables	0.3 x 0.6	
	(Alternate laterals)	0.6 x 0.75	50,000
	Vegetables	0.3 x 0.6	
	(One lateral for each row)	0.6 x 0.75	70,000

Source : Drip Irrigation for Different Crops by S.V.Kottiswaran. S.Senthilvel, K.Ramaswamy, A. Mohammed Ali, Workshop on Micro Irrigation & Role of Groundwater & Small Dams in Water Resources Development, WTC, TNAU, Coimbatore -641003 Tamil Nadu. (April 24,1994)

6.2. BENEFIT COST ANALYSIS.

There is no denial of the fact that the drip irrigation system is more remunerative to the farmers than the conventional systems. Farmers' decision to install the drip system inter-alia is conditioned by the incremental income complemented by a package of advantages as experienced by them. One of the important factors prompting the farmers is the economics of costs and benefits. The cost benefit ratio figures are presented in Table 6.3 for some of the important crops like grapes, banana, pomegranate, coconut etc without taking into account any subsidy given to the farmers.

Table 6.3

Benefit-cost ratio factor of drip irrigation over conventional irrigation for various crops.

Sl. No.	Crop	Spacing m x m	Cost of the Drip System/ ha in Rs.	B.C. Ratio Factor	
				Excluding water Saving	Including Water Saving
1.	Coconut	7.62 x 7.62	11,053	1.41	5.14
2.	i) Grapes	3.04 x 3.04	19,019	13.35	32.32

Net extra income due to drip irrigation of cucumber in Maharashtra is Rs 58,328 per ha.

Sl. No.	Crop	Spacing m x m	Cost of the Drip System/ ha in Rs.	B.C. Ratio Factor	
				Excluding water Saving	Including Water Saving
	ii) Grapes	2.44 x 2.44	23,070	11.50	27.08
3.	Banana	1.52 x 1.52	33,765	1.52	3.02
4.	Orange	4.57 x 4.57	19,859	2.60	11.05
5.	Acid lime/ Citrus Sp.	4.57 x 4.57	19,859	1.76	6.01
6.	Pomegranate	3.04 x 3.04	19,019	1.31	4.04
7.	Mango	7.62 x 7.62	11,053	1.35	8.02
8.	Papaya	2.13 x 2.13	23,465	1.54	4.01
9.	Sugarcane	Between Biwall 1.86	31,492	1.31	2.78
10.	Vegetables	Between Biwall 1.86	31,492	1.35	3.09

Source : Constraints and potential in popularising drip irrigation. Dr. Sivanappan & Associates, 1990.

The cost benefits for various crops like Banana, Chilli, Cucumber, Grapes, Groundnut, Mosambi, Pomegranate, Sugarcane, Tomato and Watermelon worked out for Drip System and Conventional System for the two situations mentioned below are presented in **Annexures VIII to Annexure XIX,** separately for each crop.

i) Excluding water saving, implying thereby the benefit will directly accrue consequent on the drip system. One of the important reasons that motivated farmers to resort to drip system was scarcity of water.

ii) Including water saving thereby assuming a conditional clause that 50 per cent of the quantity of water saved will be used to extend drip irrigation to cover additional area. Mostly the banana and grape farmers who had the system installed for 3 to 4 years and more, had made field - based assessment of the quantity of water saved. Such farmers have ventured to double the crop area, deriving full benefits.

The benefit-cost ratio excluding the proposition of water saving is found to range from 1.31 to 2.60 for the listed crops excluding grapes. For Grapes however, it is 11.5 for spacing of 2.44 m x 2.44 m and 13.5 for wider spacing of 3.04 m x 3.04 m. This accounts for the economic logic of entrepreneurial grape farmers to go in for the drip system on an extensive scale and also prompting others to join them in large numbers.

Net extra income due to drip irrigation of grapes in Maharashtra is Rs 495,435 per ha.

As could be expected, the benefit cost ratio factor is much higher when the water so saved is assumed to cover one more hectare of the same crop.

An exercise was undertaken by Dr. R.K. Sivanappan with the farmers to work out the case studies for arriving at the costs, pay back periods and cost benefits for various crops during 1988-89. A summary of the case studies is presented/furnished in Table 6.4.

The case studies reported by Shri Saksena for various crops like sugarcane, banana, citrus, pomegranate, orange, grapes, groundnut, tomato had indicated considerable increase in yields for all crops ranging from 35 to 50%, improvement in cost benefit ratios varying from 4.84 to 15.0, with pay back periods of only one to two years.

6.3. GOVERNMENT'S ROLE.

Government has to play an important role in popularising this method in view of its high initial cost, as it is economically viable and to expand the area under irrigation with the same quantity of water, especially in water scarcity areas of the country.

a. Subsidy During VI and VII Plans.

To encourage use of water saving devices like sprinklers, drip system, solar pumps, wind mills, hydrams, water turbines, man or animal operated pumps, Ministry of Water Resources (Minor Irrigation Division), Government of India had sanctioned a centrally sponsored subsidy scheme in the year 1982-83 of the 6th Five year plan. Central Government provided a subsidy of 50% to the farmers with a matching contribution of 50% from State Governments for installation of the devices. Of the total subsidy, 75% was meant for small and marginal farmers with the balance 25% for other farmers.

During the 7th Plan period also, the above subsidy scheme was continued with the following modifications. The subsidy rates for different categories of farmers and the upper limits for each, are shown in table 6.5.

i. The non-conventional energy devices like solar pumps and wind mills were excluded from this subsidy scheme as the same were included in the scheme operated by the Department of Non-Conventional Sources of Energy.

ii. The subsidy was limited to the small and marginal farmers only, excluding other farmers from the scope of the scheme.

iii. The percentage of subsidy eligible under the scheme was on par with Integrated Rural Development Programme.

Net extra income due to drip irrigation of groundnut in Maharashtra is Rs 9,035 per ha.

Net extra income due to drip irrigation of mosambi in Maharashtra is Rs 211,400 per ha.

Table 6.4

Summary of Case Studies - Cost, Payback Period, Cost Benefits for Various Crops.

Sl. No.	Crop	Cost per ha (Rs.)	Payback Period	Cost benefits	Other Advantages	Remarks/ Systems
1.	Sugarcane	25,000	1.5 years	Additional income after deduction of depreciation & interest is Rs 6,650/ha B.C. Ratio 1.80	With the same quantity of water twice the area can be irrigated and 3 times more sugarcane can be obtained.	Biwall 15, Life Period 5 years
2.	Banana	40,000	One Crop 14-18 months	Net Additional income after deducting the cost of drip is Rs.12,500 ha B.C. Ratio 6.0	With the same quantity of water twice the area can be irrigated and 3 times yield can be obtained.	Drip Life Period 10 years
3.	Tomato	20,000	One Crop 5-6 months	Net additional income after deducting depre-ciation & interest is Rs. 30000/ha B.C. Ratio 1.80	With the same quantity of water twice the area can be irrigated and nearly 3 times yield can be obtained.	Biwall 5 Life Period 2 years
4.	Orange/ Mosambi	- do - - do -	One Year	Incremental benefit is Rs.30,000/ha B.C.Ratio 1.80	From the same quantity of water twice the area can be irrigated. Quality of the produce is good compared to surface irrigation obtained.	Drip Life Period 10 years

Sl. No.	Crop	Cost per ha (Rs.)	Payback Period	Cost benefits	Other Advantages	Remarks/ Systems
5.	Grapes	20,000	One year	Additional Income Rs.1,12,500/ha B.C.Ratio 22.50	50-60% of saving in water. Quality is good.	Drip Life Period 10 years.
6.	Coconut	10,000 to 12,500	One year	B.C.Ratio 1.00 to 1.44	60-70% saving of water.	Drip Life Period 10 years.
7.	Chilli/ Onion	25,000	One year	B.C.Ratio 2.8	With the same quantity of water twice the area can be irrigated. Quality of the produce is good.	Biwall 15 Life Period 5 years.
8.	Betelvine	32,500	One year	B.C.Ratio 5.4 Additional Income Rs.37,500/ha	From the same quality of water twice the area can be irrigated. Quality of the leaves are very good.	Biwall 15 Life Period 5 years

Source : Dr. Sivanappan, R.K., State of Art of Drip Irrigation in India, its Problems, Prospects and Policies, 1988.

Net extra income due to drip irrigation of pomegranate in Maharashtra is Rs 140,628 per ha.

iv. Farmers growing horticultural crops like grapes, papaya, banana, arecanut and coconut were also eligible for subsidy.

v. Scheduled Caste and Scheduled Tribe farmers belonging to small and marginal categories and Co-operative/Community Schemes of small and marginal farmers were provided with 50% subsidy under the scheme.

The Central assistance released to the State Governments under Centrally sponsored Scheme has encouraged the use of the drip systems, Sprinklers and other devices during 6th and 7th Plans and the two annual plans thereafter. The details of central assistance are given below :

Plan	Year	Amount of Subsidy released Rs.lakhs
VI	1982-83	150.00
	1983-84	85.66
	1984-85	33.23
	TOTAL	268.89
VII	1985-86	25.00
	1986-87	144.78
	1987-88	145.52
	1988-89	92.91
	1989-90	179.98
	TOTAL	588.19
ANNUAL	1990-91	194.62
- do -	1991-92	142.76
	TOTAL	337.38
	TOTAL OF FOUR PLANS	**1194.46**

It will be seen that the subsidy amount released during the 6th plan was Rs.268.89 lakhs and the same in 7th plan was Rs.588.19 lakhs while in the two annual plans of 1990-91 and 1991-92 subsidies worth Rs.194.62 lakhs and Rs.142.76 lakhs respectively were released making the total subsidy of Rs.1194.46 lakhs released to the States under the Scheme. The year-wise subsidies released to different States are given in **Annexure - XX.** Maharashtra got the maximum subsidy of Rs.339.07 lakhs followed

Net extra income due to drip irrigation of sugarcane in Tamil Nadu is Rs 19,245 per ha.

by Madhya Pradesh with Rs. 190.45 lakhs, Gujarat with Rs. 110.17 lakhs and Tamil Nadu with Rs. 108.38 lakhs. Other States got varying amounts of subsidies ranging from Rs. 2.00 lakhs for Mizoram to Rs. 87.96 lakhs for Karnataka. These figures are combined subsidies for drip systems, sprinklers and other water saving devices and the component of central assistance for drip irrigation alone is not readily available.

The Scheme did not get good response during the 7th plan as the subsidy was limited to small and marginal farmers who could not afford these systems even at the subsidised cost, as per the report of the Working Group for formulation of 8th Plan 1992-97 (MoWR, July, 1989).

Table 6.5

Subsidy for Centrally Sponsored Programme for Different Categories of Farmers (VII Plan).

Sl. No.	Category of farmers	Subsidy Rate %	Upper Limit (Rs.)
1.	Small Farmers	25	10,000
2.	Marginal Farmers	33.33	13,333
3.	Small Farmers (SC & ST)	50	20,000
4.	Marginal farmers (SC & ST)	50	20,000
5.	Community and Cooperative schemes and admissible subsidy proportional to the area attributable to the small and marginal farmers.	50	20,000

b. Drip Irrigation Development and Subsidy Available During VIII Plan.

The Government of India has taken serious note about the possibility of having second Green Revolution through the use of drip and has provided liberal subsidy to different State Governments for adoption of this system at the field level. Accordingly, the Government of India has introduced a Rs 2.5 billion promotional scheme in the VIII Plan, on the use of plastics in agriculture, having components such as Drip Irrigation, Drip Demonstration, Plastic Mulching, Green Houses, New Plastic Applications and Training. The component-wise details are given in tables on next page :

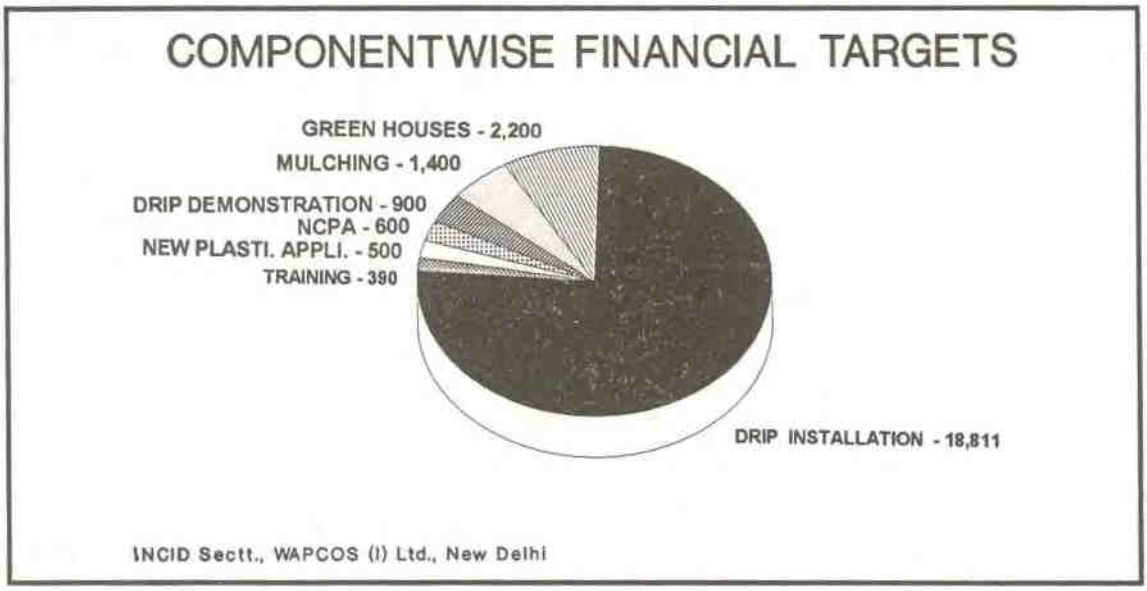
Net extra income due to drip irrigation of sugarcane in Maharashtra is Rs 77,540 per ha.

Component	Area in ha	Amount in Rs Lakhs
Drip Installation	139,185	18,810.99
Drip Demonstration	12,000	900.00
Mulching	28,000	1,400.00
Green Houses	247	2,200.00
Total	**179,432**	**23,310.99**

Other allocations made under the scheme are:

New Plasticulture Application	Rs. 500 Lakhs
Training	Rs 590 "
NCPA	Rs 600 "
Total	**Rs 1690 "**

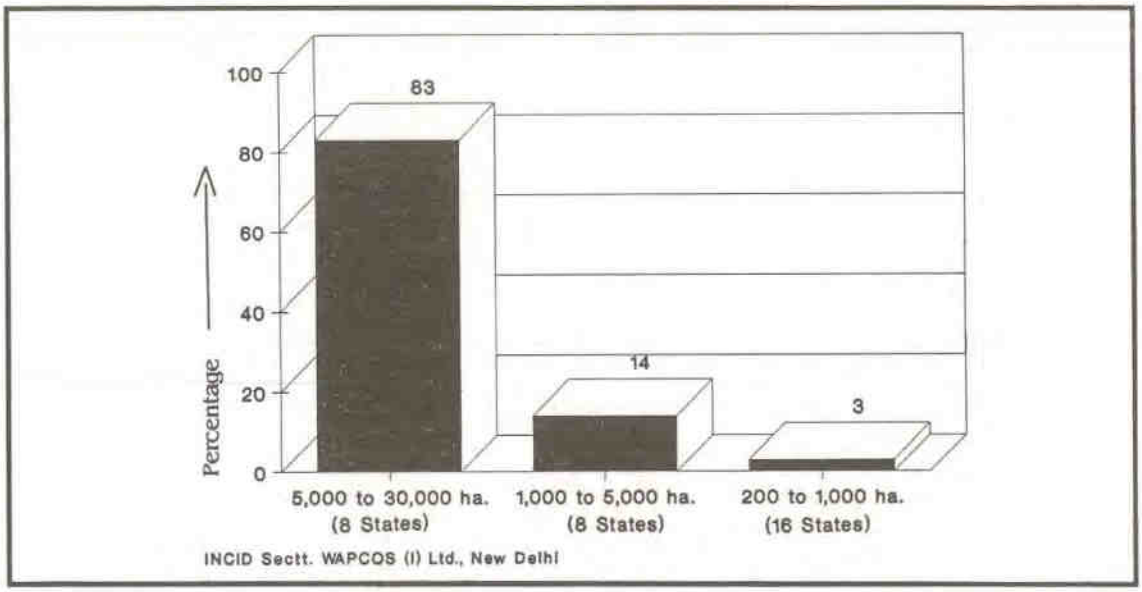
State-wise allocation of Rs 1690 lakhs has not been made.



The state-wise break-up for Drip irrigation and Drip Demonstration are presented in **Annexure - XXI**. It will be seen that Drip Installation coverage of 5,000 ha to 30,000 ha accounting for 83% is in the eight States of Andhra Pradesh, Gujarat, Karnataka, Kerala, Maharashtra, Orissa, Tamil Nadu and Uttar Pradesh. Coverage of 1,000 ha to 5,000 ha forming 14% is in the next eight States of Bihar, Haryana, Himachal Pradesh, Jammu & Kashmir, Madhya Pradesh, Punjab, Rajasthan and West Bengal. Small

Net extra income due to drip irrigation of tomato without mulch in Maharashtra is Rs 87,536 per ha.

coverage of 200 ha to 1,000 ha is proposed in the balance sixteen States and Union Territories, accounting for the remaining 3%.



With this, the Drip irrigation is expected to receive a big boost.

The detailed provisions of the two scheme components viz. Drip Installation and Drip Demonstration are as follows :

Drip Installation

Considering the advantages of drip irrigation, Government of India has decided to promote drip irrigation in all the States and Union Territories of the Country. A budget of Rs. 1.88 billion has been allocated in the VIII Plan towards subsidy component. The average cost of drip irrigation system has been worked out as Rs 30,000/ha. A subsidy of 50 percent is being offered upto 1994-95 to farmers for installation of drip system subject to a ceiling of one hectare per farmer. For the years 1995-96 and 1996-97, Centre and State will contribute 40 percent and 10 percent towards subsidy. A total of 1.39 lakh hectares shall be brought under drip irrigation under this scheme during VIII Plan period.

Drip Demonstration

To demonstrate the technology, provision has also been made to arrange for demonstration on State Government farms subject to a ceiling of one ha. Upto 1994-95, 75 per cent subsidy on demonstration farms shall be provided by the Central Government. For 1995-96 and 1996-97, Centre will provide 65 percent subsidy while the remaining contribution has to come from the State Government. An amount of Rs. 90 million shall be spent to bring 12,000 hectares of land under demonstration farms.

Water conservation is better achieved through drip irrigation.

An extensive training programme has been planned to train officials at the implementation level as well as for benificiaries. An amount of Rs 590 lakhs shall be spent on training programmes to be conducted in each State by the plasticulture Development Centres, nearest to the State. There are in all 11 existing and 6 proposed PDCs to be opened as given below :

Existing PDCs:

1. Indian Institute of Technology, West Bengal.
2. Mahatma Phule Krishi Vidyapeeth, Maharashtra.
3. Rajasthan Agricultural University, Rajasthan.
4. Andhra Pradesh Agricultural University, Andhra Pradesh.
5. G.B. Pant University of Agril. & Technology, Uttar Pradesh.
6. Assam Agricultural University, Assam.
7. Gujarat Agricultural University, Gujarat
8. Indian Agricultural Research Institute, New Delhi
9. Orissa University of Agriculture, Orissa.
10. University of Agricultural Sciences, Kamataka.
11. Tamil Nadu Agricultural University, Tamil Nadu.

Six new plasticulture Development Centres are proposed to be set up in the States of Bihar, Haryana, Himachal Pradesh, Kerala, Madhya Pradesh and Punjab.

Detailed Guidelines issued for implementation of the Scheme on Use of Plastics in Agriculture for the remaining part of the VIII Plan period are given in **Annexure - XXII**.

6.3.1. Subsidy Scheme of State Governments.

Some State Governments like Maharashtra, Tamil Nadu, Haryana, Madhya Pradesh and Gujarat are also operating subsidy schemes to promote drip irrigation in their States. Under the new promotional scheme, the States are required to contribute 10 per cent towards subsidy for the years 1995-96 and 1996-97 which will add upto 50 percent with the Centre's contribution of 40 percent.

The details of subsidy scheme in different States are as follows:

a) Maharashtra.

Land Holding	Rate	Upper Limit
2 ha (SC/ST farmers)	50%	Rs.20,500
2 - 6 ha.	35%	Rs.14,350
6 ha.	30%	Rs.12,250

N.B.: The Maharashtra Government has announced (on 14th May,1992) that 100% subsidy for drip irrigation to all farmers in the State,irrespective of their land holdings.

Overall efficiency of drip irrigation system is almost double that of surface irrigation.

b) Tamil Nadu.

Sl.No.	Category of Farmers	Rate Rs./ha.	Upper Limit (Rs.)
1.	Marginal Farmers	5,000	11,250
2.	Small Farmers	3,750	8,437
3.	SC/ST Farmers	7,500	16,875
4.	Community Farmers	-	50,000

The Government has changed the subsidy rates in 1991-92 as follows :

Sl.No.	Extent of Land	Rate of Subsidy	Amount of Subsidy (Rs./ha)
1.	Upto 1 ha	50%	12,500
2.	Above 1 ha to 2 ha	40%	10,000
3.	Above 2 ha to 3 ha	30%	7,500

This subsidy will be provided to all farmers for laying drip in an area not exceeding 3 ha per farmer. The farmer who intends to install upto 3 ha will get a subsidy of Rs 30,000/-.

c) Haryana.

The amount of subsidy for all categories of farmers is 50% subject to a maximum limit of Rs.7,000/ha.

d) Madhya Pradesh.

The rates of subsidy in Madhya Pradesh are 25%, 33.33% and 50% respectively for small, marginal and SC/ST farmers.

e) Gujarat.

A subsidy scheme in Gujarat in drought prone districts did not achieve much success.

6.4. BANKS' ROLE.

The cost of the drip system is high. Even though the Government is providing subsidy, the balance amount is to be provided by the farmer. As the amount involved is substantial, the farmer seeks assistance from Banks. Though NABARD has approved a scheme for loans to be given to the farmers by the commercial banks, the farmers feel it very cumbersome to get loans from the banks. Some liberalised arrangements should be made to get loans easily for the drip farmers.

Drip irrigation offers very high efficiency of water use.

For the purpose of loans, NABARD has approved unit costs for Drip Irrigation Systems for various crops in different States, ranging from Rs. 10,500/- per ha for Sapota, Mango, Chickoo in Maharashtra to Rs.54,400/- per ha for grapes in Karnataka. Details are given in **Annexure - XXIII**.

6.5. ACHIEVEMENTS IN COVERAGE.

Despite all the promotional schemes, the area covered under drip irrigation in the country is 70,859 ha as already reported in para 3.1.2 of Chapter III. This is only 0.09 percent of the total irrigated area of 80 M ha in the country, a meagre achievement when compared to the estimated potential of 10.5 M ha which forms 13% of the total irrigated area. Initially, the Government of India in consultation with NCPA has desired to bring out 2 M ha under drip irrigation by 2000 A.D. As this target requires significant contribution from the State exchequer, it is unlikely that the coverage of 2 million ha under drip irrigation will be achieved by the end of the Century. However, trends being favourable, if timely credit/fund is available together with increased capacity of the manufacturers, it would be possible to achieve the mark of one million ha by the end of this century.

6.6. MANUFACTURERS OF DRIP SYSTEM.

There are nearly 50 drip irrigation system manufacturers in the country. The names and addresses are given in the **Annexure-XXIV**. Many new manufacturing units, some multinational and joint venture companies, are coming up in different parts of the Country.

The total capacity that can be handled by these firms is only 47,000 ha per year. Further, most of them do not have necessary back-up support of O & M staff. Therefore, it is necessary that the companies should galvanise operation and maintenance staff cum research and development cells in their organisations. They have to open service Centres within the easy reach of farmers and provide adequate spare parts and attend to repairs/maintenance problems of farmers quickly so that the farmers could get the system back to operation with the least possible delay.

6.7 PROBLEMS OF CREDIT DELIVERY SYSTEM*

i. Techno-Economic Feasibility.

One of the conditions for providing credit through banks is the techno-economic viability of the drip irrigation system at the field level. The drip irrigation systems which were installed during the last few years have provided satisfactory information to

---

***Source :** Availability of Credit for Drip Irrigation Systems in India by Shri P.K. Chatterjee, Dy.General Manager, NABARD; All India Seminar on Sprinkler and Drip Irrigation at Hyderabad, (9-10 December, 1993).

Drip irrigation offers more crop yields.

farmers/bankers about the techno-economic viability for crop specific schemes like horticultural projects. However, horticultural projects mostly require long gestation periods. It is, therefore, necessary for the banks to satisfy about the sustainability of the small farmers during the period when there will be no additional income from the system. It is intended that in case of small farmers the coverage of drip system should be gradual so as to provide him income from some of the annual crops which he can grow in the area available with him for his sustenance.

ii. Quality Control.

Quality control measures are one of the important areas where the credit delivery system i.e. financial institutions want to satisfy before lending. As a result of the continuous dialogue between the Government and the manufacturers many of the State Governments have already identified manufacturers in their own States who are registered under the State government and are guided by certain conditions given by the Government like guarantee period, after sale service etc. Bureau of Indian Standards (BIS) has also come out with standards of laterals of drip system and also of the emitters. This has given a lot of confidence to the financial institutions to extend credit for the same. However, it has to be noted with concern that due to the thrust given by the Government on this system there is mushroom growth of manufacturers in this sector. There is, thus a need to control the quality of the equipments manufactured by such companies as specified by BIS. It may be necessary also to introduce some system efficiency in the drip irrigation system including fertiliser unit, filter unit, laterals and emitters. The code of practice has also to be evolved for installation of drip system so that farmers' interests are fully protected.

iii. Role of the Manufacturers.

Manufacturers always play a vital role in propagating certain new systems in the field amongst farmers. Therefore, it may be necessary for the manufacturers to have a pragmatic approach towards this sector not only to provide quality material to farmers but also to design the product according to the needs of the farmers. They should agree to provide farmers the most cost effective system commensurate with the crop the farmers want to grow. The role of manufacturers in imparting training to the farmers would also go a long way in propagating the system on a verly large scale.

iv. Role of Research Institutions.

The drip irrigation system although in vogue for a number of years, is even now in a nascent stage. Drip irrigation system is the most modern method not only for increasing productivity but also for saving water and fertilisers. Therefore, its application in the field has to be carefully designed taking into account agro-climatic conditions, soil conditions and the plants to be grown. Water requirements of crops by the conventional methods of irrigation are more or less well known state-wise. However, water requirement of crops in different agro-climatic zones by the drip system has not been studied separately. It is in this sector that research institutes can play a very important role. It is pertinent to note that most of the Agricultural Universities including

Drip irrigation requires less tillage.

some of the specialised Institutes like Deccan Sugarcane Research Institute have already taken up studies seriously and providing valuable information to farmers from time to time. National Bank for Agriculture and Rural Development (NABARD) has also extended some of its R&D funds to few Institutes for carrying out such tasks of determining water requirements of crops on different agro-climatic zones. NABARD has also come out with some publications which would help the manufacturers/farmers/ financial institutions in formulating proper schemes for drip irrigation systems and for deriving higher income.

v. Role of Government of India.

Taking a serious note about the possibility of having second Green Revolution through the use of drip, Government of India has provided liberal subsidy to different state governments for adoption of this system at the field level. The Government of India has provided a subsidy of Rs.188.11 crores during the VIII Five Year Plan and the figure is likely to be revised depending upon the response at field level. In this context, it is necessary to mention that release of subsidy is a very important aspect in propagation of drip system. Unless and until timely release of subsidy is made, manufacturers will not be able to effectively deliver the efficient products to the farmers because of the paucity of funds at their level.

Issues for Immediate Concern:

1. One of the major issues of immediate concern is the cost of the drip irrigation system. The cost of the drip irrigation system is related to the cost of the imported material of plasticulture used for making laterals, emitters etc. Efforts should therefore be made immediately so that some import substitutes can be manufactured in India itself. In the meanwhile the Government of India should provide some excise duty concessions to make this system cost effective.

2. In the States like Maharashtra and Tamil Nadu, there is a large demand for drip irrigation for sugarcane. The Government of India however, does not provide subsidy for drip system for sugarcane. The recent studies on sugarcane had indicated usefulness of the drip system not only in improving the quality of the yield of the sugarcane but also in the area of water management. Considering this, the Government of India may reconsider their decision and allow subsidy for drip irrigation for sugarcane also. The Government of Maharashtra has already taken a decision to provide subsidy in a limited way for drip irrigation for sugarcane out of their own budgetary resources.

Drip irrigation system has made a significant breakthrough in modern agriculture.

DRIP IRRIGATION WITH SKIP ROW TECHNIQUE
(Courtesy : Jain Irrigation)

DRIP IRRIGATION FOR BANANA.
(Courtesy : Jain Irrigation)

CHAPTER - 7

POTENTIALS, PROSPECTS AND PERSPECTIVES

The data collected on the studies carried out in the farmers' fields has indicated that the drip method is technically feasible, economically viable and socially acceptable. Drip Irrigation can be adopted in areas irrigated by wells which constitute about 35% of the total irrigated area in the country. Further, this method is ideally suited for all row crops particularly, coconut, fruit trees, vegetables, flowers, commercial crops like cotton, sugarcane, chillies etc. Although the ground water is available at shallow depths, the long coastal belts have not been fully utilised/exploited as the soil in these areas is sandy and water is brackish. Drip irrigation can be introduced in such areas depending upon the crop, terrain and the source of water. If the wind velocity is sufficient to lift water through wind mills, drip irrigation can be introduced ideally in such areas even if the water is brackish. In the undulated hilly terrains, this system is well suited for plantation crops like coffee and tea and spices like cardamom.

Available irrigation facilities particularly, ground water supplies are depleting rather fast, while demand dimensions are escalating. Manifestations of water crisis are assuming gigantic proportions particularly during summer months over a sizeable part of India. Complacency to face the emerging crisis would tend to cause immeasurable damage. To prevent such emerging crisis, it is very essential to adopt efficient technology for water use. We should therefore lay great emphasis on water use efficiency by resorting to scientifically based, economically viable, technically feasible and socially acceptable strategies. It is here the drip irrigation system with the potential of reducing the burden on the water use and improving the productivity, opens up wide opportunities for a fairly expanded operation, provided the much needed political will, policy and financial support and organisational endeavours are extended to the Indian farming community to surmount the various bottle-necks and constraints. The scope and potentials for large scale coverage are projected to be vast in the context of nearly a decade of experience in India, not to speak of other countries which have made commendable progress.

7.1 POTENTIALS.

As indicated earlier, even after harnessing all the water resources, only about 50% of the area can be brought under irrigation with the present method of irrigation. The population explosion and the consequent need to feed the growing millions demand that more areas should be brought under irrigation. Hence there is an urgency and need to switch over to the advanced methods of irrigation to save water and to increase the production.

Drip irrigation transforms deserts into goldmines.

The consumption of fruits, vegetables, and other nutrients by the people is very low in the country. In order to have a balanced diet, nutritious food, rich in vitamins and minerals should be available freely and at affordable cost. It is therefore essential to grow these crops in larger areas of the country, for which the drip irrigation is considered ideal.

The extracuon of ground water is very rapid in the last two decades by construction of a large number of open and tube wells. Consequently, the ground water table has fallen very rapidly in many parts of the Country. Thousands of wells in Chidambaram, Madurai, Coimbatore districts of Tamil Nadu have been abandoned in the last 5 to 10 years due to depletion of ground water aquifer. This position is the same in many other States as well and showing an increasing trend year after year. In order to prevent this disaster, and to maintain ground water levels to support sustained agriculture, there is an urgency now to go in for the water-saving methods like drip and sprinkler irrigation along with diversification of the crops from high water consumption to low water consumption crops. As already stated in Chapter - 5, an action plan for each agro-climatic zone may be prepared by the State Governments to determine the possibilities of drip irrigation by the year 2000 A.D. and beyond.

The present coverage under drip system is only 70,859 ha in different States for all the crops which include flowers, fibres, nuts, oilseeds, orchards, plantation crops, spices, vegetables and others. The potential for drip irrigation system is estimated to be 10.5 million ha. Initially, the Government of India in consultation with NCPA has desired to bring out 2 million ha under drip system by 2000 A.D.. However, the physical target made by the Horticulture Division, Ministry of Agriculture, Government of India is only 1.39 lakh ha by the end of Eighth Plan i.e. upto the end of 1996-97, requiring an outlay of about Rs 200 Crores. Therefore, it is unlikely that the target of 2 million ha could be covered under drip irrigation by the end of this century. Trends however are favourable and if timely credit/fund is available together with increased capacity of the manufacturers, it would be possible to achieve the mark of one million ha by the end of the century. To realise this goal, massive efforts are required to be taken up by the Government and all the concerned Departments, Research Institutes, farming Community, manufacturing agencies and voluntary/non-governmental organisations.

It is heartening to note that Government of India decided to promote drip irrigation in all the States and Union Territories of the country. For this purpose, the Government of India has introduced a promotional scheme of Rs 2.5 billion on the use of plastics in agriculture.

The farmers in Maharashtra who have grown grapes, banana, orange, vegetables and other fruit crops using drip irrigation have enlarged their income base and their living standards are fairly high. Similar development should take place in other parts of the country as well.

Drip irrigation is an efficient irrigation technique.

7.2. PROSPECTS.

7.2.1. Crops Suitable for Drip Irrigation.

Drip irrigation system has emerged as an appropriate water-saving and production augmenting technique for wide spaced crops, viz. grapes, banana, coconut, mango, pomegranate, citrus, guava, sapota, tea, coffee, cardamom and also for commercial crops like cotton, tobacco, sugarcane etc. The areas under these crops are given below in Table 7.1

Table 7.1
The Area under fruit and plantation crops.

Sl.No.	Crops	Gross cropped area in Mha (1989-90)
1.	Fruit Crops	2.5
2.	Vegetables	3.7
3.	Sugarcane	3.5
4.	Cotton	7.4
5.	Tobacco	0.4
6.	Tea, Coffee, Cardamom, Rubber etc.	2.5
	Total	**20.0**

The drip irrigated area under these crops is 45,257 ha which represents 0.23% of the total area of 20 M ha (both rainfed and irrigated). Grapes, coconut, banana and citrus require assured irrigation while other crops are partially irrigated and mostly rainfed. Extension of drip irrigation initially to these irrigated crops will increase production and help in saving of water. Supplementary/protective irrigation can be given to other crops wherever possible through drip. Feasibility of the proposal needs to be examined individually on specific location basis.

7.2.2. Drip for Waste Land Development.

As per statistics available for 1989-90, the area under culturable waste land is 15.04 M ha with 'fallow lands other than current fallows' as 10.62 M ha, making up a total of 25.66 M ha. Such a large mass of land is not put even to minimum use at present for want of water and institutional support. They are increasingly subjected to degradation. It would be worthwhile if possibilities are explored to bring in tree crops of various kinds including fruit trees atleast in a small proportion of these lands by using drip system. Immense benefits in terms of production, income and employment could be realised in addition to ecological advantages.

7.2.3. Drip for Hills and Semi-Arid Areas.

Undulating terrains, rolling topography and hilly slopes cannot be easily irrigated by

Drip irrigation is a modern scientific technology.

surface method, though water may be available. Such areas become accessible to drip irrigation without any investment on land levelling and shaping. High value crops are grown in these tracts. If irrigation is given by drip, the yield and production of these crops can be increased substantially.

7.2.4. Drip for Coastal Sandy Areas.

In the coastal belts, fairly good water becomes available at shallow depths, fit for irrigation. Technology is available to grow a wide range of vegetables, fruits and flowers in these sandy areas. Drip system offers an ideal method under these conditions.

7.2.5. Drip for Water-Scarce Areas.

Farming is becoming an extremely risky venture in regions where ground water resources have depleted considerably. In South India, the hard rock terrain occupies 75-80 per cent and the porosity of the rock is only about 1 to 3 per cent and therefore the availability of water is very limited. Due to increasing demand, the extraction is much more than what is recharged into the aquifers. Further deepening of the well to strike more water is a common phenomena resulting ultimately in drying up of large number of wells to be abandoned later. Thousands of wells in Madurai, Coimbatore and Tirunelveli districts of Tamil Nadu and many wells in Nasik, Jalgaon, Pune and Dhule districts of Maharashtra have already been abandoned. In order to maintain water table at safe level and also to ensure sustained agriculture, it is imperative to switch over to drip irrigation.

7.2.6. Drip for Community Wells.

The concept of community wells for irrigation purposes is gaining increased acceptance. Institutional funding is helping to accelerate the process of digging more number of such wells to benefit marginal and small farmers. It would be worthwhile to have the drip system if tree crops including afforestation programme is contemplated.

7.3 PERSPECTIVES.

Drip irrigation in the world is under varying degrees of development. In Israel, the entire area is now irrigated through drip. In United States of America, large areas under citrus and deciduous grape, sugarcane, cotton etc. are irrigated through drip. Similar pattern is noticed in Australia, Southern Europe and other Countries where drip is increasing at a faster rate due to the water scarcity and the need to enhance the yield and quality of the farm produce (Refer para 3.1.1 Historical Development of Drip-World).

In the Indian context too, water scarcity has compelled the farmers to go in for advanced methods of irrigation, in order to increase the production and farm income and to utilise the water more efficiently at least for high value crops. It is reported that farmers making use of drip irrigation in Maharashtra State, are able to get a net profit of Rs 1,25,000 to Rs 2,50,000 from one ha by growing grapes, orange, pomegranate, tomato and other fruit and vegetable crops. Similarly the yield of tea crop has been

A farmer can avail subsidy upto Rs.15000/- for drip irrigation.

increased by about 30% by providing drip irrigation during summer. In spite of these advantages, the area under drip irrigation is only 70,859 ha out of about 80 Mha under irrigation potential created by 1990 in India, which is considered a meagre achievement. Therefore, it needs no emphasis that planning and implementation of the increased programme of drip irrigation in future years should be such as to achieve a target of 1 M ha by the end of this century.

It is a mistaken notion that drip method is suitable only in water scarcity tracts, though it is very well suited to all places for increasing production and for sustenance of agriculture. It is a happy augury to note that Maharashtra Government has projected an area of 1.17 M ha under drip and sprinkler for the next 15 years (Maharashtra State Plan, 1992).

Taking into consideration all the relevant factors, the perspective plan for the drip irrigation for the next 8-10 years is suggested as follows :

To introduce atleast 1% of the irrigated area under drip i.e. about 1 M ha, mostly under wells and to some extent in canal and tank commands covering the crops of coconuts, grapes, oranges, cotton, sugarcane, flowers, fruits, vegetables etc.

The cost involved for the development in the next 10 years is as follows :

At Rs 25,000 per ha (average) for 930,000 ha (One per cent of 100 M ha i.e. 10,00,000 minus 70,000 ha present area of irrigation) works out to Rs 2325 crores. The area for each State can be worked out based on the need, the availability of finance, the capacity of the farmers etc. The financial requirements (Rs 2325 crores in 10 years) is not on the high side compared to the benefits accruing by way of increase in production. In addition, it will generate employment opportunities to a large extent. Therefore, there is every justification to go in for drip method and the entire cost can be met by the Government as decided by the Maharashtra Government. This method is suitable for all agro-climatic zones in all States and to all wide spaced high value crops to start with. States may be requested to prepare perspective plans suited to different agro-climatic regions and work out investments needed, and the source of funds such as private capital, Bank loan and subsidy from Government etc. Such plans will give a lead for proper promotional measures in the Eighth Plan for popularising drip irrigation. The Ministry of Agriculture have planned an investment of Rs 200 crores in the Eighth Plan (1992-97) towards subsidy, the State-wise break-up of which is given in **Annexure - XXI**. The corresponding target for drip irrigation area for the Eighth Plan is 1.39 lakh ha.

Wastelands and coastal sandy belts can be made arable with drip irrigation.

DRIP IRRIGATION FOR BAMBOO.
(Courtesy : Jain Irrigation)

DRIP IRRIGATION FOR COCONUT AS AVENUE TREES.
(Courtesy : Jain Irrigation)

CHAPTER - 8

POLICY ISSUES INCLUDING INFRASTRUCTURE REQUIREMENTS FOR IMPLEMENTING THE PROGRAMME - CONCLUSIONS AND RECOMMENDATIONS

8.1 CONSTRAINTS.

There is no second opinion about the tremendous/immense potential and prospects of drip irrigation to solve the water scarcity conditions of the country and to increase the production, but the actual problem is how to implement it in a big way. The challenge has to be met by a multi-pronged effort. The awareness is increasing on the part of the farmers about the urgent need to change the traditional methods of irrigation for achieving higher productivity and increased efficiency. However, various problems and constraints have been encountered in taking up an ambitious programme. Unless these problems are solved drip irrigation cannot be on sound footing for increased production. The Central and State Governments are very keen in bringing more and more areas under drip system. The Banks/Credit Institutions are equally interested in providing loans, facilities for the acquisition of equipment. The farmers are also compelled to go in for the water saving devices for sustained agriculture for various reasons. The Universities are also undertaking research to provide wealth of information about water requirements, reducing cost of the systems etc. There are nearly 50 manufacturing companies/firms dealing with drip irrigation systems in the country. Many have collaborations with leading manufacturers of drip system in the world. Therefore, no problem is anticipated in introducing this method on a large scale in the next 10 years. However, this requires detailed action plans in a phased manner by the Government and manufacturers and strong determination and willing co-operation by the farmers.

The constraints/impediments encountered are as follows :

a) High Initial Cost.

b) Quality of Material.

   i) Life of the system.
   ii) Clogging of drippers.
   iii) Cracking of pipes.

c) Uninterrupted power supply.

Drip irrigation can profitably be extended to the command areas of the community wells.

d) Lack of awareness which has to be set right through Extension Organisations and Voluntary Agencies

e) Lack of adequate technical improvements in design, installation and absence of timely after sale service.

f) Need for skilled labourers/trained hands particularly the educated youth in the Villages.

g) Damage due to rodents and squirrels.

h) Availability of components and cost of spares.

i) Lack of co-ordination as multiple agencies are involved.

j) Inadequate subsidy schemes/non-availability of finance.

k) Insufficient extension and promotion work by the Government.

l) High price of plastic material.

   i) Excise Duty.
   ii) Sales Tax.

m) Limited experience in the country.

Based on the major impediments mentioned above to the growth of drip irrigation, the remedial measures which are to be taken up by various agencies are listed below :

8.2 ACTION NEEDED FROM VARIOUS AGENCIES/ORGANIZATIONS.

8.2.1 Central and State Governments.

Water is a common resource and is becoming increasingly scarce. The saving of this precious commodity is the concern of one and all. Therefore, the policy should be to encourage all categories of farmers to help in saving water. Necessary incentives by way of policy measures should help all in this process.

To encourage farmers to adopt this system, subsidy is given by the Central and State Governments. However, as this subsidy is extended to only certain categories of farmers, drip method could not gather momentum. This needs to be looked into by the Central and State Governments so that the rates of subsidies are rationalised to promote healthy development. The recent scheme introduced by the Ministry of Agriculture, Government of India in the Eighth Plan provides a subsidy at the rate of 50 percent subject to a ceiling of Rs 15,000/ha. A farmer can avail subsidy for a

Unlike in Surface irrigation, drip irrigation supplies water direct to root zone.

maximum area of 1 ha and the scheme covers all horticultural crops excluding tea, coffee, rubber and oil palm. 50% subsidy has been provided by the Centrel and 10% subsidy by the State.

Farmers are experiencing innumerable problems in obtaining subsidy because of the procedural difficulties and it consumes their time, energy and effort. It would be better to have one single agency to process the applications and extend the subsidy benefits.

The field functionaries at various levels are not fully conversant with the basic philosophy and concept of drip system. They should be given sufficient training and orientation to perform the job better, consistent with the objectives.

This is a capital intensive investment and the high cost is due to imposition of excise duties, customs duty, sales tax and surcharges. The Govemment should waive all the taxes to bring down the high cost in the larger interest of the agricultural sector and in saving water for the community as a whole. The waiver will minimise the capital cost substantially and the farmers would be encouraged to install the system on their own accord. This is in tune with the current economic reforms of Central Government.

As a part of Training, the Government should arrange the visits of farmers to different successful farms in various regions to inculcate the spirit of confidence and conviction about the system and they should also be given proper training for minimum maintenance awareness etc.

To make the system popular, all means of mass media (TV, Radio, Video, News Papers and Publicity materials) and communication strategies should be adopted with special emphasis for dissemination of information incorporating success stories by various farmers in different crops. Large number of seminars/workshops and training sessions should be organised to make the farmers aware of the system and to provide technical know-how.

To educate the farming community about the overall benefits, large scale demonstration farms are to be organised in each block.

Large number of companies have mushroomed in recent years without adequate infrastructure. The materials supplied by them are substandard. This has an adverse effect on the system itself. Therefore, it is suggested that :

i) A High Level Technical Committee should be empowered to accord recognition to the manufacturing firms based on their capabilities and manufacturing facilities in association with Bureau of Indian Standards.

ii) The companies should produce materials conforming to BIS specifications.

iii) BIS standards have to be enforced to maintain the quality of equipment.

Drip irrigation facilitates maximum out-put per unit of irrigation water.

To popularise the scheme in the initial stages, interest free or low interest bearing loans through financial institutions atleast for some years should be freely made available to the farming community.

Since introduction of drip irrigation system under actual farming situations involve changes of different magnitudes in crop cultivation practices, it would be essential to design and formulate a set of package of practices including water management for each of the crops. This responsibility should devolve on extension agencies of concerned Government Departments.

To give impetus for large scale adoption, a State Level Committee may be constituted with the Commissioner and Secretary for Agriculture as Chairman to monitor and review the programme and extend policy support.

To motivate the farmers to take up drip system, power supply should be extended to them on priority basis for some years and uninterrupted power supply ensured.

The services of field functionaries who have done good work in extending drip may be recognised through awards, commendation certificates and other incentives.

Further, actively involving Panchayats, Zila Parishads, Rural Institutions and Voluntary Agencies will help in taking up drip irrigation programmes on an extensive scale.

8.2.2. Non-Availability of Raw Material.
In the drip system, laterals and drippers constitute 65% of the total cost. The required raw material is MFI grade of LLDPE. The required grade is very essential to obtain the desired life of the system. This is not manufactured indigenously with the result that manufacturers find it very difficult to obtain LLDPE. The BIS standards for all items need to be finalised and rigorously followed.

8.2.3. Drip System in Canal/Tank Command Area.
Only the farmers well conversant with irrigation have so far adopted the drip system. The drip irrigation is yet to be taken up in canal/tank command areas. Whenever commercial crops/ fruit and vegetable crops are grown under canal/tank command, drip irrigation can be introduced. Pilot study can be taken up using the drip system in canal/tank commands.

8.2.4. Role of National Committee on Use of Plastics in Agriculture (NCPA).
Looking to the advantages the plasticulture techniques extend and the benefits the developed nations could provide to their farmers, the Government of India decided to set up a Committee to look into the usefulness of these techniques. Accordingly, the NCPA was constituted in March 1981 under the Ministry of Petroleum, Chemicals and Fertilizers. The Committee was set up initially for a period of two years and was later extended upto March, 1985. During this period, certain recommendations were

Recurring expenses on inter-cultivation / hoeing are minimised with drip irrigation.

made by the Committee for the promotion of plasticulture. In principle, the Government accepted the recommendations and reconstituted NCPA for a further period of five years. One of the important terms of reference was to establish Plasticulture Development Centres (PDCs) to develop package of practices, so that the farmers can adopt these techniques fruitfully. During VII Plan, NCPA has established 23 Plasticulture Development Centres out of which 11 are Agricultural PDCs, 10 Irrigation PDCs and two Industrial PDCs. To make NCPA more purposeful, the Committee was reconstituted in 1989 for a period of five years under the Chairmanship of Secretary (Chemicals & Petrochemicals), Ministry of Chemicals and Fertilizers. In 1990, ten Irrigation PDCs were closed down as they had completed the study assigned to them. One of the important works given to the Committee was to promote research and development work and build a data-base to assist in prescribing quality standards for use in agriculture and water management.

The progress of work slowed down in the last three years because of paucity of funds and it was very difficult to continue the work in PDCs with a minimum programme. The Government of India then decided to attach NCPA with the Ministry of Agriculture and Horticulture Commissioner is the Member Secretary of the Committee. This Committee will function with the following objectives :

a. Location specific evaluation of technology for different plasticulture applications.

b. Adaptive research and modifications of the same.

c. Developing package of practices for using plasticulture applications.

d. Cost benefit analysis.

e. Impact evaluation of programme in the field.

f. To carry out awareness, training and demonstrations.

g. To act as interface for linkage between Government, Public Sector Undertakings, Industry and farmers.

Scheme on the Use of Plastics in Agriculture.

Government of India has introduced a Rs. 2.5 billion promotional scheme on the use of plastics in agriculture.

The component-wise allocations of the scheme are given below :

There is no soil erosion in drip irrigation.

(Rs. Million)

Drip Installation	1881.1	
Drip Demonstration	90.0	
Mulching	140.0	
Green Houses	220.0	
New Plasticulture Application	50.0	
Training	59.0	
NCPA	60.0	
Total	**2,500.1**	**million.**
Say	**2.5**	**billion.**

8.2.5. Manufacturers/Firms.

The Companies/firms should supply only good quality material of standard specifications.

The companies should improve upon their after-sale services since many firms are not serious and sometimes neglect, once the payment is settled. They should open service centres in the areas to provide continued maintenance support which is so vital for the success of drip system and to infuse confidence in the buyers.

The company should take up the design and estimate only after completing the analysis of soil and water (Well). The success of the system depends upon the filtering medium. If necessary both mesh and sand filters should be provided.

The company/firm should train their own staff in various areas of drip system and they should be fully aware of the various implications, problems and remedies. They should also possess basic knowledge of crops and farming methods to provide better services.

The firm should advise the farmers about duration of operation, how to maintain the system etc. for a successful working of the system. They should supply manuals to the farmers giving full information about the salient features of the system.

Companies should show their prospective customers their own demonstration unit installed in a farmer's field.

The manufacturing company should have their own R&D cell to provide necessary technical support to the farmers and also evolve cost effective improvement in the technology particularly the nozzle design to prevent clogging.

8.2.6 Financial Institutions.

Specific financial provision is to be made in the credit plan of each Bank for providing credit assistance to farmers who opt for drip/sprinkler irrigation, through coordination with NABARD. There should be a time limit for the sanction and disbursement of loans

There is less weed growth in drip irrigation.

on receipt of applications. The procedure for sanctioning Bank loans should be simplified. There should be a separate cell in each bank to help in the expeditious disposal of loan applications for drip/sprinklers.

In blocks declared as dark/grey areas with respect to ground water availability, financial assistance is not being given for digging and deepening of wells. It would be advisable to extend credit facilities for installing drip system in these blocks provided they are economical. NABARD and Ground Water Directorates may jointly review the existing guidelines for schemes in dark/grey blocks for this purpose.

8.2.7. Farmers.

Farmers continue to entertain the thought that larger the quantity of water applied to any crop, greater is the yield, despite scientific findings to the contrary. The farmers should develop conviction and confidence after seeing the successful crop performance in drip/sprinkler farms. An attitudinal change is desired through extension education.

Once the system is installed, the farmers should become conversant with the basics of the system and devote time, energy and interest for maintenance by close supervision and undertaking prompt remedial measures.

8.2.8. Research.

Irrigation scheduling as well as irrigation requirements of various kinds of crops during their different phases of growth are not precisely available. Research focus should be on field based experiments on drip system as specific to each crop. Precise information on number of drippers, type and their placement is lacking.

Rats cause damage to the laterals even if the laterals are laid beneath the soil. Experiments on rat repellent materials will be useful.

Fertilizer application through the system is recommended; but such use is negligible because of clogging and other problems. Research on liquification of fertilizers and quantum of fertilizers for various kinds of crops is necessary.

Research Institutions should integrate their activities with manufacturing companies having R&D set-up to solve field-based problems in the drip and sprinklers.

The following are the thrust areas of research which can be taken up by the research/ institutions/R&D cells of the firms :

a) Low Cost System : To find a method in which the cost of the system can be reduced drastically.

Drip irrigation saves labour and energy costs unlike lift irrigation.

b) To reduce the cost, the geometry/lay-out can be modified without affecting the number of plants and studies can be initiated i.e. optimisation of lay-out to reduce the cost.

c) Irrigation requirements for various crops, various growth stages and for various agro-climatic and soil zones are necessary.

d) The package of practices for various crops when drip irrigation is introduced are required, since the present package will not hold good for drip.

e) Action may be taken to introduce liquid fertilizer for all crops.

f) Studies may be taken up to improve the drip components/ accessories for better performance.

g) Design and fabricate clog resistant drippers.

h) More studies are necessary to use saline water through drip irrigation.

i) Cost benefit studies to be undertaken for all crops region-wise, in detail.

j) Study on effect of drip irrigation on crops, crop behaviour and macro/micro environment.

8.2.9. Training.

Drip system is becoming highly popular. What is found missing is the conviction and confidence in the efficacy of the system to subserve the dual objectives of increased productivity and saving of water, on the part of not only the field functionaries at different levels but also among the farmers. This lacuna has to be successfully overcome by sustained educational activities.

Training on Drip Irrigation should be given to the officials, farmers, and the others who are involved in popularising the drip irrigation at block, district and State levels. Seminars and workshops should be organised at Village, block, district, State and National levels to share the experiences and to update the knowledge. The officials and farmers may be taken to the successful drip irrigation farms in the country. All this will build confidence in the minds of officials and farmers in adopting drip irrigation in the coming years.

8.3 PERSPECTIVE PLAN FOR DEVELOPMENT.

The State Governments should formulate a perspective plan for the next 15 years and work out the requirement of funds for implementation and also to develop necessary infrastructure as suggested in this report. Before preparing such a plan, the concerned State Department may have a quick survey carried out in respect of the areas where the drip methods can be advantageously introduced in different agro-climatic zones of the State. The plan should also indicate the requirement of men, material and

Micro-nutrients like Zinc and Iron can be fed easily through drip system.

training needs besides infrastructural development to create the required manufacturing capacity in the country. The nodal ministries at the Centre Viz. Ministry of Water Resources, Ministry of Agriculture, Indian Council for Agricultural Research and NCPA should have a Steering Committee to propagate the use of drip irrigation in the country. Similar Co-ordination Committees may be required at the State level particularly in the States where large areas are covered under drip system both under subsidy and non-subsidy schemes (private investment).

Entire Israel is covered by drip irrigation leading to its remarkable progress.

DRIP IRRIGATION FOR BANANA.
(Courtesy : WTC, IARI, New Delhi)

DRIP IRRIGATION FOR NEW PLANTATION OF MANGO
(Courtesy : Jain Irrigation)

ANNEXURE - I

TECHNICAL PAPERS CONTRIBUTED BY INDIAN AUTHORS FOR THE WORKSHOP ON MICRO IRRIGATION WORLD-WIDE HELD ON 2ND SEPTEMBER, 1993 AT THE HAGUE, THE NETHERLANDS

S.No.	Author	Title
1.	Shri R.S.Saksena Consulting Irrigation Engineer, 319 - B (SFS Flats), C-3, Janakpuri, New Delhi-110058.	Status of Micro Irrigation in India.
2.	Dr.S.D.Khepar Dean, Punjab Agril.University, Ludhiana-141004 Punjab.	Current Use, Performance and Scope for Micro-Irrigation in India.
3.	Dr.H.S.Chauhan Professor, & Shri Prashant Nikhade Deptt.of Irrigation & Drainage Engineering, College of Technology, G.B.Pant Univ.of Agril.& Techn., Pantnagar-263145 Uttar Pradesh.	Hydraulic performance Studies of Commercial Emitters.
4.	Shri M.K. Choudhary Shri D.T. Shete & Prof.P.M. Modi Water Resources Engg. & Man.Instt., M.S.Univ.of Baroda, Samiala Centre, Samiala - 391 410. Distt.Vadodara, Gujarat	Simplified Design of Drip Irrigation System.

Entire Israel is covered by drip irrigation leading to its remarkable progress.

Annexure - I (Contd.)

S.No.	Author	Title
5.	Dr. T.B.S. Rajput, Sr.Scientist, (WTC) I.A.R.I., Pusa Campus, New Delhi-110012.	A Wind Pipe Coupled Drip Irrigation System for Remote Areas.
6.	Shri S.K. Bhatnagar Shri D.T. Shete & Prof.P.M. Modi Water Resources Engg. & Man.Instt., M.S.Univ.of Baroda, Samiala Centre, Samiala - 391 410 Distt.Vadodara, Gujarat.	Evaluation of Performance of Micro Irrigation Emitters with Special Reference to Wetted Area of Soils.
7.	Shri V.B. Dalvi Associate Professor, College of Agricultural Engineering & Technology, Punjabrao Krishi Vishwa Vidyapeeth, Krishi Nagar, Akola-444104, Maharashtra.	Controlling Algae Clogging in Micro Irrigation Systems.
8.	Dr.H.S.Chauhan Shri K.N. Shukla, & Shri G.Ravi Babu Deptt.of Irrigation & Drainage Engineering, College of Techn., G.B.Pant Univ.of Agril.& Techn., Pantnagar-263145,Uttar Pradesh.	Comparative Study of Drip and Surface Irrigation on Crop Yield & Water Requirement of Okra.
9.	Dr.H.S.Chauhan Shri S.K. Bendale, & Shri K.N. Shukla (Address same as Sl. No. 8)	Study of Drip & Surface Irrigation on Yield and Water Requirement of Cauliflower.
10.	Dr.H.S.Chauhan, Shri K.K. Singh & Shri A.K. Pandey (Address same as Sl. No. 8)	A Comparative Study of Micro Sprinklers, Trickle and Furrow Methods of Irrigation on Growth of Potatoes.

Drip irrigation system keeps space in between crop rows dry and weed free.

Annexure - I (Contd.)

S.No.	Author	Title
11.	Shri S.B. Pimplasker, Shri D.T. Shete & Prof.P.M. Modi Water Resources Engg. & Man.Instt., M.S.Univ.of Baroda, Samiala Centre, Samiala - 391 410, Distt.Vadodara, Gujarat.	Study of Economic Viability and Optimization of Micro-Irrigation System for Wheat Crop.
12.	Shri M.K. Choudhary, Shri D.T. Shete & Prof.P.M. Modi (Address same as Sl. No. 11)	A Case Study of Micro & Surface Irrigation Systems for Banana Crop.

Brackish water (Salt water) can also be used for drip irrigation.

ANNEXURE - II

TECHNICAL PAPERS CONTRIBUTED BY INDIAN AUTHORS FOR THE 5TH INTERNATIONAL MICRO IRRIGATION CONGRESS AT ORLANDO, FLORIDA, U.S.A. 2-6 APRIL, 1995.

S.No.	Author	Title
1.	Shri P. Srivastava & Dr. H.S. Chauhan Deptt.of Agril.Engg., G.B.Pant University of Agril.& Technology, Pantnagar-263145 Distt. Nainital,Uttar Pradesh	Response of Micro-Sprinkler and Other Irrigation Methods on Cabbage.
2.	Dr. H.S. Chauhan (Address same as Sl. No. 1)	Issues of Standardization and scope of Drip Irrigation in India.
3.	Shri A.K. Pandey, Dr. H.S. Chauhan, Shri K.N. Shukla & Shri K.K. Singh (Address same as Sl. No. 1)	Studies on Single Nozzle Performance of Micro Sprinklers.
4.	Dr. H.S. Chauhan & Dr. P. Kumar (Address same as Sl. No. 1)	Bio-metric characteristics of cabbage grown under micro-irrigation.
5.	Shri V.K. Sood & Dr. H.S. Chauhan (Address same as Sl. No. 1)	Hydraulic Performance of Drip Irrigation sand filters.
6.	Dr. H.S. Chauhan (Address same as Sl. No. 1)	Study approaches for trickle irrigation screen filters.
7.	Shri K.L. Singh, Dr. H.S. Chauhan, Shri K.K. Singh & Shri S.Ram (Address same as Sl. No. 1)	Response of brinjal under micro-sprinkler and other Irrigation methods.

One labourer can easily attend to drip irrigation upto 10 ha

ANNEXURE - II (Contd.)

S.No.	Author	Title
8.	Shri G.R. Babu, Shri K.N. Shukla & Dr. H.S. Chauhan (Address same as Sl. No. 1)	Studies on Drip irrigation installation for grapes around Hyderabad.
9.	Shri D.S. Parwal Dr. H.S. Chauhan & Shri C.S. Jaiswal (Address same as Sl. No. 1)	Clean pressure drop and loss co-efficients for trickle irrigation screen filters.
10.	Shri S.K. Bendate, Dr. H.S. Chauhan & Shri K.N. Shukla (Address same as Sl. No. 1)	Field Survey studies of trickle irrigation of pomegranates in Maharashtra State.
11.	Shri A.K. Pandey, Dr. H.S. Chauhan Shri K.N. Shukla & Shri K.K. Singh (Address same as Sl. No. 1)	Effective radius, radius of throw and distribution characteristics of micro-sprinklers.
12.	Dr. Ved Singh Agril.Research Station Rajasthan Agril.Univ. Sriganganagar-335001 Rajasthan	Seed yield, consumptive use and economics of safflower.
13.	Dr. Ved Singh (Address same as Sl. No. 12)	Effect of various irrigation and phosphorus levels on safflower crop (Carthamus tinctorius, L.)
14.	Dr. Ved Singh (Address same as Sl. No. 12)	Comparative performance of various crop sequences under constraints of Irrigation water.
15.	Shri D.T. Shete WREMI, Samiala Centre Samiala-391410 Distt.Vadodara, Gujarat	A new look in the design of drip Irrigation system with geometrical parameters with special reference to fields and their impact on out-turn.

Land levelling is not necessary for drip irrigation.

ANNEXURE - II (Contd.)

S.No.	Author	Title
16.	Dr. M.V. Somasundaram, Centre for Water Resources, Anna Univ., Madras-600025 Tamilnadu	Present Status of Micro-Irrigation in Tamil Nadu, India.
17.	Shri S. Sushant N.D.University of Agril.& Technology, Narendranagar(Kumarganj) Faizabad-224229 Uttar Pradesh	Comparative performance of Sprinklers and furrow irrigation with varying depths of irrigation on potato.
18.	Dr.Rajvir Singh Deptt.of Agril.Engg. College of Technology & Agricultural Engineering Rajasthan Agril.Univ. Udaipur-313001 Rajasthan	Field Studies of Drip and other methods of irrigation on yields.
19.	Dr. Rajvir Singh (Address same as Sl. No. 18)	Field Studies of Drip and other methods of irrigation on various growth aspects of tomato.
20.	Dr. S. Raman Soil & Water Mgmt. Gujarat Agril.University Navsari-396450 Gujarat	Prospects of Micro-Irrigation in Banana.
21.	Dr. D.D. Malviya Deptt. of Agronomy, Gujarat Agril.University Junagadh Campus, Junagadh-362001 Gujarat	Micro Irrigation - A great viable system for increasing & sustaining agricultural production under arid and semi-arid regions of Saurashtra, Gujarat.
22.	Dr. D.G. Holsambre WALMI, P.O.Box 304, Aurangabad-431005 Maharashtra	Status of Drip irrigation in Maharashtra

Drip irrigation is specifically suited for high value crops.

ANNEXURE - II (Contd.)

S.No.	Author	Title
23.	Dr. Satish K.Dua Government of Haryana, Irrigation Department, 95, Sector 14, Faridabad-121007 Haryana	The future of Micro Irrigation.
24.	Dr. S.S. Magar Deptt.of Irrigation Water Management, MPKV, Rahuri-413722 Distt.Ahmednagar Maharashtra	Micro Irrigation status of Maharashtra State.
25.	Dr. S.S. Magar (Address same as Sl. No. 24)	Adoption of Micro Irrigation Technology in Sugarcane (Saccharum officinarum, L.) under semi-arid climate in vertisol.
26.	Shri R.S. Saxena C-3/319-B (SFS Flats) Janakpuri, Pankha Road, New Delhi-110058.	Micro-Irrigation in India - achievements and perspectives.
27.	Dr. R.K. Sivanappan Consultant 14, Bharati Park, 4th Cross Road, Coimbatore-641003 Tamil Nadu.	Present Status and future of micro-Irrigation in India.
28.	Shri S.K. Suryawanshi Jain Irrigation Systems Ltd., Jain Fields, N.H.6 P.O.Box 72, Bambheri, Jalgaon-452001 Maharashtra	Success of Drip in India : An Example to Third World.

Expand cultivated area through drip irrigation.

ANNEXURE - II (Contd.)

S.No.	Author	Title
29.	Dr. K.N. Tiwari Deptt.of Agril.Engg. Indian Institute of Technology, Kharagpur - 721 302 West Bengal	Analysis of Drip Irrigation System using finite element techniques.
30.	Shri N.R.Sawleshwarkar Irrigation Department Govt.of Maharashtra Jayakwadi Irrigation Div.No.2, Parbhani-441401 Maharashtra	Application of Micro Irrigation Technology to Major Irrigation Projects.
31.	Shri Rajinder Singh Indo-Dutch Project, Deptt.of Soil Science CCS, Haryana Agril. University, Hisar-125004 Haryana	Irrigation Planning in mustard through simulation model.
32.	Prof. Jaspal Singh Plasticulture Dev.Centre Deptt.of Soil & Water Cons.Engg., College of Technology & Agril.Engg. Udaipur-313001 Rajasthan	Scope and potential of drip and Sprinkler Irrigation Systems in Rajasthan.
33.	Shri V.B. Dalvi Deptt.of Soil & Water Conservation, Punjabrao Krishi Vidyapeeth, P.O. Krishinagar, Akola-444104 Maharashtra	Growers' experiences and efficiency of micro-irrigation on farmers' fields.

ANNEXURE - III

CROPS GROWN UNDER DRIP IRRIGATION.

I. CEREALS.
1. Corn
2. Sorghum
3. Wheat

II. FLOWERS.
4. Chrysanthemum
5. Carnation
6. Jasmine
7. Rose
8. (All) Ornamental Trees & Shrubs

III. FODDERS.
9. Alfalfa
10. Asparagus
11. (All) Pastures

IV. FIBRES.
12. Cotton
13. Sisal

V. NUTS.
14. Almond
15. Arecanut
16. Cashewnut
17. Coconut
18. Macadmaia
19. Walnut

VI. OILSEEDS.
20. Groundnut

VII. ORCHARDS.
21. Amla
22. Apple
23. Apricot
24. Avocado
25. Banana
26. Ber
27. Betelvine
28. Boysen Berry
29. Cherry
30. Chikoo (Sapota)
31. Citrus
32. Custard Apple
33. Fig
34. Grape (Table & Wine)
35. Grape fruit
36. Guava
37. Lemon
38. Lime
39. Mango
40. Mosambi
41. Naval Orange
42. Papaya
43. Peach
44. Pear
45. Pineapple
46. Persimmon
47. Plum
48. Pomegranate
49. Strawberry
50. Tangelo
51. Tangerine
52. Valencia Orange
53. Watermelon

VIII. PLANTATION CROPS.
54. Bamboo
55. Cocoa
56. Coffee
57. Mulberry
58. Oilpalm
59. Rubber
60. Sugarcane
61. Tamarind
62. Tapioca

Drip irrigation offers improved plant protection and less diseases.

63. Tea	70. Celery
64. Teak	71. Chilli
	72. Cucumber
IX. SPICES.	73. Egg Plant
65. Cardamom	74. Lettuce
66. Pepper	75. Onion
	76. Peas
X. VEGETABLES.	77. Potato
67. Beet Root	78. Radish
68. Brinjal	79. Sweet Potato
69. Bulbs	80. Tomato

Drip irrigation offers higher efficiency in fertilizer application.

ANNEXURE - IV

STATEWISE AREA UNDER DRIP IRRIGATION (1992)

(1 Ha = 2.471 acres)

Sl. No.	Name of State	Installation in acres by different Manufacturers													Total	
		Jain Irrign. Jalgaon (Mah.)	Agroplast Tiptur Karnataka	Sathish Agril. Enterprises Pattivee-ranpatti(TN)	Polyolefins Industries Ltd. Akola (M.S)	ELGI Equip.Ltd Coimbatore (T.N.)	Ashok (I) Agro Products Jalgaon (M.S.)	Polytube Plastics Pimpalgaon Baswant (M.S.)	Irrigation Engineering Corporation Secunderabad (A.P.)	Premier Irrigation Calcutta (W.B.)	Drip India Nasik (M.S.)	Voltas Ltd Bombay (M.S.)	Pasumal Irrign. Ltd. Madras (T.N.)	Agri-Tools Hyd'bad (A.P.)	Acres	ha.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1.	Andhra Pradesh	1114	-	-	10	1114	-		24710	731	**	-	948	-	28627	11585
2.	Assam	247	-	-	-		-		-	196		-	-	-	443	180
3.	Bihar	-	-	-	-		-		-	196		-	-	-	196	80
4.	Gujarat	4951	-	-	405		-		-	2470		343	628	-	8797	3560
5.	Haryana	247	-	-	-		-		-	50		-	-	-	297	120
6.	Himachal Pradesh	-	-	-	-		-		-	50		83	-	-	133	54
7.	Karnataka	3962	14591	-	10	893	-		1235	6395		485	459	170	28200	11412
8.	Kerala	49	6800	-	-	452	-		-	-		-	199	-	7500	3035
9.	Madhya Pradesh	2475	-	-	5		-		-	781		135	100	-	3496	1415
10.	Maharashtra	51980	-	-	50		414		2471	8312		17580	548	-	81355	32924
11.	Orissa	49	-	-	-	10	-		-	50		-	-	-	109	44
12.	Punjab	25	-	-	-		-		-	25		-	-	-	50	20
13.	Rajasthan	495	-	-	-		-		-	257		-	-	-	752	304
14.	Tamil Nadu	5693	-	1500	100	4137	-		-	855		-	953	-	13238	5357
15.	Uttar Pradesh	124	-	-	100		-		-	-		-	50	-	274	111
16.	West Bengal	247	-	-	-		-		-	-		-	-	-	247	100
17.	Andaman & Nicobar Islands	-	-	-	-	7	-		-						7	3
18.	Goa, Daman & Diu	-	-	-	-	63	-		-	-		-	-	-	63	25
19.	Other States	-	-	-	-		-		-	-	1209	-	100	-	1309	530
	Total	71658	21391	1500	680	6676	414		28416	20368	1209**	18626	3985	170	175093	70859

* Installation done in Maharashtra - but records not maintained.

** State-wise details not available.

ANNEXURE - V

CROP-WISE AREA UNDER DRIP IRRIGATION SYSTEM IN INDIA (1992)

Conversion Factor - 1 Ha = 2.471 acres

Sl. No.	Name of Crop	Installation by different Manufacturers (Acres)												Total	
		Jain Irrign. Jalgaon (M.S)	Agroplast Tiptur Karnataka	Sathish Agril. Enterprises (T.N)	Polyolefins Industries Ltd. Akola (M.S)	ELGI Equip.Ltd Coimbatore (T.N.)	Ashok (I) Agro Products Jalgaon (T.N.)	Irrigation Engineering Corporation Secunderabad (M.S.)	Premier Irrigation Calcutta (W.B.)	Drip India Nasik (M.S.)	Voltas Ltd Bombay (M.S.)	Pasumai Irrign. Ltd. Madras (T.N.)	Agri-Tools Hyd'bad (A.P.)	Acres	ha.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
I.	**FLOWERS**														
1.	Rose	99												99	40
	Total	99												99	40
II.	**FIBRES**														
2.	Cotton	494									73	380		947	383
3.	Sisal	198												198	80
	Total	692									73	380		1145	463
III.	**NUTS**														
4.	Arecanut	494								20				514	208
5.	Cashewnut	297												297	120
6.	Coconut	1360				3763				20	826	430	16	6415	2596
	Total	2151				3763				40	826	430	16	7226	2924
IV.	**OILSEEDS**														
7.	Groundnut	370												370	150
	Total	370												370	150
V.	**ORCHARDS**														
8.	Amla	99												99	40
9.	Apple	371									306			677	274
10.	Banana	15000					312			316		350	2	15980	6467
11.	Ber	1483								73	157		26	1739	704
12.	Betelvine	198												198	80
13.	Chikoo (Sapota)	1112								79	906			2097	849
14.	Citrus												10	10	4
15.	Custard Apple	2050									62			2112	855
16.	Fig	865											1	866	350
17.	Grapes	17297					88	4942		554	6590	200	99	29770	12048
18.	Guava	3335								15	153	310		3813	1543
19.	Lemon	2014									251	140		2405	973
20.	Mango	1235						7413		30	2675	370	8	11731	4747

ANNEXURE - V (Contd)

Sl. No.	Name of Crop	Installation in acres by different Manufacturers												Total	
		Jain Irrign. Jalgaon (M.S)	Agroplast Tiptur Karnataka	Sathish Agril. Enterprises (T.N)	Polyolefins Industries Ltd. Akola (M.S)	ELGI Equip.Ltd Coimbatore (T.N.)	Ashok (I) Agro Products Jalgaon (T.N.)	Irrigation Engineering Corporation Secunderabad (M.S.)	Premier Irrigation Calcutta (W.B.)	Drip India Nasik (M.S.)	Voltas Ltd Bombay (M.S.)	Pasumai Irrign. Ltd. Madras (T.N.)	Agri-Tools Hyd'bad (A.P.)	Acres	ha.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
21.	Mosambi							2,471						2,471	1,000
22.	Naval Orange	4,077					14				608			4,699	1,902
23.	Papaya	2,026									42			2,068	837
24.	Peach	99												99	40
25.	Pomegranate	4,942						4,942			3,265	280	6	13,435	5,437
26.	Strawberry	494												494	200
27.	Others					1,953								1,953	790
	Total	56,697				1,953	414	19,768		1,067	15,015	1,650	152	96,716	39,140
VI.	**PLANTATIONS**														
28.	Bamboo	124												124	50
29.	Cocoa											50		50	20
30.	Coffee	99												99	40
31.	Mulberry	494										220		714	289
32.	Oil Palm	49										500		549	222
33.	Rubber											50		50	20
34.	Sugarcane	7,648									1,817	140	2	9,607	3,888
35.	Tamarind	198												198	80
36.	Tea	494								23				517	209
37.	Teak	1,000								44		225		1,269	514
	Total	10,106								67	1,817	1,285	2	13,177	5,333
VII.	**SPICES**														
38.	Cardamom											100		100	40
39.	Others	198									159			357	145
	Total	198									159	100		457	185
VIII.	**VEGETABLES**														
	Total	1,000						2,471			87	240		3,798	1,537
IX.	**OTHERS**														
	Total	345	21,391	1,500	680	960		6,177	20,368	35	649			52,105	21,087
	GRAND TOTAL	71,658	21,391	1,500	680	6,676	414	28,416	20,368	1,209	18,626	3,985	170	175,093	70,859

SEMINARS/WORKSHOPS, TRAINING PROGRAMMES AND THEIR RECOMMENDATIONS.

I. SEMINARS/WORKSHOPS/TRAININGS.

1. National Seminar on Drip Irrigation, TNAU, Coimbatore, 1981.
2. Irrigation and Water Management in India - A Modern Perspective.
3. National Seminar on Use of Plastics in Agriculture, New Delhi, 1982.
4. National Seminar on Drip Irrigation, TNAU, Coimbatore, 1983.
5. Seminar on Sprinkler and Drip Irrigation, Ministry of Irrigation, New Delhi, 1984.
6. Short Term Course on Sprinkler and Drip Irrigation, WTC, IARI, New Delhi, 1985.
7. National Seminar on Use of Plastics in Agriculture, NCPA, New Delhi, 1987.
8. National Seminar on Drip and Sprinkler Irrigation Methods, MPAU, Rahuri, 1987.
9. Development and Management of Training Course on Pressurised System of Irrigation, WAPCOS, 1987.
10. National Symposium on Drip Irrigation, PKV Akola, 1988.
11. International Congress on Use of Plastics in Agriculture, NCPA/IPCL, New Delhi, 1989.
12. Short Training Programme on Sprinkler and Drip System, Anna University, Madras, 1989.
13. National Workshop on Drip and Sprinkler Irrigation, Pune, 1990.
14. National Seminar on Drip Irrigation, Vadodara, 1991.
15. Training Course on Drip and Sprinkler Irrigation System, Design and lay-out, CWRDM, 1991 & 1992.
16. Workshop on Sprinkler and Drip Irrigation Systems, Jalgaon, 1993.
17. All India Seminar on Sprinkler and Drip Irrigation, Hyderabad, 1993.

II. RECOMMENDATIONS OF THE SEMINARS/WORKSHOPS.

a) National Seminar at Coimbatore, 1983.

The following are the major recommendations :

1. Concerted efforts should be made by all the concerned, particularly the Central and State Governments, ICAR, Agricultural Universities, NABARD, Commercial and Co- operative Banks and Manufacturers so that a reasonable

Drip irrigation offers improved infiltration in soils of low intake.

area is covered by the advanced method of irrigation within the next five years and to achieve this end, a comprehensive action plan should be worked out and such a plan should be made financially, administratively and technically feasible.

2. The NCPA, in consultation with ICAR, should co-ordinate activities on all areas relating to drip irrigation. Examining the current status of research activities on drip irrigation, the seminar recommends for undertaking need-based research by various agricultural Universities and research institutions in the country.

3, Creation of Plasticulture Development Centres charged with the responsibility of collecting, assembling and co-ordinating all research and field-based information for dissemination purpose.

4. On analysing the efficacy of the drip irrigation system, the seminar strongly recommended field-based action programmes for widespread adoption of the system in India.

5. All Commodity Boards should take active steps for promotion of drip irrigation.

6. Recognising the need for imparting professional knowledge and technical skills in this new area, it is recommended that training sessions are organised for persons at various levels at periodical intervals by research institutions in active collaboration with the manufacturers.

7. To motivate large scale adoption of drip irrigation system, undertaking adaptive and large scale demonstrations in potential zones for potential crops are suggested.

8. Since introduction of drip irrigation system under actual farming situations involves changes of differing magnitude in crop cultivation practices, it was felt essential to design and formulate a set of package of practices including management for each of the crops.

9. Having established the technical feasibility under economics of drip irrigation system, inclusion of the concept of drip irrigation in the extension programmes of the State Departments of Agriculture, Horticulture and Forests was considered essential.

Drip irrigation generally suits any type of crop, soil and climate.

10. Installation of drip irrigation system calls for initial investment. Various commodity boards like Coffee Board, Tea Board might encourage adoption of drip irrigation on par with that of sprinkler irrigation.

11. Financial institutions should pursue the proposition of advancing long term loans with other facilities to entrepreneurial farmers to install drip irrigation systems. It was further suggested to prepare projects for specific areas and specific crops and undertake the implementation in the next five years with the assistance offered by NABARD. For perennial crops like coconut, arecanut and orchard crops, suitable repayment pattern may be prescribed.

12. To reduce the cost of installation of drip irrigation system, the following suggestions have been made :

    i) Excise duty on resins used exclusively for irrigation components may be waived as in the case of aluminium sprinkler components.

    ii) Sales Tax on such sales of resins, as well as finished products may be exempted.

    iii) Some critical components are necessary for drip irrigation. Such components may be exempted from import duty as is being done in the case of Solar Cells and such commodities may be permitted under OGL.

    iv) It would be necessary to standardise all the components and accessories necessary for drip irrigation system for easy installation, servicing and replacement which would also minimise cost.

13. To motivate farmers to go in for drip system, it is recommended that not less than 50% subsidy provisions may be considered as in the case of other inputs which were under promotion. Initially this may be for a five year period.

14. Such National Seminars are to be conducted annually at the Research Institutions for the benefit of researchers, manufacturers and farmers by providing opportunities for professional interaction. Different State Governments and Agricultural Universities may hold One-Day Seminars to develop an Action Programme in each State.

Plants never face water stress with drip irrigation.

b) National Seminar on Use of Plastics in Agriculture, New Delhi, 1987.

The following are the important recommendations :

1. Plasticulture applications for increasing agricultural production and productivity should receive high priority. Particular emphasis should be laid on the proper use of water, and adoption of the latest technologies, suited to local conditions and designed to assist small farmers.

2. The State Governments may reactivate the State Level Committees on the use of plastics in agriculture and also assess the potential of relevant plasticulture applications in their States.

3. The plasticulture applications could be categorised under the following two heads :

   a) Techno-economically proven applications based on large scale experiments and adoption. (Examples: Nursery bags, Milk packaging, CAP covers, PVC pipes for water distribution).

   b) Applications tried in the country on a limited scale and hold large potential for propagation and adoption (Examples : Drip Irrigation, Green House, Low Tunnels, Mulching and Packaging of fruits and vegetables using plastic crates, Pusa bins for indoor storage of foodgrains).

4. Proven plasticulture technology as identified to be adopted. State Level Committees, in collaboration with Agriculture, Horticulture, Irrigation and Forestry Departments should take up an intenstive time bound action plan for dissemination and adoption of plasticulture technology.

5. To ensure availability of plastic material systems to the plasticulture sector, the present constraint on availability of raw material needs to be eliminated.

6. The industry/system(s) manufacturers may communicate their requirements of plastic raw materials to NCPA, so that NCPA will be able to coordinate with the Ministry of Industry (Department of Chemicals & Petro-Chemicals) for ensuring availability of the plastic material.

7. The Ministry of Agriculture, Ministry of Industry, (Department of Chemicals and Petro-Chemicals) and NCPA should identify the applications which need fiscal duty concession for facilitating their mass adoption. Users as well as system manufacturers should give their suggestions to NCPA in this regard.

Drip irrigation system is ideally suited to vineyards and orchards.

8. The Plastic Industry needs to develop durable plastic films for outdoor applications mainly for Green Houses, Low tunnels, Cap covers, etc. The industry may also extend help in promoting adequate processing activity to meet the demand.

9. State Governments should effectively implement the Central Government's subsidy scheme on Drip Irrigation and interact with the National Committee (NCPA) for necessary assistance.

10. Agricultural Universities which are assigned the setting up of Plasticulture Development Centres should make their best efforts to generate meaningful results adhering to the time schedule given to them. It is essential as successful applications developed by them will be propagated on a large scale in the shortest possible time.

11. Doordarshan, All India Radio and the News Media should be used to propagate the concept of plasticulture on a regular basis.

12. The Ministry of Agriculture (Directorate of Extension) would formulate a suitable plan of action in consultation with NCPA, for disseminating plasticulture technology to the farmers.

13. State Governments should organise Seminars/Workshops with the involvement of State Agricultural Universities to popularise the plastic technology amongst the users.

14. The Indian Agricultural Research Institutes (IARI) may constitute a task force to prepare a curriculum on plasticulture and the Indian Council of Agricultural Research (ICAR) may impress upon the Agricultural Universities in the Country the desirability of including plasticulture as a part of their under-graduate programme.

15. Areas where further developments in plasticulture applications would be desirable should be identified and such projects should be given to the post-graduate as well as under-graduate students of Agriculture Universities for study.

16. State Governments should consider appointing an Officer at the level of Joint Director (Agriculture) incharge of plasticulture activities in the States.

17. NCPA will institute a national award for meritorious adoption of plastics in Agriculture in the country.

18. Standardisation for plastic materials used in Agricultue should be taken by the Bureau of Indian Standards(BIS) in consultation with the leading plastic raw material manufacturers as well as converters, immediate areas of emphasis would be drip system, plastic sprinkler, green house film and plastic crates.

(c) All India Seminar on Sprinkler and Drip Irrigation, Hyderabad, December, 1993.

Recommendations:

1. Water, the most essential and critical element of life is becoming increasingly scarce. Thus,its efficient and economic utilization is absolutely necessary. It is, therefore, imperative that the farmers, official and non-official agencies concemed with water use and agricultural development must encourage proper, economic and efficient utilization of water through Sprinkler and Drip Irrigation Systems and other such improved technologies.

2. Greater attention should be given through coordinated efforts of scientists, engineers, research institutions and the industry to develop appropriate technologies for field adoption of the techniques of Sprinkler and Drip Irrigation Systems.

3. The industry should establish research and development base for ensuring better performance and continued improvement of the equipment. After sales services are very important and must be made available at easily accessible locations.

4. Reliable information and data on different aspects of sprinkler and drip irrigation or combined systems on specific crop/cropping pattern in different agro-climatic zones should be generated. Particular attention should be paid to the matching water requirements of each crop/ cropping pattern and to the economic viability of the system. Both the industry and the research institutions should work cooperatively to generate the information and data.

5. Farmers also should familiarise themselves and interact more meaningfully with the research scientists and the industry and participate actively in the development of useful and workable systems.

6. Training of farmers and field workers in the proper use of Sprinkler and Drip Irrigation systems should be organised on a regular basis by a competent Agency, taking into consideration the specific requirements of trainees and

Drip irrigation ensures uniform water distribution.

their potential capacities to take advantage of the improved systems. This should be done by the concerned Research and Development Institutions in close cooperation with the industry.

7. Large scale demonstrations on Sprinkler and Drip Irrigation should be organised by the Industry and the concerned agencies on different crops under varying conditions to promote the systems and ensure their viability and stability.

8. Sprinkler and Drip Irrigation equipments including their components and composition, offered to the farming community should conform strictly to the prescribed standards. Verification of conformity to these standards should be ascertained before the material is offered to the farmers and consumers. An Advisory Body will be responsible for identifying the Agency or the individual for certifying the adherence or otherwise to the prescribed standards and the suitability of the materials for the purpose offered.

9. Before recommending to the farmers the use of fertilisers and pesticides in the Drip and Sprinkler Irrigation Systems, proper data should be collected on the compatibility and feasibility of such practices. Their use must be approved or recommended by the concered official agency.

10. The practice of Drip Irrigation in sugarcane and a few other field crops has been mentioned. In such cases careful consideration should be given to the planning of follow-up cropping patterns in such fields.

11. It was suggested that under certain circumstances, particularly during a prolonged drought, some life saving water resources should be provided preferably through water ponds. Additional expenditure for the water ponds may be subsidised, if justified.

12. It was recommended that the subsidy for Sprinkler and Drip Irrigation systems should be given direct to the farmers, provided it is assured that it is used for the specific purpose. It was also suggested that the interest rate should be reduced on the loans taken for the Sprinkler and Drip Irrigations.

13. Effects of Sprinkler and Drip Irrigation on crops, crop behaviour and macro micro environment should be studied. Special attention should be paid to the possible change in major and micro nutrient status and soil microbiology under Sprinkler and Drip Irrigation Systems.

Drip irrigation is environment friendly.

14. There should be an integrated and coordinated approach in developing an appropriate irrigation system for varying farming situations. This would involve besides technical aspects, the infrastructural parameters, such as transport, marketing and post-harvest technology and pricing policy. This approach and policy if properly directed, will help in the sustained development of agriculture in harmony with the environment.

15. The Sprinkler and Drip Irrigation System, which was comparatively a recent introduction in India is becoming more popular in some horticultural crops in few selected areas. In order to develop this system on a rational and practical basis, it is proposed to create a Nodal Voluntary Body to oversee and monitor its proper development. The membership of this Nodal Body may consist of farmers, interested individuals, scientists, engineers, representatives of industry and concerned official agencies. This Body will generally formulate policies and programmes for the development of Sprinkler and Drip Irrigation systems and appoint an Advisory Body to assist it. The main aim of the Nodal Voluntary Body will be to protect the interests of farmers and ensure the stability of the Sprinkler and Drip Irrigation systems and other latest technologies for effective water use.

    The institution of Engineers with the help of scientists, advisers, representatives from industry and others concerned is requested to initiate action in creating this Nodal Voluntary Body.

Drip irrigation promotes economic use of water.

ANNEXURE - VII

RESEARCH SCHEMES SANCTIONED BY THE MINISTRY OF WATER RESOURCES, GOVERNMENT OF INDIA UNDER RIVER VALLEY PROJECTS AND FLOOD CONTROL ON THE TOPICS OF DRIP AND SPRINKLER IRRIGATION.

S.No.	INSTITUTE	TITLE	AMOUNT (Rs. lakhs)
(a)	**Sanctioned Upto 1991-92**		
1.	Punjab Agricultural University (PAU), Ludhiana-141004 Punjab	Performance Studies of Sprinklers, Drip Irrigation and Surface Irrigation Methods.	3.55
2.	Tamil Nadu Agril. University (TNAU), Coimbatore-641003 Tamil Nadu	Comparative Studies of Sprinkler and Drip Irrigation Methods with Conventional Surface Methods.	4.15
3.	Narendra Dev Univ. of Agriculture & Technology (NDUAT), Faizabad-224001 Uttar Pradesh	Comparative Studies of Sprinkler and Drip Irrigation Methods with Conventional Surface Methods for Crop Production under Eastern Uttar Pradesh Conditions.	5.77
4.	College of Technology & Agricultural Engineering (CTAE), Rajasthan Agril. University, Udaipur-313001 Rajasthan.	Performance Evaluation of Sprinkler and Drip Irrigation Methods for the Agro-Climatic Region of Southern Rajasthan.	4.59
		Total (a)	**18.06**
(b)	**Sanctioned during 1992-93.**		
5.	Andhra Pradesh Agril. University, Hyderabad	Efficient Water Management Through Drip and Sprinkler.	6.00

Drip irrigation gives bumper yields.

ANNEXURE - VII (Contd.)

S.No.	INSTITUTE	TITLE	AMOUNT
6.	WTC, TN Agricultural University, Coimbatore Tamil Nadu	Comparative Evaluation and Economic Appraisal of Different Modes of Application of Drip Systems.	3.00
7.	WREMI, Samiala Gujarat	Optimisation of Drip Irrigation Lay-out and Design for Row Crops and Orchards.	6.00
		Total (b)	**15.00**
(c)	**Sanctioned during 1993-94**		
8.	WTC, IARI; New Delhi	Evaluation of Drip Irrigation Technology for various crops	7.92
9.	WTC, IARI; New Delhi	Development and Evaluation of Micro-Irrigation Technology	6.57
10.	INCID Secretariat, New Delhi	For Publishing Status Reports on various subjects concerning Irrigation and Drainage viz. Drip irrigation in India, National Guide on OM&M of Irrigation and Drainage Systems and Preparation of report on Sprinkler Irrigation in India.	4.75
		Total (c)	**19.24**
		Total of (a) + (b) + (c)	**52.30**

Drip irrigation prevents spread of weeds and diseases.

ANNEXURE - VIII

COST BENEFIT OF BANANA

SOURCE :* MR. SAHEB RAO PATIL, BHADGAON
PLANT SPACING : 1.52 M x 1.52 M
AREA : 1 HA

S.No.	COST ECONOMICS	DRIP SYSTEM	CONVENTIONAL SYSTEM
1.	Fixed Cost (Rs)	30000	NIL
	a) Life (Years)	5	NIL
	b) Depreciation	6000	NIL
	c) Interest	1800	NIL
	d) Repairs & Maintenance	600	NIL
	e) Total (b+c+d)	8400	NIL
2.	Cost of Cultivation (Rs/ha)	34600	40000
3.	Seasonal total Cost (1e+2)(Rs/ha)	43000	40000
4.	Water Used (mm.)	970	1760
5.	Yield of Produce (q/ha)	875	575
6.	Selling Price (Rs/q)	300	300
7.	Income from produce (5 x 6)(Rs)	262500	172500
8.	Net seasonal income (7 - 3)(Rs)	219500	132500
9.	Additional area cultivated due to saving of water (ha)	0.80	NIL
10.	Additional expenditure due to Additional area (3 x 9)	34400	NIL
11.	Additional income due to additional area (7 x 9)	210000	NIL
12.	Additional Net income (11-10)(Rs)	175600	NIL
13.	Gross cost of production (3+10) (Rs)	77400	40000
14,	Gross income (7 + 11)(Rs)	472500	172500
15.	Gross benefit cost ratio (14/13)	6.10	4.31
16.	Net extra income due to drip Irrigation system over conventional (12 + 8 drip - 8 conventional)	262600	NIL
17.	Net Profit Per mm of water used (8/4)	226.29	75.28
18.	Water Use Efficiency (5/4x100)Kg/ha mm	90.21	32.67

Plants never face water stress with drip irrigation.

ANNEXURE - IX

COST BENEFIT OF CHILLI

SOURCE : MPAU, PUNE

S.No.	COST ECONOMICS	DRIP SYSTEM	CONVENTIONAL SYSTEM
1.	Fixed Cost (Rs)	32500	NIL
	a) Life (Seasons)	6	NIL
	b) Depreciation	5417	NIL
	c) Interest	1950	NIL
	d) Repairs & Maintenance	650	NIL
	e) Total (b+c+d)	8017	NIL
2.	Cost of Cultivation (Rs/ha)	8935	10600
3.	Seasonal total Cost (1e+2)(Rs/ha)	16952	10600
4.	Water Used (mm.)	290	780
5.	Yield of Produce (q/ha)	29	20
6.	Selling Price (Rs/q)	2000	2000
7.	Income from produce (5 x 6)(Rs)	58000	40000
8.	Net seasonal income (7 - 3)(Rs)	41048	29400
9.	Additional area cultivated due to saving of water (ha)	1.50	NIL
10.	Additional expenditure due to Additional area (3 x 9)	25428	NIL
11.	Additional income due to additional area (7 x 9)	87000	NIL
12.	Additional Net income (11-10)(Rs)	61572	NIL
13.	Gross cost of production (3+10) (Rs)	42380	10600
14.	Gross income (7 + 11)(Rs)	145000	40000
15.	Gross benefit cost ratio (14/13)	3.42	3.77
16.	Net extra income due to drip irrigation system over conventional (12 + 8 drip - 8 conventional)	73220	NIL
17.	Net Profit Per mm of water used(8/4)	141.55	37.69
18.	Water Use Efficiency (5/4x100)Kg/ha mm	10	2.56

Drip irrigation system is ideally suited to vineyards and orchards.

ANNEXURE - X

COST BENEFIT OF CUCUMBER

SOURCE : MPAU, PUNE

S.No.	COST ECONOMICS	DRIP + MULCH SYSTEM	COVEN-TIONAL SYSTEM	DRIP ONLY
1.	Fixed Cost (Rs)	32500	NIL	32500
	a) Life	10	NIL	10
	b) Depreciation	3250	NIL	3250
	c) Interest	1950	NIL	1950
	d) Repairs & Maintenance	650	NIL	650
	e) Total (b+c+d)	5850	NIL	5850
2.	Cost of Cultivation (Rs/ha)	16000	11300	9800
3.	Seasonal total Cost(1e+2)Rs/ha	21850	11300	15650
4.	Water Used (mm.)	243	600	363
5.	Yield of Produce (q/ha)	280	180	255
6.	Selling Price (Rs/q)	200	200	200
7.	Income from produce (5 x 6)(Rs)	56000	36000	51000
8.	Net seasonal income (7 - 3)(Rs)	34150	24700	35350
9.	Additional area cultivated due to saving of water (ha)	0.70	NIL	0.65
10.	Additional expenditure due to Additional area (3 x 9)	15295	NIL	10172.50
11.	Additional income due to additional area (7 x 9)	39200	NIL	33150
12.	Additional Net income(11 - 10)(Rs)	23905	NIL	22977.50
13.	Gross cost of production (3 + 10) (Rs)	37145	11300	25822.50
14.	Gross income (7 + 11)(Rs)	95200	36000	84150
15.	Gross benefit cost ratio (14/13)	2.56	3.19	3.26
16.	Net extra income due to drip irrigation system over conventional (12 + 8 drip - 8 conventional)	33355	NIL	58327.50
17.	Net Profit Per mm of water used(8/4)	99.56	41.17	97.38
18.	Water Use Efficiency (5 / 4 x 100) Kg/ha mm	81.63	30	70.25

Achieve higher yields and quality produce through drip irrigation.

ANNEXURE - XI

COST BENEFIT OF GRAPES

SOURCE : FARMERS' DATA, JALGAON
PLANT SPACING : 1.82 M x 1.82 M
AREA : 1 HA

S.No.	COST ECONOMICS	DRIP SYSTEM	CONVENTIONAL SYSTEM
1.	Fixed Cost (Rs)	32500	NIL
	a) Life (Years)	10	NIL
	b) Depreciation	3250	NIL
	c) Interest @12%	1950	NIL
	d) Repairs & Maintenance	650	NIL
	e) Total (b+c+d)	5850	NIL
2.	Cost of Cultivation (Rs/ha)	51000	60000
3.	Seasonal total Cost (1e+2)(Rs/ha)	56850	60000
4.	Water Used (mm.)	278	532
5.	Yield of Produce (q/ha)	325	264
6.	Selling Price (Rs/q)	1500	1450
7.	Income from produce (5 x 6)(Rs)	487500	382800
8.	Net seasonal income (7 - 3)(Rs)	430650	322800
9.	Additional area cultivated due to saving of water (ha)	0.90	NIL
10.	Additional expenditure due to Additional area (3 x 9)	51165	NIL
11.	Additional income due to additional area (7 x 9)	438750	NIL
12.	Additional Net income (11 - 10)(Rs)	387585	NIL
13.	Gross cost of production (3+10) (Rs)	108015	60000
14.	Gross income (7 + 11)(Rs)	926250	382800
15.	Gross benefit cost ratio (14/13)	8.58	6.38
16.	Net extra income due to drip irrigation system over conventional (12 + 8 drip - 8 conventional)	495435	NIL
17.	Net Profit Per mm of water used (8/4)	1549.10	606.77
18.	Water Use Efficiency (5/4x100)Kg/ha mm	116.91	49.62

Drip irrigation ensures uniform water distribution.

ANNEXURE - XII

COST BENEFIT OF GROUNDNUT

SOURCE : MPAU, PUNE

S.No.	COST ECONOMICS	DRIP SYSTEM	CONVENTIONAL SYSTEM
1.	Fixed Cost (Rs)	32000	NIL
	a) Life	5	NIL
	b) Depreciation	6400	NIL
	c) Interest	1920	NIL
	d) Repairs & Maintenance	640	NIL
	e) Total (b+c+d)	8960	NIL
2.	Cost of Cultivation (Rs/ha)	6650	7450
3.	Seasonal total Cost (1e+2)(Rs/ha)	15610	7450
4.	Water Used (mm.)	580	900
5.	Yield of Produce (q/ha)	32	16.75
6.	Selling Price (Rs/q)	800	800
7.	Income from produce (5 x 6)(Rs)	25600	13400
8.	Net seasonal income (7 - 3)(Rs)	9990	5950
9.	Additional area cultivated due to saving of water (ha)	0.50	NIL
10.	Additional expenditure due to Additional area (3 x 9)	7805	NIL
11.	Additional income due to additional area (7 x 9)	12800	NIL
12.	Additional Net income (11-10)(Rs)	4995	NIL
13.	Gross cost of production (3+10) (Rs)	23415	7450
14.	Gross income (7 + 11)(Rs)	38400	13400
15.	Gross benefit cost ratio (14 / 13)	1.64	1.80
16.	Net extra income due to drip irrigation system over conventional (12 + 8 drip - 8 conventional)	9035	NIL
17.	Net Profit Per mm water used (8 / 4)	17.22	6.61
18.	Water Use Efficiency (5/4x100)Kg/ha mm	5.52	1.86

Drip irrigation is environment friendly.

ANNEXURE - XIII

COST BENEFIT OF MOSAMBI

SOURCE : DR. R.K. SIVANAPPAN
PLANT SPACING : 5.18 M x 5.18 M **CROP GROWN : 1981**
AREA : 1 Ha. **DRIP INSTALLED : 1986**

S.No.	COST ECONOMICS	DRIP SYSTEM	CONVENTIONAL SYSTEM
1.	Fixed Cost (Rs)	20000	NIL
	a) Life (Years)	10	NIL
	b) Depreciation	2000	NIL
	c) Interest	1200	NIL
	d) Repairs & Maintenance	400	NIL
	e) Total (b+c+d)	3600	NIL
2.	Cost of Cultivation (Rs/ha)	3800	5400
3.	Seasonal total Cost (1e+2)(Rs/ha)	7400	5400
4.	Water Used (mm.)	640	1660
5.	Yield of Produce (No./ha.)	150000	100000
6.	Selling Price (Rs/fruit)	0.74	0.53
7.	Income from produce (5 x 6)(Rs)	111000	53000
8.	Net seasonal income (7 - 3)(Rs)	103600	47600
9.	Additional area cultivated due to saving of water (ha)	1.50	NIL
10.	Additional expenditure due to Additional area (3 x 9)	11100	NIL
11.	Additional income due to additional area (7 x 9)	166500	NIL
12.	Additional Net income (11 - 10)(Rs)	155400	NIL
13.	Gross cost of production (3+10) (Rs)	18500	5400
14.	Gross income (7 + 11)(Rs)	277500	53000
15.	Gross benefit cost ratio (14/13)	15	9.81
16.	Net extra income due to drip irrigation system over conventional (12 + 8 drip - 8 conventional)	211400	NIL
17.	Net Profit Per mm of water used (8/4)	161.88	28.67
18.	Water Use Efficiency (5/4) number/ha mm	23437.50	6024.10

Drip irrigation promotes economic use of water.

ANNEXURE - XIV

COST BENEFIT OF POMEGRANATE

SOURCE : FARMERS' DATA
PLANT SPACING : 3.65 M x 3.65 M
VARIETY : GANESH

S.No.	COST ECONOMICS	DRIP SYSTEM	CONVENTIONAL SYSTEM
1.	Fixed Cost (Rs)	18000	NIL
	a) Life	5	NIL
	b) Depreciation	3600	NIL
	c) Interest	1080	NIL
	d) Repairs & Maintenance	360	NIL
	e) Total (b+c+d)	5040	NIL
2.	Cost of Cultivation (Rs/ha)	17500	12500
4.	Water Used (mm.)	785	1440
5.	Yield of Produce (1000 No.)	109	75
6.	Selling Price (Rs/1000 No.)	1000	750
7.	Income from produce (5 x 6)(Rs)	10900	27500
8.	Net seasonal income (7 - 3)(Rs)	86460	15000
9.	Additional area cultivated due to saving of water (ha)	0.80	NIL
10.	Additional expenditure due to Additional area (3 x 9)	18032	NIL
11.	Additional income due to additional area (7 x 9)	87200	NIL
12.	Additional Net income (11 - 10)(Rs)	69168	NIL
13.	Gross cost of production(3 + 10)(Rs)	40572	12500
14.	Gross income (7 + 11)(Rs)	196200	27500
15.	Gross benefit cost ratio (14 / 13)	4.84	2.20
16.	Net extra income due to drip irrigation system over conventional (12 + 8 drip - 8 conventional)	140628	NIL
17.	Net Profit Per mm of water used(8 / 4)	110.14	10.42
18.	Water Use Efficiency(5/4) Number/ha mm	138.9	52

Drip irrigation gives bumper yields.

ANNEXURE - XV

COST BENEFIT OF SUGARCANE (TAMIL NADU)

SOURCE : DR. R.K. SIVANAPPAN
AREA : 1 HA.

S.No.	COST ECONOMICS	DRIP SYSTEM	CONVENTIONAL SYSTEM
1.	Fixed Cost (Rs)	25000	NIL
	a) Life (Years)	5	NIL
	b) Depreciation	5000	NIL
	c) Interest @ 12%	1500	NIL
	d) Repairs & Maintenance	500	NIL
	e) Total (b+c+d)	7000	NIL
2.	Cost of Cultivation (Rs/ha)	11250	15000
3.	Seasonal total Cost (1e+2)(Rs/ha)	18250	15000
4.	Water Used (mm.)	1540	3000
5.	Yield of Produce (q/ha)	1000	720
6.	Selling Price (Rs/q)	32.50	32.50
7.	Income from produce (5 x 6)(Rs)	32500	23400
8.	Net seasonal income (7 - 3)(Rs)	14250	8400
9.	Additional area cultivated due to saving of water (ha)	0.94	NIL
10.	Additional expenditure due to Additional area (3 x 9)	17155	NIL
11.	Additional income due to additional area (7 x 9)	30550	NIL
12.	Additional Net income (11-10)(Rs)	13395	NIL
13.	Gross cost of production (3+10) (Rs)	35405	15000
14.	Gross income (7 + 11)(Rs)	63050	23400
15.	Gross benefit cost ratio (14 / 13)	1.78	1.56
16.	Net extra income due to drip irrigation system over conventional (12 + 8 drip - 8 conventional)	19245	NIL
17.	Net Profit Per mm of water used (8/4)	9.25	2.80
18.	Water Use Efficiency (5/4x100)Kg/ha mm	64.94	24

Drip irrigation prevents spread of weeds and diseases.

ANNEXURE - XVI

COST BENEFIT OF SUGARCANE (MAHARASHTRA)

SOURCE : DECCAN SUGAR INSTITUTE, PUNE			
S.No.	**COST ECONOMICS**	**DRIP SYSTEM**	**CONVENTIONAL SYSTEM**
1.	Fixed Cost (Rs)	30000	NIL
	a) Life (Years)	5	NIL
	b) Depreciation	6000	NIL
	c) Interest @12%	1800	NIL
	d) Repairs & Maintenance	600	NIL
	e) Total (b+c+d)	8400	NIL
2.	Cost of Cultivation (Rs/ha)	11445	17375
3.	Seasonal total Cost (1e+2)(Rs/ha)	19845	17375
4.	Water Used (mm.)	940	2150
5.	Yield of Produce (q/ha)	1700	1280
6.	Selling Price (Rs/q)	31	30
7.	Income from produce (5 x 6)(Rs)	52700	38400
8.	Net seasonal income (7 - 3)(Rs)	32855	21025
9.	Additional area cultivated due to saving of water (ha)	2	NIL
10.	Additional expenditure due to Additional area (3 x 9)	39690	NIL
11.	Additional income due to additional area (7 x 9)	105400	NIL
12.	Additional Net income (11-10)(Rs)	65710	NIL
13.	Gross cost of production (3+10) (Rs)	59535	17375
14.	Gross income (7 + 11)(Rs)	158100	38400
15.	Gross benefit cost ratio (14 / 13)	2.66	2.21
16.	Net extra income due to drip irrigation system over conventional (12 + 8 drip - 8 conventional)	77540	NIL
17.	Net Profit Per mm of water used (8/4)	34.95	9.78
18.	Water Use Efficiency (5 / 4 x 100) Kg/ha mm	180.85	59.53

Drip irrigation reduces labour and energy costs.

ANNEXURE - XVII

COST BENEFIT OF TOMATO (WITHOUT MULCH)

	SOURCE : MPAU, PUNE **PLANT SPACING : 0.6 M x 0.6 M** **AREA : 1 HA**		
S.No.	**COST ECONOMICS**	**DRIP SYSTEM**	**CONVENTIONAL SYSTEM**
1.	Fixed Cost (Rs)	21000	NIL
	a) Life (Seasons)	10	NIL
	b) Depreciation	2100	NIL
	c) Interest @12%	630	NIL
	d) Repairs & Maintenance	420	NIL
	e) Total (b+c+d)	3150	NIL
2.	Cost of Cultivation (Rs/ha)	10840	12120
3.	Seasonal total Cost (1e+2)(Rs/ha)	13990	12120
4.	Water Used (mm.)	222	324
5.	Yield of Produce (q/ha)	480	320
6.	Selling Price (Rs/q)	150	150
7.	Income from produce (5 x 6)(Rs)	72000	48000
8.	Net seasonal income (7 - 3)(Rs)	58010	35880
9.	Additional area cultivated due to saving of water (ha)	0.40	NIL
10.	Additional expenditure due to Additional area (3 x 9)	5596	NIL
11.	Additional income due to additional area (7 x 9)	28800	NIL
12.	Additional Net income (11 - 10)(Rs)	23204	NIL
13.	Gross cost of production (3+10) (Rs)	19586	12120
14.	Gross income (7 + 11)(Rs)	100800	48000
15.	Gross benefit cost ratio (14 / 13)	5.15	3.96
16.	Net extra income due to drip irrigation system over conventional (12 + 8 drip - 8 conventional)	45334	NIL
17.	Net Profit Per mm of water used (8/4)	261.31	110.74
18.	Water Use Efficiency (5/4x100)Kg/ha mm	216.22	98.77

Adopt drip irrigation and become prosperous.

ANNEXURE - XVIII

COST BENEFIT OF TOMATO (WITH MULCH)

SOURCE : MPAU, PUNE				
S.No.	COST ECONOMICS	DRIP SYSTEM +MULCH SYSTEM	CONVENTIONAL SYSTEM	DRIP ONLY
1.	Fixed Cost (Rs)	32500	NIL	32500
	a) Life (Seasons)	10	NIL	10
	b) Depreciation	3250	NIL	3250
	c) Interest	1950	NIL	1950
	d) Repairs & Maintenance	650	NIL	650
	e) Total (b+c+d)	5850	NIL	5850
2.	Cost of Cultivation (Rs/ha)	17750	13000	11440
3.	Seasonal total Cost(1e+2)(Rs/ha)	23600	13000	17290
4.	Water Used (mm.)	155	300	184
5.	Yield of Produce (q/ha)	500	320	480
6.	Selling Price (Rs/q)	150	150	150
7.	Income from produce (5 x 6)(Rs)	75000	48000	72000
8.	Net seasonal income (7 - 3)(Rs)	51400	35000	54710
9.	Additional area cultivated due to saving of water (ha)	0.90	NIL	0.60
10.	Additional expenditure due to Additional area (3 x 9)	21240	NIL	10374
11.	Additional income due to additional area (7 x 9)	67500	NIL	43200
12.	Additional Net income(11 - 10)(Rs)	46260	NIL	32826
13.	Gross cost of production (3 + 10) (Rs)	44840	13000	27664
14.	Gross income (7 + 11)(Rs)	142500	48000	115200
15.	Gross benefit cost ratio (14/13)	3.18	3.69	4.16
16.	Net extra income due to drip irrigation system over conventional (12 + 8 drip -8 conventional)	62660	NIL	87536
17.	Net Profit Per mm water used (8/4)	331.61	116.67	297.34
18.	Water Use Efficiency (5 / 4 x 100) Kg/ha mm	322.58	106.67	260.87

Drip irrigation is the right choice for preventing salinity and waterlogging.

ANNEXURE - XIX

COST BENEFIT OF WATERMELON.

SOURCE : MPAU, PUNE				
S.No.	COST ECONOMICS	DRIP + MULCH SYSTEM	CONVENTIONAL SYSTEM	DRIP ONLY
1.	Fixed Cost (Rs)	33700	NIL	33700
	a) Life (Seasons)	10	NIL	10
	b) Depreciation	3370	NIL	3370
	c) Interest	2022	NIL	2022
	d) Repairs & Maintenance	674	NIL	674
	e) Total (b+c+d)	6066	NIL	6066
2.	Cost of Cultivation (Rs/ha)	16475	11790	10240
3.	Seasonal total Cost(1e+2)(Rs/ha)	22541	11790	16306
4.	Water Used (mm.)	190	330	210
5.	Yield of Produce (q/ha)	580	240	450
6.	Selling Price (Rs/q)	200	200	200
7.	Income from produce(5 x 6)(Rs)	116000	48000	90000
8.	Net seasonal income (7 - 3)(Rs)	93459	36210	73694
9.	Additional area cultivated due to saving of water (ha)	0.70	NIL	0.50
10.	Additional expenditure due to Additional area (3 x 9)	15778.70	NIL	8153
11.	Additional income due to additional area (7 x 9)	81200	NIL	45000
12.	Additional Net income(11 - 10)Rs.	65421.30	NIL	36847
13.	Gross cost of production (3 + 10) (Rs.)	38319.70	11790	24459
14.	Gross income (7 + 11)(Rs)	197200	48000	135000
15.	Gross benefit cost ratio (14/13)	5.15	4.07	5.52
16.	Net extra income due to drip irrigation system over conventional (12 + 8 drip -8 conventional)	122670.30	NIL	110541
17.	Net Profit Per mm of water used(8/4)	491.89	109.73	350.92
18.	Water Use Efficiency (5/4x100)Kg/ha mm	305.26	72.73	214.29

Drip irrigation offers higher returns and prosperity.

ANNEXURE - XX

CENTRAL ASSISTANCE* RELEASED TO THE STATE GOVERNMENTS UNDER CENTRALLY SPONSORED SCHEME FOR ENCOURAGING USE OF SPRINKLERS, DRIP SYSTEMS, HYDRAMS, SOLAR PUMPS ETC.

(Rs. in lakhs)

S.NO.	STATE	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	TOTAL
1	2	3	4	5	6	7	8	9	10	11	12	13
1.	Andhra Pradesh		58.50							17.77		76.27
2.	Bihar	5.75										5.75
3.	Goa						2.31					2.31
4.	Gujarat	88.10						8.80	3.73	9.50	0.04	110.17
5.	Haryana		17.39					20.00	9.28	24.28	5.79	76.74
6.	Karnataka	24.08				63.88						87.96
7.	Kerala	3.00					1.34		3.41	8.39		16.14
8.	Madhya Pradesh	26.44		15.72	15.75	46.75			5.58	80.21		190.45
9.	Maharashtra					10.00	25.46	49.61	97.47	47.95	108.58	339.07
10.	Manipur								0.91	4.52		5.43
11.	Mizoram									2.00		2.00
12.	Orissa	2.63										2.63
13.	Punjab							5.00			28.35	33.35
14.	Rajasthan		5.52	12.23	7.25	12.75	20.00	9.50				67.25
15.	Tamil Nadu			0.83	2.00	10.25	95.30					108.38
16.	Tripura			2.47								2.47
17.	Uttar Pradesh		4.25	1.98		1.15	1.11		59.60			68.09
	TOTAL	150.00	85.66	33.23	25.00	144.78	145.52	92.91	179.98	194.62	142.76	1194.46

* Combined figures for drip systems, sprinkler irrigation and other water saving devices.

Source : Ministry of Water Resources, Minor Irrigation Wing (April, 1994).

ANNEXURE - XXI

VIII PLAN - STATE-WISE PHYSICAL/FINANCIAL TARGETS*

Area : ha.
Amount : Rs. lakhs

SL. NO.	STATE / UTs	DRIP INSTALLATION AREA	DRIP INSTALLATION AMOUNT	DRIP DEMONSTRATION AREA	DRIP DEMONSTRATION AMOUNT	MULCHING AREA	MULCHING AMOUNT	GREEN HOUSES AREA	GREEN HOUSES AMOUNT	TOTAL AREA	TOTAL AMOUNT
1	2	3	4	5	6	7	8	9	10	11	12
1.	Andaman & Nicobar	200	27.74	40	3.00	80	4.00	4	36.62	324	71.36
2.	Andhra Pradesh	20000	2653.96	1200	90.00	3000	150.00	9	84.25	24209	2978.21
3.	Arunachal Pradesh	200	27.74	40	3.00	80	4.00	4	36.62	324	71.36
4.	Assam	720	94.93	140	10.50	900	45.00	10	84.25	1770	234.68
5.	Bihar	3200	430.04	640	48.00	800	40.00	4	36.62	4644	554.66
6.	Chandigarh	200	27.00	40	3.00	80	4.00	4	36.62	324	70.62
7.	Dadra & Nagar Haveli	200	27.74	40	3.00	80	4.00	4	36.62	324	71.36
8.	Daman & Diu	200	27.74	40	3.00	80	4.00	4	36.62	324	71.36
9.	Delhi	200	27.74	40	3.00	80	4.00	4	36.62	324	71.36
10.	Goa	250	34.34	60	4.50	80	4.00	4	36.62	394	79.46
11.	Gujarat	8000	1195.96	480	36.00	1000	50.00	9	79.25	9489	1361.21
12.	Haryana	1800	247.04	180	13.50	300	15.00	9	79.25	2289	354.79
13.	Himachal Pradesh	2000	277.04	200	15.00	1500	75.00	28	250.00	3728	617.04
14.	Jammu & Kashmir	1400	192.00	280	21.00	1400	70.00	10	84.25	3090	367.25
15.	Karnataka	20700	2784.00	1240	93.00	2800	140.00	27	235.00	24767	3252.00
16.	Kerala	7300	985.04	700	52.50	2200	110.00	4	36.62	10204	1184.16
17.	Lakshdweep	200	27.74	40	3.00	80	4.00	4	36.63	324	71.37
18.	Madhya Pradesh	4700	649.50	460	34.50	2500	125.00	10	84.25	7670	893.25
19.	Maharashtra	27000	3603.00	1620	121.50	3000	150.00	28	250.00	31648	4124.50
20.	Manipur	200	27.74	40	3.00	80	4.00	4	37.25	324	71.99
21.	Meghalaya	200	27.74	40	3.00	80	4.00	4	37.25	324	71.99
22.	Mizoram	200	27.74	40	3.00	80	4.00	4	36.63	324	71.37
23.	Nagaland	200	27.74	40	3.00	80	4.00	4	36.63	324	71.37
24.	Orissa	10300	1359.76	1000	75.00	900	45.00	4	36.63	12204	1516.39

ANNEXURE XXI (Contd.)

25.	Pondicherry	200	27.74	40	3.00	80	4.00	4	36.63	324	71.37
26.	Punjab	1500	212.54	160	12.00	500	25.00	9	79.25	2169	328.79
27.	Rajasthan	3000	414.00	300	22.50	800	40.00	4	36.63	4104	513.13
28.	Sikkim	200	27.74	40	3.00	80	4.00	4	36.63	324	71.37
29.	Tamil Nadu	14300	1930.04	860	64.00	1100	55.00	9	78.25	16269	2127.79
30.	Tripura	300	40.64	60	4.50	80	4.00	4	36.63	444	85.77
31.	Uttar Pradesh	7815	1042.34	400	105.00	1600	80.00	9	78.25	10824	1305.59
32.	West Bengal	2300	304.94	500	37.50	2500	125.00	4	36.63	5304	504.07
	Total	139185	18810.99	12000	900.00	28000	1400.00	247	2200.00	179432	23310.99

New Plasticulture Application Rs - 500 lakhs
Training Rs - 590 lakhs
NCPA Rs - 600 lakhs

Total Rs 1690 lakhs

Total VIII Plan Provision Rs 23,310.99 lakhs
Rs + 1690.00 lakhs

Rs 25,000.99 lakhs

Say Rs 250 Crores
Or Rs. 2.50 billion.

State-wise allocation of Rs 1690 lakhs has not yet been done.

* Provisional - Subject to final Clearance.

ANNEXURE - XXII

DETAILED GUIDELINES FOR IMPLEMENTATION OF SCHEMES ON THE USE OF PLASTICS IN AGRICULTURE FOR THE REMAINING PART OF VIII PLAN PERIOD PERTAINING TO DRIP IRRIGATION.

I. DRIP INSTALLATION :

The Scheme is envisaged to cover all the farmers growing horticultural crops other than tea, coffee, rubber and oil palm on compact area basis, irrespective of the land holding. To ensure uniformity in the sanction of subsidy throughout the Country, the following standardised procedure has been outlined :

(a) Farmers are required to submit applications to Agriculture/ Horticulture Development (ADO/HDO) or any other authority designated for the purpose through Village Level Workers (VLW).

(b) After scrutiny of the applications, ADO/HDO or any other designated authority is to issue eligibility certificates for availing subsidy along with a list of approved drip system manufacturers to the farmers.

(c) Farmer obtains proforma invoice from one of the approved manufacturers and submits to ADO/HDO and also indicates whether the balance amount extending subsidies will be met from his own resources or borrowed from the Bank.

(d) After scrutinising the design, water and soil test reports, quotations, ADO shall submit the document with his recommendation to the District Agriculture Development Officer (DAO)/equivalent authority.

* **If beneficiary pays his own contribution :**

- DAO conveys final approval to the farmer with a copy to the system manufacturer.
- Thereupon, the manufacturer installs system.
- Farmer pays his own share to the manufacturer.

(Source : Department of Agriculture & Co-Operation, Ministry of Agriculture, Government of India, New Delhi)

Drip irrigation is a modern scientific technology.

- Farmer informs ADO of the installation.

- ADO verifies and submits satisfactory installation of the system to DAO.

- The subsidy amount will be released by DAO to the manufacturer through the farmer.

- The State Government will ensure that the payment is released within a month from the date of installation.

* **If the beneficiary takes loan :**

- The DAO conveys sanction of subsidy by the State Government along with the farmer's intention to avail loan to the bank and system manufacturer with a copy to the farmer.

- The system manufacturer installs system on the field.

- The performance of the system is verified by the farmer, bank & State Government official.

- Farmer and State Government official approves the system and requests bank to make payment to the manufacturer on their behalf.

- Bank pays loan and subsidy amount to the system manufacturer within a month which will meet the total cost of the system.

- Bank debits to the State Government Account and farmer's account to the extent of subsidy and loan respectively.

(e) The State Government is required to ensure that only those suppliers who are manufacturing the laterals and emitters are registered. These manufacturers, however, can appoint distributors for supply of material on their behalf. These manufacturers should have obtained BIS mark for various components. The imported material having international standards like ISO should be permitted only if it matches certain physical standards as per BIS specifications. If a new technology is imported, its performance should be evaluated in the field by the recognised testing laboratories before the system is approved for subsidy. The costing of Drip Irrigation System for different spacings is worked out as per table on next page :

A farmer can avail subsidy upto Rs. 15,000/- for drip irrigation.

Spacing	Cost/ha. (Rs)
1.0 x 1.0 m	60,000
2.0 x 2.0 m	45,000
3.0 x 3.0 m	40,000
4.0 x 4.0 m	32,000
6.0 x 6.0 m	26,000
8.0 x 8.0 m	24,000
10.0 x 10.0 m	22,000

The cost includes expenses towards mains, sub-mains, laterals, drippers, microtubes, connectors, filters, control head unit and installation charges. The cost thus calculated can be taken as a base for providing subsidy for different spaced crops.

The subsidy amount will be limited to either 50% of actual cost or Rs.15,000 for ha whichever is lower. The Government of India will contribute the entire 50% subsidy upto the Financial Year 1994-95 and thereafter the Centre and State contribution towards subsidy will be 40% and 10% i.e. the Central and State Government will contribute a maximum amount of Rs.12,000/- and Rs. 3,000/- per hectare respectively. A beneficiary can avail subsidy for a maximum area of one ha. only.

The detailed procedure outlined above is intended to bring uniformity in implementation of the scheme throughout the country. However, State Governments can follow their own system if they so desire. State Governments should confirm to Government of India, the agency through which the scheme is to be implemented by 28.2.94. In case implementation is entrusted to an agency other than Department of Agriculture/Horticulture, State Governments must give an undertaking that no service charge will be levied by these agencies and debited to this scheme.

(f) The scheme is to be implemented preferably through Directorate of Horticulture/Agriculture as they have the required network/infrastructure.

(g) The subsidy may be extended to the farmers' cooperative and each member may be considered as a beneficiary for the purpose. However, it is to be ensured that the beneficiary covered under 'Cooperative' does not avail subsidy as an individual also.

Wastelands and coastal sandy belts can be made arable with drip irrigation.

(h) One or more farmers who agree to use the same water source for irrigating their land, may also be permitted to avail subsidy individually.

(i) State Governments would be required to ensure that adequate after sales services is provided by the manufacturers. Repairs and maintenance facilities should be made available at no extra cost to the farmers atleast for the initial 3 year period after installation of the system. For the 4th and 5th years, cost of the spares should be charged at 25% and 50% respectively of their market price. Balance including service charge needs to be borne by the manufacturers.

II. DRIP DEMONSTRATION :

(a) The demonstration will be done only on recognised farmer holdings belonging to State Government/Central Government/SAUs/NGOs (or their own land) having grown horticultural crops as indicated under DIS. Each farm will get a demonstration unit of one ha.

(b) The procedure to implement this component of the scheme is the same as suggested for drip installation component. The same approved drip manufacturers can supply the material.

(c) The outlay projected for the state under drip demonstration component is calculated @ 25% of the system cost which is in addition to the subsidy provided under the scheme component of drip installation. Thereby, the subsidy amount will be limited to either 75% of actual system cost or Rs.22500/- per hectare whichever is lower.

(d) All other conditions will remain the same as under drip installation system.

III. MULCHING :

Covering of soil around the root zone of plant with a plastic film is called plastic mulching. It is an effective practice to restrict weed growth, conserve moisture and reduce the effect of soil borne diseases through soil solarisation.

(a) The scheme of mulching was first introduced in some of the states during 1991-92. To promote this concept, Government of India has earmarked an outlay of Rs. 14 crores for the VIII Plan period bringing an area of 28000 ha under mulching.

Drip irrigation can profitably be extended to the command areas of the community wells.

(b) A subsidy of 50% of the cost of plastic film will be given subject to a ceiling of Rs. 5000 per ha. A farmer can avail subsidy for a maximum of one hectare cultivated area.

(c) Various thicknesses of films (15-200 microns) are available and can be used as per the following recommendations :

Thickness of Film (Microns)	Recommended Crops
15 - 40	Low duration crops (3-4 months) All vegetable crops, strawberry, sugarbeet etc.
50 - 75	Medium duration crops (11-12 months) Initial stage of fruit crops, flowers, papaya, pineapple etc.
100 - 200	Long duration crops (more than 12 months) All fruit crops.

(d) The extent of area covered under mulch also varies from crop to crop. It is uneconomical to lay one mulch film for the entire plot size. For wide spaced crops like orchards, mulch film can be cut depending upon the size of basin and can be anchored neatly around the plant. Thus there is no need to use costly film for the plant to plant and row to row uncultivated space. For vegetables, one film can be laid for each row. Hence, in wide spaced crops, area covered by the plastic film is lesser than covered in close spaced crops. The area covered plastic films, expressed in terms of percentage of total field area is recommended for different crops as follows.

Extent of area Coverage (%)	Recommended Crops
20	Initial stages of orchard crops.
40	Mango, Guava, Lemon, Pomegranate, Medium Stage Orchard Crops, Cucurbits, Melon.
40 - 60	Vegetable Crops, Papaya, medium sized fruit trees and strawberry.
70 - 80	Full grown fruit trees.
100	Soil solarisation and crops grown inside greenhouse.

Unlike in Surface irrigation, drip irrigation supplies water direct to root zone.

(e) The quantity of film required per unit area may vary with the thickness of film used and extent of area covered. The relationship between thickness of film and weight of film required per hectare is as under:

QUALITY OF PLASTIC FILM REQUIRED FOR MULCHING (Kg)

Extent of area Coverage (%)	Film Thickness (in Microns)				
	100	40	25	20	15
20	75	30	19	15	11
40	150	60	38	30	23
60	225	90	57	45	31
80	300	121	75	68	45
100	380	151	94	75	57

(f) The film after use can be removed from the field and sold since it has scrap value. It will also help in controlling environmental pollution.

(g) The State Government has to ensure that the film purchased is made from virgin raw material (not recycled) as this will be more durable. Such entrepreneurs who can supply quality film should be identified and registered. One such manufacturer is Indian Petrochemicals Corporation Limited (IPCL), A Government of India Undertaking. The order for the film can be placed at any of the regional and sales offices mentioned below :

1. Plasticulture Business Group, Site Office (Wire & Cable Building), Indian Petrochemicals Corporation Limited, P.O. Petrochemicals, Distt. Vadodara - 391346 Phone 73281.

2. Indian Petrochemicals Corporation Limited, 30 Mission Road, Rallaram Building, Bangalore 560 027 Phone 2223801-3.

3. Indian Petrochemicals Corporation Limited, Air India Building, 19th Floor, Nariman Point, Bombay-400021 Phone 2021674.

4. Indian Petrochemicals Corporation Limited, AG Towers, 7th Floor, 125/1 Park Street, Calcutta - 700 017 Phone 293545.

5. Indian Petrochemicals Corporation Limited, 10th Floor, International Trade Tower, Nehru Place, New Delhi-110019

Drip irrigation facilitates maximum out-put per unit of irrigation water.

6. Indian Petrochemicals Corporation Limited, Kirti Towers, Tilak Road, Vadodara-390001.

In case the film is purchased from any other source, the State Government would ensure that the film is purchased from a source having a test certificate either by Shri Ram Institute of Industrial Research, Delhi-110007 or IPCL to ensure that only good quality film is being used.

(h) The sequence of procedure adopted for availing subsidy by the farmer is the same as in drip installation.

IV. GREENHOUSES :

Greenhouse structures are used to raise off-season crops, high quality flowers and hardening of plants, nurseries, through tissue culture. Depending upon the need of environmental control, greenhouses may be installed without any control mechanism, partial control mechanism (medium cost) and full control mechanism (high cost). The low cost greenhouse does not have any control system. It has only the supporting structure with UV stabilized film as the cladding material. Medium cost greenhouse may have double layer UV stabilized plastic film with cooling pad/ fan or heating arrangements. The high cost greenhouse may have all the modern facilities including UV stabilised LDPE film/ FRP/Poly Carbonate sheet as the cladding material, humidification system, Drip Irrigation System, auto control mechanism etc. The green houses could be constructed by the beneficiaries themselves using the local material also. The tentative cost of all the three types of greenhouses is enclosed at **Appendix-I**. There may, however, be some local variations in actual cost.

(a) Three different types of greenhouses have been proposed.

The details are as follows :

TYPE	COST SQ.MT	SUBSIDY %	CEILING (Area/ Sq. Metre)	CEILING AMOUNT (Rs.)
Low Cost	125	50	500	31250
Medium Cost	500	40	500	100000
High Cost	2000	10	500	100000

Recurring expenses on inter-cultivation / hoeing are minimised with drip irrigation.

(b) A farmer can adopt a combination of all the three greenhouses also but the subsidy will be restricted to a total of 500 sq.mt. area only. The subsidy rate will be as per the type of greenhouse erected. The farmer can also go in for multiple sub-units within the ceiling.

(c) A total budget of Rs 22 crores has been kept for promotion of greenhouses. It is proposed to bring 247 ha under greenhouse cultivation during the VIII Plan.

(d) In case, enough number of beneficiaries are not available for a particular category of greenhouse, Secretary (Agriculture) of the respective State can allocate the amount under any other category of greenhouse for which demand exists.

(e) The sequence of procedure adopted for availing subsidy by the farmer is the same as in drip irrigation.

NEW PLASTICULTURE APPLICATIONS.

This component of the scheme will be directly implemented by NCPA. An amount of Rs 5 crores has been earmarked towards promotion of relatively new plasticulture applications in the country. These are like shading nets, better post harvest management and packaging of seeds.

Assistance would be provided for developing new technologies, pilot testing of projects and adoption of new technologies for promotion of plasticulture applications.

1. NCPA will provide financial assistance directly to the agencies involved in developing new technologies and pilot testing of the projects. The assistance would be limited to Rs 3 lakh per project. The projects will be evaluated by NCPA for approval. However, NCPA can change the limits as per the merit.

2. The performance of the project will be judged by the following broad criteria.
   a. Cost economics of the technology.
   b. Scope of technology in the country.

3. For successful technologies, a 50% subsidy of the total cost will be provided for demonstration at Government farms. The States will submit the proposals separately to NCPA for their requirements.

There is no soil erosion in drip irrigation.

Since the development of technologies may vary with the need and potential in a state, hence no state-wise targets have been fixed.

The state-wise financial and physical targets for the drip installation, drip demonstration, mulching and greenhouses for the VIII Plan are given in **Annexure-XXI.**

The proposed financial outlays (state-wise) for these four components for the financial year 1994-95 are given in **Appendix-II (a), II (b) and II (c).** The financial out lays for the seven components for the financial year 1994-95 are given in **Appendix - III.**

TRAINING PROGRAMME.

In order to ensure effective implementation of the Scheme, it is imperative that the beneficiaries as well as State Government Officials at the implementation level are trained to understand the plasticulture applications. Therefore an extensive training programme has been planned and an amount of Rs 5.9 crores is earmarked for this component.

The training programmes need to be organised for different segments: Farmers, State Government Officials and representatives from financial institutions. The various awareness programmes will be organised by the eleven existing and six new PDCs as per the regional needs. The PDCs will have all the required infrastructure to conduct such training programmes; help may also be sought from some more organisations having the required infrastructure to train people.

At times, farmers may have to be taken to different areas for showing the demonstration of plasticulture applications.

Besides this, national level seminars/conferences will be organised to have better interaction for improvement in implementation procedures. National/Regional level exhibitions will also be organised.

The States/UTs will inform the nearest NCPA personnel about their requirement for training/field visits of farmers alongwith the tentative budget requirement. NCPA will release the funds to the PDCs/agencies directly involved in organising the programme.

There is less weed growth in drip irrigation.

PROGRAMMES FOR STATE GOVERNMENT OFFICIALS.

Eligibility - State/District/Block Level Officers sponsored by State Government.

Pattern of Assistance - Financial Assistance would be provided by NCPA to the organising agency to conduct training programme on receipt of specific proposal by the concerned PDC.

PROGRAMMES FOR SCIENTISTS:

Eligibility - Scientists from PDCs, Agricultural and other Research Institutes.

Pattern - Directly to the organising agencies on receiving assistance request by PDC concerned from the State Government/Agricultural University/Research Institute. The ideal batch size will be 20.

FIELD VISIT FOR FARMERS.

Eligibility
- Farmers having their own land preferably in the age group of 20 - 50 years.
- Farmers should preferably be literate.
- Farmers should grow horticultural crops.

Pattern - Directly to the State Government/PDC on receiving assistance request from State Government. A batch size of 50 will be most ideal. Detailed programme of places to be visited should be informed.

SUBMISSION OF PROPOSAL.

The proposal must be submitted by the State Government in advance to PDC/NCPA and should contain the following information.

- Names and addresses of participants proposed.
- Details of the proposed expenditure to be incurred.
- The approximate cost for organising training programmes/field visits is given at **Appendix-IV.**

Drip irrigation saves labour and energy costs unlike lift irrigation.

SANCTION OF PROPOSAL :

- Upon receipt of requests for training programme/field visit, PDC/NCPA shall confirm the programme or suggest necessary changes if required.
- The amount sanctioned for the year must be spent within the same financial year.
- The organising agency shall subsequently provide the utilisation certificate and detailed progress report.
- Monitoring of the scheme shall be done by NCPA.

Drip irrigation generally suits any type of crop, soil and climate.

COST ESTIMATE OF LOW COST GREEN HOUSE (GH1)

Size - 4 m X 25 m

Specifications	Quantity required	Rate/ unit (Rs)	Total Amount (Rs)
G.I. Pipes 15 mm	180 m	27/m	4,860
G.I. Pipes 25 mm	51 m	40/m	2,040
MS Flats 25 mm x 3 mm	4 Kg	12/Kg.	48
Nuts 6 mm - 35 mm long	4 Kg	20/Kg	80
Cement 1:3:6	1 cubic		500
Concrete mix	metre	500	
End Frames			
Labour		500	500
UV Stabilised LLDPE Film	32 Kg	125/Kg	4,000
Total cost			12,528
Say			12,500
Rate			Rs 125 per sq.mt.

COST ESTIMATE OF MEDIUM COST GREEN HOUSE (GH2).

Size 4 m x 25 m

Cost for GH1 (100 Sq.mt.)	12500
Additional Items over GH1	
Skirt Wall 30 cm high, 22 cm wide	5000
Louvers (for fans) - 2	1000
Electrical fittings (Power Point)	3000
Distribution box (MCB etc)	2500
Poly grip assembly	1000
Environmental Control Equipment	
One inflation blower	1000
Two fans (60 cm diameter)	10000
One monoblock AC Pump	2000

Micro-nutrients like Zinc and Iron can be fed easily through drip system.

Water Tank (Concrete with top cover)	3000
Thermostat/humidifier	2000
Cooling pad and fittings	2000
Labour	1000
Additional film for double layer (40 Kg film)	5000
Total Expenses for GH2	50,000
	Say Rs. 500 per sq. mt.

COST ESTIMATE OF HIGH COST GREEN HOUSE (GH3).

Size 4 m x 25 m

High cost greenhouse may be a multi-span structure. The cost estimates may vary considerably due to crop, cladding material and environment control system. The per sq.m. tentative cost of the additional items is stated below. The items may be used as per the requirement.

	Cost (Rs/sqm.)
Cladding material	
If used double layer polyethlene sheet	100
Environmental Control Equipment.	
CO_2 generator - distributor	150
Evaporation cooling	200
Heating system	200
Humidification system	100
Lighting	250
Night Curtain shading System	150
Drip Irrigation System	20
Nutrient Application System	100
Porous flooring	100
Benches	150
Structural Cost	250
Miscellaneous	230
The total average cost is taken as Rs.2000 per sq.m.	

Entire Israel is covered by drip irrigation leading to its remarkable progress.

APPENDIX - II (a)

PROPOSED FINANCIAL OUTLAY FOR FINANCIAL YEAR 1994-95.
(DRIP INSTALLATION)

S. No.	STATE	DRIP AREA ha.	INSTALLATION AMOUNT Rs lakhs	DRIP AREA ha.	DEMONSTRATION AMOUNT Rs lakhs
Category A					
1.	Andhra Pradesh	3040	456.00	160	12.00
2.	Gujarat	1200	180.00	100	7.50
3.	Karnataka	3300	495.00	140	10.50
4.	Maharashtra	4680	702.00	400	30.00
5.	Tamil Nadu	2480	372.00	140	10.50
	Sub-Total	14700	2205.00	940	70.50
Category B					
1.	Haryana	280	42.00	40	3.00
2.	Himachal Pradesh	280	42.00	40	3.00
3.	Kerala	1320	198.00	120	9.00
4.	Madhya Pradesh	780	117.00	80	6.00
5.	Orissa	1660	249.00	140	10.50
6.	Punjab	220	33.00	40	3.00
7.	Rajasthan	440	66.00	40	3.00
	Sub-Total	4980	747.00	500	37.50
Category C					
1.	Uttar Pradesh	1100	165.00	220	16.50
2.	Arunachal Pradesh	40	6.00	8	0.60
3.	Andaman & Nicobar	40	6.00	8	0.60
4.	Assam	120	18.00	24	1.80
5.	Bihar	620	93.00	80	6.00
6.	Chandigarh	40	6.00	8	0.60
7.	Dadra & Nagar Haveli	40	6.00	8	0.60
8.	Daman & Diu	40	6.00	8	0.60
9.	Delhi	40	6.00	8	0.60
10	Goa	40	6.00	10	0.75
11	Jammu & Kashmir	260	39.00	40	3.00

Drip irrigation system keeps space in between crop rows dry and weed free.

APPENDIX-II(a) (Contd.)

12	Lakshdweep	40	6.00	8	0.60
13	Manipur	40	6.00	8	0.60
14	Meghalaya	40	6.00	8	0.60
15	Mizoram	40	6.00	8	0.60
16	Nagaland	40	6.00	8	0.60
17	Pondicherry	40	6.00	8	0.60
18	Sikkim	40	6.00	8	0.60
19	Tripura	40	6.00	10	0.75
20	West Bengal	420	63.00	72	5.40
	Sub-Total	3120	468.00	560	42.00
	Grand Total	22800	3420.00	2000	150.00

APPENDIX-II (b)

PROPOSED FINANCIAL OUTLAY FOR FINANCIAL YEAR 1994-95.

GREENHOUSE

S. No.	STATE	AREA ha.	AMOUNT Rs lakhs
Category A			
1.	Maharashtra	4.20	38.63
2.	Himachal Pradesh	4.15	36.25
3.	Kamataka	4.10	38.00
	Sub-Total	12.45	112.88
Category B			
1.	Madhya Pradesh	1.55	14.50
2.	Assam	1.55	14.50
3.	Jammu & Kashmir	0.55	5.50
4.	Andhra Pradesh	1.55	14.50
5.	Gujarat	1.35	13.25
6.	Haryana	1.35	13.25
7.	Punjab	1.55	14.50
8.	Uttar Pradesh	1.05	10.00
9.	Tamil Nadu	1.15	12.00
	Sub-Total	11.65	112.00

Brackish water (Salt water) can also be used for drip irrigation.

APPENDIX-II (b) (Contd.)

Category C			
1.	Meghalaya	0.75	6.06
2.	Manipur	0.75	6.06
3.	Mizoram	0.80	6.38
4.	Sikkim	0.75	6.06
5.	Delhi	0.80	6.38
6.	Rajasthan	0.80	6.38
7.	West Bengal	0.70	6.44
8.	Andaman & Nicobar	0.80	6.38
9.	Arunachal Pradesh	0.75	0.06
10	Bihar	0.65	0.13
11	Chandigarh	0.80	6.38
12	Dadra & Nagar Haveli	0.80	6.38
13	Daman & Diu	0.80	6.38
14	Goa	0.80	6.38
15	Lakshdweep	0.80	6.38
16	Orissa	0.80	6.38
17	Pondicherry	0.80	6.38
18	Tripura	0.70	5.75
19	Nagaland	0.70	5.75
20	Kerala	0.75	6.75
	Sub-Total	15.30	125.19
	Grand Total	39.40	350.07

APPENDIX - II (c)

PROPOSED FINANCIAL OUTLAY FOR FINANCIAL YEAR 1994-95.

MULCHING

S. No.	STATE	AREA ha.	AMOUNT **Rs lakhs**
Category A			
1.	Andhra Pradesh	420	21.00
2.	Gujarat	160	8.00
3.	Karnataka	400	20.00
4.	Maharashtra	420	21.00
5.	Himachal Pradesh	220	11.00
6.	Madhya Pradesh	360	18.00

One labourer can easily attend to drip irrigation upto 10 ha

APPENDIX - II (c) (Contd.)

7.	Rajasthan	110	5.50
8.	Assam	110	5.50
	Sub-Total	2200	110.00
Category B			
1.	Haryana	40	2.00
2.	West Bengal	340	17.00
3.	Kerala	300	15.00
4.	Jammu & Kashmir	210	10.50
5.	Punjab	60	3.00
6.	Tamil Nadu	160	8.00
	Sub-Total	1110	55.50
Category C			
1.	Uttar Pradesh	220	11.00
2.	Arunachal Pradesh	14	0.70
3.	Andaman & Nicobar	14	0.70
4.	Orissa	140	7.00
5.	Bihar	120	6.00
6.	Chandigarh	14	0.70
7.	Dadra & Nagar Haveli	14	0.70
8.	Daman & Diu	14	0.70
9.	Delhi	14	0.70
10	Goa	14	0.70
11	Lakshdweep	14	0.70
12	Manipur	14	0.70
13	Meghalaya	14	0.70
14	Mizoram	14	0.70
15	Nagaland	14	0.70
16	Pondicherry	14	0.70
17	Sikkim	14	0.70
18	Tripura	14	0.70
	Sub-Total	690	34.50
	Grand Total	4000	200.00

Land levelling is not necessary for drip irrigation.

APPENDIX - II (c) (Contd.)

Category	Status of Development	States
A	Drip System is established and adoption is reasonably rapid.	Andhra Pradesh; Karnataka Maharashtra; Tamil Nadu and Gujarat.
B	Awareness is being created and more prone to adoption level.	Haryana, Himachal Pradesh Madhya Pradesh, Orissa, Punjab, Rajasthan and Uttar Pradesh
C	Very low awareness level needs a beginning.	Arunachal Pradesh; Assam; Goa; J.& K.; Manipur; Meghalaya; Mizoram; Nagaland; Sikkim; Tripura West Bengal; Andaman & Nicobar; Dadra & Nagar Haveli; Pondicherry; Lakshdweep and other UTs.

Source : No.5-10/92 M.A. Government of India, Ministry of Agriculture (Department of Agriculture & Co-operation) Memorandum for Expenditure, Finance Committee.

Drip irrigation is specifically suited for high value crops.

APPENDIX - III

PROPOSED FINANCIAL OUTLAY FOR FINANCIAL YEAR 1994-95

Sl. No.	Scheme Component	Area to be Covered (ha)	Proposed Outlay (Rs. lakhs)
1.	Drip Installation	22800	3420
2.	Drip Demonstration	2000	150
3.	Poly Greenhouse	40	350
4.	Mulching	4000	200
5.	New Applications	-	100
6.	Training	-	100
7.	N C P A	-	180
	Total	-	4500

Expand cultivated area through drip irrigation.

MAXIMUM LIMIT OF EXPENDITURE FOR ORGANISING TRAINING PROGRAMME FOR SCIENTISTS/STATE GOVERNMENT OFFICIALS.

Duration of Programme		-	3-5 days
No. of Participants		-	25
1.	Working lunch and tea (25 persons) Rs. 50 per person per day	-	Rs. 6250 (assuming 5 days)
2.	Field Visits (hiring of Vehicle)	-	Rs. 5000
3.	Expenses on teaching material & Stationery (Rs.400 per head)	-	Rs. 10000
4.	Local travel/field visits	-	Rs. 2000
5.	Audio Visual Aids, photos, Banners etc.	-	Rs. 1500
6.	TA/DA/Honorarium	-	Rs. 12000
			Rs. 36750
7.	Institutional overheads @10%	-	Rs. 3675
			Rs. 40425
			Say Rs. 40000

- Boarding/Lodging charges will be borne by the sponsoring agencies.
- If the duration of participants is less than proposed, then the expenditure is to be restricted proportionately.

ESTIMATES OF EXPENDITURE FOR VISITS OF FARMERS.

(Group of 50 Persons)

1.	Bus/2nd Class Rail Fare for farmers	As per actuals
2.	Boarding/Lodging charges for ten days (seven days for visits and three days for travel) @Rs.50/- per farmer/day (50 x 50 x 10)	Rs. 25,000

3.	Transport expenses for local travel/ field visits.	Rs. 2,000
	Total	Rs.27,000

(Plus actual travel expenses for farmers)

Note : If the number of farmers is less than prescribed number of 50, then expenditure to be restricted proportionately for boarding and lodging.)

UNIT COSTS FOR DRIP IRRIGATION SYSTEM APPROVED BY NABARD FOR VARIOUS CROPS IN DIFFERENT STATES

System Cost in Rs. per ha

Sl. No.	State / Crop: / Spacing : 'm'	Sapota Mango 10 x 10	Sapota 9 x 9	Ber Coconut* 7.5x7.5	Citrus/ Almond Apple Guava 6 x 6	Orange Peach Custard Apple 5 x 5	Lemon Pome-Granate 4 x 4	Banana Grapes Papaya 3 x 3	Grapes 1.8x1.2	Roses Banana 1.5x1.5	Month of Approval
1.	Andhra Pradesh	13,250		14,500	19,000		20,500	30,750			Jul.91
2.	Assam										
3.	Bihar										
4.	Gujarat		11,500		13,000	15,000	17,300				Apr.91
5.	Haryana			13,500	16,050		17,950	28,250			Jun.92
6.	Himachal Pradesh			13,550	16,050		17,950	28,250			Mar.92
7.	Jammu & Kashmir										
8.	Kamataka	13,800	14,500	16,300	18,900		24,000		54,400	31,400	Mar.92
9.	Kerala			23,100							Jul.92
10.	Madhya Pradesh				16,500		20,550	26,400		46,550	Mar.92
11.	Maharashtra	10,500		12,150	14,650	16,500	18,500	21,900	34,250	25,150	Jun.92
12.	Orissa										
13.	Punjab			13,500	16,050		17,950	28,250			Jun.92
14.	Rajasthan		14,000		17,600			29,000	30,700		May,92
15.	Tamil Nadu	15,000		18,000	20,000						Feb.92
16.	Tripura										
17.	Uttar Pradesh	11,200		12,400	15,100		21,900		42,100		Apr.92

* Coconut with banana as intercrop
(Source - Tech.Seminar Division (MI) NABARD)

ANNEXURE - XXIV

MANUFACTURERS OF DRIP IRRIGATION SYSTEM

1. Agritools, 1-2-33/5, Gaganmahal Road, Domalguda, Hyderabad - 500029, Andhra Pradesh; Grams: AGRITOOLS;

2. Agro Engineering Co. 6-6-37-4 Kavadiguda, Adjacent lane to Petrol Pump, Secunderabad - 500 003, Andhra Pradesh, Phones:833339, 884177.

3. **Agroplast, 14 Belladapet, Tiptur-572201 Karnataka. Phone 08134-2653.**

4. Ajanta Plastic Industries, 31/A, Co-op.Industrial Estate, MIDC, Ahmednagar - 431 005, Maharashtra

5. **Alpha Plastic Industries, L-2326/3 & 4 GIDC, 3rd Phase, Vapi - 396 191. Gujarat.**
   Bombay Office: 46, Nagdevi Street, Bombay-400003 Maharashtra Phones : 3423179 & 3424017
   Ahmedabad Office: 2, Kumar Complex, Kadia Kui, Ahmedabad-380001 Gujarat, Phones: 334005

6. Anil Kumar & Co., Opp. Pathik Ashram, 1st Floor, Bhavnagar - 364001, Gujarat.

7. Ashok India Agro Products, Post Box No.66, C-5/2 New MIDC Area, Ajanta Road, Jalgaon - 425003 Maharashtra, Phones 3991, 6137, 5183, 6930; Grams: CAKPRODUCT;

8. Batliboi & Co. Ltd.; 3-A, Surya Towers, Sardar Patel Road, Secunderabad-500003, Andhra Pradesh; Phone: 841701, Telex: 0425-6242, Fax: 91-842-841700

9. **Bhoruka Aluminium Limited, No.1, K.R.S. Road, Metagalli, Mysore - 570016. Tel.: 511116, 511066; GRAM: EXTRUSION Telex: 0846-347 Fax No.: 0821-513067. Corporate: 26/1, Lavelle Road, Bangalore-560001. Telex: 0845-8511 BLS IN.**

10. Coimbatore Irrigation Equipment and Consultancy Services, Kungarupalayam, P.O. Kangayam TK, Udhiyur 638703, Erode RMS, Tamil Nadu.

Drip irrigation offers very high efficiency of water use.

11. Coromandel Indag Products (I) Ltd., 62 Spurtank Road, Chetput, Madras - 600031 Tamil Nadu. Phones: 861092, 861114;
Telex : 041-7647; Grams : COROCOMBI;

12. Desert Gold India Irrigation Limited, Agro Products andProduces Hi-Tech System Design of Irrigation Project, 157, Aarey Road, Goregaon (West), Bombay-400062, Maharashtra. Phones:8720478, 8722033, Fax: 91-22-8724367, Telex: 011-70056 VPI IN.

13. Drip India, Lasalgaon, Tal.Niphad, Nasik, Maharashtra.

14. ELGI Equipments Ltd., India House, Trichy Road, Coimbatore-641018, Tamil Nadu; Phone 210155; Grams: HYDRAULICS; Telex: 0855-222 ELGI IN.

15. **EPC Irrigation Limited, B-20 MIDC, Ambad, Nashik-422010 Maharashtra. Phones: 23241, 23242 & 22152. Telex : 0752-363 EPCN IN. Fax: 91-0253-22975 EPC IND. Branches at: Ahmedabad, Aurangabad, Bombay, Bhubaneshwar, Coimbatore, Hubli, Hyderabad, Jabalpur, Jaipur and Sangli.**

16. Flow Tech Power, 137 London Mission School St., Papanaickenpalayam, Coimbatore - 641047, Tamil Nadu.

17. Greenthumb Engineers Pvt. Ltd., 103 Pavanbhumi, Somalwada, Wardha Road, Nagpur 440025, Maharashtra, Telephone : 2819.

18. Irrigation Engineering Company, 5-5-44/45, Ground Floor, 5-5-97 1st Floor, 5-5-42, 2nd Floor, Ranigunj, Hill Street, Secunderabad-500003, Andhra Pradesh, Phones: 75749, 77548;Fax: 0842-842477; Telex: 0425-8484 PCO IN; Grams: IEC DRIP.

19. Jain Irrigation Systems Ltd., Jain Industrial Complex, Jain Pipe Nagar, P.O.Box No.20, Jalgaon - 425001, Maharashtra, Phone: 23201(5 lines), 24603 Fax: 0257-24602; Grams: JAINS, Telex : 0753-201 JAIN IN;

20. Jindal Irrigation Limited, 101, Pragati Tower, 26 Rajendra Place, New Delhi-110008, Phones: 5721954, 5717984, 5727984, 5748638; Telex:31-77283 JIL-IN, Grams: JINDSPRINK.

Drip irrigation offers more crop yields.

21. Jindal Irrigation Systems Limited, B-7, Electronic Complex, Kushaiguda, Hyderabad - 500 712, Andhra Pradesh, Phones: 623909/623974, Fax: 040-622776.

22. Jivan Irrigation Equipments, 503 Shivganga Chambers, 656/1, Budhwar Peth, Near Prabhat Cinema, Pune, Maharashtra.

23. Jyoti Marketing & Projects Ltd., Agri Products Division, B-3/15 BIDC, Gorwa, Vadodara-390016; Phones: 320448, 320561; Telex: 0175-215 JMP IN Grams: SERVEJYOTI.

24. Kalpataru Irrigation Systems Ltd., 917/190 A Sivajinagar, P.O.Road, Pune-411004 Maharashtra; Telephone : 52195; Fax : 212-52894; Gram ; KICONS; Telex : 145-226.

25. Kaveri Drip Irrigation Systems, Plot No.23/A, Phase III, I.D.A., Jeedimetla, Hyderabad, Andhra Pradesh; Phone: 263007, Grams: OCTYL.

26. Kisan Irrigation Equipments, 1696, Vijayshree Buildings, Trichy Road, Ramanathapuram, Coimbatore - 641045. Tamil Nadu

27. Maya Agencies, 2078, Ushama, 10th Lane, Rajarampuri, Kolhapur, Maharashtra.

28. Neo Sud Plantation Pvt. Ltd., Baldota Bhavan, 6th Floor, 117 Maharshi Karve Marg, Churchgate, Bombay-400020, Maharashtra.

29. New Bharat Minerals and Chem., 10 B Haresh Chambers, 313/319 Samuel Street, Bombay-400030

30. Parimal Irrigation Engineering, Arvind 1244, Sadashiv Peth, Near Shivaji Mandi, Pune 411030; Maharashtra.

31. Pasumai Irrigations Limited, 29, Police Commissioner's Office Road, Egmore, Madras-600008, Phones: 044-8255404/861799 Fax: 91-44-880401, Telex: 041-7547/041-6432, Grams: Pasumai.

32. Plastro Irrigation Systems (India) Limited (A Finolex Joint Venture), Block D-1, Plot No.10, MIDC, Chinchwad, Pune-411019 Maharashtra, Phone: 774381-82, Fax: (0212)777217.

Drip irrigation requires less tillage.

33. **Polyene General Industries Pvt. Ltd., P.O.Box 3208, Regd. Office & Factory A-11 & A-1, Industrial Estate, Guindy, MadraS-600032 Tamil Nadu; Phone: 2342306, 2342307, 2343025; Telex: 041-26093 POND; Fax: 044-2341470; Grams: POGENIND.**

34. **Polytube Plastics, 175 Shri Samrath Industrial Estate, Pimpalgaon Baswant-422209 Distt.Nashik, Maharashtra; Phones: (02553) 50340, 50350, Grams: BORASTES, Telex: 0752-276 B Fax IN, Fax: 02553-50106. Regional Office:**
MADRAS: Polytube Plastics, Pragati Irrigation, 13th, 3rd Floor, Armenian Street, MADRAS-600001 TAMIL NADU.
COCHIN: Sterling Farm Research & Services Pvt.Ltd. Post Box No.2344, Sterling House, 35/1865 - Valanjabalam, COCHIN-682016.

35. Polyolefins Industries Ltd., Mafatlal Centre, Nariman Point Bombay- 400021, Phone: 2024226; Fax: 022-2020691; Grams: PILENE; Telex : 011-83478 PIL IN

36. **Premier Irrigation Equipment Ltd., 17/1-C Alipore Road, Calcutta-700027 West Bengal; Phone: 4795155, 4797455 & 4799530; Grams: PREQUI; Telex: 021-8033 PIEC IN. Fax: 91-33- 4797626.**

37. Raindrop Equipments (India) Ltd., A-7, MIDC Area, Amravati- 444605 Maharashtra. Phone: 4969; Grams: RAINDROP;

38. Sprinkler and Drip Irrigation Equipments, Fakhri Manzil Near Pawar Bungalow Amrai, Baramati 413102, Pune, Maharashtra; Phone 2441.

39. Sathish Agricultural Enterprises, 12-3-8 Main Road, Patti-veeranpatti-624211, Anna Distt.Tamil Nadu.

40. Spento Plastics, 'Zamavaz', HK Marg, Dahanu Road, Thane- 401602, Maharashtra, Phone: 2306.

41. Sujay Irrigation System, 497, 1st 'G' Cross, 18th Main, 3rd Stage, 4th Block Basavareshvaranagar, Bangalore-560079, Karnataka

42. Santharaj & Sons, 122 Nanjappa Block, Govipuram Post, Bangalore 560019. Karnataka.

Drip irrigation offers improved plant protection and less diseases.

43. Southern Agro Industries, 161 Greams Road, Post Box 7412, Madras 600006.

44. Shivaji Engineering & M/C Co., 7-A, Murarji Peth Sholapur-413001 Maharashtra.

45. Telecom Wires & Cables; MS Ramaiah Industrial Estate, Gokula, Bangalore-560054. Karnataka

46. Voltas Limited, 19 JN Heredis Marg, Ballard Estate, Bombay- 400038 Maharashtra; Phone :2614771, Fax : 4151852; Grams: VOLTAIP; Telex : 733339/73354.

47. Watman Irrigation Systems Pvt.Ltd., Kinkhede Layout,Opp. Hislop College, Civil Lines, Nagpur-440001, Maharashtra.

48. Wavin India Limited, Irrigation System Division, 706 Rohit House, 3 Tolstoy Marg, New Delhi-110001; Gram : INDWAVIN; Telex : 031-4235.

Drip irrigation offers higher efficiency in fertilizer application.

REFERENCES

1. Abbott, J. S., Micro Irrigation - Worldwide Usage Report by Micro Irrigation Working group, ICID Bulletin, 1988, Vol.37, No.1

2. Agricultural Statistics at a Glance - Directorate of Economics & Statistics, Department of Agriculture & Co-operation, Ministry of Agriculture, Government of India, March, 1993.

3. Annual Reports of the Plastic Culture Development Centres, NCPA, 1988.

4. Bucks, A., Nakayama, F. S. and Warrick, W. Principles, Practices and Potentialities of Trickle (Drip) Irrigation : Advances in Irrigation, Volume I, Academic Press, 1982.

5. Case Histories in India's Experiences - Wavin Polyene Drip Irrigation Systems, 1984.

6. Central Board of Irrigation and Power. Statistics of Minor Irrigation Development, New Delhi, 1989.

7. Dalvi, V.B., Some Research Studies on Drip Irrigation, PKV, Akola, 1992.

8. Department of Agriculture and Co-operation, February, 1991 - Report on the Committee on Drip Irrigation Scheme.

9. Directorate of Irrigation Research and Development, Status Paper on Drip Irrigation, Government of Maharashtra, Pune, (Date not given).

10. Economic Aspects of Irrigation and Pricing of Water by B. N. Navalawala, 1992.

11. Eighth Five Year Plan, Planning Commission, Government of India, 1992.

12. Horticulture Development in Eighth Plan (1992-97) - Scheme Profiles - Horticulture Division, Ministry of Agriculture, Government of India, December, 1993.

13. Indian Petro Chemicals Limited (IPCL). Financing Drip Irrigation Schemes, Gujarat, Karnataka, 1985.

14. Irrigation Research Management Improvement Organisation, Central Water Commission, New Delhi - Drip Irrigation System and Its Relevance in Better Water Use (April, 1991).

Drip irrigation permits use of poor quality of water.

15. Khan, H. K., Micro Irrigation - State-of-the Art in India. Paper presented in the 4th International Congress in Australia, 1988.

16. Kumar, Dr. Ashwani, Sr. Scientist, Water Technology Centre, IARI, Pusa Campus, New Delhi-110012 - Design of Drip Irrigation System.

17. Mahatma Phule Agricultural University, Rahuri 413722 Distt. Ahmednagar, (Maharashtra) - Design, Operation & Maintenance of Drip Irrigation System in India.

18. Mahatma Phule Agricultural University, Rahuri 413722 Distt. Ahmednagar, (Maharashtra) - Symposium on Drip Irrigation (M.P.A.U., Pub.No.34)

19. Mark Svendsen, Sources of Future Growth in Indian Irrigated Agriculture. FPRI and TNAU, 1988.

20. Minor Irrigation Division, Min.of Water Resources, Govt. of India-Central Assistance released to the State Govts.under Centrally Sponsored scheme for Encouraging Use of Sprinklers, Drip System etc. for the years 1982-83 to 1991-92.

21. National Commission on Agriculture, Report of the 1976.

22. NCPA, Plasticulture Presentation to the Minister of State for Petroleum and Chemicals, NCPA (No Date).

23. NCPA, Status, Potential and Approach for Adoption in Drip and Sprinkler Irrigation system, 1990.

24. National Committee on the Use of Plastics in Agriculture, Government of India, Ministry of Industry, New Delhi - Progress of Plasticulture (1986-88).

25. National Committee on the Use of Plastics in Agriculture, Department of Chemicals & Petro-Chemicals, Ministry of Petroleum & Chemicals, New Delhi-110001 - Development of Plastics in Agriculture.

26. Padhye,A. H., Micro and Sprinkler Irrigation in India. Proceedings International Congress on the Use of Plastics in Agriculture, New Delhi, 1989.

27. Patil, V. K. and Chougule, M. Drip Irrigation, Indian Scenario. Personal Communication.

28. Proceedings of Development and Management Training Course on Pressure System of Irrigation.

Drip irrigation offers less weed growth and prevents potential pests.

29. Proceedings of All India Seminar on Sprinkler and Drip Irrigation at Hyderabad, 9-10 December, 1993.

30. Proceedings of the Second National Seminar on Drip Irrigation, TNAU, Coimbatore, 1983.

31. Proceedings of the National Seminar on Use of Plastics in Agriculture, NCPA, New Delhi, 1987.

32. Proceedings of the Workshop on Sprinkler and Drip Irrigation Systems at Jalgaon, Maharashtra, 8-10 December, 1993.

33. Proceedings of the Workshop on Micro Irrigation - Worldwide by ICID at The Hague, The Netherlands, September, 1993.

34. Proceedings - Symposium on Drip Irrigation, Rahuri, 1987

35. Proceedings of the 4th International Congress on Drip Irrigation, Australia, 1988.

36. Proceedings of XI International Congress, The Use of Plastics in Agriculture, New Delhi, 1990.

37. Progress of Plasticulture (1986-88). NCPA, New Delhi, 1989.

38. Rao, K.L., India's Water Resources - Its Assessment, Uses and Projections. Orient Longman, Delhi, 1974.

39. Report on Drip and Sprinkler Irrigation. Agricultural Department, Maharashtra State, April, 1992.

40. Responses from Various Drip Equipment Manufacturers.

41. Responses received from various Members of erstwhile INCID Working Group on Micro Irrigation and the Present Special Committee on Micro and Mechanized Irrigation.

42. Saksena, R.S., Drip Irrigation in India, Status and Issues. Land Bank Journal, Bombay, March, 1992.

43. Sawant, B. F. et. al. Comparative Study of Drip and Traditional irrigation System in Various Crops in India. Indian Journal of Rural Technology, New Delhi, 1991.

44. Shan, S. I., How to boost Drip Irrigation for Farmers. Presented to NCPA, New Delhi, 1990.

Drip irrigation can be used conveniently in hilly terrain and problematic soils.

45. Singh, A., Bamboo Drip Irrigation System. Journal of Agricultural Engineering, Vol.XVI, No.3.

46. Sivanappan, R.K. and Padmakumari, O. Drip Irrigation TNAU, Booklet, 1980.

47. Sivanappan, R. K., Drip Irrigation Research and Development in India, Paper presented in the 3rd International Drip Congress at Fresno, USA, 1985.

48. Sivanappan,R.K., Drip Irrigation Potential and Possibilities in the Developing Countries, Paper presented at the 3rd International Drip Congress at Fresno, USA, 1985.

49. Sivanappan, R.K., Status and Prospects of Drip Irrigation in India. Paper presented in the National Seminar on Use of Plastics in Agriculture, New Delhi, 1987.

50. Sivanappan, R.K. et al Drip Irrigation. Kerthi Publishers, Coimbatore, 1987.

51. Sivanappan, R.K. Drip Irrigation Potential and Possibilities in India. Paper presented at the National Seminar on Drip and Sprinkler Irrigation Methods, Rahuri, 1987.

52. Sivanappan, R. K., Economics of Drip/Sprinkler/Biwall Irrigation for Various Crops in India. Paper presented at the 4th International Micro Irrigation Congress, Australia, 1988.

53. Sivanappan, R.K., Drip/Trickle Irrigation prospects in India Paper presented at the 4th International Micro Irrigation Congress, Australia, 1988.

54. Sivanappan, R.K. and Santhana Basu. Drip Irrigation Research and Development, Design Evaluation and Field Practices, ISAE, New Delhi, 1989.

55. Sivanappan, R. K., Drip Irrigation ; Problems and Prospects Financial Express, 14th October, 1989.

56. Sivanappan, R.K., Draft Report on Perspective Plan for Drip and Sprinkler Irrigation in India, NCPA, New Delhi, 1990.

57. Sivanappan, R. K., Techno Economic Survey of Drip and Sprinkler Irrigation Schemes for Various Crops and Soils. College of Agricultural Banking, Pune, 1990.

58. Sivanappan and Associates. Constraints and Potentials in Popularising Drip and Sprinkler Irrigation System, Coimbatore, 1990.

Drip irrigation offers improved infiltration in soils of low intake.

59. Sivanappan, R.K. Experiences with Drip and sprinkler Irrigation in India. Lecture delivered in the Drip Irrigation Training conducted by CWDRM, Calicut, 1992.

60. Study Group under the auspices of Agri-Energy Round Table, India and Deccan Sagar Institute, Pune, Maharashtra (October, 1988) - Techno-Economic Feasibility Study of Drip Irrigation with Special Reference to Sugarcane.

61. Souvenir Published by the Horticulture Division, Ministry of Agriculture, Government of India, on the occasion of National Horticulture Conference held on December 22, 1993 at New Delhi

62. V.K. Patil, and Chougule, A.A. - Drip Irrigation - Indian Scenario.

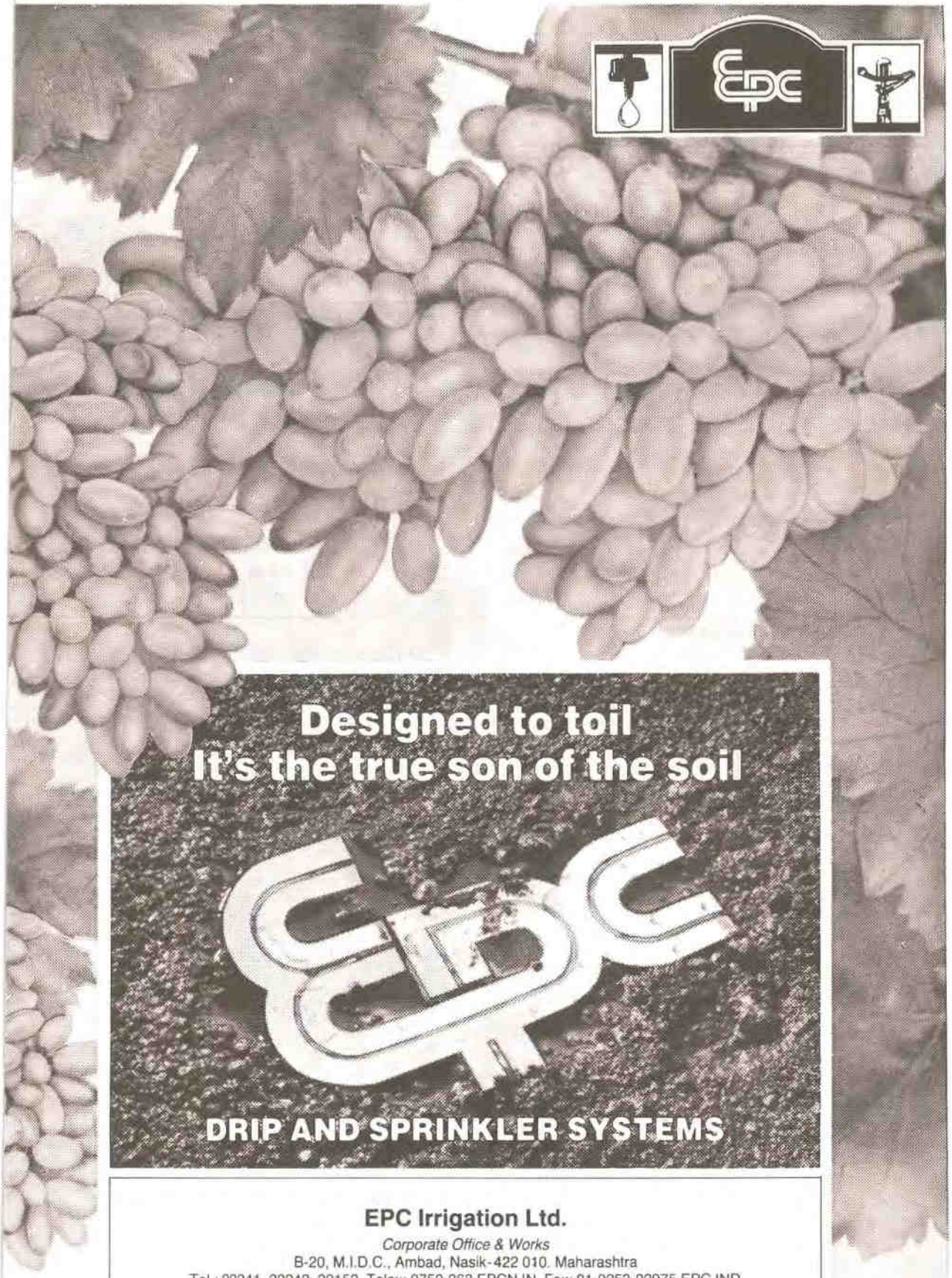
63. Water and Land Management Institute (WALMI), Aurangabad, Maharashtra - Publication No.34, September, 1988 - Drip Irrigation.

64. Water Resources Development in 21st Century - Policy Options for India by Dr. M.S. Reddy, September, 1992.

65. Water Resources of India Publication No.30/88 of Central Water Commission, New Delhi, 1988.

66. Water Resources Potential of India - Reassessment - A CWC Publication, March, 1993.

Drip irrigation generally suits any type of crop, soil and climate.

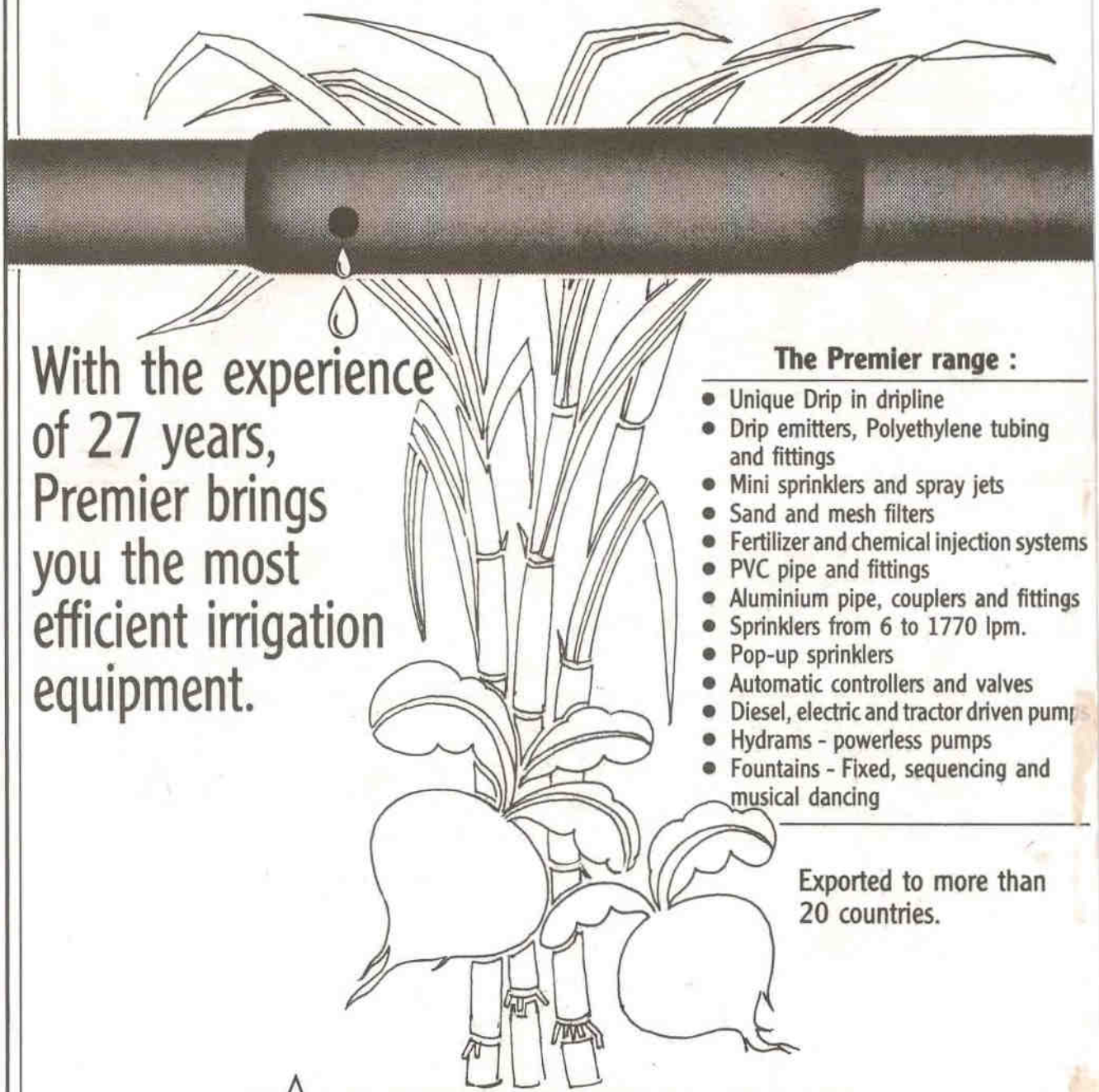


EPC Irrigation Ltd.

Corporate Office & Works
B-20, M.I.D.C., Ambad, Nasik-422 010. Maharashtra
Tel.: 23241, 23242, 22152. Telex: 0752-363 EPCN IN. Fax: 91-0253-22975 EPC IND.
Branches at: Ahmedabad, Aurangabad, Bombay, Bhubaneshwar, Coimbatore, Hubli, Hyderabad, Jabalpur, Jaipur and Sangli.

Avishkar/EPC-1066

Grow More With Less Water



With the experience of 27 years, Premier brings you the most efficient irrigation equipment.

The Premier range :

- Unique Drip in dripline
- Drip emitters, Polyethylene tubing and fittings
- Mini sprinklers and spray jets
- Sand and mesh filters
- Fertilizer and chemical injection systems
- PVC pipe and fittings
- Aluminium pipe, couplers and fittings
- Sprinklers from 6 to 1770 lpm.
- Pop-up sprinklers
- Automatic controllers and valves
- Diesel, electric and tractor driven pumps
- Hydrams - powerless pumps
- Fountains - Fixed, sequencing and musical dancing

Exported to more than 20 countries.

PREMIER IRRIGATION
EQUIPMENT LTD.
17/1C, Alipore Road, Calcutta 700 027 India.
Leaders in total irrigation systems.

DRIP IRRIGATION FOR GRAPEVINE
(Courtesy : Jain Irrigation)

DRIP IRRIGATION FOR KINNOW WITH ADJUSTABLE DISCHARGE EMITTERS
(Courtesy : WTC, IARI, New Delhi)

New address of INCID Secretariat :

M/s WATER AND POWER CONSULTANCY SERVICES (INDIA) LIMITED
301 & 303, Ansal Chambers - II, 6 Bhikaiji Cama Place, New Delhi - 110 066
Telephones : EPABX : 608587, 606807, 608799, 608575,
Fax : (91-11) 6874393

Head Office:

'KAILASH', 26 Kasturba Gandhi Marg, New Delhi - 110 001
Telephones : EPABX : 3313131-4; Cable : WAPCOS, New Delhi;
Fax : (91-11) 3316403; Telex : (81-31) 61961 WAP IN